EDITORIAL BOARD

Editor
Barney Warf
University of Kansas

Associate Editors
Piotr Jankowski
San Diego State University
Barry D. Solomon
Michigan Technological University
Mark Welford
Georgia Southern University

Managing Editor
Jonathan Leib
Old Dominion University
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Entries</td>
<td>vii</td>
</tr>
<tr>
<td>Entries</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>2726</td>
</tr>
<tr>
<td>T</td>
<td>2775</td>
</tr>
<tr>
<td>U</td>
<td>2895</td>
</tr>
<tr>
<td>V</td>
<td>3005</td>
</tr>
<tr>
<td>W</td>
<td>3041</td>
</tr>
<tr>
<td>X</td>
<td>3143</td>
</tr>
<tr>
<td>Z</td>
<td>3147</td>
</tr>
<tr>
<td>Atlas of the World: A Brief Cartographic Overview</td>
<td>3151</td>
</tr>
<tr>
<td>Index</td>
<td>3171</td>
</tr>
<tr>
<td>Abler, Ronald</td>
<td>Air Pollution. See Atmospheric Pollution</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Absolute Space</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td></td>
</tr>
<tr>
<td>Acid Rain</td>
<td></td>
</tr>
<tr>
<td>Actor-Network Theory</td>
<td></td>
</tr>
<tr>
<td>Adaptation to Climate Change</td>
<td></td>
</tr>
<tr>
<td>Adaptive Harvest Management</td>
<td></td>
</tr>
<tr>
<td>Adaptive Radiation</td>
<td></td>
</tr>
<tr>
<td>Adiabatic Temperature Changes</td>
<td></td>
</tr>
<tr>
<td>Aerial Imagery: Data</td>
<td></td>
</tr>
<tr>
<td>Aerial Imagery: Interpretation</td>
<td></td>
</tr>
<tr>
<td>African Union</td>
<td></td>
</tr>
<tr>
<td>Agamben, Giorgio</td>
<td></td>
</tr>
<tr>
<td>Agent-Based Models</td>
<td></td>
</tr>
<tr>
<td>Agglomeration Economies</td>
<td></td>
</tr>
<tr>
<td>Aging and the Aged, Geography of. See Elderly, Geography and the</td>
<td></td>
</tr>
<tr>
<td>Agnew, John</td>
<td></td>
</tr>
<tr>
<td>Agricultural Biotechnology</td>
<td></td>
</tr>
<tr>
<td>Agricultural Intensification</td>
<td></td>
</tr>
<tr>
<td>Agricultural Land Use</td>
<td></td>
</tr>
<tr>
<td>Agriculture, Industrialized</td>
<td></td>
</tr>
<tr>
<td>Agriculture, Preindustrial</td>
<td></td>
</tr>
<tr>
<td>Agrobidiversity</td>
<td></td>
</tr>
<tr>
<td>Agrochemical Pollution</td>
<td></td>
</tr>
<tr>
<td>Agroecology</td>
<td></td>
</tr>
<tr>
<td>Agrofoods</td>
<td></td>
</tr>
<tr>
<td>Agroforestry</td>
<td></td>
</tr>
<tr>
<td>AIDS, Geography of. See Disease, Geography of; HIV/AIDS, Geography of Air Masses</td>
<td></td>
</tr>
<tr>
<td>Arid Topography</td>
<td></td>
</tr>
<tr>
<td>Aristotle</td>
<td></td>
</tr>
<tr>
<td>Armstrong, Marc</td>
<td></td>
</tr>
<tr>
<td>Art and Geography</td>
<td></td>
</tr>
<tr>
<td>Asia-Pacific Economic Cooperation</td>
<td></td>
</tr>
<tr>
<td>Association of American Geographers</td>
<td></td>
</tr>
<tr>
<td>Association of Geographic Information Laboratories for Europe</td>
<td></td>
</tr>
<tr>
<td>Association of Southeast Asian Nations</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Circulation</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Composition and Structure</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Energy Transfer</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Moisture</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Particulates Across Scales</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Pollution</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Pressure</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Remote Sensing</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Variations in Energy</td>
<td></td>
</tr>
<tr>
<td>Atoll</td>
<td></td>
</tr>
<tr>
<td>Automobile Industry</td>
<td></td>
</tr>
<tr>
<td>Automobility</td>
<td></td>
</tr>
<tr>
<td>Avalanches</td>
<td></td>
</tr>
<tr>
<td>Aviation and Geography</td>
<td></td>
</tr>
<tr>
<td>Barrier Islands</td>
<td></td>
</tr>
<tr>
<td>Barrows, Harlan</td>
<td></td>
</tr>
<tr>
<td>Basin and Range Topography</td>
<td></td>
</tr>
<tr>
<td>Batty, Michael</td>
<td>Business Models for Geographic Information Systems</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Buttermer, Anne</td>
</tr>
<tr>
<td>Behavioral Geography</td>
<td>Cadastral Systems</td>
</tr>
<tr>
<td>Berkeley School</td>
<td>CAD Systems</td>
</tr>
<tr>
<td>Berry, Brian</td>
<td>Câmara, Gilberto</td>
</tr>
<tr>
<td>Bhopal, India, Chemical Disaster</td>
<td>Canadian Association of Geographers</td>
</tr>
<tr>
<td>Biblical Mapping</td>
<td>Cancer, Geography of Carbonation</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Carbon Cycle</td>
</tr>
<tr>
<td>Biofuels</td>
<td>Carbon Trading and Carbon Offsets</td>
</tr>
<tr>
<td>Biogeochemistry</td>
<td>Carcinogens</td>
</tr>
<tr>
<td>Biogeography</td>
<td>Carrying Capacity</td>
</tr>
<tr>
<td>Biome: Boreal Forest</td>
<td>Cartograms</td>
</tr>
<tr>
<td>Biome: Desert</td>
<td>Cartography</td>
</tr>
<tr>
<td>Biome: Midlatitude Deciduous Forest</td>
<td>Cartography, History of Castells, Manuel</td>
</tr>
<tr>
<td>Biome: Midlatitude Grassland</td>
<td>Casts, Manuel</td>
</tr>
<tr>
<td>Biome: Tropical Deciduous Forest</td>
<td>Caverns</td>
</tr>
<tr>
<td>Biome: Tropical Rain Forest</td>
<td>Cellular Automata</td>
</tr>
<tr>
<td>Biome: Tropical Savanna</td>
<td>Census</td>
</tr>
<tr>
<td>Biome: Tropical Scrub</td>
<td>Census Tracts</td>
</tr>
<tr>
<td>Biome: Tundra</td>
<td>Centers of Domestication</td>
</tr>
<tr>
<td>Biophysical Remote Sensing</td>
<td>Central Business District</td>
</tr>
<tr>
<td>Bioregionalism</td>
<td>Central Place Theory</td>
</tr>
<tr>
<td>Biosphere Reserves</td>
<td>Chemical Spills, Environment, and Society</td>
</tr>
<tr>
<td>Biota and Climate</td>
<td>Chernobyl Nuclear Accident</td>
</tr>
<tr>
<td>Biota and Soils</td>
<td>Chicago School</td>
</tr>
<tr>
<td>Biota and Topography</td>
<td>Childhood Spatial and Environmental Learning</td>
</tr>
<tr>
<td>Biota Migration and Dispersal</td>
<td>Children, Geography of Chinooks/Foehns</td>
</tr>
<tr>
<td>Biotechnology and Ecological Risk</td>
<td>Chipko Movement</td>
</tr>
<tr>
<td>Biotechnology Industry</td>
<td>Chlorinated Hydrocarbons</td>
</tr>
<tr>
<td>Biruni</td>
<td>Chlorofluorocarbons</td>
</tr>
<tr>
<td>Blaikie, Piers</td>
<td>Cholera, Geography of Chorley, Richard</td>
</tr>
<tr>
<td>Blaut, James</td>
<td>Chorology</td>
</tr>
<tr>
<td>Blindness and Geography</td>
<td>Choropleth Maps</td>
</tr>
<tr>
<td>Body, Geography of Borderlands</td>
<td>Chrisman, Nicholas</td>
</tr>
<tr>
<td>Borders and Boundaries</td>
<td>Christaller, Walter</td>
</tr>
<tr>
<td>Bourguissi, Carmina</td>
<td>Circuits of Capital</td>
</tr>
<tr>
<td>Bowman, Isaiah</td>
<td>Citizenship</td>
</tr>
<tr>
<td>Brownfields</td>
<td>Civil Society</td>
</tr>
<tr>
<td>Built Environment</td>
<td>Clark, Andrew</td>
</tr>
<tr>
<td>Bunge, William</td>
<td>Clark, William</td>
</tr>
<tr>
<td>Bush Fallow Farming</td>
<td>Commons, Tragedy of the Commonwealth of Independent States</td>
</tr>
<tr>
<td>Business Cycles and Geography</td>
<td>Communications Geography</td>
</tr>
<tr>
<td>Business Geography</td>
<td>Communism and Geography</td>
</tr>
<tr>
<td>Business Geography</td>
<td>Community-Based Conservation</td>
</tr>
<tr>
<td>Business Geography</td>
<td>Community-Based Environmental Planning</td>
</tr>
<tr>
<td>Business Geography</td>
<td>Community-Based Natural Resource Management</td>
</tr>
<tr>
<td>Class, Geography and Class, Nature and</td>
<td>Conference of Latin Americanist Geographers</td>
</tr>
<tr>
<td>Client-Server Architecture</td>
<td>Climate: Dry</td>
</tr>
<tr>
<td>Climate: Midlatitude, Mild</td>
<td>Climate: Midlatitude, Severe</td>
</tr>
<tr>
<td>Climate: Mountain</td>
<td>Climate: Polar</td>
</tr>
<tr>
<td>Climate: Tropical Humid</td>
<td>Climate Change</td>
</tr>
<tr>
<td>Climate Policy</td>
<td>Climate Types</td>
</tr>
<tr>
<td>Climatic Relict</td>
<td>Climatology</td>
</tr>
<tr>
<td>Clouds</td>
<td>Clusters</td>
</tr>
<tr>
<td>Coal</td>
<td>Coastal Dead Zones</td>
</tr>
<tr>
<td>Coastal Erosion and Deposition</td>
<td>Coastal Hazards</td>
</tr>
<tr>
<td>Coastal Zone and Marine Pollution</td>
<td>Cold War, Geography of Collaborative GIS</td>
</tr>
<tr>
<td>Colonialism</td>
<td>Color in Map Design</td>
</tr>
<tr>
<td>Columbus, Christopher</td>
<td>Commodity Chains</td>
</tr>
<tr>
<td>Commons, Tragedy of the Commonwealth of Independent States</td>
<td>Common Pool Resources</td>
</tr>
<tr>
<td>Communications Geography</td>
<td>Common Property Resource Management</td>
</tr>
<tr>
<td>Communism and Geography</td>
<td>Community-Based Conservation</td>
</tr>
<tr>
<td>Community-Based Environmental Planning</td>
<td>Community-Based Natural Resource Management</td>
</tr>
<tr>
<td>Community Forestry</td>
<td>Commuting</td>
</tr>
<tr>
<td>Competitive Advantage</td>
<td>Complex Systems Models</td>
</tr>
<tr>
<td>Complexity Theory</td>
<td>Conference of Latin Americanist Geographers</td>
</tr>
</tbody>
</table>
Conflation
Conservation
Conservation Zoning
Consumption, Geographies of
Continental Drift. See Plate
   Tectonics
Cook, Captain James
Coordinate Geometry
Coordinate Systems
Coordinate Transformations
Coral Reef
Coral Reef Geomorphology
Coriolis Force
Corporate Voluntary
   Environmental Initiatives
   and Self-Regulation
Cosgrove, Denis
Cosmopolitanism
Cost-Benefit Analysis
Council for Mutual Economic
   Assistance (COMECON)
Countermapping
Counterurbanization
Coupled Human and Animal
   Systems
Coupled Human and Natural
   Systems
Creep
Crime, Geography of
   Crisis
Critical Geopolitics
Critical GIS
Critical Human Geography
Critical Studies of Nature
Crop Genetic Diversity
Crop Rotation
Cross-Border Cooperation
Cultural Ecology
Cultural Geography
Cultural Landscape
Cultural Turn
Cyberspace
Cyborg Ecologies
Cyclones: Extratropical
Cyclones: Occluded
Dangermond, Jack
Darby, Henry Clifford
Darwinism and Geography
Dasymetric Maps
Database Management Systems
Database Versioning
Data Classification Schemes
Data Compression Methods
Data Editing
Data Format Conversion
Data Indexing
Data Querying in GIS
Datums
Davis, William Morris
Dear, Michael
Debt and Debt Crisis
Decolonization
Deep Ecology Movements
Deforestation
Deindustrialization
Delta
Democracy
Demographic Transition
Dendrochronology
Dependency Theory
Derechos
Desertification
Desert Varnish
Deterritorialization and
   Reterritorialization
Developing World
Development Theory
Diamond, Jared
Diaspora
Diastrophism
Difference, Geographies of
   Differential Heating
Differential Vulnerabilities to
   Hazards
Diffusion
Digital Divide
Digital Terrain Model
Digitizing
Disability, Geography of
Disaster Prediction and
   Warning
Disaster Preparedness
Discourse and Geography
Disease, Geography of
Distance Decay
Distributed Computing
Distribution of Resource
   Access
Division of Labor
Domestication Centers. See
   Centers of Domestication
Domestication of Animals
Domestication of Plants
Domino Theory
Dot Density Maps
Drought Risk and Hazard
Drugs, Geography of
Dunes
Dynamic and Interactive
   Displays
Earle, Carville
Earthquakes
Earth’s Coordinate Grid
Eastman, Ronald
Ecofeminism
Ecological Economics
Ecological Fallacy
Ecological Footprint
Ecological Imaginaries
Ecological Justice
Ecological Mapping
Ecological Modernization
Ecological Regimes
Ecological Risk Analysis
Ecological Services. See
   Environmental Services
Ecological Zones
E-Commerce and
   Geography
Economic Base Analysis
Economic Geography
Economies of Scale
Economies of Scope
Ecoregions
Ecoshed
Ecosystem Decay
Ecosystems
Ecotone
Ecotourism
Education, Geographies of
Egenhofer, Max
Elderly, Geography and the
Electoral Geography
Electronic Atlases
Electronics Industry,
   Geography of
El Niño
Emerging Markets
LIST OF ENTRIES

Emotions, Geography and Empiricism
Endogenous Growth Theory. See Knowledge Spillovers; Learning Regions
Energy and Human Ecology
Energy Models
Energy Policy
Energy Resources
Enlightenment
Enterprise GIS
Environmental Certification
Environmental Determinism
Environmental Discourse
Environmental Entitlements
Environmental Ethics
Environmental Footprint. See Ecological Footprint
Environmental History
Environmental Imaginaries
Environmental Impact Assessment
Environmental Impacts of Agriculture
Environmental Impacts of Cities
Environmental Impacts of Manufacturing
Environmental Impacts of Mining. See Open-Pit Mining
Environmental Impacts of Oil Fields
Environmental Impacts of Pipelines
Environmental Impacts of Roads
Environmental Impacts of Tourism
Environmental Impacts of War
Environmental Impact Statement
Environmental Justice
Environmental Law
Environmental Management
Environmental Management: Drylands
Environmental Mapping
Environmental Perception
Environmental Planning
Environmental Protection
Environmental Racism
Environmental Refugees
Environmental Restoration
Environmental Rights
Environmental Security
Environmental Services
Environmental Social Movements. See International Environmental Movements
Environment and Development
Epistemology
Equator
Equinox
Eratosthenes
Error Propagation
Ethics, Geography and Ethnicity
Ethnicity
Ethnicity and Nature
Ethnic Segregation
Ethnocentrism
Eurocentrism
Euromarkets
European Green Movements
European Union
Everglades Restoration
Everyday Life, Geography and Existentialism and Geography
Exotic Species
Exploration
Exploratory Spatial Data Analysis
Export-Led Development
Export Processing Zones
Externalities
Extinctions
Extractive Reserves
Extinctions
Exotic Species
Floodplain
Floods
Flow
Flow Maps
Folding
Folk Culture and Geography
Food, Geography of
Food and Agriculture Organization (FAO)
Footprint Analysis. See Ecological Footprint
Fordism
Foreign Aid
Foreign Direct Investment
Forest Degradation
Forest Fragmentation
Forest Land Use
Forest Restoration
Fotheringham, A. Stewart
Frank, Andrew
Frontiers
Fronts
Gaia Theory
Gama, Vasco da
Game Ranching
Gated Community
Gays and Lesbians, Geography and/of
Gazetteers
Feminist Environmentalism
Feminist Geographies
Feminist Methodologies
Feminist Political Ecology
Fertility Rate
Fieldwork in Human Geography
Fieldwork in Physical Geography
Film and Geography
Filtering
Filtration
Finance, Geography of
Fisher, Peter
Fish Farming
Fjords
Flash Floods
Flexible Production
Flocculation
Floodplain
Floods
Flow
Flow Maps
Folding
Folk Culture and Geography
Food, Geography of
Food and Agriculture Organization (FAO)
Footprint Analysis. See Ecological Footprint
Fordism
Foreign Aid
Foreign Direct Investment
Forest Degradation
Forest Fragmentation
Forest Land Use
Forest Restoration
Fotheringham, A. Stewart
Frank, Andrew
Frontiers
Fronts
Gaia Theory
Gama, Vasco da
Game Ranching
Gated Community
Gays and Lesbians, Geography and/of
Gazetteers
<table>
<thead>
<tr>
<th>Gender and Environmental Hazards</th>
<th>GIS, History of GIScience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender and Geography</td>
<td>GIS Design</td>
</tr>
<tr>
<td>Gender and Nature</td>
<td>GIS Implementation</td>
</tr>
<tr>
<td>General Circulation Model (GCM)</td>
<td>GIS in Archaeology</td>
</tr>
<tr>
<td>See Anthropogenic Climate Change; Atmospheric Energy Transfer; Climate Change</td>
<td>GIS in Disaster Response</td>
</tr>
<tr>
<td>Genetically Modified Organisms (GMOs)</td>
<td>GIS in Environmental Management</td>
</tr>
<tr>
<td>Genocide, Geographies of Gentrification</td>
<td>GIS in Health Research and Health Care</td>
</tr>
<tr>
<td>Geocoding</td>
<td>GIS in Land Use Management</td>
</tr>
<tr>
<td>Geocollaboration</td>
<td>GIS in Local Government</td>
</tr>
<tr>
<td>Geocomputation</td>
<td>GIS in Public Policy</td>
</tr>
<tr>
<td>Geodemographics</td>
<td>GIS in Transportation</td>
</tr>
<tr>
<td>Geodesy</td>
<td>GIS in Urban Planning</td>
</tr>
<tr>
<td>Geographical Ignorance</td>
<td>GIS in Utilities</td>
</tr>
<tr>
<td>Geographical Imagination</td>
<td>GIS in Water Management</td>
</tr>
<tr>
<td>Geographically Weighted Regression</td>
<td>GIS Software</td>
</tr>
<tr>
<td>Geographic Information Systems</td>
<td>GIS Web Services</td>
</tr>
<tr>
<td>Geography Education</td>
<td>Glaciers: Continental</td>
</tr>
<tr>
<td>Geolibraries</td>
<td>Glaciers: Mountain</td>
</tr>
<tr>
<td>Geologic Timescale</td>
<td>Global Climate Change. See Anthropogenic Climate Change</td>
</tr>
<tr>
<td>Geomancy</td>
<td>Global Environmental Change</td>
</tr>
<tr>
<td>Geometric Correction</td>
<td>Globalization</td>
</tr>
<tr>
<td>Geometric Measures</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>Geomorphic Cycle</td>
<td>Global Sea-Level Rise</td>
</tr>
<tr>
<td>Geomorphology</td>
<td>Global Warming. See</td>
</tr>
<tr>
<td>Geophagy</td>
<td>Anthropogenic Climate Change</td>
</tr>
<tr>
<td>Geopolitics</td>
<td>Globes. See Cartography; Map Projections</td>
</tr>
<tr>
<td>Geosensor Networks</td>
<td>Glocalization</td>
</tr>
<tr>
<td>Geospatial Industry</td>
<td>Golley, Reginald</td>
</tr>
<tr>
<td>Geospatial Semantic Web</td>
<td>Goodchild, Michael</td>
</tr>
<tr>
<td>Geostatistics</td>
<td>Goode, J. Paul</td>
</tr>
<tr>
<td>Geothermal Energy</td>
<td>Google Earth</td>
</tr>
<tr>
<td>Geothermal Features</td>
<td>Gottmann, Jean</td>
</tr>
<tr>
<td>Geovisualization. See Cartography; Dynamic and Interactive Displays; Three-Dimensional Models</td>
<td>Gould, Peter</td>
</tr>
<tr>
<td>Getis, Arthur</td>
<td>Governance</td>
</tr>
<tr>
<td>Ghetto</td>
<td>Governmentality and Conservation</td>
</tr>
<tr>
<td>Giddens, Anthony</td>
<td>Gravity Model</td>
</tr>
<tr>
<td>Gilbert, Grove Karl</td>
<td>Great American Exchange</td>
</tr>
<tr>
<td>GIS, Environmental Model Integration and</td>
<td>Greenbelts</td>
</tr>
<tr>
<td></td>
<td>Green Building</td>
</tr>
<tr>
<td></td>
<td>Green Design and Development</td>
</tr>
<tr>
<td></td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td></td>
<td>Green Revolution. See</td>
</tr>
<tr>
<td></td>
<td>Environmental Impacts of Agriculture</td>
</tr>
<tr>
<td></td>
<td>Gregory, Derek</td>
</tr>
<tr>
<td></td>
<td>Gross Domestic Product/Gross National Product</td>
</tr>
<tr>
<td></td>
<td>Ground Reference Data</td>
</tr>
<tr>
<td></td>
<td>Groundwater</td>
</tr>
<tr>
<td></td>
<td>Growth Machine</td>
</tr>
<tr>
<td></td>
<td>Growth Poles</td>
</tr>
<tr>
<td></td>
<td>Gully Erosion</td>
</tr>
<tr>
<td></td>
<td>Guyot, Arnold</td>
</tr>
<tr>
<td></td>
<td>Hadley Cell</td>
</tr>
<tr>
<td></td>
<td>Hägerstrand, Torsten</td>
</tr>
<tr>
<td></td>
<td>Haggett, Peter</td>
</tr>
<tr>
<td></td>
<td>Hanson, Susan</td>
</tr>
<tr>
<td></td>
<td>Harley, Brian</td>
</tr>
<tr>
<td></td>
<td>Hartshorne, Richard</td>
</tr>
<tr>
<td></td>
<td>Harvey, David</td>
</tr>
<tr>
<td></td>
<td>Hate, Geographies of</td>
</tr>
<tr>
<td></td>
<td>Haushofer, Karl</td>
</tr>
<tr>
<td></td>
<td>Hayden, Ferdinand</td>
</tr>
<tr>
<td></td>
<td>Health and Health Care, Geographical Analysis</td>
</tr>
<tr>
<td></td>
<td>Heavy Metals as Pollutants</td>
</tr>
<tr>
<td></td>
<td>Hegemony</td>
</tr>
<tr>
<td></td>
<td>Herbicides</td>
</tr>
<tr>
<td></td>
<td>Herodotus</td>
</tr>
<tr>
<td></td>
<td>Hettner, Alfred</td>
</tr>
<tr>
<td></td>
<td>Heuristic Methods in Spatial Analysis</td>
</tr>
<tr>
<td></td>
<td>High-Performance Computing</td>
</tr>
<tr>
<td></td>
<td>High Technology</td>
</tr>
<tr>
<td></td>
<td>Hipparchus</td>
</tr>
<tr>
<td></td>
<td>Historical Geography</td>
</tr>
<tr>
<td></td>
<td>Historicism</td>
</tr>
<tr>
<td></td>
<td>Historic Preservation</td>
</tr>
<tr>
<td></td>
<td>History of Geography. See</td>
</tr>
<tr>
<td></td>
<td>Cartography, History of; GIS, History of; Human Geography, History of; Physical Geography, History of HIV/AIDS, Geography of Home Homelessness Hou Renzhi</td>
</tr>
<tr>
<td>Housing and Housing Markets</td>
<td>Indigenous and Community Conserved Areas</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Housing Policy</td>
<td>Indigenous Cartographies</td>
</tr>
<tr>
<td>Hoyt, Homer</td>
<td>Indigenous Environmental Knowledge</td>
</tr>
<tr>
<td>Human Dimensions of Global</td>
<td>Indigenous Environmental Practices</td>
</tr>
<tr>
<td>Environmental Change</td>
<td>Indigenous Forestry</td>
</tr>
<tr>
<td>Human Ecology</td>
<td>Indigenous Reserves</td>
</tr>
<tr>
<td>Human Geography, History of</td>
<td>Indigenous Water Management</td>
</tr>
<tr>
<td>Human-Induced Invasion of</td>
<td>Industrial Districts</td>
</tr>
<tr>
<td>Species</td>
<td>Industrial Ecology</td>
</tr>
<tr>
<td>Humanistic Geography</td>
<td>Industrialization</td>
</tr>
<tr>
<td>Humanistic GIScience</td>
<td>Industrial Revolution</td>
</tr>
<tr>
<td>Human Rights, Geography and</td>
<td>Inequality and Geography</td>
</tr>
<tr>
<td>Humboldt, Alexander von</td>
<td>Informal Economy</td>
</tr>
<tr>
<td>Humidity</td>
<td>Information Society</td>
</tr>
<tr>
<td>Hunger</td>
<td>Infrastructure</td>
</tr>
<tr>
<td>Hunting and Gathering</td>
<td>Innovation, Geography of</td>
</tr>
<tr>
<td>Huntington, Ellsworth</td>
<td>Input-Output Models</td>
</tr>
<tr>
<td>Hurricane Katrina</td>
<td>International Criminal Court</td>
</tr>
<tr>
<td>Hurricanes, Physical</td>
<td>International Environmental Movements</td>
</tr>
<tr>
<td>Geography of</td>
<td>International Environmental NGOs</td>
</tr>
<tr>
<td>Hurricanes, Risk and Hazard</td>
<td>International Geographical Union</td>
</tr>
<tr>
<td>Hybrid Geographies</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>Hybridization of Plant and</td>
<td>International Watershed Management</td>
</tr>
<tr>
<td>Animal Species</td>
<td>Internet. See Communications, Geography</td>
</tr>
<tr>
<td>Hydroelectric Power</td>
<td>of; Cyberspace; Digital Divide;</td>
</tr>
<tr>
<td>Hydrological Connectivity</td>
<td>Telecommunications and Geography</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Internet GIS</td>
</tr>
<tr>
<td>Hydrothermal Energy. See</td>
<td>Interoperability and Spatial</td>
</tr>
<tr>
<td>Geothermal Energy</td>
<td>Data Standards</td>
</tr>
<tr>
<td>Ibn Battuta</td>
<td>Interviewing</td>
</tr>
<tr>
<td>Ibn Khaldūn</td>
<td>Invasion and Succession</td>
</tr>
<tr>
<td>Ice</td>
<td>Isard, Walter</td>
</tr>
<tr>
<td>Identity, Geography and</td>
<td>Island Biogeography</td>
</tr>
<tr>
<td>Idiographic</td>
<td>Islands, Small</td>
</tr>
<tr>
<td>Image Enhancement</td>
<td>Isopleth Maps</td>
</tr>
<tr>
<td>Image Fusion</td>
<td>Jackson, John Brinckerhoff</td>
</tr>
<tr>
<td>Image Interpretation</td>
<td>Jefferson, Thomas</td>
</tr>
<tr>
<td>Image Processing</td>
<td>Johnston, R. J.</td>
</tr>
<tr>
<td>Image Registration</td>
<td>Journey-to-Work. See</td>
</tr>
<tr>
<td>Image Texture</td>
<td>Commuting</td>
</tr>
<tr>
<td>Imaging Spectroscopy</td>
<td>Justice, Geography of</td>
</tr>
<tr>
<td>Immigration</td>
<td>Kant, Immanuel</td>
</tr>
<tr>
<td>Imperialism</td>
<td>Karst Topography</td>
</tr>
<tr>
<td>Impermeable Surfaces</td>
<td>Kates, Robert</td>
</tr>
<tr>
<td>Import Substitution</td>
<td>Keystone Species</td>
</tr>
<tr>
<td>Industrialization</td>
<td>Knowledge, Geography of</td>
</tr>
<tr>
<td>Incubator Zones</td>
<td>Knowledge Spillovers</td>
</tr>
<tr>
<td>Indigeneity</td>
<td>Köppen, Wladimir</td>
</tr>
<tr>
<td>Indigenous Agriculture</td>
<td>Köppen-Geiger Climate Classification</td>
</tr>
<tr>
<td></td>
<td>Kropotkin, Peter</td>
</tr>
<tr>
<td></td>
<td>Krummholtz</td>
</tr>
<tr>
<td></td>
<td>Kuhn, Werner</td>
</tr>
<tr>
<td></td>
<td>Kwan, Mei-Po</td>
</tr>
<tr>
<td></td>
<td>Kyoto Protocol. See</td>
</tr>
<tr>
<td></td>
<td>Climate Policy</td>
</tr>
<tr>
<td></td>
<td>Labor, Geography of</td>
</tr>
<tr>
<td></td>
<td>Lahar. See Volcanoes</td>
</tr>
<tr>
<td></td>
<td>Land Degradation</td>
</tr>
<tr>
<td></td>
<td>Landfills</td>
</tr>
<tr>
<td></td>
<td>Landforms</td>
</tr>
<tr>
<td></td>
<td>Land Reform</td>
</tr>
<tr>
<td></td>
<td>Landscape and Wildlife Conservation</td>
</tr>
<tr>
<td></td>
<td>Landscape Architecture</td>
</tr>
<tr>
<td></td>
<td>Landscape Biodiversity</td>
</tr>
<tr>
<td></td>
<td>Landscape Design</td>
</tr>
<tr>
<td></td>
<td>Landscape Ecology</td>
</tr>
<tr>
<td></td>
<td>Landscape Interpretation</td>
</tr>
<tr>
<td></td>
<td>Landscape Quality Assessment</td>
</tr>
<tr>
<td></td>
<td>Landscape Restoration</td>
</tr>
<tr>
<td></td>
<td>Landslide</td>
</tr>
<tr>
<td></td>
<td>Land Tenure</td>
</tr>
<tr>
<td></td>
<td>Land Tenure Reform</td>
</tr>
<tr>
<td></td>
<td>Land Use</td>
</tr>
<tr>
<td></td>
<td>Land Use Analysis</td>
</tr>
<tr>
<td></td>
<td>Land Use and Cover Change (LUCC)</td>
</tr>
<tr>
<td></td>
<td>Land Use and Land Cover Mapping</td>
</tr>
<tr>
<td></td>
<td>Land Use History</td>
</tr>
<tr>
<td></td>
<td>Land Use Planning</td>
</tr>
</tbody>
</table>
LIST OF ENTRIES

Land-Water Breeze
Languages, Geography of
La Niña
Lapse Rate
Latent Heat
Latitude
Law, Geography of
Learning Regions
Lefebvre, Henri
Legal Aspects of Geospatial Information
Lewis, Peirce
Lewis and Clark Expedition
Ley, David
LiDAR and Airborne Laser Scanning
Lightning
Lillesand, Thomas
Linear Referencing and Dynamic Segmentation
Literature, Geography and
Livingstone, David
Locality
Locally Unwanted Land Uses (LULUs)
Location-Allocation Modeling
Location-Based Services
Location Quotients
Location Theory
Logical Positivism
Longitude
Los Angeles School
Lösch, August
Love Canal
Lynch, William

MacEachren, Alan
Mackinder, Sir Halford
Magellan, Ferdinand
Mahan, Alfred Thayer
Malaria, Geography of
Malthusianism
Manufacturing Belt
Map Algebra
Map Animation
Map Design
Map Evaluation and Testing
Map Generalization
Map Projections
Map Visualization
Marcus, Melvin G.
Marginal Regions
Marine Aquaculture
Maritime Spaces. See Oceans
Mark, David M.
Market-Based Environmental Regulation
Marsh, George Perkins
Marxism, Geography and Masculinities and Geography
Massey, Doreen
Mass Wasting
Mather, John Russell
Maury, Matthew Fontaine
McKnight, Tom L.
Media and Geography
Medical Geography
Meinig, Donald
Mental Maps
Mercator, Gerardus
Metadata
Metropolitan Area
Microwave/RADAR Data
Migration
Military Geography
Military Spending
Miller, Harvey J.
Minerals
Mining and Geography
Mitchell, Don
Mixed Farming
Mobile GIS
Mobility
Models and Modeling
Modernity
Modernization Theory
Modifiable Areal Unit Problem
Money, Geographies of
Monmonier, Mark
Monsoons
Morrill, Richard
Morse, Jedediah
Mortality Rate
Most Favored Nation Status
Movimento Sem Terra
Multimedia Mapping
Multispectral Imagery
Multistakeholder Participation
Multitemporal Imaging
Multivariate Analysis Methods
Multivariate Mapping
Music and Sound, Geography and
Nation
National Aeronautics and Space Administration (NASA)
National Center for Geographic Information and Analysis
National Council for Geographic Education
National Geographic Society
Nationalism
Natural Growth Rate
Natural Hazards and Risk Analysis
Nature
Nature-Society Theory
Neighborhood
Neocolonialism
Neogeography
Neoliberal Environmental Policy
Neoliberalism
Neo-Malthusianism
Network Analysis
Network Data Model
New International Division of Labor
Newly Industrializing Countries
New Urbanism
Nitrogen Cycle
Nomadic Herding
Nomadism
Nomothetic
Nongovernmental Organizations (NGOs)
Nonpoint Sources of Pollution
Nonrenewable Resources
Nonrepresentational Theory
Nonvisual Geographies
North American Free Trade Agreement (NAFTA)
North Atlantic Treaty Organization (NATO)
Not in My Backyard (NIMBY)
Nuclear Energy
Nutrient Cycles
Nyerges, Timothy

Object-Based Image Analysis
Oceanic Circulation
Oceans
Offshore Finance
Oil Spills
Okabe, Atsuyuki
Olsson, Gunnar
Ontological Foundations of Geographical Data
Ontology
Open Geodata Standards
Open Geospatial Consortium (OGC)
Open-Pit Mining
Open Source Geospatial Foundation
Open Source GIS
Open Space
Organic Agriculture
Organisation for Economic Co-operation and Development (OECD)
Organization of the Petroleum Exporting Countries (OPEC)
Organophosphates
Orientalism
Ortelius
Other/Otherness
Outsourcing
Overpopulation. See Malthusianism; Neo-Malthusianism

Palimpsest
Panchromatic Imagery
Panopticon
Parks and Reserves
Parsons, James
Participant Observation
Participatory Learning and Action
Participatory Mapping
Participatory Planning
Participatory Rural Appraisal
Pastoral Herding. See Nomadic Herding

Patches and Corridors in Wildlife Conservation
Path Dependence
Patriarchy, Geography and Peasants and Peasantry
Peat
Pedology. See Soils
Peet, Richard
Penck, Walther
Periglacial Environments
Permaculture
Permafrost
Pesticides
Pest Management
Petroleum
Penuquet, Donna
Phenomenology
Phosphorus Cycle
Photochemical Smog
Photogrammetric Methods
Photography, Geography and Physical Geography, History of
Pickles, John
Pilgrimage
Place
Place Names
Place Promotion
Plantations
Plate Tectonics
Playas
Point Pattern Analysis
Point Sources of Pollution
Poles, North and South
Political Ecology
Political Economy
Political Economy of Resources
Political Geography
Polychlorinated Biphenyls (PCBs)
Popular Culture, Geography and Population and Land Degradation
Population and Land Use
Population Density
Population, Environment, and Development
Population Geography
Population Pyramid
Portolan Charts
Ports and Maritime Trade

Positionality
Positivism. See Logical Positivism
Postcolonialism
Post-Fordism. See Flexible Production
Postindustrial Society
Postmodernism
Poststructuralism
Poverty
Powell, John Wesley
Prairie Restoration
Prairies
Precipitation, Global
Precipitation Formation
Pred, Allan
Primate Cities
Prime Meridian. See Longitude
Privacy and Security of Geospatial Information
Producer Services
Product Cycle
Production of Space
Psychoanalysis, Geography and Ptolemy
Public Housing
Public Participation GIS
Public Policy, Geography of Public-Private Partnerships
Public Space
Public Water Services
Pyrogeography

Qualitative Methods
Quantitative Methods
Quantitative Revolution
Queer Theory

Race and Empire
Race and Nature
Race and Racism
Racial Segregation
Radiation: Solar and Terrestrial
Radical Geography
Radiometric Correction
Radiometric Normalization
Radiometric Resolution
Railroads and Geography
Raisz, Erwin
| Rank-Size Rule                                 |
| Ratzel, Friedrich                             |
| Real Estate, Geography and Realism            |
| Reclus, Élisée                                |
| Recycling of Municipal Solid Waste            |
| Redistricting                                |
| Refugees                                     |
| Regional Economic Development                 |
| Regional Environmental Planning               |
| Regional Geography                            |
| Regional Governance                           |
| Regional Science                              |
| Regional Science Association International (RSAI) |
| Regions and Regionalism                       |
| Regulation Theory                            |
| Relational Space. See Relative/Relational Space |
| Relative/Relational Space                    |
| Religion, Geography and Relph, Edward         |
| Remittances                                  |
| Remote Sensing                               |
| Remote Sensing: Platforms and Sensors         |
| Remote Sensing in Disaster Response          |
| Renewable Resources                          |
| Rent-Gap                                     |
| Representations of Space                     |
| Research and Development, Geographies of Resilience |
| Resistance, Geographies of Resource Economics |
| Resource Geography                           |
| Resource Management. See Environmental Management |
| Resource Management, Decision Models in Resource Mapping |
| Resource Tenure                              |
| Restoration Ecology. See Environmental Restoration |
| Restructuring                                |
| Retail Trade, Geography of Rill Erosion       |
| Risk Analysis and Assessment                 |
| Ritter, Carl                                 |
| Rivers                                       |
| Rock Weathering                              |
| Rose, Gillian                                |
| Royal Geographical Society                   |
| Rural Development                            |
| Rural Geography                              |
| Rural-Urban Migration                        |
| Russian Geographical Society                 |
| Satellites and Geography                     |
| Sauer, Carl                                  |
| Scale, Social Production of Scale in GIS     |
| Schaefer, Fred                               |
| Science, Technology, and Environment         |
| Science and Technology Studies               |
| Scott, Allen                                 |
| Sedimentary Rock                             |
| Sedimentation                                |
| Segregation and Geography                    |
| Self-Organizing Maps                         |
| Semantic Interoperability                    |
| Semantic Reference Systems                   |
| Semple, Ellen Churchill                      |
| Sense of Place                               |
| Sequent Occupance                            |
| Services. See Producer Services              |
| Settlement Geography                         |
| Sexuality, Geography and/or Shifting Cultivation |
| Shortest-Path Problem                        |
| Single Large or Several Small (SLOSS) Debate |
| Situated Knowledge                           |
| Smart Growth                                 |
| Smith, Neil                                  |
| Smog. See Photochemical Smog                 |
| Social and Economic Impacts of Climate Change|
| Social Construction of Nature                |
| Social Darwinism                             |
| Social Forestry                              |
| Social Geography                             |
| Socialism and Geography                      |
| Social Justice                               |
| Social Movements                             |
| Soil Conservation                            |
| Soil Degradation                             |
| Soil Depletion                               |
| Soil Erosion                                 |
| Soils                                        |
| Soja, Edward                                 |
| Solar Energy                                 |
| Solstices                                    |
| Sovereignty                                  |
| Space, Production of. See Production of Space |
| Space of Flows                               |
| Spaces of Representation/Representational Spaces |
| Spatial Analysis                             |
| Spatial Autocorrelation                      |
| Spatial Cognition                            |
| Spatial Cognitive Engineering                |
| Spatial Data Infrastructures                 |
| Spatial Data Integration                     |
| Spatial Data Mining                          |
| Spatial Data Models                          |
| Spatial Data Structures                      |
| Spatial Decision Support Systems              |
| Spatial Econometrics                         |
| Spatial Fix                                  |
| Spatial Inequality                           |
| Spatial Interaction Models                   |
| Spatial Interpolation                        |
| Spatialization                               |
| Spatially Integrated Social Science          |
| Spatial Multicriteria Evaluation             |
| Spatial Optimization Methods                 |
| Spatial Resolution                           |
| Spatial Statistics                           |
| Spatial Strategies of Conservation           |
| Spatial Turn                                 |
| Species-Area Relationship                    |
| Spectral Characteristics of Terrestrial Surfaces |
| Spectral Resolution                          |
| Spectral Transformations                      |
| Spit. See Coastal Erosion and Deposition      |
| Sports, Geography of Squatter Settlements    |
| State                                        |
Steel Industry, Geography of
Stereoscopy and Orthoimagery
Storper, Michael
Strabo
Strahler, Arthur
Stratospheric Ozone Depletion
Strip Mining
Structural Adjustment
Structuralism
Stratification Theory
Subaltern Studies
Suburban Land Use
Suburbs and Suburbanization
Sui, Daniel
Suitability Analysis
Sunbelt
Supervised Classification
Supranational Integration
Surface Water
Surveillance
Surveying
Sustainability Science
Sustainable Agriculture
Sustainable Cities
Sustainable Development
Sustainable Development Alternatives
Sustainable Fisheries
Sustainable Forestry
Sustainable Production
Symbolism and Place
Symptoms and Effects of Climate Change
Taphonomy
Taylor, Griffith
Taylor, Peter
Technological Change, Geography of
Telecommunications and Geography
Teleconnections
Television and Geography
Temperature Patterns
Temporal GIS
Temporal Resolution
Terrain Analysis
Territory
Terrorism, Geography of
Text/Textuality
Textile Industry
Thales
Thermal Imagery
Thornthwaite, C. Warren
Three-Dimensional Data Models
Three Mile Island Nuclear Accident
Thrift, Nigel
Thunderstorms
Thunen Model
Timber Plantations
Time, Geographies of
Time-Geography
Time-Space Compression
T-in-O Maps
Tobler, Waldo
Tomlinson, Roger
Topological Relationships
Toponymy
Topophilia
Tornadoes
Tourism
Township and Range System
Trade
Transhumance. See Nomadism
Transnational Corporation
Transnationalism
Transportation Geography
Trap Streets
Travel Writing, Geography and
Tree Farming
Trewartha, Glenn
Triangulated Irregular Network (TIN) Data Model
Troll, Carl
Tropical Rain Forests. See Biome: Tropical Rain Forest
Tsunami
Tsunami of 2004, Indian Ocean
Tuan, Yi-Fu
Turner, Billie Lee, II
Typhoons. See Hurricanes,
Physical Geography of
Typography in Map Design
Underdevelopment
Uneven Development
United Nations
United Nations Conference on Environment and Development
United Nations Environmental Summits
United Nations Environment Programme (UNEP)
United States Census Bureau
United States Geological Survey (USGS)
University Consortium for Geographic Information Science
Unsupervised Classification
Unwin, David
Urban and Regional Development
Urban and Regional Planning
Urban Ecology
Urban Environmental Studies
Urban Gardens
Urban Geography
Urban Green Space
Urban Heat Island
Urban Hierarchy
Urbanization
Urban Land Use
Urban Metabolism
Urban Planning and Geography
Urban Policy
Urban Solid Waste Management
Urban Spatial Structure
Urban Sprawl
Urban Storm Water Management
Urban Sustainability
Urban Underclass
Urban Water Supply
Usability of Geospatial Information
Vagueness in Spatial Data
Vance, James
Varenius
Vectorization
Vernacular Landscapes as Expressions of Environmental Ideas
Via Campesina (International Farmers’ Movement)
Vidal de la Blache, Paul
Video Games, Geography and Viewshed Analysis
Virilio, Paul
Virtual and Immersive Environments
Virtual Geographies
Virtual Globes
Vision and Geography
Volcanic Eruptions as Risk and Hazard
Volcanoes
Voronoi Diagrams
Vulnerability, Risks, and Hazards
Waldseemüller, Martin
Walker, Richard
War, Geography of
Waste Incineration
Wastewater Management
Water Degradation
Water Management and Treatment
Water Needs
Water Pollution
Watershed Management
Watershed Yield
Water Supply Siting and Management
Watts, Michael
Wayfinding
Weather and Climate Controls
Weber, Alfred
Web Geoprocessing Workflows
Web Service Architectures for GIS
Wetlands
White, Gilbert
Whiteness
Whittlesey, Derwent
Wilderness
Wildfires: Risk and Hazard
Wilson, John
Wind
Wind Energy
Wind Erosion
Wine, Geography of
Wine Terroir
Wise Use Movement
Wittfogel, Karl
Wood, Denis
Woodfuel
Woodlots. See Forest Fragmentation
World Bank
World Cities
World Court
World Health Organization (WHO)
World Summit on Sustainable Development
World-Systems Theory
World Trade Organization (WTO)
Wright, Dawn
Wright, John Kirtland
Writing
Xeriscaping
Zelinsky, Wilbur
Zoning
Supranational integration can be described as a process in which two or more nation-states or subnational regions within states come together by themselves or are brought together by a third party to form a new territorial configuration. As a concept, it usually refers to state-level memberships of political coalitions, but it can also be boosted by subnational organizations such as regional councils.

Supranational integration has been a globally important feature of political and economic life, especially since the end of World War II. It has been regarded as important for reducing political tensions and disparities between both nation-states and subnational regions. Apart from its political and economic origins, supranational integration has sometimes taken on a distinctively cultural character. This is the case when regional identity and a shared cultural history, for example, serve to bind administratively separate regions together and trigger the integration process. It can be claimed, however, that the emphasis more recently has been on economic issues, as much supranational integration takes place to increase competitiveness and to better performance in interregional competition. Supranational integration has thus been to a large extent linked with the interconnection and globalization of the world economy, where, among other things, new cross-border regional entities are being established with a view to better economic performance. The boosting of the economy is efficiently supported in this context by a diminishing of the role of borders, which are often regarded as obstacles to growth. Stability, on the other hand, is gained by reducing the regional cross-border imbalances and tensions caused by differences in political and economic structures and thereby evening out development.

The common goals laid down in the process of supranational integration serve to some extent to reduce the sovereignty of the individual state in favor of collective interests, given that both nation-states and subnational actors usually enter into agreements that enhance supranational cooperation by establishing joint institutions that are subject to sets of common rules. Supranational integration has traditionally focused on removal of barriers to trade and promotion of the free movement of labor, capital, and goods.

As a consequence of the partial transfer of sovereignty to supranational bodies, supranational integration is considered to “hollow out” the nation-state. There has recently been some debate, however, as to whether the state is a passive reactor to these processes or proactive, as devolution of power can equally well be a strategic choice made by the central authorities. Also, only a certain amount of sovereignty is normally given to multinational bodies in connection with supranational integration, as the integration processes are usually controlled by nation-states. If all the sovereignty is given (or taken) away, the process becomes a merger rather than an instance of integration.

The rescaling of nation-states has nevertheless been a part of a broader pattern of regionalist thinking in which devolution of power is regarded as an essential element. Power is, however, said to be delegated not only upward to supranational institutions or downward to regions and cities but also outward to various nonstate bodies such as nongovernmental organizations and businesses. Rescaling has thus led to two-level or even three-level structures in which subnational and regional organizations and institutions implement supranational integration strategies at the practical level (often together with various development agencies and enterprises), but nation-states—and, increasingly, multinational bodies—nevertheless wield the decisive political and administrative power.

As a result of reterritorialization of the state and rescaling of its governance, supranational integration has resulted in the emergence of a number of recently conceived cross-border regional entities. These “nonstandard regions” are constantly being institutionalized by region builders all around the world. Especially in Europe, the idea of “a Europe of the regions” has led to the formation of new cross-border regions. Some of them are truly functional, but in some cases, it is the borders of the nation-states that remain as the lines of division, and no genuine cooperation or uniform supranational regional identity has actually evolved.

All in all, cross-border arrangements, that is, the coalitions and treaties that nation-states, subnational regions, and, to some extent, supranational bodies make to gain economic advantages and improve their stability, are essential for
Supranational integration. In supranational integration, politics and business are immanent and usually intertwined to form sometimes fuzzy networks of governance in which several administrative levels are involved. Supranational integration can be either multilateral or bilateral in nature, but the essential point is that it should encompass international decision making and as such enable national boundaries to become more porous.

**Supranational Integration as a Process**

Supranational integration can also be conceptualized as a process that involves numerous starting points and stages. On the general level, the process of integration contains elements from below and from above, making it characteristically either a top-down or a bottom-up process by nature or something in between. *Functioning from below* means simply that the subnational authorities do not wait for formal procedures from above before initiating cross-border cooperation but use new types of interaction without justification from the formal administration, while *functioning from above* refers to forms of development in which regions are established and are given power and freedom of action by the formal authorities and central governments (nation-states) or by multinational organizations. Supranational integration can evidently take on quite different shapes and paths and aim at quite different things. Sometimes, region building can be quite explicit, as in the case of new competitive regions or “growth corridors,” but occasionally, the construction process is more vague, veiled, and contested. Such is the case when integration takes place against the will of the dominant political forces, being imposed by nongovernmental organizations and private actors, for example.

Although supranational integration is not necessarily anything more than a bilateral cooperation agreement in a defined sector concluded between states or cross-border regions, it is common for the integration process to have several ingredients and aspects. Supranational integration, especially when taking place between subnational regions, is typically a region-building process in which a new region is institutionalized and identified as a distinct unit in the spatial structure of society. There are several mechanisms by which this can happen, but one key aspect is the increasing of territorial awareness by the creation of regional symbols, including the name of the region. More essential in the case of newly established supranational regions, however, is the emergence of region-based institutions. These exist to a large extent due to the establishment of the region itself, but at the same time they produce and reproduce the region, for example, by constructing regional symbols and representing the borders of the region. Regional development agencies and regional councils that operate at a supranational level are examples of such region-based institutions. As region building is about the discursive production of a region, these actors are also builders of regional identity. This is essential, as a certain amount of regional identity is thought necessary to bind inhabitants to their region and create a regional spirit of initiative. The process of supranational region building is in a sense twofold, however, as, on the one hand, regions are represented as fixed, bounded entities but, on the other hand, they are also networked, porous, and fluid. New regions are thus engaged in competition; but they also, according to the ideas of the new regionalism, which emphasize the significance of linked city-regions, collaborate within various supranational networks and assemblages. New supranational configurations, often created to promote competitiveness, are in direct competition not only with each other but also with administrative regions that have much longer histories.

**Cases**

An abundance of cases of supranational integration exist, including the regions defined by the North American Free Trade Agreement (NAFTA), the southern Latin American common market (Mercosur), and the Association of Southeast Asian Nations (ASEAN). Perhaps the best-known and most developed case, however, is the European Union (EU), where the shared principles of cohesion and a single market have paved the way for supranational integration covering almost the whole of Europe. European integration has been regarded as an interstate process implemented mainly by central governments. The main bodies that run the EU and approve its legislation include the Council of the European Union, the European
Figure 1  The Barents Euro-Arctic region
Source: Courtesy of the Arctic Centre, University of Lapland.
Commission, and the European Parliament. The aim of this integration has been quite typical of contemporary supranational integration processes in general, that is, to develop freedom and to promote economic and social progress. Although the EU was officially established in 1993, when the Maastricht Treaty was approved by the 12 founding members, its history may be traced back to the 1950s, when the European Coal and Steel Community was established. This developed into the European Economic Community in 1957, with the signing of the Treaty of Rome. The EU currently has 27 member states, which have agreed to maintain and strengthen peace, prosperity, and freedom at a supranational level.

The single market in Europe, with its increasingly porous borders, has also paved the way for supranational regions within the EU, resulting in smaller-scale supranational integration. Good examples of this are the Euroregions, of which there are about 70 at the moment, mostly concentrating on cross-border cooperation in the fields of culture, tourism, and other economic activities. The political power of the Euroregions is limited, however, as they are mostly run by regional and local authorities. Some of the Euroregion initiatives have their roots in the 1950s, for example, the Cross-Channel and Baltic Euroregions. As inter-regional (and, from the EU’s standpoint, intercontinental) competition is considered more or less unavoidable, the institutionalization of internationally competitive supranational regions inside the EU is currently attracting increased support.

Another example of supranational integration, at both the state and the regional level involved, is the establishment of the Barents Euro-Arctic region (BEAR) in the far north of Europe (Figure 1). The official act of establishment took place in Kirkenes, Norway, on January 11, 1993, together with the founding of the intergovernmental Barents Euro-Arctic Council (BEAC) and the interregional Barents Regional Council (BRC). The initiative to establish the region (also known as Barents Cooperation) was actually taken by the Norwegians, and it represented a political strategy for handling the opportunities and also the problems related to the post–Cold War reality of East-West relationships. The original proposal was made by the Norwegian Ministry of Foreign Affairs, and as such, it is often described as an attempt to widen and restructure ongoing activities in order to promote security. At the moment, the Barents Region includes the 13 subnational territories located in Norway, Sweden, Finland, and Russia that are members of the BRC. Economic issues concerned with energy, natural resources, and business cooperation have been high on the agenda recently, but several projects dealing with security, health, culture, and education have also been implemented by multilateral consortia.

Kaj Zimmerbauer

See also Asia-Pacific Economic Cooperation; Association of Southeast Asian Nations; Borderlands; Cross-Border Cooperation; Deterritorialization and Reterritorialization; European Union; Globalization; North American Free Trade Agreement (NAFTA); North Atlantic Treaty Organization (NATO); Scale, Social Production of; Sovereignty; Transnationalism; United Nations

Further Readings


Surface Water

Surface water is intrinsic to global, dynamic human activities: population and urban geography, politics, economics, and culture. As global climate change begins to influence the geography of surface water, the world’s population must adapt in concert. Surface water is discussed here as a factor shaping the physical and cultural landscape, which includes the geography of surface water, the different surface water types, its effects on the physical environment, and its importance to the activities of humans.
Approximately 70% of the Earth’s surface is water. Surface water is an important part of the hydrologic cycle and is defined as water above the surface that collects in oceans, seas, rivers, streams, lakes, ponds, springs, wetlands, and glaciers. Water found in the atmosphere or contained in rock beneath the surface (groundwater) is part of the hydrosphere but is not categorized as surface water. Because the Earth is a closed system, the total amount of water is constant. However, water is always on the move and is a renewable resource constantly recycled through evaporation, condensation, and precipitation. Through these processes, and over geologic time, surface water will change phase and geography repeatedly to become ground water, atmospheric water, terrestrial water, and oceanic water. Although not addressed here, it is important to mention the interconnectedness of surface water and groundwater; for instance, some water bodies such as springs and seeps are the visual expression of groundwater at the surface.

The Geography of Surface Water

The majority of surface water is found in the oceans (97.2%) and is saline. Oceans are the largest input to the global hydrologic cycle, where 320,000 cubic kilometers evaporates from their surfaces each year. The world’s oceans are highly influential on climate patterns, as these massive water bodies act as a sink for solar energy. Oceanic water circulation moves warm water away from the equator, while cold water is forced toward lower latitudes. These massive transfers of energy drive global temperature and precipitation patterns and explain a great deal about climate and biogeography. For example, the cold current flowing adjacent to the western edge of South America produces dry air and is a factor in the formation of the Atacama Desert climate, while the warm current of the western Atlantic Ocean flows toward Western Europe and keeps annual temperatures mild.

The remaining 2.8% of the Earth’s hydrosphere is the nonocean component, and only a tiny 2.5% of this water is fresh. Termed the cryosphere, ice sheets and glaciers constitute the frozen fraction of the hydrosphere and are the largest nonocean component of surface water (2.15% of the total hydrosphere). These huge volumes of ice are concentrated in alpine regions on every continent and at the polar latitudes, specifically the Arctic, the Greenland Ice Sheet, and the continent of Antarctica. Only a fraction of the total global hydrosphere is fresh, liquid surface water: Lakes and reservoirs make up 0.009%, while only 0.0001% is found in rivers and stream channels. The remaining surface water is found in inland seas and saline lakes (0.008%) and in soil moisture (0.005%).

Drainage Basins

The expression of surface water on the landscape is largely controlled by geology and topography. When water flows downhill to collect in a water body, the land surface area that contributes to that collection is termed a drainage, or catchment, basin. Drainage divides separate drainage basins, where the division of two basins occurs because of higher ground at their shared perimeter. These divisions can be distinct ridges or subtle rises in elevation. A drainage divide may also be called a watershed. However, in some cases, watershed may also refer to the drainage basin itself. As a classic example of scale in geography, drainage basins can be subdivided into progressively smaller units.

Types of Surface Water

Runoff

Running water is the most important geomorphic factor on Earth. Surface water in the form of runoff is generated when a precipitation event saturates the soil and subsurface to such a degree that it can no longer absorb the moisture and water begins to flow across the land. The volume of runoff is determined by several factors, including the local climate, volume of water generated by the precipitation event, duration of the event, land slope, soil type, geology, and vegetation. Surface runoff can degrade the landscape if the velocity of water is great enough to entrain sediment and erode the soil. Snowmelt runoff is an important contributor to the volume of water in streams and rivers, especially in mountainous regions around the globe.

Streams and Rivers

When surface water flows across the landscape and is concentrated, a stream forms. Streams and
rivers carry surface water and sediments downstream toward a local (lake) or ultimate (ocean) base level. Rivers transport, deposit, and store extensive volumes of sediment that create landforms in fluvial and coastal plain environments, and they are the primary factor involved in terrestrial landscape formation. Over geologic time, surface water deposits materials that form sedimentary rocks. Globally, the longest river is the Nile, while the largest river (in total volume) is the Amazon. Because of the widespread influence of humans, most rivers have been modified in some way.

**Lake and Ponds**

Lakes are large terrestrial bodies of water that occur where water collects in a depression or basin, and they may or may not have an outlet. Ponds are smaller water bodies than lakes, although debate remains about the definition of each, specifically pertaining to the threshold where a pond is large enough to be deemed a lake. Many sources cite lakes as water bodies large enough to generate waves across their surface. Most lakes on Earth are found in the Northern Hemisphere, where hundreds of thousands of depressions litter the landscape as a result of Pleistocene continental glaciation and are now water filled. The largest lake in the world (in surface area) is the Caspian Sea, while the deepest is Siberia’s Lake Baikal (also the largest in volume). Although it is called a sea, the Caspian is a saline lake that lacks a drainage outlet.

**Oceans and Seas**

The oceans of the world are divided into four main water bodies: Atlantic, Pacific, Indian, and Arctic. There are no distinct geographic divisions defining where one ocean begins and another ends. Seas are smaller, saline water bodies geographically joined with oceans and also lacking definitive boundaries. The nomenclature for seas is not consistent throughout the globe; however, some gulfs are seas, such as the Persian Gulf, while some seas are saline lakes, such as the Caspian Sea, as mentioned above. The International Hydrographic Organization is the agency responsible for classifying the world’s water bodies, and this agency should be referenced for specific naming conventions for global water bodies.
Surface Water and Humans

Surface water is an important factor in human activities. Rivers have led to the colonization of continental interiors, are used in military strategy, and provide the means to transport products to the market. The global economy relies on the presence of surface water to transport large quantities of consumable products. Ocean transportation moves billions of cubic tons of goods and resources throughout the globe each year.

Irrigated Agriculture

Due to the practice of irrigated agriculture, surface water has played a defining role in the diaspora of humans throughout the globe. Cultural groups have arisen around the practice of moving surface water through human-made channels and waterworks, thus furthering the settlement of arid regions otherwise uninhabitable by humans. The earliest origins of irrigated agriculture lie in the Middle East; however, it has also arisen independently in the Far East and in the Americas.

Dams

Dams impound surface water for regulated release downstream and are used for flood control, public water and fire suppression supply, recreation, and electricity generation. Dams fragment watersheds by changing the natural flow of rivers and causing significant changes to upstream and downstream hydrology, riparian ecosystems, water chemistry, and fluvial landforms. The reservoirs created by dams may be sizeable enough to affect the local climate. Although dam construction peaked in the 1970s in the United States, the amount of water currently stored behind dams can spatially cover a surface area the size of France.

The Effects of Global Climate Change on Surface Water

Surface water is a renewable resource and the primary source of global public water supply. Currently, there is sufficient surface water to support the ever-increasing global population, but the geography of that water will continue to be a challenge, as global climate change is altering its distribution and availability. As glacial ice around the globe melts as a result of climate change, significant effects on surface water are becoming evident. In mountain environments, glaciers, which provide important meltwater for the local ecosystem, public supplies, and irrigation, are diminishing. In many areas, river flows resulting from this melting are volumetrically less than their historic flows. Over one sixth of the world’s population depends on this water for its daily needs, and concern about future availability is growing. As the continental glaciers melt, the introduction of freshwater to the saline oceans is predicted to affect global circulation patterns. Sea-level rise in response to global climate change also has the potential to create a variety of hazards, as 10% of the world’s population lives within 150 miles of the coast.

Tara M. Plewa

See also Coastal Erosion and Deposition; Glaciers: Continental; Glaciers: Mountain; Global Sea-Level Rise; Groundwater; Hydrology; Oceans; Public Water Services; Rill Erosion; Rivers; Soil Erosion; Urban Water Supply; Water Degradation; Water Management and Treatment; Watershed Management; Water Needs; Water Pollution

Further Readings


https://vk.com/readinglecture
Surveillance is the practice of watching over a given terrain, its inhabitants, and their relations, commonly for the purpose of exercising instrumental control over that which is being watched. As such, surveillance is central to the establishment and maintenance of “scopic regimes” that enact power to order the world. From its inception as a discipline, and indeed even prior to its attainment of disciplinary status, geography has engaged with surveillance as both participant and observer.

Observing the distribution of human and natural variation across the surface of the Earth, and reporting on that variation, has been a key geographical practice from the times of Strabo through those of Ibn Battuta, John Mandeville, Xu Xiake, and beyond. Such accounts tend to be cartographical exercises conjoined to richly descriptive, and sometimes apocryphal, travelogues. A subset of these, however, serves the additional purpose of providing rulers and their administrative bureaucracies information on the presence and distribution of resources in given territories. Such information, in turn, informs the policies and actions by means of which rule may be imposed on the ground.

But the rise of the European empires, and the corollary entrance into an “age of renaissance,” required an unprecedented demarcation of new territories and the cataloguing of their contents. This not only heightened the prominence of expeditionary surveys but was, to no small extent, dependent on them too. Geographers and their explorations, as, for instance, those of Alexander von Humboldt, Richard Francis Burton, and Piotr Kropotkin, were at least initially charged with and supported by the task of seeing for empire building. Empires in turn claimed and asserted, however incompletely in practice, a mastery over all that they saw in no small part through the lenses of such expeditions. This process contributed centrally to both the legitimization and the elaboration of geography as a discipline.

The role of surveillance to fix things in space was complemented by the fixing of attributes to things—the application of categories to that which was surveyed and the ascription of fixed attributes to these categories. Thus, the expeditionary practice of geography did not merely undertake surveillance but created surveillability, rendering that which was seen recognizable within a disciplined system of spaces understood as both substrate and container. Outgrowths of this process ranged from intricate and intimate catalogs of a given locale’s vegetal and mineral resources to cut-and-dried global mappings of the distribution of the world’s putative races.

Although it was developed and deployed most extensively at and beyond colonized peripheries, intensive geographical surveillance was quickly repatriated back to core territories and, most prominently, to the metropolis. With the rise of the modern state, surveillance was key to the concomitant transformation of subjects into manageable, governable populations. This was accomplished through the innovation of initially geographical sciences, such as demography and its allied statistics, and their implementation through a range of practices, such as the mandatory assignation and stabilization of surnames conjoined to the conduct of increasingly regular censuses. Nor did these innovations remain conceptual abstractions or occasional events. Rather, they were palpably and even immutably materialized on the ground to facilitate state functions such as policing and fire suppression, as with the 19th-century parcelization of Berlin into courtyard apartments or the still extant ward system of Edo (now Tokyo).

Grand expeditionary surveys are now largely a thing of the past. The impetus for intensive and extensive surveillability, however, has continued unabated and, if anything, intensified in recent years. This drive toward *panopticism* (the capacity to readily see into all places) and *synopticism* (the capacity to see everything simultaneously and in relation) has in turn been facilitated by, and spawned, a host of new technologies. Most notable among these, at least from the demonstrated perspective of contemporary geographical research, are those of geographic information systems conjoined to remote sensing (GIS/RS) and closed circuit television (CCTV) monitoring. But equally notable is the shift in the perspectives and roles of many geographers themselves from collaborators in surveillance to critics of it.
GIS/RS is a relatively novel complex of technologies ranging from satellites to desktop computers. Predominantly a research tool, this complex is targeted and interfaced so as to gather, process, and graphically represent data pertaining to the disposition of selected objects and attributes at discretionarily specified points across the face of the Earth. In contrast, CCTV has emerged predominantly as a tool of law enforcement, consisting of numerous observation cameras dispersed across commonplace landscapes so as to insert an unprecedented reach of centralized observation into the spaces of everyday public life.

Neither technology is necessarily oppressive, and both provide opportunities for creative and even emancipatory use. For example, GIS/RS affords a potential for wide public access to, comprehension of, and intervention in geographical data gathering and the application of such data to popular decision making. Similarly, the devolution of CCTV’s observational capacities into compact and affordable handheld devices permits unprecedented opportunities for popular monitoring of, and reporting on, public malfeasance. But taken together, and fused with innovations such as states’ and business corporations’ monitoring, databasing, and mining of electronically mediated personal interactions, these technologies work to embody what many geographers caution is becoming a “society of surveillance.” Inherent in such a society are radical loss of privacy and the potential for severe new delimitations to permissible ranges of action, expression, and even thought. Furthermore, geographers warn, these ominous possibilities are becoming ever more concrete and rhetorically legitimized realities in the diffusing wake of terrorist activity and the concomitant, putative war on terror. As such, surveillance is
increasingly understood as not just the practice of watching over but as something that itself needs to be carefully watched over.

Steven Flusty

See also Legal Aspects of Geospatial Information; Panopticon; Vision and Geography

Further Readings


Surveying is the art, science, and technology of determining or establishing the three-dimensional (3D; x, y, z) position of points on or beneath Earth’s surface. Because geographic surveying deals primarily with topography, two other terms, topographic surveying and field surveying, are interchangeably used. Geographic survey data are used to produce topographic maps, block diagrams, and cross-sectional profiles and to establish vertical and horizontal controls such as spot heights and benchmarks.

Conventional geographic surveying uses theodolites, levels, chains, links, steel (or invar, a steel alloy) tapes, altimeters, compasses, clino meters, tachymeters, stadia rods, plane-table alidades, ranging poles, tripods, and the total station. Three basic sets of readings are taken during a conventional survey: distances, heights, and angles. Horizontal distance can be measured with a tape using slope distance and reducing it to horizontal distance using the cosine of the slope gradient. Elevation (height) is measured using a leveling instrument with a level telescope and a stadia rod or by observing the vertical angle with a clinometer and deriving height. The horizontal angle is measured with a compass. Direction is expressed relative to a reference line (meridian). A North-South line is the true meridian, although a magnetic meridian may be used if compass azimuths are recorded without adjusting for declination.

The total station is the instrument of choice for many topographic surveyors because it integrates theodolite functions and an electronic distance meter (EDM) with a built-in or external computer for data storage. Its capability to automate and integrate the measurement of distances, heights, and direction greatly improves topographic surveying and mapping.

In any conventional survey, the starting or initial position(s) must be known and must be accessible. Subsequent positions are observed and determined based on preceding point base positions. There are four common approaches used in surveying—namely, triangulation, trilateration, triangulateration, and traversing. In triangulation, the location of a point is determined by measuring the angles to it from the initial points at either end of a fixed baseline rather than measuring the distances to the point directly. The point can then be fixed as the third point of a triangle with one known side and two known angles. Triangulation is used in surveying large areas for geodetic purposes. Trilateration is used in conjunction with triangulation to determine the intersections of three sphere surfaces given their centers and radii. Triangulateration is a combination of triangulation and trilateration. Traversing is the establishment of a series of consecutive lines (legs) and directions whose ends define points (also called stations, hubs, or corners).

There are four main types of traverse: link (azimuth), closed loop (polygonal), closed, and open (free). A link traverse follows along a single direction (azimuth). This method is common for slope profile surveys and is always perpendicular to the contours. Closed-loop traverses begin and end at the same station. In this method, interior and deflection angles can be established. A closed traverse uses a known endpoint, and its exterior angles can be measured. An open traverse ends in an unknown position.

Inaccuracy in surveys is a common problem. Sometimes even closed traverses will not “close”
because the initial point and the endpoint fail to coincide. This error is called the closure error (gap). Closed-loop and closed traverses permit calculation and adjustment for closure error. However, it is more difficult to maintain good accuracy in an open traverse, as it does not enable computational checks for error.

Error is related to the quality of the equipment, the nature of the terrain, and the skill level or experience of the surveyor. The amount of error that can be tolerated (degree of tolerance) is a function of the order of accuracy desired, which in turn depends on the intended use of the survey data. Accuracy is expressed in terms of the proportion of the traverse length, stated as 1/x: For every x units measured, the survey should be off by 1 unit. First-order accuracy = 1/25,000, second-order accuracy = 1/10,000, and third-order accuracy = 1/5,000. In a typical topographic survey, the desired level of accuracy is the plottable error—the shortest distance that can be depicted on a map at a given scale. The drafting of lines generally is accurate to within 0.25 mm (millimeters). Survey errors are minimized by conducting quality surveys, repeating measurements in the field, using calibrated instruments, and adjusting and correcting measurements. Several standard survey correction formulae spread the closure error to all angles and legs, especially in closed-loop and closed traverse.

The introduction of the global positioning system (GPS) has revolutionized surveying. GPS is capable of determining positional and navigational information accurately and instantaneously. Two positioning methods can be achieved with the GPS: absolute and differential GPS (DGPS). Absolute positioning uses a single GPS receiver and does not require known survey control points. DGPS uses at least two GPS receivers. One is the reference receiver (base station), resident at a known location. The other receivers are used in the field to position points of interest. Both absolute positioning and DGPS can be performed in real time or through postprocessing. Real-time positioning is achieved by effecting communication links between the field receiver and an augmentation system. The method of choice depends on the accuracy required, the equipment available, and the logistical requirements. Accuracy in GPS survey is a function of the quality of the equipment and the surveying method employed—absolute positioning or DGPS. DGPS is the more accurate. The use of GPS has added efficiency and productivity to surveying.

Charles Manyara
The growing recognition that human activities are transforming Earth systems and having far-reaching implications for society has given rise to the ambitious research field of sustainability science. This area of study is concerned with the most complex challenges that societies face, focusing on the dynamic interaction of nature-society systems in response to stresses emanating from multiple sources. Sustainability science grapples with societal problems that are characterized by multiple viewpoints and a high degree of uncertainty. It evolves from a scientific perspective of critically examining the relationship between nature and society. It addresses tensions among economic, social, technological, and environmental interests among a broad range of stakeholders while focusing on interactions across scales. Though sustainability science has not been clearly defined, in recent years, its central elements have begun to gain clarity; hence, the field has begun to be recognized as an area of inquiry that can point the way toward sustainable development. The field has focused on the nature of a sustainability transition, described by the U.S. National Research Council (NRC) as meeting the needs of a stabilizing future population while reducing hunger and maintaining Earth’s life support systems. This entry synthesizes the emerging scholarship on sustainability science in its quest for a societal transition toward sustainable economic development.

**Emergence of Sustainability Science**

Sustainability science reflects several decades of scholarship in the fields of natural resource sciences and technology. Indeed, the use of the term sustainability can be traced back to a 1712 book, *Sylvicultura Oeconomica*, by the German scientist and forester Hans Carl von Carlowitz. Intellectual contributions on sustainability also come from pioneering scholarship on human-environment interaction by the geographer and anthropologist Peter Glacken in his seminal work *Traces on the Rhodian Shore*, the work of the agricultural economists Yujiro Hayami and Vernon Ruttan on land-saving and yield-enhancing technologies, and the insights from Earth-friendly and user-friendly technology, also termed appropriate technology, following the economist E. F. Schumacher’s publication of his famous book *Small Is Beautiful*. However, a more academic perspective on sustainability emerged during the environmental movement of the 1970s as well as from the seminal document *The World Conservation Strategy*, published by the International Union for Conservation of Nature in 1980.

Much of today’s work on sustainability science is inspired by the landmark Brundtland Commission report on sustainable development, published in 1987 by the World Commission on Environment and Development (WCED). This report argued that the complex challenge of environmental degradation should be integrated with the equally complex challenges of human development and poverty alleviation, suggesting that both challenges need to be resolved simultaneously and in a mutually reinforcing way. Additional impetus to sustainability science was given at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. The conference’s Rio Declaration and Agenda 21 together developed detailed strategies, action plans, and resource needs for attaining sustainable development in the 21st century.

**See also** Cadastral Systems; Geodesy; Global Positioning System; Ground Reference Data; Land Use and Land Cover Mapping
While Agenda 21 exhibited a much needed political and moral appeal, the global community remained divided about the meaning and practice of sustainability. The United Nations Commission on Sustainable Development (UNCSD), established in the wake of the Rio conference to monitor and report on the agreement reached in Rio, provided a sobering appraisal of the first decade of the effort to realize the vision of sustainable development in the 1997 Special Session of the United Nations General Assembly. The report concluded that no significant progress had been made on the sustainable development front despite the limelight that the concept received at the global meeting.

In the ensuing years, the terms sustainability and sustainable development were revisited and redefined to establish a conceptual basis and to encapsulate various aspects of society and environment relations. In their report *Our Common Journey*, the Board on Sustainable Development of the U.S. National Research Council outlined a scientific agenda and a general strategy for research and development (R&D) in support of the transition to sustainability. Although the report did not describe paths of sustainability science, it concluded that many of the most problematic threats to society and its life support systems come from the multiple stresses resulting from cumulative human activities. This conclusion was significant in that it recognized the value of studying the multiple drivers of environmental and social stressors. More specifically, the report emphasized a move toward a more holistic approach for addressing sustainability challenges by taking into account the dynamic and complex interactions among human-environment systems. The report also laid a much needed foundation for R&D in sustainability science.

During the succeeding years, the discussion about the role of R&D in the sustainability transition, particularly in science and technology (S&T), intensified. This discussion began involving researchers, practitioners, academics, citizen forums, and development and nongovernmental organizations (NGOs) worldwide. When the World Summit on Sustainable Development was held in Johannesburg (2002), consensus was forged on the most important ways in which R&D could contribute to sustainability. The message emerging from Johannesburg was that the scholarly community must contribute to identifying problems of sustainability with a greater willingness to join the nonacademic communities to work on practical solutions to the challenge of sustainability. While various disciplines and interest groups influenced and contributed to the debate differently, the global challenge of sustainability is now understood to lie in the complex interdependencies of environmental, social, and economic development across scales. Moreover, though threats to sustainability occur more in some regions than in others, the degree and extent of any threat depends largely on the region’s social, political, economic, and ecological characteristics. For this reason, the transition to sustainability will often need to happen in local areas first. At the same time, however, it needs to be integrated across geographic scales. Regardless of the spatial scale in question, obtaining insights into events on both global and local scales will continue to be a major challenge facing sustainability science. Thus, a transition to sustainability ultimately rests on the choices that society makes on what to develop versus what to sustain and for how long.

### Conceptualizing Sustainability Science

The epistemology of sustainability science draws largely from the study of the Earth and Earth’s social and human systems and is characterized by great complexity and uncertainty. Given the nature of such complexity, system thinking has become a way of understanding reality that emphasizes the nonlinear relationships among the different system components. In pursuing sustainability science, it is important to construct a knowledge platform that enables society to replace piecemeal approaches with an approach that can develop and apply more comprehensive solutions to the challenges that society is facing. Structuring knowledge production systems across the global, social, and human systems (discussed below briefly) is therefore an important task of sustainability science.

According to Hiroshi Komiyama and Kazuhiko Takeuchi, the global system constitutes a planetary base for human survival. It is capable of influencing the entire network of Earth systems...
and can have severe implications for human existence. Conversely, the rapid expansion of human activities has become a significant driver in altering Earth’s systems. Global warming due to increased concentrations of greenhouse gases, destruction of the ozone layer, and biodiversity loss due to land use and land cover change are salient examples of global change that are the outcomes of human and social systems. Given these developments, addressing global systems requires a more integrated approach, for which sustainability science offers a greater potential.

The social system consists of cultural, political, economic, and other institutions that are an important basis for driving economic growth and development. Existing institutions, however, are associated with environmental ills such as degradation of the natural resource base and are also responsible for creating the growing inequality between the rich and the poor. The integrated nature of this situation is responsible for exerting greater stress on global systems. If sustainability science is to be policy relevant, it is important to address both environmental and social issues simultaneously. By incorporating social science into sustainability issues, sustainability science can make major advances in the pursuit of sustainable development.

The healthy functioning of human systems requires the integration of global and social systems in a manner that enables human beings to thrive and sustain their communities. In today’s world, people are experiencing emotional distress, inequities, and deterioration of their means of production. Such problems put pressure on social and environmental systems worldwide. As this stress increases and the environment deteriorates, the social system becomes more fragmented, making human society less sustainable—all of which can have a global effect. Emblematic of this trend are the problems of extreme poverty, disease, social exclusion, and conflicts, weakening the sustainability of human systems.

Thus, the emerging field of sustainability science is an ambitious attempt to build a new discipline that seeks to integrate all three systems. Since sustainability science requires integration of multiple and complex systems, system thinking has a special role to play. System thinking helps actors to see the various elements of systems and cross the boundaries of science in order to create new conceptual frames that highlight interconnectedness and feedback loops. It also offers a powerful perspective and a set of tools to address the most complex challenges facing human society. Efforts to provide useful knowledge for solving the practical but highly complex problems discussed above require advances in the conceptualization and understanding of coupled human-environment systems. While strategies to address the emerging threats of global climate change, governance of emerging technologies, poverty, and hunger are all complex sustainability challenges, the potential exists to galvanize global action to place sustainability science at the forefront of educational, research, and career development agendas. In recent years, rising concerns over global climate change, the conservation of ecosystem services, biodiversity protection, diversification of energy portfolios, improving efficiency and access to water supplies, and enhancing agrobiodiversity and food security have become important priorities of sustainability science.

The conceptual model for sustainability science can be represented as “coevolution,” “coproduction,” and “colearning,” encompassing the three interrelated systems discussed above. This conceptual model is inspired by what researchers call “Mode 2,” or “postnormal,” science. According to Pim Martens, “Mode 1” science is conventional and purely academic and focuses on single disciplines to generate its knowledge base. The researchers who are involved in this process are the major players. In Mode 2 science, researchers are part of a heterogeneous social network focusing on social and anticipatory learning, where everyone contributes to knowledge production and dissemination. In other words, Mode 1, or conventional science, as opposed to Mode 2 science, is predictive and seeks to rationalize certainty, a desirable goal for policy making. Mode 1 science is thus characterized as deterministic and is often disconnected from the challenges facing the real world. Mode 2 science, in contrast, acknowledges that the complete elimination of uncertainty is not possible in decision making and argues that this can be addressed through participatory processes in knowledge production, an idea completely rejected by Mode 1, or rational, science. Postnormal science provides a
well-informed knowledge platform for complex problems, thereby enhancing the interface between science and society. It allows stakeholders to identify and employ strategies that will respond to the transition toward sustainability.

As opposed to Mode 1 science, which generally holds the notion of the community as a passive recipient of knowledge, Mode 2 science leans on the conceptual underpinning of social and anticipatory learning and emphasizes the study of interlocking factors embedded in the socioeconomic and political fabric of communities to understand strategies for sustainability at the local level. It highlights inherent community-based skills, knowledge, strategic responses, and anticipatory capacity to attain sustainability and seeks the cooperation of local institutions and/or individuals in the process. It is through this process of social and anticipatory learning that Mode 2 science fosters a community’s capacity to influence its future through iterative planning.

The new research paradigm emerging from Mode 2, or postnormal, science has given impetus to sustainability science, which cuts across multiple scales (time and space) and multiple stakeholders (interest groups). Sustainability science seeks to integrate not only different disciplines but also individual viewpoints and knowledge so that the scientific processes of deliberation and assessment are smoother. And no one set of knowledges or viewpoints is privileged over another. The new frontier of sustainability science also recognizes the value of alternative knowledge systems that have hitherto been neglected by scholarly communities. It differs from normal academic science, which is monodisciplinary in nature and heavily dependent on peer reviews by the scientists themselves.

As an emerging field of study, sustainability science is not yet a discipline. It is the interface of science, practice, and visions of sustainable development. Given the integrated nature of this field of study, the research framework in sustainability science derives its methodological tools from all fields of inquiries, including the social, human, and natural sciences. So the core organizing questions for sustainability science are as follows: How best can global, social, and human systems be integrated and conceptualized so that the goal of sustainable development is attained? How is the societal relationship with the environment and development reshaped by innovations of science and technology? What contextual factors hinder the path toward sustainable trajectories, and what incentive structures can do that most effectively? How can today’s knowledge systems, which are locked in across various cultures and traditions, be harnessed to provide more useful guidance for efforts to navigate a transition toward sustainability? How can today’s relatively independent activities of research planning, monitoring, assessments, and decision support be more integrated into systems of social and anticipatory learning?

**Sustainability Science: Basic or Applied?**

One of the major characteristics of sustainability science is that it seeks the involvement of nonacademic stakeholders in the integration of human and social systems with the global system and aims to integrate different norms and values in order to generate socially acceptable and environmentally just knowledge about sustainability. It challenges traditional concepts and institutions of scientific knowledge generation and serves as an experiment in a new model of science. It recognizes the value of supporting interdisciplinary research and is driven by the goal of creating integrated knowledge that supports decision making for sustainable development. As an integrated science, it seeks to break down the disciplinary boundaries of the traditional sciences and calls for mutual learning, integrated assessment, and coproduction of knowledge. From its core focus of advancing an understanding of coupled human-environment systems, sustainability science has, in a short time period, pursued an ambitious research agenda that challenges academic traditions with respect to fundamental ontological (real-world problem orientation), methodological (participatory research), and epistemological (“linking knowledge to action”) issues. In its quest for transition toward sustainability, sustainability science seeks to harness S&T in order to address the sustainability challenges of the human-environment system.

In his seminal treatise on science policy, Vannevar Bush described the conflict between applied and pure research and wrote that applied research
invariably drives out pure research to the detriment of the national capacity for technological innovation. The subsequent separation of applied and basic research shaped the evolution of S&T research and remained a point of departure for the “appropriate technology” movement pioneered by E. F. Schumacher. The rise of pure science research also meant the neglect of what Michael Dove and Daniel Kammen call “mundane science,” which involves the use of location-specific knowledge and small-scale technologies that are problem driven with potential advances to pure science. The inability of pure science research, with its disciplinary focus, to address myriad social concerns led to a growing recognition of the value of interdisciplinary research. This can be seen as a precursor to sustainability science that involved identifying important but neglected fields of research and scholarship.

William Clark has argued that the research framework for sustainability science lies beyond the confines of basic and applied research. Just as sustainability science has reached out to contribute to and learn from the world of applied problem solving, so, too, has it remained closely linked with curiosity-driven research across a range of disciplines. It is an academic endeavor that is geared toward use-inspired basic research and is driven by the integration of knowledge and action across the three systems discussed earlier. By bridging applied and basic research, sustainability science advances the interface between science and policy. Since the issues and problems that sustainability science tackles are interdisciplinary in nature, it involves different stakeholders and actors from different disciplines and requires their collaborative inputs. Thus, interdisciplinarity becomes the hallmark of research orientation in this field. This has meant that scientists seeking to promote a sustainability transition have needed to tap into, and indeed engage in, cutting-edge research in areas ranging from complex systems theory to cultural and political ecology. Sustainability science is an academic enterprise geared toward creating use-inspired research and is therefore neither strictly “basic” nor strictly “applied.” By creating a dynamic bridge between applied and basic research, sustainability science seeks to contribute to the quest for a sustainability transition by increasing the interface between knowledge and policy-based action.

**Conclusion**

Sustainability science is an integrative science that is interdisciplinary in nature and committed to linking different scientific disciplines such as biology/ecology, the Earth sciences, geography, economics, and other social sciences to provide a guide to science policy for society. Through interdisciplinary research and scholarship, sustainability science helps identify directions for societal actions. The outcomes of sustainability science can bridge the gap between science and policy, which increases the societal value of science and improves decision making through the provision of integrated knowledge about social and environmental problems. Sustainability science must ensure the integration of different styles of knowledge creation to bridge the gulf between science, practice, and politics. Through research, publications, and academic organizations, the field of sustainability science is becoming increasingly prominent in academia. It has the potential to transform research and education and make sustainability an integrated and common theme for scholars, policymakers, and civil society actors alike.

*Netra B. Chhetri and Nalini Chhetri*

**See also** Complexity Theory; Coupled Human and Natural Systems; Environment and Development; Political Ecology; Population and Land Degradation; Science and Technology Studies; Sustainable Agriculture; Sustainable Cities; Sustainable Development; Sustainable Development Alternatives; Sustainable Production; United Nations Conference on Environment and Development

**Further Readings**


_Agriculture’s Roots_

It is generally understood that agriculture was born around 10,000 to 13,000 years ago, when hunter-gatherers began to domesticate wild plant and animal species for food, predominately along the Fertile Crescent, an event called the Neolithic Revolution. By domesticating plants and animals, these “first farmers” produced food surpluses that supported permanent settlements, which led to rapid population growth, specialized labor, and the development of modern civilization. Agriculture has radically transformed humanity’s trajectory as a species and its relationship with and impact on the natural world, creating many opportunities and challenges, especially over the past century.

**The Rise of Industrial Agriculture**

The rise of industrial agriculture in the 20th century—predicated on mechanical, biological, and chemical technologies—exceeded in magnitude all previous changes in farming. Governments and industry promoted industrial agriculture, as it was their belief that Fordist principles of manufacturing and large-scale production could be applied to agriculture. After World War II, the chemicals developed for military activities were subsequently used in agriculture as synthetic pesticides and fertilizers, and in combination with tractor power, these inputs dramatically increased labor and land productivity.
Farmer-led plant breeding was quickly replaced by expert-based approaches using the new science of genetics, leading to the development of hybrids and other high-yielding and high-input varieties that were distributed worldwide during the Green Revolution. The discovery of antibiotics and vaccines enabled industrial-scale livestock production—often called “factory farming”—in which animals are raised in densely crowded spaces without a significant buildup of disease. Indeed, industrial agriculture increased global food production and helped feed and ultimately increase the world’s human population, now estimated at 6.8 billion people. Despite these significant production benefits, industrial agriculture has caused substantial social, ecological, and genetic erosion worldwide.

### Social, Ecological, and Genetic Erosion

The shift toward industrial agriculture has had adverse consequences for farmers, rural communities, and the environment. Many suggest that farmers have become beholden to a “technology treadmill” with the rise of mechanical, biological, and chemical innovations, as increases in production depress prices and require that farmers adopt ever newer technology to stay competitive. Larger farms have generally been able to adopt new technology more easily, which has created fierce competition within rural communities, and many smaller family farms have not been able to stay viable. High input costs remain the number one obstacle to farm profitability. In North America, farmers are facing the worst farm income crisis in history, with the countryside being increasingly depopulated, while agribusiness has garnered record profits. In the global South, reports of farmer suicides are becoming pervasive, as mounting debts tear apart the social fabric of many communities. The environmental costs of industrial agriculture are also placing enormous pressure on human and ecological systems.

Rachel Carson’s publication of the best-selling book *Silent Spring* in 1962 exposed the extent to which chemicals, primarily those used in agriculture, were compromising environmental and human health. Globally, the use of pesticides has grown since World War II, costing billions of dollars annually and causing thousands of human deaths and adverse health risks due to cancer, acute poisonings, and neurological damage each year. Pesticides also harm a wide variety of wildlife, including microorganisms, fish, birds, and mammals, through direct or secondary environmental exposure. Estimates indicate that this chemical pollution from agriculture costs more than $100 billion each year in human health and environmental damage worldwide. Soil health, which is critical for food production, has also been damaged by industrial agriculture due to increasing farm specialization, ever-larger farms, and monoculture cropping practices. Because of the use of inorganic fertilizers, the natural organic matter of the soil is not being replenished; thus, despite these chemical substitutes, soil has lost its productivity, resulting in major yield decreases. Some even argue that excessive soil damage has caused the downfall of past civilizations and may cause the downfall of the modern era.

With the increased use of pesticides, some insects, weeds, and fungi evade being controlled and eventually evolve resistance. These “superpests” are often difficult to control, leading some to conclude that chemicals might actually create greater pest problems than they solve. Similarly, the overuse of antibiotics in industrial livestock production is a global concern, given that agricultural pathogens are becoming antibiotic resistant and are being passed to humans via the food chain, which causes health risks and reduces the efficacy of important antimicrobial drugs. These problems are further compounded by the overall loss of genetic diversity in agriculture. To overcome superpests, plant breeders increasingly use genetic materials from locally adapted nonindustrial varieties, as these traditional landraces often have natural pest resistance. However, with the development of scientific breeding programs, many of these landraces were domesticated, and their genetic diversity has been irrevocably lost. As industrial livestock production favors “high-performing” species, many traditional breeds are now becoming endangered and extinct, and this combined loss of livestock and crop agricultural biodiversity is a major global problem. Indeed, agricultural systems that promote social, ecological, and economic sustainability are desperately needed, especially given the environmental and energy challenges of the next decade.
Sustainable Agriculture: From Crisis to Opportunity

In an era of global climate change and depleting fossil fuel, industrial agriculture is increasingly recognized as being very energy inefficient, and this has been deemed its “Achilles’ heel.” Industrial agriculture requires external energy inputs in the form of fossil fuels for tractors and irrigation, petrochemical-derived fertilizers to increase yields, and massive energy requirements to transport food globally. In an era of environmental awareness and concern, industry, governments, farmers, and the public largely agree that sustainable agriculture is desirable. However, sustainability is a contested term, and how it is to be achieved in agriculture remains elusive if not controversial. This is because sustainable agriculture is a philosophical approach, rather than a specific production system, that promotes social, ecological, and economic health in food- and fiber-producing lands and communities. Any agricultural system that is financially and socially prosperous, knowledge intensive, and based on renewable, low-input, and locally based resources is generally considered sustainable. Arguably, the crisis in industrial agriculture has created a necessary opportunity for those countries practicing it to transition to sustainable approaches, and there is no better example of this than Cuba.

The Cuban Experience

The most successful demonstration of the transition to a low-input, self-reliant, and knowledge-based agriculture has taken place in Cuba, which is a world leader in sustainable agriculture. After the fall of the USSR and the continuing U.S. trade embargo, Cuba was largely unable to import either food or the chemicals, fertilizers, fossil fuel, and machines required for the agricultural sector, which at that time was technologically comparable with that of California. Although the crisis initially caused drastic yield reductions in the country, small-scale farmers quickly increased their domestic production, largely by relying on their local knowledge of preindustrial farming techniques such as intercropping, plant breeding, animal traction, manure spreading, and composting. This success led the government to downsize its industrial-scale state-owned farms, which it gave to farmer cooperatives to manage using their knowledge of low-input and ecology-based agriculture. Technology was developed that supported this transition, and government scientists developed new, ecologically friendly biopesticides and biofertilizers to support the efforts of small-scale farmers. Furthermore, in Havana and in other cities, urban farm and greenhouse initiatives were implemented to create local food security and employment in the most populous regions. Cuba stands as an example of how farmer knowledge, political will, and appropriate technology can be combined to overcome a crisis and create sustainable agriculture and food self-sufficiency.

“Alternative” Agriculture

Sustainable agricultural systems are often referred to as alternative, yet this is a misnomer, as these approaches are actually quite normal and are practiced by millions of farmers worldwide. In Africa, Asia, and Latin America, many farmers have increased their yields, provided for their families, and enriched their communities while being stewards of the land without having adopted high-cost external inputs. Many farmers in North America, Europe, and Australia found that industrial agriculture was making their operations unviable, and they have successfully and sustainably reverted back to older ways of farming that predate the introduction of synthetic pesticides and fertilizers. Indeed, many farm systems around the world exist that subscribe to the philosophy of sustainability.

Approaches that follow the principles of sustainable agriculture include organic farming, biodynamic farming, agroecology, holistic management, urban agriculture, community-supported agriculture, and natural systems agriculture, among others. Diversity is the strength of sustainable agriculture, and many of these systems are used in combination, which allows for a holistic piecing together of the necessary yet complex social, ecological, and economic components of sustainability. The overwhelming similarity among sustainable agricultural systems is that
they rely on local knowledge and are ecologically regenerative. Farmers’ local knowledge represents a rich and reliable source of information on agroecosystems and helps replace the costly external inputs of industrial agriculture. It is experience based, place specific, and holistic in nature, and it enriches and complements scientific data. In sustainable agricultural systems, farmers’ local knowledge often improves and increases nutrient cycling and associated productivity, self-reliance and profitability, and conservation of soil, water, energy, and biological resources. This is achieved in combination with the reduction or elimination of external, nonlocal, and nonrenewable inputs, which often have associated financial and environmental costs. Sustainable agricultural systems are often labor intensive, requiring many skilled and committed people to contribute to these farms, which in turn leads to populated, vibrant, and socially cohesive rural communities.

Sustainable agricultural approaches are not low technology or “neo-Luddite,” as they can incorporate both scientific and farmer knowledge and can be adopted by a diversity of farmers. Farmers, agroecologists, and plant breeders working together at The Land Institute in Salina, Kansas, are developing “natural systems agriculture,” which is a model of food production that mimics the prairie ecosystem. They have been breeding perennial versions of major annual grain crops and growing them in polycultures, which reduces the need for tilling, uses few chemicals, and creates a food system that regenerates every year. Importantly, any farmer worldwide—regardless of current practices, motivation, skill,
and knowledge—can incorporate sustainable agricultural approaches into existing operations. Indeed, many people subscribing to the values of sustainable agriculture will be required to participate in future food production.

### The Future of Food Production

Worldwide, both farmers and consumers increasingly recognize the importance of sustainable agriculture for society and the environment, especially given the ecological and energy crisis facing humanity and the planet. As the sustainable agricultural movement continues to grow, it will be rooted in values that promote diversity and social, ecological, and economic health and prosperity for the land and its communities.

*Ian J. Mauro*

See also Agricultural, Industrialized; Agriculture, Preindustrial; Agrobiodiversity; Agroecology; Crop Rotation; Food, Geography of; Organic Agriculture; Permaculture; Urban Gardens; Via Campesina (International Farmers’ Movement)

### Further Readings


---

### SUSTAINABLE CITIES

A sustainable city is one that while providing a high quality of life to a diversified and plural society in the present, establishes the mechanisms necessary to ensure suitable economic and social growth in the long term while maintaining the natural resources of the environment. This will allow future generations of citizens to satisfy their needs on the same terms.

Initially, local governments were considered, from the economic and political points of view, as the most ill suited to resolve major and expensive environmental and social problems. However, in the agreements reached at the United Nations Conference on Environment and Development (the Earth Summit) held in Rio de Janeiro in 1992, it was established that many of the problems and solutions being addressed by *Agenda 21*, have their roots in local activities. Thus, the participation and cooperation of local authorities would be a determining factor in meeting such objectives. In this regard, it was affirmed that local authorities should maintain and promote economic, social, and environmental infrastructure; inspect urban planning projects; develop and implement local environmental policies and laws, and assist other supramunicipal administrations in implementing other environmental policies. As the administration closest to the people, they have to foment citizenship education to promote sustainable development.

The European Conference on Sustainable Cities and Towns, held in Aalborg, Denmark, in 1994 and organized by the International Council of Local Environmental Initiatives (ICLEI), approved the Aalborg Charter. This establishes that the objective of European sustainable cities is to achieve social justice, sustainable economies, and environmental sustainability.

According to the Charter, social justice will necessarily have to be based on economic sustainability and equity, which require environmental sustainability. Socially, cities should create a cooperative environment where unemployment, deprivation, and underachievement are absent and where economic development is compatible with respect for social rights. This will promote an environment where social integration—that is, the compatible cohabitation of racially, culturally, and socially diverse groups—is a reality and where, at the same time, the quality of life for all segments of the population has improved.

Environmentally, cities should use resources ethically, which means that they should minimize their consumption of resource inputs from outside the community and minimize the production of waste outputs. They must also create a society based on renewable energy, complete cycling of resources, no use or release of toxins,
and development as the restoration and enhancement of the environment’s and economy’s capacity to support life.

Environmental sustainability requires the maintenance of natural capital, which means that the consumption of renewable resources should not exceed the capacity of natural systems to replace them and that the speed at which we consume nonrenewable resources should not surpass the rhythm of substitution of lasting renewable resources. Environmental sustainability also means that the speed at which pollutants are emitted should not exceed the capability of the resources to absorb and process them.

Isabel-María García-Sánchez and José-Manuel Prado-Lorenzo

See also New Urbanism; Smart Growth; Sustainability Science; Sustainable Development; United Nations Conference on Environment and Development

Further Readings


Sustainable Development and the UN Debates

The Earth Summit was called to harmonize the many disparate paths of environmental protection that countries had pursued since the UN Conference on the Human Environment held in Stockholm in 1972, 25 years earlier. Many industrialized countries had incorporated environmental protection into their policymaking, but in the developing world, change had been much slower. Few developing countries had the capacity to respond to environmental threats, and still fewer had any inclination to build the capacity to do so. The major reason for this perceived discrepancy was that for the countries of the global South, environmental protection was inseparable from economic issues. Because of the persistence of severe poverty and perceived injustice in the
global South, environmental protection never attained the level of public concern that it did in the global North. This realization convinced the WCED (which issued the Brundtland Report) that it was futile to attempt to address environmental problems without a broader perspective that encompassed the factors underlying world poverty. When the WCED presented its report to the UN General Assembly in 1987, among its recommendations was a call for the UN to prepare a universal declaration and a convention on environmental protection and sustainable development. The official and stated purpose of the UNCED was to design strategies and measures to halt and reverse the effects of environmental degradation in the context of increased national and international efforts to promote sustainable and environmentally sound development in all countries. As a result, the mandate of the Earth Summit was extremely broad.

The WCED defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The report called for cooperation between government and business and for the use of technology to address the pressing problems of balancing the social and economic needs of a growing world population with the requirements of a healthy ecosystem. The view prevailed that concerns about sustainability would stimulate society’s efforts to become less resource intensive through the use of new technologies and to become more concerned about fulfilling human needs through global environmental management. The Commission was confident that human society would reverse the conflicts between economic growth and the environment, alleviate poverty, and lead the global community to greater cooperation between the global North and the global South.

The UNCED Earth Summit was perhaps the largest, and certainly the most publicized, gathering of heads of state and delegates from national governments, representatives of nongovernmental organizations (NGOs), journalists, youth groups, indigenous people, and other interested parties to discuss environmental and development issues. Maurice Strong—UNCED’s Secretary-General—referred to the Earth Summit as a new beginning, but doubts remain about the sincerity of the negotiating partners in trying to reach an agreement on major global environmental problems, which have since compounded in severity. Several treaties were signed and specific actions agreed to, but how effective the Earth Summit ultimately was remains an issue of debate.

Consensus was reached on the Rio Declaration and Agenda 21, and these agreements, along with the Framework Convention on Climate Change and the Convention on Biological Diversity, were adopted at the Earth Summit. Agenda 21 set out to formulate a blueprint for implementation of the other UN agencies’ sector-specific activities regarding environment and development issues and to monitor progress on UNCED’s agenda. To finance Agenda 21 and projects related to climate change/global warming and biodiversity, the World Bank’s Global Environment Facility (GEF) was approached, and UNCED’s Business Council for Sustainable Development—headed by Maurice Strong—was formed to advise UNCED on business issues and to stimulate involvement in specific actions. The developing countries’ “Group of 77” wanted to establish an independent green fund in lieu of GEF, which it perceived as beholden to the interests of industrialized countries, the World Bank, and the corporate establishment; however, the idea was defeated by established interest groups from the global North.

Whose Common Future?

Within 1 year of the Earth Summit, the authors of the magazine the Ecologist published an edited volume that questioned the success and credibility of the UNCED Earth Summit. From their perspective, it was clear that the corporate sector was the dominant player both in the formulation of the various conventions and in the negotiations. Free market environmentalism was promoted—in their opinion—and corporate sponsors were given special access to the UN Secretariat. The desirability of economic growth, the market economy, and the Western development model were never questioned, and UNCED, thus, never had a chance to address the real problems of the environment and development relationship, according to these critics. The Earth Summit’s action plan, Agenda 21, suggested ways to enable poor nations to achieve sustainable development.
but never questioned the desirability of the rich nations pursuing the same. So the authors of the *Ecologist* asked the questions “In whose interest are we promoting sustainable development?” and “Who is managing it?” That the stage had been set for conflict between the global North and the global South was confirmed during later climate change negotiations under the UN Framework Convention on Climate Change (UNFCCC).

In a fundamental way, the Western development model is at odds with sustainability of the Earth resource base and carrying capacity, as it denies principles of equity that mandate equal access to resources and the “global commons.” The WCED called for justice toward the next generations but was unable to address the equity demands of the global South in the present time. The call from the developing countries for a more equitable share in wealth and resources was articulated in the Rio Declaration in terms of the “right to development.” At the Earth Summit, many leaders from the global South aligned with the global North in their advocacy of economic growth as the solution to global environmental problems. The prevailing view was that higher levels of economic development would lead to greater care of the environment and more efficient use of energy, thus resulting in lower pollution and greenhouse gas emission levels. Thus, the quest for justice was firmly wedded to the idea of development, and all parties could return to business as usual.

**Growth Within Limits or Limits to Growth?**

There are essentially two schools of thought on how to proceed toward a more sustainable development path. One—the UNCED approach—recognizes that change is necessary but believes in the power of existing institutions and economic forces to design new directives based on greater consideration for environmental and ecological concerns. Critics of this approach argue that a pro-growth economic model must be replaced by an economic system that takes into account the limits of Earth’s ecosystem.

**The UNCED’s Global Management Approach**

From the UNCED perspective, some reforms and, in particular, new technologies are needed to confront environmental threats and ecological needs, but no fundamental economic change is necessary. Based on concepts of green development and green technology, supporters of this approach believe that with the application of the right legal, policy, and management tools, nature’s resource base and its ecological services can be maintained and sustained. This approach reflects a commitment to economic growth and global expansion. Business-as-usual policies and proposed solutions are never questioned. As environment and development debates became more mainstream in the 1980s, attempts were made to mold environmental and ecological concerns into market-based models. Following the neoliberal trends in society, a search began for practical ways to incorporate sustainability into existing policies and planning approaches, which led to a whole new cadre of policy and business professionals working on sustainable development issues. The “greening of America” movement was the result. The UN’s warning that global warming threatened the upper and middle classes’ ski resorts in the Alps and the Rockies captured the headlines and brought out more support for climate change policies than any concern about poverty, floods, and food shortages in the developing countries.

**Criticism of the UNCED Approach**

It is this latter aspect that raised the question of sincerity and true commitment to UNCED’s sustainable development approach. One of the most outspoken critics of the sustainable development as global management approach has been Herman Daly. Daly questions the efficacy of pro-growth economics in addressing global environmental problems. He also argues that if the marginal benefits of physical growth decline while marginal costs rise (as elementary economic theory would indicate), then there will be an intersection beyond which further growth would be uneconomical and unsustainable. The application of more advanced technology can (temporarily) expand production, but technological “progress” is usually accompanied by further resource depletion and pollution.

The economy is an open subsystem of Earth’s ecosystem, which is finite, nongrowing, and
materially closed. As the economic subsystem grows, it will incorporate an ever-greater proportion of the total ecosystem. Thus, economic growth is unsustainable, assuming that “natural capital,” or the sum of nature’s resources, is used up faster than it is being replenished. In effect, unsustainable development is intertwined with the loss of carrying capacity and limits to growth. The long-term result of unsustainable development is the inability to sustain human life, and such degradation on a global scale could lead to the extinction of humanity. Daly derides the concept of “sustainable growth” as an oxymoron and maintains that if we truly want to pursue sustainable development and if we value equity and fair share as human values, then the global North must make a commitment to use fewer resources and claim a smaller share of the global commons. It is for this reason that sustainable development has become a very laden political term in mainstream society. Critics of UN policies argue that it is hard to imagine that sustainability through improved environmental management would be achieved by means of greater integration of environmental reforms in the global economy even if the free market were to foster greater efficiency, higher productivity, and improved technology. Thus, the question “Is capitalism sustainable?” needs a serious answer.

Capitalism, Globalization, and Sustainable Development

Those who recognize the bipolar challenges of bio-physical limits to growth on the one hand and business-as-usual approaches to development on the other argue that profound transformations of contemporary capitalism are needed sooner rather than later if we are to avoid dramatic disruptions of life on Earth. As the global economy is driven by the profit motive and foreign and corporate investment, and as we possibly approach the limits to growth, a less than equitable distribution of wealth and livelihood security has resulted. The implication of this is that sustainable development efforts require a restructuring of societal relationships, which has made discussions about sustainability and sustainable development highly politicized.

On this view of sustainable development, the Rio Conference has perpetuated a fixation on the Western development model that fails to acknowledge ecological limits, and this has done a disservice to the global South, since equity concerns were never addressed. At the World Summit on Sustainable Development in Johannesburg in 2002, critics argued that it was time to move beyond Rio, to elevate development and equity concerns on the UN political agenda, and to focus more on the structural inequities in the global economy. This, critics argued, required that the Western development model be abandoned and that the rich reduce their “footprint” to ensure that the poor would be able to protect their livelihood rights.

Arguing that capitalism in its present form is unsustainable has become one of the major points of discussion among the critics of the impacts of globalization, including political ecologists, some of whom charge that sustainable development is an agenda of the global North designed to ensure the dominance of corporate elites. Environmental concerns associated with global production and foreign trade question the validity of the neoliberal economic agenda promoted by the United States, the World Trade Organization, the International Monetary Fund, and the World Bank. Since many negative effects of global production and foreign trade are not confined within national boundaries but spill over to affect other parts of the world (as, e.g., with greenhouse gas emissions) and since negative spillover effects are often more severe in developing countries than in the developed world, some environmentalists and ecologists argue that under the more open international trade regime, the economic growth model associated with capitalism should be abandoned. In its stead, we should pursue a sustainable development course that would promote fair-trade and fair-share principles.

Daly and others have argued that capitalist economic growth is about quantitative expansion and limitless transformation of natural capital into manufactured capital. Sustainable development, on the other hand, is about qualitative improvement in livelihoods, permitting increased economic activity only in so far as it does not exceed the capacity of the ecosystem. Thus, sustainable development requires an emphasis on physical parameters such as resources and carrying capacity, along with an acceptance that economic variables such
as income and profit will have to be adjusted accordingly. To many, it has become abundantly clear that the world’s poor will bear the brunt of the damage to ecological systems and will carry most of the costs associated with it, while they are hardly to blame or in a position to make any changes themselves. New core values such as interdependence, empathy, equity, personal responsibility, and intergenerational justice will have to become the guiding principles and the basis for the transformation necessary to meet sustainability challenges.

An Equitable and Sustainable Climate Change Regime

To illustrate, greenhouse gas emissions reduction, necessary to achieve long-term stabilization of emissions concentrations in the atmosphere in order to avert climate change, will require a significantly lower carbon footprint of higher-income countries. If we consider that every person should have equal access to and share equal responsibility for the global atmospheric commons, and if we aim to achieve sustainable levels of greenhouse gas concentrations (450 parts per million) by the year 2050, as projected by the Intergovernmental Panel on Climate Change (IPCC), then we can assign specific carbon budgets for each country. The Stern Report projected the need for cuts of 80% or more in human-induced greenhouse gas emissions worldwide. Using the latest IPCC data, it is estimated that a safe level of emissions per person worldwide would be 2.0 tons of CO₂ (carbon dioxide) in 2050. Whereas most developing countries are currently well below a sustainable per capita limit, residents of the United States emit more than 20 tons of CO₂ per person per year, which means that substantial reductions will have to be made in the United States in order to reach both equitable and sustainable levels worldwide.

The implications of this are far-reaching, and it would seem that the longer we wait to implement the new energy systems, the more difficult it will be to achieve a sustainable level of emissions in an equitable way in the future. An equity- and sustainability-based policy response to global climate change would require that higher-income countries reduce their emissions to the greenhouse gas stabilization level of 2.0 tons of CO₂ per capita at a rapid rate. Lower-income countries, in contrast, would be allowed to further expand their emissions until about 2040 and then cut back their CO₂ emissions to reach equity and sustainability levels at around 2050. As would seem clear from this example, it is hard to imagine that this can be accomplished under the business-as-usual UNCED approach.

Yda Schreuder

See also Ecological Economics; Ecological Footprint; Global Environmental Change; Globalization; Greenhouse Gases; Neoliberal Environmental Policy; Political Ecology; Political Economy of Resources; Sustainability Science; Sustainable Agriculture; Sustainable Cities; Sustainable Development Alternatives; Sustainable Fisheries; Sustainable Forestry; Sustainable Production; United Nations Conference on Environment and Development; World Bank; World Trade Organization (WTO)

Further Readings

The literature on sustainable development has long purported to focus on the tripartite relationship between economy, environment, and social justice. While all definitions of sustainability imply this trio of interrelated interests, only two are typically addressed in contemporary analysis: economic sustainability and environmental sustainability. This is true in conceptual and empirical analyses and policy practice. In conceptual terms, sustainability scholarship has focused primarily on normative accounts of sustainable development—the way it should be. Sustainability as a policy discourse and an embodied set of practices has yet to live up to its progressive potential to bring together these issues in a holistic way. In response to these forms of analysis, a new body of work on local and regional sustainability, with a more critical and empirical orientation, is emerging. The concepts of “alternative” sustainable development and “critical” sustainability studies sharpen their analytical foci on the relationship between conventional thinking and the “sustainability transition,” how sustainable development looks in practice, and what and who gets overlooked.

This entry has three sections. The first briefly introduces some conventional accounts of the sustainability literature and a critique of these perspectives. The second section summarizes the different perspectives from the critical sustainability studies standpoint. The final section seeks to ground this point of view further by summarizing the linkages between sustainable development and environmental justice.

Concerns for sustainable development made the international scene in the 1980s, when the Brundtland Commission, named after Gro Brundtland, the former Prime Minister of Norway, published its now famous definition of sustainable development. In the decades since, a variety of perspectives have emerged under the Brundtland mantle of sustainable development or have at least gained traction as a result of its popularity. Two key scales of intervention have been proposed by scholars and engaged in by policymakers—systemic and local engagement.

**Systemic Intervention**

At the systemic level, various perspectives have a key commonality worth noting. These perspectives share a belief in the power of the current economic system and faith in its intrinsic ability to regulate itself to produce progressive outcomes. These accounts are thus tinged with the neoclassical logic of “getting the markets right” and often conclude with appeals to a vague mix of moral imperatives, social conscience, and the threat of looming ecological disaster.

Specifically, these perspectives, which are exemplified by the work of environmental and ecological economists, economic futurists, and ecological modernists, focus on reformulating our current economic systems, especially in terms of redefining how the economic value of the environment is calculated. While these analyses are rigorous, especially those of environmental economists, and may even provide short-term fixes to environmental problems, they return to the same proposition as their neoclassical predecessors: that the market, properly defined, incentivized, and reflecting the real costs of development, is the most desirable institution for delivering human prosperity and ecological integrity. Here, market-produced values are surrogates for the value of “environment.” Wastewater treatment plants, for example, can account for the ecological services of a wetland by...
calculating the cost of construction, maintenance, and human resource requirements. Thus, the economic value of a wetland is established by its ability to cleanse impurities from water. Market-oriented values also suggest that prices are triggered solely by signals from the system. Once growth surpasses replacement, for example, disincentives will trigger slower growth.

Ecological modernization theorists share this view, as its progenitors suggest that the ways in which societies value the environment are maturing and taking into account broader concerns than merely simple price triggers and costs. While these developments represent a breakthrough in valuing the environment in ways that traditional economists did not, the analysis falls short of engaging key questions such as the following: What “environment” is being saved? For whom? To what end? How do we measure a contested concept such as “nature’s” services? How do institutions work under conditions of economic change?

Local Engagement

Over the past few years, analyses that bridge the calls for developing a more sustainable society have been taken up by scholars who focus their analyses on the roles of individuals, nongovernmental organizations, and institutions in shaping more sustainable outcomes. In particular, these scholars have not focused on how existing systems can be overhauled to support economic growth per se, nor have they kept an overly narrow focus on the “environment.” These scholars have also called into question the societal implications of sustainable development goals and polices.

Critical Sustainability Studies

Critical commentaries on sustainable development have begun to ask some of the crucial questions raised above. Debates rage on the capacity of local authorities to act in the service of sustainability and the meaning and usefulness of the concept itself. For some, many of the environmental benefits of urban sustainability initiatives accrue to middle-class communities, often at the expense of peripheral local sites as well as those far away. Others have commented on the discursive nature of sustainability. In sustainable development, there is a central storyline for policy discourses such as ecological modernization. This notion of a “storyline” suggests that sustainable development can be read as a new power/knowledge discourse for organizations seeking to accumulate power. Do the values and institutions of sustainability prioritize the value of capital and the maintenance of existing patterns of social relations? Or can sustainability discourses offer a counterhegemonic opportunity for subaltern groups to reshape urban environments, making them more equitable? Are there complementarities between those actors who focus on social reproduction and sustainability discourses—rather than those solely with environmental concerns—to produce outcomes that have a “red-green” tinge?

Subaltern Sustainability

Scholars are now applying the concept of environmental justice to sustainability practice to reveal that equity and justice are largely divorced from sustainability initiatives. Instead, these authors argue, sustainability is really focused on environmental protection or sustained economic development. They also argue that to be environmentally sustainable, cities must also be socially sustainable. Indeed, a sustainable society is one that looks to issues of social inclusion and welfare, along with economic opportunity and a green environment. The terms just sustainability, actually existing sustainabilities, and subaltern sustainability were coined as an explicit attempt to link issues of social equity to economic and environmental sustainability policy and practice. These concepts are important in critical sustainability theory. By bringing together the sustainability literature and the environmental justice literature, scholars have sought to create a vocabulary for political opportunity and mobilization, both in local government and in the grassroots. Indeed, there remains a critical need to examine how sustainability might be “mapped” onto the current geography of neoliberal capitalism and, more important, where the opportunities for broader, more inclusive political engagement with sustainability might present themselves.

Rob J. Krueger
SUSTAINABLE FISHERIES

Until well into the 20th century, ocean resources were believed to be infinite. The “freedom of the seas” paradigm that existed from the 1800s was largely informed by Hugo Grotius, the 17th-century natural rights writer, who argued that the oceans’ resources were inexhaustible and that fishing regulation was unnecessary. However, more modern scientific reports represent a very different state of affairs, making apocalyptic predictions about the state of the planet’s fish stocks. The most alarming forecasts claim that the stocks of all commercial fish and seafood species could collapse by the middle of the 21st century if present trends continue. Indeed, fears have reached such epic proportions that many commentators argue that the current international fisheries situation amounts to a crisis, second only to global warming in significance. Although such forecasts are typically contested by the world’s fishing industries, there is little doubt that many fish stocks around the world are well below their “maximum sustainable yield”—that is, the largest catch that can be taken continuously from a stock so that it does not deplete it irreparably. This entry reviews the status of fish stocks today and explores the causes of, as well as various government responses to, the problem on national and international levels.

Collapsing Fisheries

A worldwide increase in “fishing effort” (the amount of fishing) since the late 20th century has corresponded with declining stocks and smaller catches. The total fall in global catch between 1994 and 2003 has been estimated at 13%. The explanation most frequently offered for this decline is that there are now too many boats chasing too few fish. Between 1970 and 1990, the Food and Agriculture Organization of the United Nations (FAO) recorded a doubling in the world fishing fleet to more than 1 million large vessels and 3 million smaller boats. Not only are there now more boats at sea, but each of these is likely to be more successful than ever before at catching fish. Fishing underwent vast technological changes over the 20th century, a process known as “technical creep.” The so-called overfishing crisis has its roots in the turn of the 20th century, which saw the capitalization and mechanization of fishing fleets and the widespread use of steam trawlers in the Atlantic. For instance, these technological developments resulted in the collapse of the Great North Whale Fishery in 1880 and the once booming herring and tuna fisheries in the Atlantic in the early part of the 20th century. Despite such crashes, advancements in catching technology continued. Fishing gear such as nets and modern equipment such as sonar and geographic information systems are being constantly improved so that each vessel can catch many more fish than ever before in a single trip.

As a result of this continuous increase in fishing activity, the United Nations (UN) states that 52% of the world’s commercial fish species are fully exploited, 17% are overexploited, and 8% are depleted. And according to the International Council for the Exploration of the Sea, slow-growing and therefore vulnerable deep sea fish,

See also Ecological Economics; Ecological Modernization; Environmental Justice; Political Ecology; Political Economy; Resource Economics; Sustainability Science; Sustainable Agriculture; Sustainable Cities; Sustainable Development; Sustainable Fisheries; Sustainable Forestry; Sustainable Production

Further Readings

such as orange roughy, are roughly 90% less numerous than they were in the early 1970s.

These alarming global statistics take on even more significance when considered with respect to particular geographical regions. For example, the collapse of the once abundant Grand Banks cod fishery in Canada in the early 1990s has become emblematic, and many people are familiar with the contemporary decline of the North Sea cod. This has caused widespread concern as the numbers of these fish are well below what is considered sustainable. Europe’s fisheries scientists now estimate that cod spawning stock in the North Sea—that is, the section of the population responsible for reproducing—has declined by more than 80% since the early 1970s, and many are concerned that it could follow the Canadian example if radical action is not taken. But such problems are not confined to the Western world. For instance, some tuna stocks in the Pacific have been reduced to 15% of what they once were, and the economically important Patagonian toothfish fisheries in the Southern Pacific Ocean are also considered vulnerable to stock collapse. Similar stories can be told about almost every ocean.

Sustainable management of fish stocks is crucial because as fisheries are an extractive resource, fishing practices such as trawling can harm marine environments more generally. Moreover, these reports of unsustainable fisheries are even more disturbing if seen in the light of the rapidly increasing global demand for fish, which has doubled in less than 30 years, according to the FAO. Fish and seafood provide an important source of nutrition for both humans and animals (in the form of fishmeal, which is often harvested unsustainably), and they provide important employment. The collapse of the Grand Banks fishery, for example, cost that region more than 40,000 jobs. Fishing directly or indirectly sustains the welfare of many coastal regions around the world. However, the dependence on fisheries and related industries varies from country to country. In the United Kingdom, the fishing industry makes up less than 0.5% of gross domestic product, a figure less than the British lawnmower business. But dependence on fishing increases to 10% on the Atlantic coast of Spain and around the shores of Scotland. So while the number of jobs in the fisheries sector represents a low percentage of overall employment in many countries, their socioeconomic importance is still huge.

**A “Tragedy of the Commons” and Government Responses**

Given that fisheries are so crucial to us as a source of food and means of employment, it is perhaps surprising that we are still facing major problems with their sustainability. One of the reasons for this can be explained with reference to the “tragedy of the commons,” in which the rational, self-interested acts of individuals destroy a common good. This allegory, developed by Garrett Hardin in 1968, is probably the most enduring explanation for resource overexploitation. Many natural resource commentators have used this allegory to exemplify the dilemmas involved in fisheries management. Fisheries are often described as “common-pool resources,” which, because of their nature, are difficult to divide up or fence in. Hence, what one user of the resource does can affect what is available to another user. This situation may lead to a scenario where resource exploitation happens in a way that neglects broader social-environmental responsibilities. The allegory shows how environmental or social externalities arise because self-interest drives economically rational actors to maximize their individual profit, since in a commons, the costs of doing so are shared by all yet the benefits accrue fully to the individual. The ultimate result is resource overexploitation, where everyone loses.

With respect to the world’s common fisheries, the “external cost” relates to the fact that an individual fisherman’s unrestrained profit maximization can damage the sustainability of fish stocks, thus making it harder for other fishermen to catch fish today and in the future. Essentially, it is the “common property” condition of ocean resources that has been blamed for overfishing.

**European Union Policy**

This conundrum of open access to common fishing grounds affected most 19th- and 20th-century fisheries, and many observers maintained that its solution was beyond the scope of single nation-states acting alone. One of the most notable multilateral solutions to overfishing is the
European Union’s (EU’s) Common Fisheries Policy. Although fisheries policy in the EU dates back to the early 1970s, the Common Fisheries Policy was not ratified by the member states until 1983. It was designed to give Europe’s fishermen equal access to the resources of the EU’s “common pond” and to ensure the “economically rational” use of fisheries within the context of a series of social and, later, environmental objectives. That is, the primary purpose of this policy is to ensure the sustainable exploitation of Europe’s fisheries.

Notwithstanding this commitment to the goal of sustainable development, stresses remain between the policy’s environmental, economic, and social objectives. For instance, tensions still exist between the need to protect vulnerable stocks such as the North Sea cod for environmental reasons and the fishing industry’s requirement to make a living and support coastal communities. Indeed, it is generally believed that the Common Fisheries Policy may have compounded the problem of unsustainable fisheries in Europe. Under it, for example, the limits on the amounts of fish that fishermen can legally land in a specific time period (fish “quotas”) are said to promote overfishing, through a practice known as “high grading.” This means discarding from the catch “substandard,” or unsellable, fish to increase the proportion of valuable fish in the allocated quota. Often, fishermen cannot bring themselves to throw back the already dead fish and so may land them illegally. These fish, caught and landed outside quota limits, are known as “black fish.”

Overfishing in the EU has also been blamed on lax enforcement of existing regulations, fishermen’s reluctance to comply with them, and the failure of politicians to follow scientific advice on stocks and put in place the measures needed to secure sustainability. But overfishing problems are not confined to Europe. Through access agreements, the EU has actively encouraged deployment of its excess fishing capacity to Africa, South America, and the Indian Ocean. Nongovernmental environment and development organizations have voiced concerns about this export of resource overexploitation to developing countries, arguing that access agreements represent a form of neocolonialism.

For some commentators, the solution to the tragedy of the commons is privatization of resources that were once open access. As the allegory demonstrates, it appears to be the disjunction between the universal right of entry to a fishery and the lack of individual responsibility for its overall maintenance that creates the incentive to overfish. Therefore, these commentators argue, externalization of the costs of exploitation onto the whole community of commons users can be remedied by establishing private property rights over the commons. Such rights encourage the internalization of externalities, because if you are legally identified as the owner of the resource (so the argument goes), then you will be more likely to look after it.

Individual Transferable Quotas

Privatizing ocean resources may not be an attractive solution, so long as they are regarded as what the UN calls the “common heritage of mankind.” What is more, even if using property rights as a management method were theoretically sound, enforcing them on mobile resources might be problematic, for it is not yet feasible to fence off migratory fish species, such as herring or tuna. Consequently, it is only possible to apply a manner of privatization in the form of “individual transferable quotas,” or ITQs. These are shares of fishing effort allocated to individual fishermen, who can either use that effort themselves or sell it to someone else. ITQs thus approximate a privatized situation, providing the conditions for a market to operate. They are used in Iceland, New Zealand, and elsewhere and have had some success. They are said to afford greater flexibility than standard quotas because fishermen can sell them in hard times, or purchase quotas for valuable fish they could not otherwise land legally, instead of discarding them overboard.

Despite its attractions, there are several significant limitations to this system. For example, ITQs have in some circumstances led to “buysouts” whereby economically thriving operators buy quotas from smaller or less successful fishermen, and as a result, some coastal communities have eventually been altogether deprived of their fishing industries. Hence, the system may not be socially sustainable. What is more, this system does not entirely solve the problem of high grading, and so it is not fully environmentally sustainable either.
International Policy Responses

As well as the quasi privatization of fish resources, some policies have privatized the sea itself. Although much of the ocean is still part of the global commons, some of it is now “territorialized,” or, in effect, privatized, by nation-states. The conditions for this were created by the UN Convention on the Law of the Sea of 1982, which provides the overall legal framework for all ocean activities and establishes general obligations for safeguarding the marine environment. Its key provision is the establishment and extension of exclusive economic zones, or EEZs. These zones allow nations to have territorial and exploitation rights up to 200 nautical miles from the shore, covering all natural resources.

The international fisheries governance regime, however, may fall short. First, coastal countries are not obligated to responsibly manage their fisheries within their EEZs. Second, problems arise when some countries do not wish to collaborate or cannot reach agreement, as there are no binding laws on resolving disputes over resources. Also, introducing EEZs has actually encouraged governments to expand their fleets, thus stimulating overfishing. Yet, paradoxically, the expansion of territorial limits partly stemmed from an “overfishing” crisis in the internationally shared territory beyond them: the “high seas”—a global commons where open-access conditions prevailed and where there was a regulatory free-for-all.

Today, the high seas are managed by the UN’s Regional Fisheries Management Organisations. However, they are largely ineffective, principally because they have no means to exclude vessels not abiding by their rules.

International fisheries governance is a mishmash of codes of conduct and frameworks. Global commitments to sustainable fisheries include the UN’s Convention on Biological Diversity (Article 14) with its Action Plan for Fisheries (1992) and the UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (Article 12, 1995). The most far-reaching is the nonbinding FAO Code of Conduct for Responsible Fisheries (1995). The code explicitly demands participative and transparent decision making by countries and regions. It also calls for “efficiency and effectiveness” to achieve “timely solutions.” At the United Nations Conference on Environment and Development (the Rio Conference, or Earth Summit) in 1992, countries agreed to ensure “rational and sustainable” fishing. This commitment was reinforced and elaborated at the World Summit on Sustainable Development in Johannesburg in 2002, where it was decided that fish stocks should be maintained or restored by 2015. Given all these codes, it is easy to see why fisheries policy is an expanding area for governance.

One set of mechanisms that is fast gaining purchase in the search for sustainable fisheries consists of market-based instruments targeted to consumers. Eco-labeling and green consumerism now form part of a dominant discourse that might go some way toward eliminating unsustainable fishing practices. Consumer pressure sometimes forces retailers, keen to appear “green,” to source from fisheries certified as “sustainable,” and this encourages fishermen to move to healthier grounds or to use “friendlier” fishing gear. However, as in the ITQ example above, these market mechanisms may be inadequate to achieve and maintain maximum sustainable yield. Among other problems, they rely on consumers having sophisticated information about complex ecological processes and on their being prepared to exercise their spending powers. Second, although eco-labels may tell us that a fishery is “sustainable,” it may not tell us how many miles the fish has travelled in its journey from the ocean to the supermarket shelf and how much atmospheric carbon this has contributed to climate change.

Liza Griffin

See also Aquaculture; Common Pool Resources; Common Property Resource Management; Commons, Tragedy of the; Environmental Certification; Market-Based Environmental Regulation; Marine Aquaculture; Oceans; Sustainable Production

Further Readings

SUSTAINABLE FORESTRY

According to the Food and Agriculture Organization of the United Nations (FAO), sustainable forestry may be defined as

the stewardship and use of forests and forestlands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and their potential to fulfill, now and in the future, relevant ecological, economic, and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems. (UN Forum on Forests, n.d.)

There are four general goals of sustainable forest management (SFM): (1) to ensure a continuous supply of timber; (2) to ensure local populations’ access to a wide range of nontimber forest products; (3) to conserve natural forests for biodiversity, habitat, amenities, and ecosystem services; and (4) to sequester atmospheric carbon in support of climate change remediation. Strategies for pursuing SFM typically make the following assumptions:

- Forests will continue to regenerate naturally over the long term (more than one human generation).
- Forest resource stakeholders (from local communities to transnational timber companies) have sufficient technical knowledge, institutional capacity, and self-interest to manage natural forests for the long term.
- A clear policy framework for SFM exists that is consistent at various intergovernmental levels.
- A politically accountable public entity exists, with the capacity to effectively identify various forest resource stakeholders and consistently monitor their behavior over time.
- Market demand for products and access to markets are relatively stable over the long term.
- Forestland tenure (i.e., property ownership) is clearly delineated, and viable judiciary and police capabilities exist to justly enforce legitimate individual and collective property ownership rights to forest lands.

Despite regional variations, three common themes have emerged among the guidelines for SFM that distinguish it from its predecessor, sustained yield management: (1) a shift toward a more holistic perspective by changing the unit of analysis from the individual natural resource (e.g., timber or wildlife) to the larger ecosystem with which the resource is entwined; (2) a broadening of scope, from the economics and biology of renewable resource extraction to the social and cultural contexts in which such activities occur; and (3) an expansion in the range of benefits (products and services) provided, from timber for industrial wood production to timber and numerous different nontimber forest products and ecosystem services (carbon sequestration, soil and watershed protection) that SFM claims to provide.

Global Extent of Sustainably Managed Natural Forests

According to the FAO, approximately 30% of Earth’s land cover (4 billion ha [hectares]) is forested. From 1990 to 2000, 8.9 million ha of forestland was lost annually to deforestation. In the 21st century, this rate has decreased to 7.3 million ha per year. A global estimate of how much of the remaining forestland is sustainably managed is difficult to determine. More than 200 million ha is currently certified as being sustainably managed by the Programme for the Endorsement of Forest Certification Schemes (PEFC). There are also large areas of land enrolled in programs that promote SFM that are not certified by the PEFC. For example, 440 million ha (11% of the world’s total forest cover) is under some form of community-based ownership, and another 12% to 15% of the world’s natural forests are managed by timber concession agreements. Another 12% of the world’s forests (468 million ha) are in designated protected areas. Therefore, approximately 35% to 37% of the world’s forestlands are being managed in some fashion. It is important to note, however, that not all community forests, forests under timber concessions, or protected forests are managed sustainably.

The Montreal Process

The ecological dimensions of SFM are predicated on the first five criteria for SFM, as endorsed by the Montreal Process of 2003, one of nine working groups established to develop SFM guidelines.
The Montreal Process criteria are discussed below because the countries involved in the process account for the majority of the world's forests.

*Creation and Maintenance of Biological Diversity.* Ecological research demonstrates that diverse ecosystems are resilient ecosystems. A forest with a wide array of species is less susceptible to potentially catastrophic disturbances such as insect and disease outbreaks, wildfires, and major storm events than a forest with relatively fewer species. Biological diversity is measured in terms of habitat, species, and genetic composition. SFM seeks to create and maintain biodiversity by focusing on management at the landscape level rather than at smaller scales (such as an individual forest).

*Forest Health.* Maintaining forest health through SFM is essential to ensure that basic ecosystem processes operate within their historic ranges of variation (in terms of frequency, intensity, and scale). Health can be assessed by evaluating the area of forest affected by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinization, and domestic animals occurring above and beyond the historic range of variation. Additionally, changes in fundamental ecological processes, such as nutrient cycling and pollination, can affect forest health.

*Ecosystem Services.* Healthy forests contribute to the protection of adjoining ecosystems, especially the soil and water regimes of those areas, and thereby provide useful environmental services within the larger landscape. Healthy forests act as buffers against soil erosion from both runoff and wind and as a filter, removing pollutants from water before they reach groundwater supplies and streams. Reductions in soil erosion result in less sedimentation in streams and rivers. Additionally, forests help provide clean air by filtering pollutants such as ash, pollen, and smoke in Earth’s troposphere.

Forests can also have a significant effect on climate. At the local level, trees provide shade and absorb heat energy, resulting in a cooling effect on both land and water. In the winter, trees can act as a windbreak and can moderate soil temperatures. And at both local and global levels, forests play an important role in the carbon cycle.

*Role of Carbon*

Forests are both carbon sources and carbon sinks. A forest is a source when the amount of carbon released through respiration, decomposition, and burning exceeds the amount of carbon taken up (sequestered) through photosynthesis. Conservatively, deforestation and unsustainable forest management account for about one sixth of global carbon dioxide (CO₂) emissions.

A forest is a sink when the amount of carbon sequestered exceeds the amount of carbon released. A global estimate of the total carbon stored annually in forest biomass is 283 Gt (gigatons; 1 Gt = 1,000,000,000 tons). Well-managed forests have the potential to absorb about 10% of global carbon emissions into their biomass and soils. Additionally, solid wood products, such as building materials and furniture, provide long-term carbon storage.

Currently, incentive-based carbon markets are emerging to encourage landowners to engage in forest management practices that increase carbon uptake and storage. Market-based cap-and-trade mechanisms for reducing CO₂ emissions (similar to that currently in place in the United States for sulfur dioxide) would likely have important implications for SFM.

*Forest Productivity*

Traditionally, forest productivity was measured in direct relation to timber production (i.e., the production of forest land area, the volume of growing stock, the area of planted vs. naturally regenerated forests, and the annual removal of timber products vs. the amount of annual growth). While these indicators are still important, the definition of forest productivity has expanded to include other measures, such as biodiversity, the economic values of nontimber forest products, and ecosystem services.

Forest management practices can have significant impacts on productivity (both positive and negative). Choosing species well suited to a particular area, incorporating genetic improvements such as disease resistance and rapid growth, and
applying management tools (such as prescribed fire, thinning, and control of exotic invasive species) can increase both traditional and nontraditional measures of forest productivity. Other factors that affect productivity include forest species composition, temperature, rainfall, and soil depth and nutrient content.

**Social Dimensions**

Sustainable forest management explicitly recognizes the importance of the human and social dimensions of forest management, more so than conventional notions of sustained yield harvesting. The emerging interest in the human dimensions and social aspects of forest management correspond with a growing awareness of the significant contribution of deforestation to biodiversity reduction, climate change, and watershed degradation in low-income countries of the global South. As much as 30% of tropical deforestation is caused by small-scale, resource-poor cultivators, many of whom have been economically marginalized by large-scale, Western-style development projects. Accordingly, many proponents of SFM have argued for the inclusion of local communities into SFM programs. These have taken several forms (including biosphere reserves, integrated conservation and development projects, extractive reserves, social forestry, and community forestry), the objectives of which are the following:

- To protect agricultural land from soil and wind erosion, water pollution, and other adverse environmental conditions, thereby improving environmental quality
- To increase the supply of fuelwood, basic construction materials, and nontimber forest products, typically for noncommercial household consumption, thereby improving the quality of life at the household level
- To enhance the natural beauty of the landscape for passive recreational activities
- To provide employment for unskilled rural workers

**Challenges in Sustainable Forest Management**

Ecologically, the inadvertent and unintentional introduction of exotic invasive species is probably the most serious challenge to the health and integrity of almost any ecosystem today and also to SFM. Exotic invasive species typically have a negative impact on biodiversity by displacing native species and altering ecosystem functions (e.g., changing the fire regime, nutrient cycling, or hydrology). Genetic biodiversity can also be corrupted as exotics hybridize with native species, altering the native gene pool. Worldwide, upward of 80% of endangered species could suffer losses due to exotic invasives, at a cost of $1.4 trillion.

Other ecological challenges include soil conservation (minimizing erosion and compaction), water quality and quantity, and wildfires. Policies that encourage the identification and removal of invasion pathways and support public education for recognition and eradication of exotics are needed to fight this particular battle. Forest management practices that minimize soil damage and protect waterways are also needed.

**Economic Challenges**

The expansion of traditional forest management, based on the principle of maximum sustained yield of a single forest product such as timber, to management for multiple products, environmental services, and cultural values poses troublesome challenges to conventional neoclassical resource economics, with its focus on utility-maximizing, self-interested, rational economic actors operating in a free market context. Most equilibrium models of sustained-yield timber management presume concave utility and production functions, resulting in a single equilibrium point indicating the level of maximum sustainable harvest during a specific production cycle.

In the multiproduct, multiuse definition of SFM, however, where there are many production functions, there will be multiple equilibria, each of which may be affected by different rates of biological reproduction for different species, by their varying degrees of resilience to disturbance, and by the resource use behaviors of various forest stakeholders. Add to this the additional layer of complexity associated with the multiple institutional contexts in which different forest stakeholders operate, and a market-driven model for SFM becomes problematic for effectively balancing the
economic wants of society with the ecological requirements of forests.

**Social (Tenurial) Challenges**

Land ownership and tenure patterns also pose challenges to SFM. Large forested areas around the world are increasingly being subdivided into smaller parcels as a result of various social processes (e.g., inheritance, in-migration, and household agricultural failure). Parcelization of property ownership often leads to forest fragmentation—the alteration of a continuous forest into isolated forest patches interspersed with land in other, nonforested uses.

From an SFM standpoint, applying traditional forest management practices to smaller parcels can be difficult, particularly when adjacent properties have conflicting uses. Additionally, these smaller parcels of forestland are subject to increasing levels of disturbance along their edges and may not be suitable for species that require interior forest habitat, even as the habitat for edge-adapted species is increased.

Policies that encourage connectivity between fragmented forests, maintenance of structural complexity in forests (i.e., multiple-age classes, snags, and coarse woody debris), and the adoption of varied management practices at multiple scales could offset the negative impacts of forest fragmentation.

**Political Challenges**

Sustainable forest management can be negatively affected by illegal activities, such as trespassing, timber theft, logging endangered species, and wildlife poaching. In major tropical timber-exporting countries, illegal logging accounts for more than 50% of total timber cutting. The World Bank estimates that illegal logging costs the developing world an estimated $15 billion annually in lost assets and revenues, in addition to human rights violations and social conflicts. Additionally, up to 10 million ha are annually deforested or degraded as a result of illegal activities.

Other external threats to SFM, especially pertaining to protected areas, in the form of illegal land settlement by migrants and land speculators pose significant political challenges for governments seeking to balance social problems (e.g., chronic landlessness) with forest conservation commitments. Many of these challenges could be addressed through effective political will and commitment to public policies that support the implementation of forest management plans and the enforcement of existing forestry laws.

**Institutional Challenges**

Sustainable forest management is also impeded by deficient institutional capacity. Where SFM is a national policy goal, governments often lack the institutional resources to effectively enforce policies that support SFM. At the community level, where SFM is often introduced by outside technical experts, it can be stymied by the lack of a preexisting communal land management tradition or by the domination of individual interests within the community, which may prevent the gains of SFM from being shared broadly.

**Forest Concession Challenges**

Worldwide, a minimum of 450 million to 500 million ha of natural forest is leased to private timber extraction and/or industrial wood-processing corporations under long-term forest concession agreements. Although the terms of such agreements may contain attributes of SFM (e.g., sustained yield management), many concessions, in practice, have been criticized by conservationists and economists for being overly destructive and economically wasteful, highly susceptible to corruption, harmful to local communities, and unsustainable over even the short term. Logging is believed to account for approximately one third of global deforestation, raising questions as to whether large-scale timber concessions can ever be sustainable.

Recent interest in community-based forest concessions for timber extraction has scaled down forest management areas from large industrial forest concessions (ranging from 50,000 to 25 million ha) to smaller (500–10,000 ha) production units, with strong local (community) participation and management interest in logging and marketing operations.
Innovations in Sustainable Forest Management

Conservation Concessions

Some conservation groups (e.g., Conservation International) have recently proposed to adapt the forest timber concession model to promote forest protection. In the adapted model, forest landowners (private, governmental, and customary) lease forests to investors (e.g., nongovernmental organizations) for a stable rent in exchange for maintaining the intact forest. The rental income from such concessions is allocated to local communities to offset their opportunity cost of income foregone in order to ensure forest conservation. In practice, the effectiveness of conservation concessions is often constrained by the inadequate concession enforcement capacity of forest owners, by questions of national sovereignty, and by external forces over which local concession holders have little control.

Sustainable Urban Forestry (SUF)

As defined by the Sustainable Urban Forests Coalition (SUFC), urban forests are “the aggregate of all vegetation and green spaces that provide a myriad of environmental, health and economic benefits for a community.” Sustainable urban forestry is defined as “the art, science and technology of managing trees, forests and natural systems in and around cities, suburbs and towns for the health and well-being of all people.” Recognizing the positive public health and local watershed and climate benefits of maintaining forests in an urban landscape, several municipalities in the United States and elsewhere have initiated urban forest management plans as part of active land stewardship programs.

Reduced-Impact Logging (RIL)

Reduced-impact logging is the application of scientific and engineering knowledge and techniques, in conjunction with education and training, to improve operating methods for harvesting of industrial timber so as to minimize collateral damage to the residual forest and other elements of the forest ecosystem during a harvesting operation.

Forest Certification

Forest certification is a voluntary process in which a third party evaluates and certifies the management of a forest against a particular set of sustainability standards. Although applied mainly to timber extraction, certification also can be applied to the management of nontimber forest products.

Secondary Forest Management

Forested areas that have regrown through natural regeneration after a major disturbance (e.g., clear-cutting, fire, timber harvest, and/or insect infestation) over time such that the effects of the disturbance are no longer evident are commonly called “secondary forests.” As human pressures reduce the global area in natural forests, the sustainable management of tropical secondary forests will become an increasingly important component of SFM.

Conclusion

The attributes of forests around the globe, and the social and political challenges that shape them, vary widely. As a result, there is no one prescription for SFM for all forest types. Management activities must first be tailored to address the specific needs and challenges of forests at the local level. These local-level management practices must then be integrated at regional, national, and international levels. This is not an easy task. But the continued efforts of the nine international working groups to formulate measurable guidelines for SFM demonstrate a global interest in enhancing forest management strategies and ensuring sustainability of forest resources for future generations.

John O. Browder and Jennifer L. Gagnon

See also Agroforestry; Carbon Cycle; Carbon Trading and Carbon Offsets; Community Forestry; Deforestation; Environmental Services; Forest Degradation; Forest Fragmentation; Forest Land Use; Forest Restoration; Indigenous Forestry; Sustainability Science; Sustainable Development
SUSTAINABLE PRODUCTION

Sustainable production is the process of creating goods and services that are both environmentally and socially responsible in addition to being economically successful. The geographical effects of sustainable production are ubiquitous, from the transport of goods and the location of facilities to the effects of industry on people and the environment. The motivation for sustainable production, approaches to implementation, frameworks for consideration, and ongoing efforts are all described in this entry.

Motivation for Sustainable Production

Environmental, economic, and social concerns have catalyzed the development of methods, tools, and techniques for sustainable production. Industry-related environmental disasters, such as the deaths from the release of methyl isocyanate gas in Bhopal, India (1984), and the widespread publicity of the hole in the stratospheric ozone layer in the 1980s caused by ozone-depleting chemicals (e.g., chlorofluorocarbons, or CFCs) have spurred public outcry for better regulation of production practices and emissions. In response, international, regional, and national legislation has been enacted. The Montreal Protocol on Substances That Deplete the Ozone Layer (1987), adopted by many nations, bans the production and use of ozone-depleting chemicals. The 2002 European Union Waste Electrical and Electronic Equipment (WEEE) and the 2003 Restriction of Hazardous Substances (RoHS) directives place responsibility on producers to take actions that reduce environmental impacts. The 1990 U.S. Clean Air Act requires the U.S. Environmental Protection Agency to enforce limits on emissions from production facilities.

Additionally, the economic and social consequences of globalization have created a need for sustainable production. Increases in global competition have prompted the production of goods to move from industrialized to developing nations to avail of the benefits of lower labor costs and less regulation. This shift in industrial activities has changed global patterns of employment and production, with concerns raised about environmental impacts, labor practices, and worker health and safety. These concerns have inspired the development of economies and societies to improve quality of life. This inspiration evolved into the holistic concept of sustainable development.

Toward this aim, sustainability-oriented approaches have been adopted to reduce costs and improve manufacturing productivity and efficiency. The goal is to maintain manufacturing competitiveness while reducing the environmental impacts of production. Such approaches include cleaner production, pollution prevention, and just-in-time, lean, and environmentally responsible manufacturing. Adoption of these approaches by companies starts the institutionalization of sustainable production goals and practices.

Industry has sought to expand transparency and accountability for financial, social, and environmental policies and practices through the

Further Readings


Sustainable Production of Goods and Services

Sustainable production strives to increase processing efficiency, eliminate waste, and create benign outputs. Increase in processing efficiency is achieved by reducing the use of materials, energy, storage, labor, and time while improving product quality and reducing process variation. Microlevel and macrolevel process planning strategies form the backbone of pollution prevention or cleaner production efforts by improving operational parameters and process flows. The Toyota Production System improves quality by eliminating inefficiencies (muda), overloading of equipment or people (muri), and variation in processes and products (mura). Under a just-in-time manufacturing approach, production is output pulled instead of input pushed—that is, production occurs when demands for products arise rather than when supplies for production are available. A just-in-time philosophy necessitates fast distribution of inputs across the supply chain once a demand is recognized. Lean manufacturing concepts have grown out of these approaches, which started to be widely adopted in the 1980s. Lean manufacturing has a similar goal of eliminating waste by ensuring that each production activity creates the value the customer demands; the catch phrase “lean and green” has emerged to capture this connection.

Eliminating Waste

Quality engineering methods reduce waste by decreasing the number of defective products through continuous improvement efforts such as Statistical Process Control. Guidelines such as design for assembly eliminate waste by reducing labor and the time needed for assembly through optimization of object handling. The concept of eliminating waste is derived from process efficiency efforts but involves thinking beyond traditional processing concerns. Extending the usable life of process consumables can directly eliminate waste, as, for example, in cleaning and reusing metal-cutting fluids. Similarly, finding uses for by-products of processes (often unintentional outputs) eliminates waste while creating market opportunities. Industrial ecology and cradle-to-cradle approaches, developed in the 1990s, seek to establish an ecosystem-like view of production systems, where outputs become inputs to secondary production operations. For example, the eco-industrial park in Kalundborg, Denmark, started sharing waste steam and other by-products between an electric power generator, product manufacturers, and the local community in the 1970s.

Creating Benign Outputs

Sustainable production encourages the creation of benign rather than detrimental outputs for environmental and human health. Green Chemistry, developed in the 1990s, innovated processing alternatives that reduce toxic chemical inputs, outputs, and by-products. Substituting hazardous inputs with more benign, reclaimed, renewable, recycled, or recyclable materials promotes sustainability and can be aided by Design for Environment (DfE), which evolved in the 1990s. Energy efficiency efforts reduce emissions along with using renewable energy; for example, wind turbines power the Ecover factory in Belgium, which makes environmentally friendly cleaning products. Some companies purchase renewable energy credits (RECs) or carbon offsets to offset emissions.

Frameworks of Sustainable Production

The efforts described above mainly affect production processes, but production involves much
more than manufacturing. Through the lens of sustainability, production can be viewed as a supply, value, or commodity chain that includes many actors and flows of resources. A life cycle view of production aids the formulation and implementation of policies and practices based on geographical, demographical, and sustainability concerns.

**Supply Chains**

A supply chain considers the relative location and capabilities of all stakeholders involved in the creation of a product. Typically, a supply chain is thought of as moving linearly forward between material processors, suppliers, manufacturers, distributors, retailers, and consumers. A supply chain may include reverse flows of discarded goods from consumers to collectors that take back, disassemble, and reuse the products. For sustainability, supply chains are considered as closed loops of material and energy flows through society and the environment that ultimately are conserved. Figure 1 depicts a simplified supply chain, where the arrows represent material and energy flows, which are labeled for reuse processes. No matter how processing for production or reuse rearranges materials and energy, by conservation laws, the sum total of resources remains the same within society and the environment.

**Value Chains**

The value chain evaluates the remaining value of a product at different points in the supply chain. Product value may not correspond to ownership of the physical artifact but rather to its use, which has led to the development of services and product service systems to deliver value to consumers (e.g., auto leasing).

**Commodity Chains**

Commodity chain analysis studies the relationships between stakeholders and the steps involved in creating or delivering commodities (e.g., bananas) to consumers. The commodity chain evaluates social relations by financial transactions between actors, steps that increase commodity value, and methods of delivery. Analysis considers details such as commodity origin and destination; cost functions of steps; delivery by load, method, and supplier through particular hubs; regulation of commodities and transport; and value flows.
**Life Cycle View**

A product life cycle view considers all stages of product life, generally including materials extraction, production, manufacturing, use, and product recovery (or disposal). This final stage is also referred to as product end of life, end of use, or retirement. Product end of use and retirement convey the notion that products should be recovered to conserve materials within society and the environment, supporting sustainability goals. Life cycle assessment can be used to contrast the material and energy flows between products with comparable functions for all life cycle stages.

Each framework’s view on material, energy, and monetary flows provides a unique approach to defining production, including a wider range of actors and steps than for processing alone. Additional sustainable production efforts address a wider range of stakeholders affected by production.

---

### Sustainable Production Efforts Throughout the Supply Chain

Improving sustainability across the supply chain involves choices about supplier selection, logistics management, facility construction, and product end of life. Corporate social responsibility (CSR) encourages companies to work for the common good in terms of how products are made and sold and who profits. For example, Timberland, a footwear and apparel producer, established an annually assessed code of conduct for suppliers that requires fair treatment of workers and environmental performance improvement.

### Logistics Management

Logistics management improves sustainability by reducing the need for and the impacts of transportation. “Going local” promotes procurement of materials, suppliers, labor, and products in the communities where businesses reside to keep economic flows within those areas and to reduce environmental impacts from transportation. Optimizing logistical networks can reduce transportation distances by locating operations near key supply chain partners (e.g., material processors, distribution hubs, or end consumers) or transporting goods in the largest loads possible. Choosing cleaner transportation methods, as Peace Coffee, a fair-trade coffee roaster that delivers products to customers by bicycle and biodiesel-fueled vehicles, has done, reduces environmental impacts.

### Facility Construction

Factories, warehouses, offices, and other supply chain buildings have impacts. Constructing new facilities on polluted sites, termed *brownfields*, reduces the social and environmental impacts of production on communities and the environment. The U.S. Green Building Council created the Leadership in Energy and Environmental Design Green Building Rating System (or LEED standards) in 2000 to promote the use of environmentally friendly materials and energy efficiency in the construction, renovation, and operation of buildings.

### Product End-of-Use Options

Much attention focuses on product end-of-use and reuse options, which add reverse flows to the supply chain and contribute to sustainable production. Product collectors recover retired products for reuse, repair, remanufacturing, or recycling. Remanufacturing inspects and repairs or replaces components to create a product of comparable quality with newly manufactured products. Recycling creates material inputs for production by separating, breaking down, and processing the materials embodied in discarded products. Discarded products that can be easily disassembled facilitate recovery and reuse. Design for disassembly guidelines assist in defining product structures that allow for nondestructive, efficient separation and reuse of product materials and components. Additionally, reverse logistics pose challenges for product reuse. Take-back systems, such as those in use in Germany, encounter difficulties in reaggregating products, dispersed to customers throughout markets, back to centralized locations. The burden of returning retired products is often placed on users, who may choose to store or discard the products, thus arresting the flow of energy and materials.

*Abigail R. Clarke-Sather, Timothy L. Jenkins, Karl R. Haapala, and John W. Sutherland*
Humans have always used symbols, and archaeological evidence suggests that in nearly all societies, including prehistoric ones, particular places have held symbolic significance. Symbols are stand-ins for something, whether material (as in the case of places) or not (as in the case of the dove of peace or the Nazi swastika). Indeed, places are intrinsically symbolic, since places are, by their very nature, a part of space with meaning.

Geographers have long been interested in symbolic places and how symbols represent places. The Parthenon represented the birthplace of democracy in ancient Greece as, among U.S. citizens, the Liberty Bell may stand for independence from England. Paris and France may be symbolized by the Eiffel Tower, and St. Louis, Missouri, may be symbolized by its Arch. After the destruction of the World Trade Center, when New York City lost one of its significant symbols, an element in the debate about what would replace it involved the issue of whether to combine the symbolism of New York’s dominance with memorialization of the victims of the terrorist attack.

Humans have imbued features of the natural as well as the built environment with symbolism. Ayers Rock in Australia, the San Francisco Peaks of Arizona, and Shaman’s Rock in Baikal all have symbolic value to indigenous peoples, sometimes representing the domain of the gods or sacred space. The built environment of most cultures is replete with such sacred symbols—the medieval cathedral, the mosque, pilgrimage sites, and graveyards. Many countries are also imbued with symbols of the state, whether the mega blocks of Soviet communism or the Greco-Roman town hall of many small towns in the United States. Perhaps most pervasive in the newer built environments worldwide are symbols of the power of Mammon. As others have shown, the rich are more able to imprint their symbolism in places than are the poor.

The purposeful construction of buildings intended to be symbols has accelerated since the late 20th century; indeed, the millennium itself was intended to be symbolized in Britain by the eponymous Millennium Dome, a project characterized by cost overruns, delays, and rapid obsolescence. The Renaissance Center was built to symbolize Detroit’s emergence from a dark age of urban distress. The world’s tallest buildings, including Malaysia’s Petronas Towers, Taipei’s 101, the Burj Dubai in the United Arab Emirates, Shanghai’s World Financial Center, and Seoul’s International Business Center, symbolize...
a never-ending race for superlative height and associated global status. The transformation of Bilbao from working industrial port to leisure destination is symbolized in Frank Gehry’s Guggenheim Museum Bilbao, while each symbol of Dubai’s conspicuous consumption outdoes its predecessors—from the Burj Arab to the Palm and World Islands. Sydney’s Opera House arguably remains the only globally iconic symbol in Australia’s built environment. Beijing’s “bird’s nest” stadium reflected the aspiration that the 2008 Olympics would be a coming-out party for China as a global superpower. The list of recently built and future projects intended to “put a city on the world map” expands with each mega event and burst of capitalistic optimism.

But, of course, place has many scales, and everyday places are small, domestic, and imbued with meaning and symbolism. The word *place* derives from the Greek word *plateia*, meaning a square or courtyard surrounded by houses—hence, *piazza* and *plaza*. Places can range in size from a garden allotment with a symbolic scarecrow to a village with its green, a shanty town with legible (if transient) territorial markers, or a city replete with symbols (some copyrighted, such as New York’s “I ♥ New York”), to countries (Egypt’s pyramids) or perhaps even continents. These symbols are a form of shorthand. As examples of synecdoche, they stand in for the larger place of which they are a part. They may also represent a critical event in history (e.g., the Berlin Wall or civil rights monuments).

Symbolic places may be sites of continued strife and controversy, representing alternative interpretations of reality past and present, as in the case of Jerusalem. Indeed, when symbolic places are consciously designed and constructed, as in the case of the memorial at the crash site of Flight 93 in Pennsylvania, it would probably be impossible to satisfy conflicting preferences. Symbolic representations in places where atrocities and tragedies have occurred, from Buchenwald to Belfast to Salem to Sebastopol, frequently have multiple and conflicting meanings or interpretations to both locals and visitors and to subgroups among them.

When New York City lost one of its significant symbols, the World Trade Center, on September 11, 2001, an element in the debate about what would replace it involved the issue of combining the symbolism of New York’s dominance with memorialization of the victims.

*Source:* Markus Seide/iStockphoto.
Vernacular residential landscapes are encoded with conventional signs of social status and group membership legible to neighbors and outsiders. The landscape of privilege in high-income suburbs brims with the symbolism of class and exclusion. Lot size, architectural type, decorative detail, and even horticultural plantings symbolize the status of residents and broadcast messages of belonging or repulsion. Ethnic neighborhoods of American cities are usually easily recognizable by symbols even in the absence of their inhabitants. A Katrina-devastated small town in Louisiana may symbolize home and hope to some while simultaneously signaling governmental failure and global climate change to others. The symbolism of place is often in the eye of the beholder, as Dolores Hayden convincingly demonstrated, although she also rued the relative paucity of public memory in the urban landscape related to women and other marginalized groups.

Although some argue that symbols cannot be produced intentionally but rather are “organic,” in that they grow and decline as social meaning attaches to them, the contemporary marketing industry disagrees with that assumption, and certainly place marketing takes symbolism very seriously. Places lacking symbolic capital—that is, that are absent from mental maps or are vague in the public psyche—must build or buy symbols that imprint in the minds of potential tourists, residents, and investors. Places unlucky enough to possess negative mental vibes must invest particular effort in metamorphosing their symbolic imagery. Slough, an industrial town west of London, was unlucky enough to be the target of a poet laureate (John Betjeman’s “Come Friendly Bombs and Fall on Slough”) in 1937 and is still defending itself against the slings and arrows of adverse publicity. Other locations, such as Tiananmen Square in Beijing, undergo refurbishment to fit the newly desired image. Places, of course, gain symbolic freight both from their material landscape and from the events that transpire in them. The government of China hoped that the Olympic celebrations of 2008 would subsume the events of 1989 in its most symbolic public space. But for most locations, changing the physical and/or psychic imagery to attract people and capital is a preoccupation that is generating a new profession—place marketing—and transforming (particularly urban) landscapes into places dressed to impress.

Briavel Holcomb
Symptoms and Effects of Climate Change

Long-term changes in the atmospheric concentration of greenhouse gases—notably carbon dioxide (CO₂), methane, and nitrous oxide—due to human activities has altered the radiative forcing of the atmosphere and its energy balance. The physical impacts of these disruptions, known collectively as climate change, are varied but present across the globe. Due to the central importance of the atmosphere in all global environmental cycles, the symptoms and effects of climate change are potentially present anywhere on Earth. Study of these issues requires practitioners to maintain a holistic view of global biogeochemical interactions. The primary feature of climate change effects, as increased energy is expressed in the atmosphere, is less predictability and greater oscillations in environmental system behavior.

Air Temperatures

Globally measured surface temperatures have increased rapidly since 1979. Generally, the temperature increases are more severe at higher latitudes, as the atmosphere moves excess energy poleward. The warmest years in the instrumental record (extending back to 1850) are 2005, 2007, 1998, 2002, 2003, and 2006. However, temperature increases are not uniform, because of changes in atmospheric circulation and localized effects such as urbanization. These local processes are accounted for in global temperature change calculations and are not the cause of the documented global temperature increase.

Warming air leads to greater occurrence of heat waves; this trend is most pronounced in the polar regions (averaging twice the rate of lower latitudes) and becomes less evident toward the equator. Extreme high temperatures affect older or stressed organisms because the cardiovascular system must work so much harder to regulate temperature. While warmer winter temperatures have led to reduced death rates during the colder months, the increase in summer deaths far outweighs that reduction. These trends have been documented in human populations across the world and in multiple animal species as well. Warmer winter and nighttime average temperatures also mean decreased frost risk, changes in snowfall, and changes in the length of the growing season.

Ocean Changes

Global sea level has risen by more than 3 millimeters per year in the past decade, and it is uncertain if this rate will remain constant or increase. Sea-level rise is caused by oceanic thermal expansion and the melting of the world’s ice caps and glaciers. As the majority of the world’s surface is covered by water, warmer air temperatures are warming the ocean as well. However, due to the high heat capacity of water and the layered nature of the ocean, with little mixing of surface and deep water, ocean warming is a slow process that will occur over the next century-to-millennia timeframe. If temperatures stabilized today, the ocean
would continue warming for hundreds of years as deep-water mixing slowly occurs. Deep-ocean measurements have measured steady temperature increases throughout the world’s ocean basins.

Warmer water is less dense than cold water, and thermal expansion of water has led to increasing sea-level rise. An increase in water temperature also lowers the ability of water to retain dissolved oxygen and carbon dioxide (CO₂), so that biological systems are stressed due to less oxygen for fish and other organisms and warm water releases even more CO₂ into the atmosphere. However, increased freshwater flow from melting glaciers in Greenland and other locations will lower ocean salinity in the high latitudes at areas of ocean multilevel mixing. Lower salinity allows water to absorb more CO₂. This may be sufficient to offset CO₂ release from ocean warming in other areas but will lead to increased acidification of the oceans.

CO₂ reacts with water to form carbonic acid (used in carbonated beverages), which has a detrimental impact on calcium carbonate (sea shells) as it dissolves them and weakens their structure. Current models estimate pH being lowered to acid levels not seen for millions of years—which will have a catastrophic impact on corals and other calcium carbonate–shelled organisms. Changes in ocean circulation patterns could drastically alter the regional nature of these impacts.

While natural variability makes it difficult to determine trends, the intensity of tropical ocean storms—called hurricanes (Atlantic Ocean), typhoons (Pacific Ocean), and cyclones (Indian Ocean)—has increased, as measured by the Power Dissipation Index (PDI) in recent decades. The PDI is proportional to wind speed cubed and is highly correlated to temperature. While the number of tropical cyclones may or may not be increasing (this is difficult to determine due to the short record of data), the PDI is unequivocally increasing. The number of storms is less critical than the size of the storms because the nonlinear nature of storm damage (damage is correlated to the cubed power of wind speed) means that one severe storm may cause far more damage than several smaller storms put together. Increased El Niño activity has been posited by some studies, but results to date have been inconclusive. However, El Niño events disrupt hurricane formation because of wind shear effects that do not allow hurricane vortexes to form. A better understanding of El Niño and climate change effects is critically needed for long-term planning purposes.

### Changes in the Hydrologic Cycle

As climate impacts are expressed throughout the system, changes will be most amplified by extreme events. Increases in moderate to heavy precipitation events in the midlatitudes are the best documented of recent changes. Evaporation and transpiration from plants is accelerated under warmer air temperatures and increasing atmospheric moisture content. Increases in atmospheric water vapor have been observed in recent decades, as every increase in atmospheric temperature of 1 degree Fahrenheit allows air to hold 4% more water vapor. A warming ocean combined with higher evapotranspiration leads to an accelerated hydrologic cycle. These factors interact to paradoxically create both increased drought and increased precipitation. Drought impacts are widespread, as the entire land surface heats and dries, while storm events are local-scale phenomena. Increased frequency of extreme daily rainfall has been documented and is coupled with an overall decline in the number of days with precipitation, so that there is heavier rainfall during a shorter period of time but more rarely than before. A major impact of increased continental drought is an increase in desertification—notably in the Sahel of Africa, in China, and in Australia.

### Fires

Forest fires are affected by three major factors—fuel load, ignition agents, and weather. Climate change perturbations to natural systems increase fire risk in all three areas. Warmer temperatures mean longer growing seasons in boreal forests and more fuel production. Frequent storms lead to lightning ignition. Most important, climate change has caused increasing drought and hotter daytime temperatures, which correspond to more violent fires. Increases in fire frequency and extent have been documented in North America, Africa, and Australia. As fires increase in extent, they release the terrestrial stored carbon; this is a
positive feedback cycle, increasing the effects of climate change.

**Ice Sheet and Glacier Impacts**

The most visible impact of climate change has been changes in the Earth’s cryosphere as ice melts globally under warmer temperature—especially in the polar regions. Greenland and Antarctica hold a substantial portion of the Earth’s freshwater, and both of these areas have seen unprecedented changes in recent years. Decreases in the Greenland and West Antarctic ice sheets have been accelerating, and these two bodies of ice have sufficient stored-water volumes to raise the sea level by more than 10 m (meters) if both would melt completely. The East Antarctic ice sheet contains far more water and fortunately is currently stable. However, the dynamics of glacier retreat rates are not well understood, as conditions are changing in ways unprecedented in scientific history. A major uncertainty is how the meltwater below glaciers acts to speed their movements. Glacial speeds have dramatically increased in the past few years (especially in Greenland), and the recent Intergovernmental Panel on Climate Change (IPCC) assessment (AR4) noted that calculating future sea-level rise is speculative until these uncertainties can be better parameterized.

Globally, the vast majority of smaller glaciers are retreating, for example, in the high Himalayas, in the Andes, in Patagonia, and in Alaska. Mountain glaciers retreat has multiple additional impacts beyond sea-level rise. The impacts include increases in river volumes, more frequent flash floods, and increased risk of catastrophic floods from high-mountain glacial lakes. Once the upper-elevation glaciers have melted, there will be an increasing collapse in late-summer river volumes, as there is no more glacial melt available to supply rivers (and cities) in the dry season. River flows have also been measured to be peaking earlier in spring due to earlier snowmelt.

Sea ice extent in the Arctic decreases roughly 3% per decade, with higher shrinkage rates (about 7%) during summer, according to the IPCC AR4. This decrease is accelerating and is driven by a positive feedback mechanism that amplifies melting. The white surface of sea ice is highly reflective, and 80% to 90% of the sunlight reaching the surface can be reflected without warming the system. This energy is thus lost. As sea ice retreats, dark blue water is exposed to sunlight. This dark water captures nearly all this energy, and the warmed water in turn melts more ice. Sea-ice extent and thickness have been decreasing at roughly 10% per decade since the 1970s.

The reduction in global ice volumes, however, is not universal. Ice volume is controlled both by loss due to melting or calving and by deposition from snow. A limited number of glaciers globally have increased in volume due to increased snowfall overwhelming the increased melting rates.

**Biogeographical Impacts**

Warming temperatures mean milder winters and earlier spring thaws. This results in a longer growing season and favors different plant species. Changes in phenology have been documented across the Earth, and 90% of these changes are consistent with temperature rise, including earlier spring blooming. These factors favor allergenic pollen–producing plants, and pollen counts have increased globally. Overall, it is estimated that Northern Hemisphere plants may rise 500 m or more in elevation and/or shift poleward more than 300 kilometers if dispersal corridors are available.

Cold winter temperatures are a major deterrent to insect population growth, and recent warming has increased the ranges of most insects, including mosquitoes and agricultural pest insects. Tropical infectious disease occurrence has exploded globally as human populations grow and temperatures warm. Disease occurrence is limited to regions where their vectors, such as mosquitoes or ticks, are able to thrive. *Anopheles* spp. and *Aedes aegypti* are two mosquito species responsible for the spread of malaria and other major tropical diseases. They have established temperature thresholds for survival, and the viruses/parasites within them have incubation periods that are also affected by temperature. As disease vector habitat increases because of warmer temperatures, diseases are expanding their range—especially in tropical highland areas that had previously provided refuges for populations from Papua New Guinea to Kenya. According to the World Health Organization, 30 new diseases have emerged worldwide since 1980.
Climate dictates the general range of vectors, while weather affects the timing and intensity of specific disease outbreaks. Climate change is creating more weather events that lead to longer and more sustained disease outbreaks. Moisture availability is also a limiting factor for vector survival, and the changes in the hydrologic cycle noted above have led to more frequent storm events, creating the stagnant water necessary for mosquito propagation.

Warmer winter temperatures are having a similar impact on agricultural and forest pest insects. Millions of acres of timber in Canada have been lost to beetle outbreaks due to the warm winters over the past decade. Agricultural fields have seen major shifts and increases in pest insects globally on account of less frost and fewer cold nights. This is a dynamic process that has had inadequate research, and so the long-term effects are not well understood. Based on reproductive rates, white flies, locusts, and aphids have been found to be especially responsive to rapid changes in weather and climate.

Overall, the IPCC AR4 report cites 29,000 observational data series that show change in environmental and biological systems. Nine out of 10 of these data show an increase in warming consistent with anthropogenic climate change. Most of these data are from the higher latitudes and more industrialized countries. Further research in the tropics may yield additional symptoms and effects of climate change.

John All

See also Adaptation to Climate Change; Anthropogenic Climate Change; Biota and Climate; Climate Change; Climate Policy; Desertification; Drought Risk and Hazard; El Niño; Global Sea-Level Rise; Social and Economic Impacts of Climate Change; Urban Heat Island

Further Readings


Taphonomy is a multidisciplinary, multitasking body of knowledge that studies the processes affecting organic remains after death—that is, the transition of these remains from the biosphere into the lithosphere. Taphonomic studies are key to paleobiology, paleontology, archaeology, geology, and geography, among other disciplines, as they impinge directly on our capacity to reconstruct paleoenvironments and past biotas. They do so by understanding the postmortem processes on biological materials and how they affect the fossil record—broadly defined as the set of nonliving remains and traces of organisms—and the information therein.

The term *taphonomy*, from the Greek *taphos* and *nomos* (the “laws of burial”), was coined by Ivan Efremov in 1940, although such inquiries had been carried out well before, notably by German paleontologists in the late 19th and early 20th centuries. These researchers focused primarily on paleoenvironmental reconstruction, while Efremov and others emphasized information loss and biases introduced in the fossil record. Other researchers, especially after the input by Anna Behrensmeyer, Susan Kidwell, and Diane Gifford, have focused on the “positive” contributions of taphonomy as well. These emphasize the preservation of the fossil record and the paleoecological and paleobiological information contained in the signatures of the processes that have affected it through time. Moreover, all the recycling pathways of biologically derived materials are informative to taphonomic enquiry.

The processes affecting organic remains from death to final burial, such as carnivore scavenging of vertebrate carcasses, are different from those occurring from final burial until recovery, as is the case with mineral replacement in different organic remains. The former are known as biostratinomy and the latter, as diagenesis, and both constitute taphonomy. On infrequent occasions, as in the case of severe floods and catastrophic death, rapid burial of organisms lead to large concentrations of exceptionally well-preserved fossils, known as fossil *lagerstätten*.

Taphonomists study both direct and indirect evidence—that is, not only the organic remains themselves but also the traces of different organisms, such as the tooth marks of a predator on bones or a leaf imprint on a sedimentary matrix. These traces or signatures of activity by an organism are also known as ichnofossils and commonly inform us of the interactions with its environment. Finally, they study the geological context where the fossils and traces are deposited as well.

To understand and interpret all these lines of evidence, taphonomic principles are needed. As in other historical sciences, the most powerful
strategy for doing so is actualism—that is, the study of contemporary, observable taphonomic processes producing effects analogous to those observed in the fossil record, and their causes. This strategy has been key in taphonomy since the German Aktupaläontologie (invertebrate) program in the early 20th century. Observing present-day processes and their contexts links causes and effects, thereby generating models that can be applied to the fossil record by analogy. In some cases, experiments can help understand the effects of some processes as well. Such studies require assuming that the processes operating in the past are essentially the same as those operating in the present, although their rates and configurations and their interactions may well have changed through time. This methodological assumption is called uniformitarianism.

Another important strategy is the comparative method, namely, the comparison of different fossil records, which allows considering processes at a larger scale of operation. Deductions from general models and strong links among different lines of evidence complement both strategies.

All these approaches allow reconstructing and interpreting the taphonomic histories of different fossils. It should be noted that each specimen—that is, an individual organic remain or trace—has its own history, which can differ from that of other specimens in the same assemblage. Some variables, such as morphological and qualitative ones (e.g., chemical alterations), are monitored on each specimen. Other variables, though, such as the quantitative and contextual ones (e.g., the spatial relationships among different specimens), can only be assessed at the assemblage level. Therefore, analysis always begins at the specimen level, while fossil assemblages, with their specific properties—such as specimen arrangement, statistical trends in specimen properties, and the paleoecological information they bear—turn out to be the main unit of analysis and comparison. The geological context bearing the assemblages provides important, independent evidence as well that helps infer the taphonomic history of the fossil record, for instance, by shedding light on the accumulation processes that concentrated the fossils under study. All these lines of evidence can be integrated at the landscape level so as to interpret taphonomic patterns and processes at a regional scale.

A more general approach considers taphonomic modes, which encompass fossil records resulting from similar processes (physical, chemical, and biological), involving similar preservational contexts. Hence, different taphonomic modes are characterized by different biases. Changes through time in taphonomic modes would thus generate megabiases.

One particular taphonomic mode is archaeological accumulations, where humans are the main taphonomic agents. These can be isolated or can even modify whole landscapes, as in the case of shellmound concentrations in coastal Brazil and Uruguay. Humans can not only be taphonomic agents but also the subject of taphonomic processes, as has been studied by forensics and paleoanthropology, two disciplines where taphonomy is also central.

It is the multidisciplinary nature of taphonomy, whereby very different questions are posed at varying scales, that contributes to the richness of this research field.

A. Sebastián Muñoz and Mariana Mondini

See also Biota and Climate; Environmental History

Further Readings


Thomas Griffith Taylor was an important figure in early-20th-century geography as an advocate of the doctrine of environmental determinism and social Darwinism.

British by birth, his family moved to New South Wales, Australia, when he was a young teenager. He earned a BSc at Sydney and returned to Cambridge for his BA. Trained in engineering, geology, and meteorology, he was selected from 7,000 applicants to serve on Robert Scott’s ill-fated Antarctic Terra Nova Expedition in 1911, focusing on that continent’s influence on Australia. He led a second expedition there later that year and drew some of the first maps of that continent. On his return to Australia, he assisted with the survey of the site for the new federal capital, even suggesting the name Canberra (of Aboriginal significance). He founded the New South Wales Geographical Society and was the founding editor of the journal *Australian Geographer*. In 1911, he published *Australia in Its Physiographic and Economic Aspects*. He earned a doctorate in geology from the University of Sydney in 1916, using his Antarctic research for his dissertation, and 4 years later, he became the founding head of that institution’s geography department, Australia’s first, and the McCaughey professor.

Taylor soon became known for his controversial support for environmental determinism, which he liberally laced with racism. He consistently advocated pseudoscientific notions that intelligence was correlated with skin color or the shape of skulls. Justifying the white conquest of the continent as an inevitable result of white racial superiority, he consistently portrayed Australia as too dry and harsh for the large numbers of immigrants seeking entry, in opposition to the boosterist “Australia Unlimited” school of thought. Taylor emphasized the region’s limited carrying capacity, arguing that it was essentially a desert capable of supporting no more than 20 to 30 million people, and he was often criticized for an overly pessimistic reading of the continent’s economic potential and population limit. His textbook espousing this view was banned in some school districts.

From the specific instance of Australia, he began to generalize to the wider world, theorizing links between race, nationality, migration, and climate. His major work on this topic was *Environment and Race* in 1927, which was widely read and translated into several languages. In *Australia: A Study of Warm Environments and Their Effect on British Settlement*, published in 1940, he put forth the opinion that the optimal course for a country to follow is dictated by the natural environment and that human deviations from this trajectory inevitably led to lower levels of social and economic development.

Frustrated by the university’s denial of promotion, he left Australia to become professor of geography at the University of Chicago in 1929, and in 1935, at the initiative of the famed economist Harold Innis, he left for the University of Toronto, where he founded the geography department and remained until 1951. In 1941, he became president of the Association of American Geographers, the first non-American to hold that post; later, he was also elected president of the Canadian Association of Geographers. Over his career, he published 20 books, including his autobiography, *Journeyman Taylor*, and roughly 200 journal articles. After retirement, he returned to Australia, where he became a hero to those opposed to nonwhite immigration, and in 1959, he became president of the Institute of Australian Geographers. He died in 1963 and was cremated.

*Barney Warf*

**See also** Environmental Determinism; Race and Racism; Social Darwinism

**Further Readings**


Peter J. Taylor is one of the most prominent contemporary human geographers. Born in England in 1944, he earned his BA (1966) and PhD (1970) from the University of Liverpool. His record of scholarship spans more than 40 years and currently includes more than 300 publications, some of which have been translated into as many as 23 different languages. Taylor has contributed to a range of subdisciplines within human geography, most notably in political and urban geography. Indeed, Taylor is recognized as a key figure in the development of political geography as a thriving subdiscipline and is a founding editor of the journal Political Geography.

While his contributions to political geography are myriad (indeed, the limited space afforded here cannot adequately do justice to them), he is perhaps best known for integrating world-systems analysis with political geography. His interest in world-systems analysis began as he sought to incorporate political economy into political geography, a subdiscipline he once critiqued as ironically being the most “apolitical” component of human geography. Taylor’s emphasis on world systems opened new spaces for critically assessing and modeling global interstate relations within the context of global cores and peripheries. This project in many ways demystified the development of the modern nation-state as a “container” of social, economic, and cultural forces, on the one hand, and the global liberalization of trade in recent decades known as globalization, on the other. Most recently, Taylor has further used a world-systems approach to investigate global structures of capital flows, contributing to understandings of the rise, and functioning, of “world cities” as command centers of global capital.

These two-tiered thrusts of research—global interstate relations and world cities—coincide with an earlier call by Taylor to reconsider prevailing notions of scale. Taylor proposed that scale be reconceptualized as encompassing three interlocking or interconnected realms: (1) a realm of everyday experience occurring at the level of the “urban,” (2) a realm of ideology encompassing the nation-state, and (3) a universal level of the capitalist world economy in which the previous two are situated. While this scalar hierarchy of realms has come under critical reassessment in recent years, Taylor is credited with launching an important and ongoing debate that has deepened and nuanced a concept of scale that was often akin to cartographic scale and was otherwise taken for granted among human geographers.

Mark de Socio

See also Political Geography; World Cities; World-Systems Theory

Further Readings

Technological change is a direct driver of economic growth. New technologies allow societies to produce existing goods more efficiently and also open up entirely new and previously unimagined possibilities. It was technological change that largely eliminated the persistent cycles of famine and overpopulation that plagued humanity before the Industrial Revolution. Since that time, technology has facilitated an unprecedented expansion of standards of living. Simply put, current incomes as well as levels of health and amounts of leisure time for many people, particularly in the First World, are dramatically better than they were as recently as 150 years ago, and in many ways technological change is largely responsible.

Nonetheless, not everyone has made use of technology as well as today’s developed economies. Great disparities in per capita income and other measures of well-being divide developed from developing economies, and technology’s uneven geography is central to understanding why this remains so. Moreover, the geography of technological change has important implications for the changing shape of the increasingly interconnected global economy.

Technology: A Unique Component of Production

The word *technology* typically describes a material item, such as an oven or a computer. Academics, however, define technology differently—that is, as the set of rules and ideas that direct the production of an oven, computer, or other economically meaningful products. Under this definition, a technology is like a recipe used in the kitchen. A given technology will call for raw or semifinished materials as ingredients. To carry out the recipe and create a finished product, people apply their skills (human capital), tools (physical capital), and labor. Among these required components, capital, labor, and raw materials are all mostly privately held. Technology, however, bears some resemblance to a public good.

Two characteristics distinguish public from private goods: nonrivalry and nonexcludability. To grasp technology’s quasi-public nature, consider computers, mobile phones, and other electronic devices that contain semiconductors. Semiconductors in turn are the product of a particular set of rules and ideas about electrical conductivity. Like all technologies, the ideas that permit the building of semiconductors are nonrivalrous, meaning that one person’s sharing the recipe for semiconductors with another will not diminish the owner’s knowledge of it (unlike, say, sharing a private good such as a sandwich, which leaves less for the owner). The technology is also at least partially nonexcludable: It is hard for the owner to prevent another from learning about semiconductors, such that the acquirer might employ them for his or her own gain.

If technologies were “pure” public goods, a new and better semiconductor design created in one location would be immediately, costlessly, and universally available. Entrepreneurs in Paris and Bengaluru could instantly apply the electronic innovations that researchers produced in San Jose. Technology would be without meaningful geographical dimensions because of its perfect nonexcludability. Do we live in that kind of world? One way to answer this question is to compare countries’ overall technology levels. Researchers often estimate levels of technology using “total factor productivity” (TFP), which accounts for the efficiency with which an economy or industry combines its factors of production. Simply, an economy with higher TFP can produce more output with less input because its deployment of technology is more sophisticated. TFP is not a perfect measure of technological sophistication, since nontechnological factors might cause these efficiency differences, but it is the most widely accepted indicator available. Table 1 shows TFP levels as ratios to the U.S. level for a handful of economies. Note the large gap between the United Kingdom and India. The United States, Italy, France, and the United Kingdom have productivity levels that are roughly comparable with one another. But each is between four and seven times the level of productivity enjoyed by India, China, Kenya, and Zaire. By this measure, rich countries are much more technologically advanced than poor countries, and these large differences remain even when we control for differences in the kinds of goods that
countries make. For example, even if international productivity levels for a particular industry are compared, rich economies tend to be more productive than poor ones. This kind of evidence suggests that we do not live in a world where technology is a pure public good.

**Technology Diffusion**

If technology is not a pure public good, then how excludable is it? Since the 1950s, economic geographers have sought to measure the spread of technology among people and across space, an idea commonly termed *technology diffusion*, or *knowledge spillovers*. Some researchers traced the proliferation of individual innovations: Zvi Griliches, for example, conducted a pioneering study of American farmers’ adoption of hybrid corn seeds in the early 20th century. Others examined patterns of collaboration between scientists and innovators. In general, these studies confirm that technologies diffuse across space but usually do so slowly and unevenly.

One reason why technologies do not circulate freely is that their creators actively seek to contain them. Innovators typically spend a great deal of time, effort, and expense to produce new technologies, and they want to make sure that they reap the rewards. To protect their intellectual property, they might take out a patent that legally mandates that others must pay to use it. They might also engage in secrecy and other less formal means of protection. Hence, an uneven pattern of technological diffusion might result from a creator’s desire to protect his or her technological investment.

Some studies of innovation suggest a more subtle reason that leads to a distinctive spatial pattern of diffusion. Most new technologies are not produced by lone scientists in dustfree laboratories but rather are the result of collective efforts that span organizations. These collaborations can be legally specified joint ventures, but they also frequently arise from casual interactions. Anna-Lee Saxenian discovered this notion in her study of Silicon Valley in the 1980s and 1990s. She learned that local computer engineers and entrepreneurs exchanged vital information at places such as the Mountain View’s Wagon Wheel Bar. Silicon Valley’s global technological leadership was constituted as much through these informal information-sharing links as by connections to Stanford University. The resulting social system permitted rapid transmission of ideas and generated specific cultural norms of collaboration and competition that helped propel Silicon Valley’s firms to the leading edge of computer technology and to keep them there. Moreover, this system of localized, informal, insider knowledge meant that entrepreneurs in Paris and Bengaluru were in an important sense “locked out” of the conversation by their distance. Without the required geographically localized relationships, they were not privy to the exchange of information, and they lacked the cultural norms to participate.

To understand the importance of being in the right place, consider technologies dependent on two different kinds of knowledge or ideas. *Codified knowledge* is akin to the kind of recipe found in cookbooks, which contain a well-defined list of ingredients in the right proportions and offer careful instructions on how to combine them. Professional chefs, however—those who *create* new recipes and are responsible for culinary innovations—are more likely to employ *tacit* knowledge. Their procedures may have some loose structure that can be put down on paper, but they depend on their experience and creativity to fill in the blanks and bring it all together. Tacit knowledge is hard to turn into a blueprint that can be shared with anyone, because it depends on practice, trust, and acculturation. But two skilled chefs working in the same restaurant

<table>
<thead>
<tr>
<th>Country</th>
<th>TFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1.000</td>
</tr>
<tr>
<td>Italy</td>
<td>1.207</td>
</tr>
<tr>
<td>France</td>
<td>1.126</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.011</td>
</tr>
<tr>
<td>India</td>
<td>0.267</td>
</tr>
<tr>
<td>China</td>
<td>0.106</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.165</td>
</tr>
<tr>
<td>Zaire</td>
<td>0.160</td>
</tr>
</tbody>
</table>

*Table 1* Total factor productivity (TFP; country/U.S. ratio) for selected countries, 1988

might quickly and easily convey the needed information so that they could work together to produce a new dish. Tacit knowledge is often associated with innovation and new ideas, while technologies that have been with us for some time find their knowledge becoming increasingly codified. Some tasks, however, such as the job of a professional chef, demand tacit knowledge that can never be fully codified.

What geographical pattern does the distinction between tacit and codified ideas suggest? Codified technologies can be easily exchanged across space. Producers in one part of the world send rigorously specified blueprints for automobile parts to far-flung global suppliers, and they can reasonably expect the suppliers to closely adhere to the requirements. If a supplier fails, myriad competitors are capable of following the recipe. As a result of this intense competition, the production of products whose technology is fully codifiable is likely to occur wherever the cost is lowest. Codified technologies lead to a lowest-cost geographical pattern.

In contrast, tacit knowledge has a high degree of excludability; only individuals with certain shared characteristics can easily exchange it. This common frame of reference is most often born of repeated face-to-face encounters, such as the ones at the Wagon Wheel. As a result, tacit knowledge is typically produced and held in constrained geographical spaces. In addition to Silicon Valley’s technology firms, we can see further evidence of this spatial clustering around relationships, complex tasks, and innovations among investment bankers in London, film and television workers in Los Angeles, and fashion designers in Paris. More systematic evidence emerges from examining patent citations. When someone files a patent for a new technology, he or she must cite the patents of other inventors on which the new invention is based. An inventor might cite patents held by scientists working anywhere in the world. But citations indicate strong geographical patterns: Inventors are most influenced by the work of nearby colleagues. In contrast to codified forms of knowledge, technologies dependent on tacit knowledge are therefore likely to lead to highly clustered geographical forms.

Spatial clustering because of tacit knowledge helps explain why cities exist and grow. Individuals and firms continue to be drawn to dense urban areas to be “in the know.” Urban regions are filled with people interacting face-to-face, exchanging ideas, and building social networks. Even in an age of instant messaging and social networking Web sites, engineers and entrepreneurs brave sky-high real estate prices in Silicon Valley to gain access to the social networks and tacit knowledge it contains.

Knowledge-based geographical clustering is also part of the reason for the large differences in economic well-being. Since technology dependent on tacit knowledge is hard to imitate, its producers are to some extent insulated from the kind of lowest-cost competition facing those using recipes that are more easily codified. In aggregate, this means that those regions and nations where new and complex technologies are being produced will typically enjoy high per capita incomes. In this way, technology’s uneven geography leads to disparities in people’s standards of living.

Globalization and the Geography of Technological Change

Can this uneven pattern of technological change and income continue in the Internet age as international trade ties far-flung economies ever closer together? Is globalization withering technology’s excludability, taking it ever closer to the status of a pure public good? With a new generation as comfortable communicating online as off-line, there might come a day when relationships are as easily formed across the world as across a hallway. If this day comes, then technology’s geography could conceivably disappear.

But most scholars agree that this situation has not arrived yet. In fact, the world might even be headed in the opposite direction. Greater trade and better communication technologies make it easier for everybody to specialize in what they do best and to farm everything else out to others who can excel in the remaining tasks. Edward Leamer notes that this is leading to a spatial division between “geek work” and “manly work.” Advanced economies such as the United States are increasingly dedicated toward skilled “geek work”: complex tasks with a high tacit knowledge content. Developing countries are focused on unskilled or semiskilled “manly work,” such
as manufacturing and agriculture, which depend more heavily on codified technology. Hence, the emerging geography of technological change might be one in which innovation-oriented tasks and routine production-oriented tasks are increasingly spatially disparate. And proximity to the site of technological change matters for learning and income growth. A more optimistic view is that production and innovation are complementary. Developing economies are exposed to new ideas when they get involved in new forms of production. They might yet learn from these experiences and spawn new, world-changing ideas that shift the geographical center of tacit knowledge.

*Thomas Kemeny*

**See also** Agglomeration Economies; Business Cycles and Geography; Clusters; Diffusion; Economic Geography; Electronics Industry, Geography of; Externalities; Factors Affecting Location of Firms; Flexible Production; Globalization; High Technology; Innovation, Geography of; Knowledge, Geography of; Knowledge Spillovers; Learning Regions; Uneven Development

**Further Readings**


**Telecommunications and Geography**

Telecommunications have a long history of folding and reshaping space that extends to the telegraph in the mid 19th century and the telephone in the late 19th and 20th centuries. Today, the collection, transformation, and transmission of large volumes of information constitute a fundamental part of contemporary economies. The majority of jobs in industrialized nations consist of information processing in one form or another. These functions have increased in importance as computing has dramatically declined in cost and risen in power, the production of all goods and services has become more information intensive, technological change accelerated, product cycles shortened, and a deregulated, worldwide market has increased uncertainty and accelerated the competition among places for investment and jobs.

Information systems used to be confined to simple telephone service. For many decades, during which AT&T enjoyed a monopoly over this industry in the United States (and similar monopolies applied in other countries) and there were few incentives for change, the primary focus was on guaranteeing universal access, resulting in 95% penetration rates among U.S. households (second only to the television). During the 1980s and 1990s, as the cost of computing capacity dropped rapidly, communications became the largest bottleneck for information-intensive firms. Simultaneously, the microelectronics revolution unleashed a series of new technologies, including microwave, fiber optics, and satellites, that have increased the power, sophistication, and diversity of telecommunications qualitatively. With the digitization of information, telecommunications
merged with computers to form integrated networks, most spectacularly through the Internet. Technologies such as Electronic Data Interchange (EDI) and wireless services are becoming increasingly popular.

**Misconceptions About Telecommunications and Geography**

There exists considerable confusion about the real and potential impacts of telecommunications on urban structure, in part due to the long history of exaggerated claims made in the past, particularly by those subscribing to the “postindustrial” theory. Often, such views hinge on a simplistic and utopian technological determinism that ignores the complex, often contradictory relations between telecommunications and local economic, social, and political circumstances.

For example, repeated proclamations that information systems would allow everyone to work at home via telecommuting, dispersing all functions and spelling the obsolescence of cities, have fallen flat in the face of the persistence of growth in dense urbanized places. In fact, advances in videoconferencing notwithstanding, telecommunications are generally a poor substitute for face-to-face meetings, the medium through which most sensitive corporate interactions occur, particularly when the information involved is irregular and unstandardized in nature. Most managers spend the bulk of their working time engaged in face-to-face contact, and no electronic technology can allow for the subtlety and nuances critical to such encounters. For this reason, a century of technological change, from the telephone to fiber optics, has left most high-value-added, white-collar, and administrative command-and-control functions clustered in downtown areas (despite their high rents), their agglomerative advantages intact if not unchallenged. In contrast, telecommunications are ideally suited for the transmission of routinized, standardized forms of data such as back office clerical functions. In short, contrary to much received opinion, there is no a priori reason to believe that telecommunications inevitably lead to the dispersal or deconcentration of functions; by allowing the decentralization of routinized functions, information technology may enhance the comparative advantage of inner cities (albeit with jobs generally filled by suburban commuters). Information systems thus allow for the simultaneous concentration and deconcentration of economic activities.

**Fiber Optics**

The core of the global telecommunications infrastructure is an extensive and seamlessly integrated network of fiber-optic lines—long, thin, flexible, and highly transparent rods of quartz glass (or less commonly, plastic) about the thickness of a human hair that can transmit light signals through a process of internal reflection, which retains light in the core and transforms the cable into a waveguide. They can transmit voice, video, or data traffic at the speed of light; because light oscillates much more rapidly than other wavelengths, such lines can carry much more information than other types of telecommunications. Modern fiber cables contain up to 1,000 fibers each and are ideal for high-capacity, point-to-point transmissions. Indeed, far more than any other technology, such as copper cables, microwaves, or satellites, fiber optics supply the vast bulk of data, voice, and video transmission services around the world. Because of their capacity to deliver high volumes of information rapidly and securely (e.g., via broadband), fiber optics cables form the backbone of the Internet as well as private corporate lines and are widely used in the electronic media for commercial and residential purposes (e.g., cable television).

Today, the world’s fiber system totals more than 25 million km (kilometers) in length, connecting all the world’s continents except Antarctica (Figure 1). The geography of global fiber networks centers primarily on two distinct telecommunications markets across the Atlantic and Pacific Oceans, connecting two of the major engines of the world economy, North America and East Asia. In 1988, AT&T initiated the world’s first transoceanic fiber-optic cable, Trans-Atlantic Telecommunications (TAT-8), which could carry 40,000 telephone calls simultaneously. The Trans-Atlantic line was the first of a much broader series of globe-girdling fiber lines that AT&T erected in conjunction with a variety of local partners. Because large corporate users
Figure 1  The world’s major fiber-optic cables, 2006. Fiber has displaced other forms of telecommunications to become the world’s leading method of transmitting information.

Source: Author.
are the primary clients of such networks, it is no accident that the original and densest web of fiber lines connects London and New York, a pattern that extends historically to the telegraph and telephone. The next generation, TAT-9 and TAT-10, which began in 1992, could carry double the volume of traffic of TAT-8. The third generation, TAT-11 to TAT-13, was the first to use the erbium-doped fiber amplifier rather than the older repeaters. Newer generations of cable were even more powerful. Starting with the Trans-Pacific Cable (TPC-3) in 1989, connecting New York and Tokyo, a growing web of Trans-Pacific lines mirrored the rise of East Asian trade with North America, including the surging economies of the newly industrialized countries. The complex interplay of deregulation, globalization, and technological change increased the international transmission capacities and traffic volumes for fiber-optic carriers explosively.

In addition, fiber lines have extended into several newer markets. In 1997, AT&T, NYNEX, and several other firms (including, for the first time, nontelecommunications firms) opened the self-healing Fiberoptic Link Around the Globe (FLAG), a system that eventually expanded to 55,000 km, connecting Europe and southeast Asia. The world’s longest submarine telecommunications network, FLAG, the world’s longest submarine telecommunications cable, filled a void in undersea cable capacity between Europe, the Middle East, and Asia. In Africa, long marginalized in global telecommunications, AT&T’s $2 billion Africa ONE (Optical NEtwork) system circumnavigates the continent with a 39,000-km, high-capacity, self-healing undersea fiber-optic network.

### Telecommunications and Finance

Telecommunications have had their most important impacts in the capital markets. Banks, insurance companies, and securities firms, which are generally very information intensive in nature, have been at the forefront of the construction of an extensive network of leased and private communication networks. Electronic funds transfer systems, in particular, which form the nerve center of the international financial economy, allow banks to move capital at a moment’s notice, arbitraging interest rate differentials, taking advantage of favorable exchange rates, and avoiding political unrest. Such networks give banks the ability to move money—by some estimates, more than $2 trillion daily—around the globe at stupendous rates (the average trade takes less than 25 seconds). Subject to the process of digitization, information and capital become two sides of the same coin.

In the securities markets, global telecommunications systems have facilitated the emergence of 24-hr./d (hour per day) trading, linking stock markets through computerized trading programs. The ascendancy of electronic money has shifted the function of finance from investing to transacting, institutionalizing volatility in the process. Traveling at the speed of light, as nothing but assemblages of zeros and ones, global money performs a syncopated electronic dance around the world’s neural networks in astonishing volumes. The world’s currency markets, for example, dwarf the funds that change hands daily to cover global trade in goods and services. National boundaries mean little in this context: It is much easier, say, to move $1 billion from London to New York than a truckload of grapes from California to Nevada.

As large sums of funds flow with mounting ease across countries’ borders, national monetary policies became increasingly ineffective, making monetary controls over exchange, interest, and inflation rates progressively difficult to sustain. In the United States, for example, the Federal Reserve, alarmed at the prospect of inflation, changed the reserve ratio of banks numerous times in the 1990s and 2000s, only to find that its control over the national money supply had diminished severely. This is not to say that nation-states enjoy no leverage whatsoever over such factors, but the steady convergence of short-term interest (but not profit) rates globally undoubtedly reflects the mounting ease with which capital transcends national borders.

Another way in which telecommunications have affected the financial industries is through the growth of offshore banking, a reflection of the broader shift from traditional banking services (loans and deposits) to lucrative nontraditional functions, including debt repackaging, foreign exchange transactions, and cash management. Usually introduced in response to favorable tax laws, offshore banking has become important to
many microstates in the Caribbean (e.g., Cayman Islands, Bahamas, Panama), Europe (e.g., Gibraltar, Luxembourg, the Isle of Man, Liechtenstein), the Middle East (e.g., Cyprus, Bahrain), and the South Pacific (e.g., Vanuatu). Thus, as the technological barriers to moving money have fallen, legal and regulatory ones have increased in importance, dispelling simplistic assertions about the “death of geography.”

Other applications of telecommunications in finance include Electronic Data Interchange (EDI) systems, which allow information to move directly among computers, including data, forms, funds, invoices, and text. In insurance, these systems have streamlined underwriting policies, and centralized database management systems have minimized data redundancy and allowed for updates irrespective of the data’s physical location. Networks such as the Internet even allow professionals to move into rural areas.

**Telecommunications and Global Cities**

One of the most significant repercussions of the growth of financial markets has been the growth of “global cities” or “world cities,” notably London, New York, and Tokyo, each of which seems to be as attuned to the rhythms of the global economy as the nation-state in which it is located. At their core, global cities allow the generation of specialized expertise on which so much of the current producer services economy depends. Furthermore, each city is tied through vast tentacles of investment, trade, migration, and telecommunications to clients and markets, suppliers and competitors, and consumers and producers around the world. Each metropolitan area seems to be as attuned, if not more so, to the global economy as the nation-state in which it is located. While several other cities (e.g., Paris, Toronto, Los Angeles, Osaka, Hong Kong, and Singapore) certainly can lay claim to being national cities in a global economy, the trio of New York, London, and Tokyo has played a disproportionate role in the production and transformation of international economic relations in the late 20th century. London, for example, boomed under the impetus of the Euromarket in the 1980s and has become increasingly detached from the rest of Britain. New York rebounded from the crisis of the mid 1970s with a prolonged bull market on Wall Street facilitated by electronic trading. Tokyo, despite the woes of the Japanese economy, remains an important center of financial activity and home to many of the world’s largest banks by asset value. In each city, a large agglomeration of banks and related firms generates well-paying jobs; in each, soaring incomes for a wealthy stratum of traders and professionals has lifted real estate prices to astronomical levels. The primacy of global cities, and their unique niche internationally, hinges largely on their role as producers and conveyors of specialized pools of information. All three metropolises are endowed with enormous telecommunications infrastructures that allow corporate headquarters to stay firmly in touch with global networks of branch plants, back offices, suppliers, clients, subcontractors, subsidiaries, and competitors. This phenomenon illustrates how geographic centralization can be facilitated, not eradicated, by telecommunications.

However, telecommunications simultaneously threaten the agglomerative advantages of dense urban areas, particularly the advantages of face-to-face communications. This trend is particularly evident in finance—the bread and butter of global cities. For example, the National Associated Automated Dealers Quotation System (NASDAQ) has emerged as the world’s largest stock market; unlike many other exchanges, NASDAQ lacks a trading floor, connecting millions of traders worldwide through fiber-optic lines in the over-the-counter market. Similarly, Paris, Belgium, Spain, Vancouver, and Toronto all recently abolished their trading floors in favor of screen-based trading.

**Back Office and Call Center Relocations**

Few domains of economic activity have been as heavily affected by telecommunications as the low-level, routinized back office functions. Back offices perform clerical functions such as data entry of office records, telephone books, library catalogs, stock transfers, payroll or billing information, bank checks, insurance claims, and magazine subscriptions. These tasks involve unskilled or semiskilled labor, primarily women, and frequently operate on a 24-hr./day basis. Back offices have few of the interfirm linkages associated with
headquarters activities and require extensive data-processing facilities, reliable sources of electricity, and sophisticated telecommunications networks.

Historically, back offices have been located adjacent to headquarters activities in downtown areas to ensure close management supervision and rapid turnaround of information. However, under the impetus of rising central-city rents and shortages of sufficiently qualified (i.e., computer-literate) labor, many service firms began to uncouple their headquarters and back office functions, moving the latter out of the downtown to cheaper locations on the urban periphery. Most back office relocations, therefore, have been to suburbs.

Given the increasing locational flexibility afforded by satellites and a growing web of interurban fiber-optics systems, back offices have begun to relocate on a much broader, continental scale. Under the impetus of new telecommunications systems, many clerical tasks have become increasingly footloose and susceptible to spatial variations in production costs. New digital call distribution systems have made possible the relocation of phone services that were once confined to centralized locations. Internationally, this trend has taken the form of the offshore office. The primary motivation for offshore relocation is low labor costs, although other considerations include worker productivity, skills, turnover, and benefits. Offshore offices are established not to serve foreign markets but to generate cost savings for U.S. firms by tapping Third World labor pools, where wages are as low as one fifth of those in the United States. Notably, many firms with offshore back offices are in industries facing strong competitive pressure to enhance productivity, including insurance, publishing, and airlines. Offshore back office operations remained insignificant until transoceanic fiber-optic lines made possible geographic flexibility on an international scale. Such functions either may be subsidiaries of multinational firms or they may operate under contract with U.S.-based businesses. Inputs, usually documents or magnetic tapes, are sent by air to offshore processing facilities (e.g., via Federal Express). After processing, generally a few days at most, the results are returned via satellite or dedicated telephone or fiber-optic line. Thus, the capital investments in such operations are minimal, and they possess great flexibility, maximizing their ability to choose among locations based on slight variations in cost or profitability.

Several New York–based life insurance companies have erected back office facilities in Ireland, with the active encouragement of the Irish Development Authority. Often situated near Shannon Airport, they move documents in by Federal Express and the final product back via satellite or one of the numerous fiber-optic lines that connects New York and London. Likewise, the Caribbean, particularly Anglophone countries such as Jamaica and Barbados, has become a particularly important locus for American back offices. American Airlines paved the way in the Caribbean when it moved its data processing center from Tulsa to Barbados in 1981; through its subsidiary Caribbean Data Services, it expanded operations to Montego Bay, Jamaica, and Santo Domingo, Dominican Republic, in 1987. In Asia, Manila, Philippines, has emerged as a back office center for British firms, with wages 20% of those in the United Kingdom. Such trends indicate that telecommunications may accelerate the offshoring of many low-wage, low-value-added jobs from the United States, with dire consequences for unskilled workers in the home country.

A similar form of low-wage, low-value-added services involves centers of telework, often labeled call centers. Call center functions include telemarketing, customer assistance, and phone orders, often with designated 1-800 numbers. They range greatly in size, from as few as five to as many as several thousand employees. Like back offices, call centers are primarily screen based and do not require proximity to clients. The major cost consideration is labor, although the workforce consists primarily of low-skilled women and high turnover rates are common. They are thus the epitome of a footloose industry, disembedded from their local milieu and highly mobile. There are an estimated 80,000 to 100,000 call centers within the United States, which employ between 3% and 5% of the national labor force, the majority of which are located in urban or suburban locations. Like back offices, call centers have become increasingly globalized. India, for example, has attracted a significant number of customer service centers near its software capital Bengaluru, where workers are trained to speak in the U.S. dialect of English and are able to gossip.
with customers about pop culture. Wages there, which average US$2,000 per year, are higher than average Indian salaries but are only 10% of what equivalent jobs pay in the United States.

Urban Telecommunications Infrastructures

Urban infrastructure investments in communication technologies have by and large remained surprisingly unimportant to policymakers. While many cities and localities are willing to invest in new roads or water control projects, urban planners and economic development officials have often overlooked or ignored altogether the role that telecommunications can play in stimulating economic growth. For example, only 5% of U.S. municipalities have explicit plans for telecommunications. One reason is that there is no statistical correlation between local investment in telecommunications and economic growth. However, while the telecommunications industry per se is relatively small and capital intensive, generating few jobs, and while telecommunications by themselves do not guarantee economic development, such systems have become necessities for many firms.

Although large cities typically have much better developed telecommunications infrastructures, the technology has rapidly diffused through the urban hierarchy and is becoming increasingly equalized among regions. In the future, therefore, the marginal returns from investments in this infrastructure are bound to diminish, minimizing competitive advantages based on an information systems infrastructure alone and forcing competition among localities to be based on other factors, such as the cost and quality of labor, taxes, and the regulatory framework. Regions with an advantage in telecommunications generally succeed because they have attracted successful firms for other reasons.

Telecommunications may affect the urban infrastructure in other, less obvious ways. One increasingly important effect of new information systems is “telework” or “telecommuting,” in which workers substitute some or all of their working day at a remote location (almost always home) for time usually spent at the office. The self-employed do not count as teleworkers because they do not substitute it for commuting. Telework is most appropriate for jobs involving mobile activities or routine information handling, such as data entry or directory assistance. Proponents of telework claim that it enhances productivity and morale, reduces employee turnover and office space, and leads to reduction in traffic congestion (especially at peak hours), air pollution, energy use, and accidents. If this phenomenon grows as expected, it will lead to further decentralization of economic activity in suburban areas.

However, while telecommuting may reduce flows of people, flows of information can never be a substitute for flows of water, electricity, gas, goods, or trash. Indeed, there are countervailing reasons why telecommunications may, in apparent contradictory fashion, increase the demand for transportation rather than decrease it. First, it is not at all clear that telecommuters have shorter weekly commutes overall; indeed, by allowing them to live farther from their workplace, the total distances traveled may actually rise. Second, time freed from commuting may be spent traveling for other purposes, such as shopping or recreation. Telecommuting may alter the reasons for travel but not necessarily the frequency or volume. Third, by reducing congestion, telecommuting may lead to significant induced effects, whereby others formerly inhibited from driving may be induced to do so. In short, the substitutability, rather than complementarity, of telecommunications for commuting is far from clear.

Another potential, and growing, impact of information systems on urban form concerns transportation informatics, including a variety of improvements in surface transportation such as smart metering, electronic road pricing, synchronized traffic lights, automated toll payments and turnpikes, automated road maps, information for trip planning and navigation, travel advisory systems, electronic tourist guides, remote traffic monitoring and displays, and computerized traffic management and control systems, all of which are designed to minimize congestion and optimize traffic flow (particularly at peak hours), enhancing the efficiency, reliability, and attractiveness of travel. Wireless technologies such as cellular phones allow more productive use of time otherwise lost to congestion. Such systems do not so much incorporate new technologies as improve on the existing ones. In-vehicle navigation
systems with inboard computers, such as the Intelligent Vehicle Highway System currently under way in Southern California, represent the next generation of this technology.

**Conclusion**

The widespread adoption of telecommunications is reflective of a series of broader transformations in the world economy. Economic development officials can adapt their views to these changes by recognizing that economic activity has relatively little to do with the production of tangibles, such as in agriculture and manufacturing, and is dominated by invisible flows of data and capital, which the digital revolution has transformed into twin aspects of the same phenomenon—one that moves at the speed of light—giving firms unprecedented mobility and flexibility. Markets, labor processes, policy planning, and spatial structures have changed accordingly. Cities and regions can search for a competitive advantage in this world in several ways. In large metropolitan areas, buoyed by the historical legacy of dense nucleations of firms interconnected by face-to-face interaction, telecommunications have left agglomeration economies largely intact, albeit not unchallenged, as in the case of electronic screen trading of stocks. In some cases, information systems have contributed to a marked centralization of key activities in a handful of fortunate cities as firms consolidate operations in an attempt to derive economies of scale. Other services, however, that rely primarily on unskilled inputs of routinized information are increasingly vulnerable to substitution by new telecommunications systems, such as back offices. A key theme here, therefore, is that information systems tend to centralize high-wage, high-value-added, white-collar functions while decentralizing low-wage, low-value-added, blue (or pink) collar ones.

_Barney Warf_

---

### Further Readings


---

**Teleconnections**

Teleconnections are hemispheric-scale statistical relationships that result from the spatial interdependencies between the atmosphere and the ocean. In other words, teleconnections describe how atmospheric or oceanic circulation changes occurring at one location are linked to changes at other locations that are widely separated geographically. On the order of weeks to years, these global associations are recognized by an atmospheric circulation disturbance occurring at select locations or “centers of action,” thereby producing oscillations affecting weather patterns downstream. These action centers identify the climatological positions of low- and high-pressure areas associated with particular atmospheric teleconnection patterns or cold and warm sea surface temperature regions with oceanic teleconnection patterns. Frequently, atmospheric oscillations are strongly linked or coupled with oceanic changes. Locations in the vicinity of the action centers shift from characteristic climatologically normal conditions to distinct patterns of climate anomalies that...
occur over a range of time periods. The climate anomalies produced by a teleconnection pattern depend on its phase, indicating the prevailing extremes in the action center variable. Teleconnection patterns represent a principal mode of annual large-scale atmospheric circulation variability that produces both short- and long-term regional climate effects.

Teleconnections are identified through statistical techniques demonstrating the degree to which fluctuations in a variable are related to two or more separate areas. Correlation analysis describes the strength and direction of association between paired variables, such as pressure changes in one location compared with all other locations. The El Niño Southern Oscillation (ENSO) is typically identified in this manner. ENSO is an interannual periodic abnormal warming or cooling of the eastern equatorial Pacific SSTs that is regularly accompanied by a shift in the typical surface pressure field between the Australian and Peruvian coasts, the primary action centers that are strongly negatively correlated. Eigenvector-based methods, such as principal component analysis, allow one to detect groups of interrelated variables, simplify the representation of the data field, and recognize similar regional modes of variability. The Pacific/North American pattern is often produced from eigenvector methods that distinguish three primary action centers across North America based on the cold season midtropospheric geopotential height field (i.e., the altitude of the 500- or 700-hectopascal pressure surface). Statistical methods such as these have been used to recognize sets of action centers unique to each teleconnection pattern.

The strength, phase, and location of the teleconnection pattern establish the geographical extent and severity of the climate impacts. For instance, strongly positive ENSO phases (or El Niño) during December to February are typically linked to increased precipitation in northwestern South America and the Southern United States, decreased precipitation in Northern Australia, and higher temperatures in northwestern Canada and South Asia; negative ENSO phases (or La Niña) usually have the reverse effects. The expected climate anomalies associated with a teleconnection phase suggests a potential for increased long-range climate forecasting. Consequently, teleconnections has been a major component of atmospheric research in recent decades.

Jill S. M. Coleman

See also Climatology; El Niño; La Niña

Further Readings

Over the past two decades, human geographers have taken an increasing critical interest in the mass media. This development reflects the growing recognition that the media are centrally implicated in both (a) the constitution, experience, and representation of space, place, landscape, and environment (in short, geography) and (b) the mechanisms by which geography in its various incarnations, in turn, is implicated in social processes. Of all the mass media, television is seen as perhaps centrally important in these regards; for, despite the rapid growth in penetration and usage of the Internet and notwithstanding the ongoing cultural, economic, and political significance of newspapers, magazines, and radio, it is widely believed that for the bulk of the world’s population, television is the most socially material mass medium.

Geographers have studied television’s social role from a large number of different angles, which can usefully be grouped into three categories, and it is around these three categories that this entry is organized. The first category is geographies on television—in other words, the ways in which geography (i.e., space, place, landscape,
and environment) is represented in television programming. The second category is geographies of television: what significant geographical patterns and processes can be identified in the organization of television itself as both an industry (which produces and distributes programming) and a technology (through which people receive and watch such programming). The final category is harder to define but can perhaps best be described as the myriad ways in which television shapes and reshapes the fundamental experience of space and place and of spatially mediated identities.

### Geographies on Television

There is now a large and rapidly expanding literature dealing with the ways in which geographies are conveyed on screen. The literature shows that it pays to think closely about the representation of both generic and more specific geographies. Generic geographies include the following generalized places: the city, the suburbs, “nature,” the desert, the road, and “home.” By “specific” geographies, we mean actual real-world places situated at all manner of different scales: Africa, the Middle East, the United States, Northern England, Baghdad, Manhattan, and so on.

Just as geographers have been interested in a wide range of different geographies and their materialization in programming, so too have they analyzed these representations from a variety of different vantage points. Some of the analysis has been relatively straightforward—concerned “merely” with understanding how a particular space or place has been conveyed and what that representation tells us about the geography in question that we might not have known before. Increasingly, however, geographers have sought to read “back” from programming to the society that produces it. What can we learn from geography’s representation on television—its structure, form, contents, and even absences—about, for instance, the prevailing social constructions of race, gender, and class? Finally, geographers have sought to more directly link representation and “reality.” A good example of this has been work demonstrating how television’s representation of a particular place can radically alter social consumption (e.g., tourist visits) of that place.

### Geographies of Television

The analysis of geographies of television has looked at television as a material process through all stages of its life span. These begin with production: Where is television programming filmed, and what notable trends can we discern in this respect? Here, for instance, one of the central themes of recent literatures has been to track the emigration of shooting from traditional locations—Hollywood being the archetypal example—to newer and often lower-cost sites, a development referred to as “runaway” productions.

After production, comes packaging: the editing and then bundling of programming into, most familiarly, television channels. Where does this activity—arguably the nerve center of the television industry—take place? It has been shown that it typically occurs in large industrial clusters or agglomerations, of which Hollywood is, again, the classic case. Allen Scott’s work has been seminal in demonstrating this idea.

The third link in the chain is distribution and its geographies. Once more, the literature on this topic is vast, but its central gist has been to show that on an international scale the main flow of programming has long been from the United States to the rest of the world—sparking, particularly in the 1970s and 1980s, repeated accusations of U.S. cultural imperialism. Since then, it has been shown that while the United States remains overwhelmingly dominant in global television trade, more complex interregional flows from multiple origins do exist and are rapidly proliferating.

The final important geography of television concerns its consumption. Here, especially in the work of David Morley, the emphasis has been on the consumption of television in the home—on family and the social relations of domestic space. But it has also been recognized that television long ago breached the boundaries of home—it is consumed in bars, in malls, in airports, and now on mobile phones and similar handheld devices. Discussion of these geographies has been an increasing focal point.

### Television, Space, and Identity

Geography is itself produced and reproduced on television; television has its own geographies, and
television also shapes and reshapes wider human geographies. This last claim potentially can mean many different things, but two are arguably important. First, watching television can affect how we experience space and place per se—and, moreover, how space interacts with time. Many influential authors have pondered on such themes and have offered arresting phrases to capture these experiential changes. John Thompson, for example, suggests that television and other electronic media have “uncoupled” time and space by breaking down what was traditionally a linear relationship between spatial and temporal distance. Along similar lines, the geographer David Harvey coined the popular phrase “time-space compression” to evoke the way in which the media have shrunk the world and the time taken to electronically navigate it.

Second, by reworking the experience of space and place, television also reshapes social identities that are themselves geographically grounded: identities such as nation, community, or, more broadly, “us” and “them.” Joshua Meyrowitz, for instance, famously argued that our social place and physical place in the world used to mutually reinforce one another but that by familiarizing us with places far away, television ruptured this symbiosis and has left us, literally, with “no sense of place.” Again, there is an enormous literature on such matters. But one example perhaps suffices to demonstrate the complexity of the relationships in question: satellite television. By allowing for single broadcasts that transcend traditional nation-state boundaries, satellite television can arguably lead to the dissolution of narrow, national, place-bounded identities. Equally,
however, satellite television can harden national identities precisely by virtue of its spatial scope—the identities, for example, of diaspora nations spread around the globe and traditionally fractured by space. It is just these types of complexities that geographers of television are increasingly grappling with.

*Brett Christophers*

*See also* Communications Geography; Cyberspace; Identity, Geography and; Information Society; Media and Geography; Representations of Space; Telecommunications and Geography; Virtual Geographies

**Further Readings**


---

**Global temperature patterns** are primarily determined by the amount of solar radiation reaching Earth’s surface, which in turn is influenced by factors such as latitude, the distribution of land masses and oceans, cloud cover, topography, and the circulation of the atmosphere and oceans. As solar radiation reaches the surface, it is absorbed—resulting in warming, reflected, or converted to latent heat in the evaporation of water. Surface temperature is thus determined by the flux of radiation to the surface and the disposition of this energy as it arrives.

---

**Latitude and Temperature**

The average surface temperature of Earth as a whole is 15 °C (59 °F), and the most obvious spatial pattern is a latitudinal gradient: Low-lying tropical regions near the equator typically experience annual average temperatures around 27 °C (81 °F), while high-latitude ice caps in Antarctica and Greenland have annual average temperatures below –40 °C (–40 °F). The seasonal variation in temperature will likewise differ significantly across the planet—low-latitude coasts will have seasonal temperature swings of less than 3 °C (37 °F), while high-latitude continental interiors will experience swings in excess of 40 °C (104 °F).

The latitudinal temperature gradient is due to the variation in the sun angle (the elevation of the sun above the horizon) between the equator and the poles. Earth is an oblate spheroid orbiting the sun at an average distance of 150 million kilometers (93 million miles). Due to the curve of the Earth, the noontime sun will pass directly overhead (the sun angle will be 90°) at a specific latitude, known as the solar declination, with lower sun angles at latitudes away from the solar declination. Due to the constant tilt of Earth’s axis relative to the plane of the orbit, the solar declination cycles between the Tropic of Cancer (23.5° N) on the summer solstice to the Tropic of Capricorn (23.5° S) on the winter solstice, passes over the equator twice a year—one on each equinox.

Lower sun angles mainly result in cooler temperatures because the solar radiation is spread over a larger surface area when the sunlight strikes the surface obliquely. When the sunlight is thus diffused, less energy is absorbed per unit of surface and less warming occurs. Two additional
factors also contribute to cooler temperatures at higher latitudes: First, polar surfaces such as ice tend to have higher albedos, so a larger amount of insolation is reflected rather than absorbed. Second, radiation arriving with a low sun angle travels a longer, slanting path through the atmosphere than when the sun is directly overhead, and therefore, more energy is absorbed or scattered before reaching the surface.

Seasonal variability in temperature results from seasonal variations in the sun angle. As Earth orbits the sun, the solar declination latitude moves north and south, producing higher sun angles and warmer temperatures during the summer season. Outside the tropics, there is a 47° swing in noontime sun angle from summer to winter. In addition to sun angle, day length (hours of sunlight) varies from summer to winter, with larger variations at greater distances from the equator. At high latitudes, winters are characterized by short days and low sun angles, while in the summer the days are longer and the sun is higher. As a result, high-latitude locations experience large seasonal variations in temperature, with extremely cold winters and moderate summers. In contrast, at low-latitude locations, the sun remains relatively high above the horizon throughout the year, and seasonal changes in day length are small, resulting in reduced seasonal variation in temperature. Therefore, during winter, the extremely low temperatures at high latitudes result in a significant temperature gradient from the equator to the poles, while high-latitude warming during summer produces a reduced latitudinal gradient.

The Principle of Continentality

Another major factor affecting temperature variations is the difference in heating characteristics of land surfaces versus water surfaces—a set of processes referred to as the principle of continentality. Given the same amount of insolation, a land surface will heat up and cool off more rapidly than an ocean surface, resulting in greater diurnal and seasonal temperature variations in continental interiors compared with coastal locations. There are four key reasons for this difference: (1) the transparency of ocean water, (2) the mobility of ocean water, (3) the differing amounts of latent heat transfer from the two surfaces, and (4) the differences in the specific heats of the surface materials. Because water is relatively transparent to solar radiation, incoming energy is absorbed throughout the top several meters of the water column. In contrast, insolation striking a land area is entirely absorbed at the surface itself. Because the energy received by the water surface is spread out over a larger volume of the material, the amount of warming experienced directly at the surface is reduced.

In addition to the penetration of solar radiation through the upper layers of the water column, the fluidity of water means that energy can be distributed deeper into the water column once it is absorbed. Thus, energy that might lead to increased warming during periods of high insolation may instead be circulated downward, and heat may circulate upward to moderate episodes of cooling. Land surfaces do experience some conduction of heat downward through the soil column, but the effect is relatively small—in general, energy absorbed at the land surface remains at the surface to produce warming.

A third factor contributing to continentality is the generally higher amount of evaporation that occurs from water surfaces. When water evaporates, energy is used to effect the change in state from liquid to gas. This energy, referred to as the latent heat of evaporation, is used to break the weak bonds between the water molecules and is stored in the higher-energy configuration of the water vapor. When the vapor condenses, the same amount of energy is liberated as the latent heat of condensation. The energy that is used for evaporation does not contribute to any sensible warming at the point of evaporation. Therefore, given the same amount of surplus radiation, a wet surface will experience less warming than a dry surface because a larger amount of energy will be transferred away as latent heat from the wet area. Over a dry surface, most of the surplus radiation will be converted to sensible heat, resulting in warming.

The final factor in the varying temperature responses between land and water surfaces is the difference in specific heat between the surface materials. Specific heat is the physical property of a substance that determines the amount of energy required to raise the temperature of the material. Water has a higher specific heat than land, which means that it takes more energy to produce a given amount of warming in a water surface.
Given the same input of insolation, therefore, a land surface will warm up more quickly than an ocean surface. Conversely, as the surfaces cool by radiating long-wave energy, the land will experience a larger drop in temperature than the water.

Taken together, these four factors produce larger diurnal and seasonal temperature variability in continental interiors compared with coastal locations. Combined with the latitudinal effect on temperature variability discussed above, the largest seasonal swings in temperature will occur at high-latitude continental interiors, for example, Eastern Siberia, and the lowest temperature swings will occur at low-latitude coastal and oceanic locations. Because the prevailing upper-level flow and storm movement in the mid and high latitudes is west to east, the cold dry air masses produced in continental interiors are pushed eastward, and so the most “continental” regions are in the eastern portions of the land masses. Conversely, the maritime effect is more pronounced on west coasts.

Cloud Cover and Water Vapor

A third major control on global- and regional-scale temperature patterns is the amount of cloud cover and water vapor. Clouds are a significant contributor to the planetary albedo and have an overall cooling effect of approximately 5°C (41°F) on the global average temperature. Due to the extensive cloud cover associated with the Intertropical Convergence Zone (ITCZ), latitudes near the equator are not the hottest part of the planet, despite the high sun angles. Rather, the hottest temperatures are found in the cloudfree subtropical latitudes (~30° N and S) under the tropospheric subsidence of the subtropical highs. While equatorial temperatures typically average around 27°C (81°F) throughout the year, summertime average temperatures in the subtropical deserts will exceed 40°C (104°F) in many places.

In addition to reflective cooling, clouds also have a warming effect on the surface as they absorb long-wave radiation leaving the surface and radiate energy back downward in what is referred to as the cloud-greenhouse effect. This effect is most pronounced with high thin clouds, which are effectively opaque to outgoing long-wave radiation but thin enough to pass solar radiation. The warming effect of clouds is particularly noticeable at night, when only the warming process is operating. Therefore, although the overall impact of cloud cover is one of cooling, the local effect will vary between warming and cooling depending on the time of day and the type of clouds present. In terms of variability, cloud cover tends to reduce the diurnal temperature range as daytime temperatures are reduced by the reflection of insolation and nighttime temperatures are increased by the downward radiation of long-wave energy.

High levels of humidity in the atmosphere play a role similar to the warming effect of clouds, as water vapor is a potent greenhouse gas. In humid environments, long-wave radiation is absorbed as it propagates upward from the surface. The main impact of this is a sharp reduction in diurnal variability—humid and cloudy tropical regions may experience day-to-night temperature ranges as small as 5°C (41°F), while diurnal temperature swings of 30°C (86°F) are not uncommon in the dry desert areas.

Topography

Topographic features have an impact on temperature at a regional and local scale. Because the main source of heat for the troposphere is Earth’s surface, temperature decreases with altitude, and mountaintops have cooler temperatures than lowlands. In addition, the density and humidity of the atmosphere decrease at higher elevations, reducing the amount of outgoing long-wave radiation absorbed. Thus, high elevations cool rapidly over the nighttime, producing increased diurnal temperature ranges compared with lower regions.

Mountain ranges also affect regional temperature patterns through the production of rainshadow deserts. Where topographical barriers lie across the prevailing wind flow, orographic uplift leads to cloud formation and precipitation on the windward side of the range. As the now drier air descends on the leeward side of the feature, it is warmed adiabatically, which results in warm arid conditions behind the mountain range.

Circulation of the Atmosphere and Oceans

A final factor that influences global temperature patterns is the large-scale circulation of the
atmosphere and the oceans, which is a product of the latitudinal energy gradient. Surplus energy from the lower latitudes is moved poleward through the atmosphere as well as via the major warm ocean currents, such as the Gulf Stream, found on the western margins of ocean basins in the midlatitudes. This shift of energy produces some warming at the higher latitudes and helps explain why Western Europe has a somewhat more temperate climate than latitude alone would suggest.

*Gregory S. Bohr*

See also Adiabatic Temperature Changes; Atmospheric Circulation; Atmospheric Energy Transfer; Atmospheric Moisture; Atmospheric Pressure; Atmospheric Variations in Energy; Climatology; Equator; Equinox; Lapse Rate; Solstices; Radiation: Solar and Terrestrial; Weather and Climate Controls

Further Readings


**TEMPORAL GIS**

Temporal geographic information systems (GIS) (also known as spatiotemporal GIS) is a concept and an active area of research within geographic information science focusing on representation, management, manipulation, and analysis of spatiotemporal data. Time presents an important component of spatial analysis. However, conventional GIS approaches adopt a static view to model time-dependent processes; thus, they are incapable of representing the changes and dynamics of geographic phenomena. Research efforts to extend GIS with the capabilities of handling spatiotemporal data have been ongoing since the 1980s.

The efforts of augmenting GIS with the capabilities of handling spatiotemporal data have been directed primarily at developing data models for time-dependent processes and phenomena. Similar to the object-based and field-based views of space, a discrete or a continuous view of time can be adopted in a temporal GIS design. The discrete time view uses two types of time objects to describe individually distinguishable events. A *time point* labels the existence of an event or the occurrence of a change, while a *time interval* denotes the duration of a certain status of a geographic entity. On the other hand, the continuous view treats time as a stage where the evolutions of various geographic events occur. This view is particularly important for tracing and studying the process of a geographic phenomenon in which changes take place gradually rather than abruptly.

Time-stamping presents a straightforward approach to adding temporal information to geographic entities. It has been widely used in various temporal GIS applications to integrate the geographic and temporal information of real-world entities. Depending on how a timestamp is applied to an entity, temporal GIS can represent its temporal information at different levels. A timestamp can be attached to a geographic layer (usually stored as a table in a relational database), and all geographic entities in the layer will share the same temporal information. A timestamp can be attached to every single geographic entity in a layer, and each entity will have its own temporal information. Also, multiple timestamps can be applied to different attributes of a geographic entity, and the entity will have attributes with different temporal characteristics. These time-stamping methods have been used in various temporal GIS models to represent changes of geographic entities and support relevant to spatiotemporal queries and analyses.

Another straightforward approach, the *snapshot model*, uses a collection of snapshots to represent the status change of geographic entities in an area. Each snapshot is taken at a specific time point; thus, all geographic entities in one snapshot share the same timestamp. The sequence of the snapshots then presents the change history of geographic entities in a particular area. In the late 1980s, Langran and Chrisman proposed a *space-time composite model* to record accumulated
changes in one single composite layer. A composite layer consists of a set of space-time composites that are derived from combining the geographic entities in multiple snapshots and represent homogeneous features sharing the same history and attributes. Each composite unit in the layer has its own timestamp. A historical state of a geographic entity can be constructed by combining several composite units associated to the entity according to their temporal sequence.

The snapshot model and the space-time composite model are capable of recoding spatiotemporal changes of geographic entities constituting a spatial data layer. However, neither of them can efficiently trace the change history of individual entities. In the 1990s, efforts were made to develop temporal GIS models that could explicitly maintain the lifelines of individual geographic entities. Special links are used to connect different states of entities that are stored in the consecutive snapshots or represented as a collection of space-time composite units. Therefore, a list of such links associated with a particular entity is able to capture the entity’s lifeline, which may include various change events such as creation, transformation, disappearance, reappearance, destruction, and so on. As a special case, it is possible to model in temporal GIS the lifelines of moving objects (i.e., geographic entities with continuous motion but without changes of shape, such as human beings, vehicles, and wild animals). Since this type of entities can be simplified as point features, their trajectories, which record the history of their movements, can be conveniently represented as spatiotemporal lines in a temporal GIS environment.

The above approaches are mainly designed to deal with discrete changes. However, a continuous view of time is required for researchers to properly understand the dynamics of many geographic phenomena, such as the development of a weather system and an urban sprawl process. Thus, the ultimate goal of temporal GIS is to represent the dynamic process of geographic phenomena. This implies that a temporal GIS needs to go beyond simply recording the events and tracing the change history of geographic entities to developing the capability of capturing the driving mechanisms behind the displayed changes. Such an approach demands that researchers have a clear understanding of the dynamic process behind the geographic phenomenon. Given the complexity of this approach, a temporal GIS application of this type usually focuses on a narrowly defined problem domain (e.g., meteorology) and uses mathematical models to simulate the process. Most existing efforts have been concentrating on loosely coupling a GIS framework with a separate system running a simulation model. So far, representing the dynamics of geographic processes remains a major research challenge in temporal GIS.

Temporal GIS also supports spatiotemporal reasoning that provides a theoretical foundation for analyzing the relationships and interactions among geographic entities. Researchers have been working on defining basic temporal relationships. For example, two time intervals can share various relationships such as before, equal, meet, during, overlap, start, and end. These temporal relationships can be combined with spatial relationships to represent rather complex spatiotemporal patterns of geographic entities. Various query and analysis functions have been developed in different temporal GIS applications to support the investigations of spatiotemporal relationships. These functions provide powerful tools for researchers to examine the dynamics and interactions of geographic entities in various research fields.

Hongbo Yu

See also GIScience; Temporal Resolution

Further Readings

TEMPORAL RESOLUTION

Temporal resolution, well defined in the field of remote sensing, is one of four major resolutions that characterize a remote sensing system; the others are spectral, spatial, and radiometric resolutions. Temporal resolution is the length of time that has elapsed between measurements and captures the rate of data collection for a particular area. It can range from seconds to hours to days to years. Temporal resolution defines the minimum length of time over which an event can occur to be discernible in the database. For example, satellite images acquired for a forested landscape every year during the summer season will not capture phonological changes. Temporal resolution also plays an important role in geographic information science (GIScience) because all geographic data are defined with regard to spatial, temporal, and thematic dimensions.

In remote sensing, temporal resolution represents how often a remote sensing system records imagery for the same area. It is a measure of the length of time required for the sensor to pass over and return to exactly the same location, typically referred to as the revisit time. Remote sensing systems often differ with respect to temporal resolution. For example, Landsat 1 was able to acquire imagery of the same location every 18 days. Landsat 7 acquires imagery of the same location every 16 days. Therefore, Landsat 7 has greater temporal resolution. As the temporal resolution of a remote sensing sensor improves and the length of time between image acquisition declines, the number of images that can be acquired for the same area increases.

One of the most important aspects of a remote sensing system is its ability to collect imagery for the same location at multiple points in time. Comparing multitemporal imagery allows researchers to detect changes in spectral properties on the Earth’s surface. Temporal resolution plays an important role in our ability to monitor these changes. For example, monitoring the growth of urban development would require a different temporal resolution (months to years) than monitoring the spread of a forest fire (hours to days). The temporal resolution of the remote sensing system should reflect the changes occurring in the phenomenon under investigation.

In geographic information systems (GIS), temporal resolution refers to the length of time between map updates. For practical reasons, data in a GIS are measured and recorded in discrete temporal units, where each data layer displays the spatial distribution of the variable of interest at one point in time. When a set of data layers are acquired for a variable of interest over the same area at several time steps, the length of the time step between the layers represents the temporal resolution of the GIS database.

Amy C. Burnicki

See also Remote Sensing; Remote Sensing: Platforms and Sensors; Spatial Data Models; Temporal GIS; Topological Relationships; Triangulated Irregular Network (TIN) Data Model

Further Readings


TERRAIN ANALYSIS

Generically, the term terrain analysis covers all processes that extract information from all kinds of terrain surface representation data. Such representations may include contour lines, profile lines, triangulated irregular networks, and square-grid digital elevation models (DEMs). The primary information extracted from terrain surface representations may be about local morphology or the characteristics of the entire catchment/watershed. Based on this primary information, the movements of materials controlled by gravity and the dynamics of energy...
controlled by solar radiation over the land surface can be understood and described, and in turn, complex hydrological, geomorphological, pedological, and biological processes can be modeled. For this reason, terrain analysis has found applications in different fields, including geomorphology, soil science, hydrology, ecology, civil engineering, and environmental science.

The relationships between certain components in the natural system and terrain features have long been studied. A typical example of this type of relationship is the appearance of a “chain” of soils at different terrain positions along a slope. “Catena,” a concept proposed to refer to this soil-terrain pattern, became a cornerstone of the contemporary soil survey and mapping. However, only with the development of the contemporary digital technology did terrain analysis grow into a serious research field. Nowadays terrain analysis is almost a synonym of digital terrain analysis and is a significant aspect of the general spatial analysis that is based on geographical information science and technology. The most widely used terrain surface representation in digital terrain analysis is the square-grid DEM, due to its simplicity of format and easiness of algorithm implementation.

Terrain Attributes Characterizing Local Morphology

In digital terrain analysis, to measure the local morphological features at a given location, including slope gradient, slope aspect, and various types of curvatures, a conceptual procedure is to first represent the actual terrain surface in a mathematical way and then calculate morphological features as the derivatives of the mathematical surface. Specifically, slope gradient and slope aspect are calculated as the first-order derivatives of the surface, and the two most useful curvatures, profile curvature and planform curvature, are modeled as the second-order derivatives of the surface.

With a square-grid DEM, the primary approach to deriving derivatives from a discrete raster representation is the finite difference estimation. The basic idea of this method is to first fit a polynomial to a neighborhood defined by a group of cells (pixels) and then calculate the derivatives of the polynomial surface for the center location of the neighborhood. The two most widely used polynomials for this purpose are the quadratic polynomial,

\[ Z = \frac{1}{2}x^2 + \frac{1}{2}y^2 + sxy + px + qy + u, \]

and the Lagrange polynomial,

\[ Z = ax^2y^2 + bx^2y + cxy^2 + \frac{1}{2}x^2 + \frac{1}{2}y^2 + sxy + px + qy + u. \]

In the above equations, \( Z \) is the elevation, \( x \) and \( y \) are geographical coordinates, and \( a, b, \ldots, u \) are coefficients whose values need to be derived from the actual terrain surface.

As an example, for a neighborhood typically defined by \( 3 \times 3 \) cells, the equation for calculating the slope gradient (in angular degrees) for the center cell is as follows:

\[ g = \arctan \sqrt{p^2 + q^2}, \]

where \( p \) and \( q \) are calculated as follows:

\[ p = (z_3 + z_6 + z_9 - z_1 - z_4 - z_7)/6w \] (under the quadratic polynomial)
\[ q = (z_1 + z_2 + z_3 - z_7 - z_4 - z_8)/6w \] (under the quadratic polynomial)
\[ p = (z_4 + z_9)/2w \] (under the Lagrange polynomial)
\[ q = (z_2 - z_8)/2w \] (under the Lagrange polynomial),

where \( z_1, z_2, \ldots, z_9 \) are elevation values for the cells in the \( 3 \times 3 \) neighborhood illustrated in Figure 1 (\( w \) is the length of one side of a cell).

Terrain Attributes Characterizing Catchment/Watershed

From a digital terrain surface representation, one can also derive information that characterizes the entire catchment/watershed. This information typically includes descriptive statistics of the watershed (e.g., minimum and maximum elevations of the watershed) and attributes regarding water flows.

Most attributes regarding water flows are based on the information about local flow direction,
which is derived from differences between nearby elevations. The most common method for calculating flow direction is the D8 algorithm, which assumes that the water in the center cell of a neighborhood flows only into one of its eight neighboring cells—that is, in the direction of the steepest descent. Based on the flow direction calculated in this way, information about flow path, slope length, upper-stream drainage area (flow accumulation), and watershed boundary can be derived.

Combining flow accumulation and slope gradient leads to an attribute that effectively characterizes the local moisture condition. This attribute is called wetness index or sometimes compound topographic index, which is calculated as follows:

\[ w = \ln \left( \frac{A}{\tan g} \right), \]

where \( A \) is the flow accumulation and \( g \) is the slope gradient measured in degrees.

### Ongoing Research

One challenging issue in terrain analysis is to automatically recognize the predefined terrain positions from a digital terrain surface representation, such as a square-grid DEM. This type of technique is useful because much of the existing knowledge in a field-based soil survey and mapping is associated with terrain positions. This recognition requires an integration of local morphological information and contextual information. Fuzzy logic has also been introduced to this problem to improve the accuracy and precision of the terrain position representation.

Another major research topic in terrain analysis is the impact of the resolution of the input DEM on the resulting terrain attribute values. This research is driven by the increasing diversity of data sources (particularly from remote sensing) and the increasing availability of high-spatial-resolution data. Understanding the advantages, disadvantages, and uncertainties associated with these data and their suitability for different applications is the prerequisite to the proper and full utilization of the data.

**See also** Hydrology; Landscape Interpretation; Watershed Management; Watershed Yield

### Further Readings


Territory is an important concept for understanding politics and social behavior. Although unsettled etymologically, the term territory is usually taken as a derivative of the Latin terra (land); however, it has also been suggested that it is derived from the Latin terrēre (to frighten), indicating that territory is a place that frightens people. This dual meaning is key to understanding territory. Most theories of the state point to territory, in combination with sovereignty and population, as the defining features of the modern state. Yet in a broader context, territory refers to the space occupied, or claimed, by a group of social beings. Essentially, territory indicates a bounded social space of dominance, identity, or jurisdiction.

Common to these three understandings is the creation of a space from where something, or somebody, else is potentially excluded.

### Three Key Functions of Territory

There are three dominant ways of understanding territory:

1. It refers to the natural habitat of a group of people or animals. In zoology, it refers to an area occupied by an animal or a group of animals, which they defend against others of their own kind.

2. It represents a social space that is constituted as a result of the behavior of a group of people, for example, when the supporters of one football team occupy a part of a section of a stadium, they create an area designated for them, where supporters of the other team are not welcome.

3. It denotes an area over which a polity claims dominion. This could be the area surrounding a city-state in early modern Italy or a modern state territory as that of contemporary France. In international law, territory plays an essential role in defining nation-states as legal members of the international community.

### Thing Versus Process

It is impossible to understand territory without a reference to land; however, the physical character of territory is often overestimated. While territory is constituted through the demarcation of a physical space, it is the delimitation and character of this space that give territory its characteristics. The existence of boundaries is never a natural phenomenon; even if mountain ranges or seas can make it impractical for people to move across them, boundaries are always a relational, and hence socially created, phenomenon. One should be careful, therefore, about treating territory simply as a physical object. Rather, territory should be understood in terms of the social relations that produce territory and are affected by territory. For example, it was the development of cartography that provided the spatial knowledge necessary for states to precisely define and agree on the boundaries vis-à-vis each other. This change, in turn, facilitated the development of distinct territorial societies. Without these developments in geographic knowledge and technologies, territory is unlikely to have played the central role that it plays in current affairs. Therefore, to understand what territory is, and how territory is created, we need to look at the historical social processes involved. Such processes are usually described as territoriality or territorial behavior.
Territorial Behavior

As a general concept, territorial behavior describes actions that aim to create a bound social space within which one dominates, and thus excludes others. This can refer to the territory of animals or the erection of a fence to mark off one’s property. Understood in this way, territory is a central aspect of any social order referring to the distribution of space, as well as a strategy to create space as one’s own. When an urban gang competes with another gang to control a part of a city where it seeks to control drug trade and other illegal activities, it constitutes a territory where members of the gang dominate and from which others are frightened off. In extreme cases, such as the clashes between gangs and paramilitary troops in urban slum areas in Brazil in the early 2000s, the gangs openly challenged the sovereign authority of the state and created territories where authority was disputed. Conflicts between groups of people, such as the divisions in Northern Ireland, can also result in territorial divisions, where sections of the capital, Belfast, have been divided into strict zones for Protestants and Catholics. These zones would not be officially sanctioned by state authority but would be recognized in, and maintained by, the everyday patterns of behavior of the population. Whereas these examples of territoriality produce shifting and maybe vaguely bounded territorial spaces, the political territories of states, appear as more static and settled.

Political History

International politics is based on what is called a sovereign territorial order. This means that the international system is based on sovereign territorial states that recognize each other as legal subjects of international law. Without territory, a state cannot be a legal entity. Territory plays the role of dividing the legal jurisdictions among states into distinct sovereign spheres, and it is, therefore, territory that serves as the foundation of differentiating different sovereign entities as states. Historically, this system is accredited to the peace treaties of Westphalia, officially marking the end of the Thirty Years War in Europe (1618–1648) and initiating a new system in which nation-states rather than feudal empires played the dominant role in continental (and later, global) politics. These events signaled the spatialization of politics and replaced the system of jurisdic- tional sovereignty that had characterized medieval politics in Europe. Jurisdictional sovereignty represented a relationship between the sovereign ruler and his or her subjects. As such, it was primarily a hierarchy of personal relationships that decided the extent of the territory over which a ruler could claim dominion. In contrast, the spatialization of politics meant that sovereignty began to refer to a specific area of geographical space; and whoever was living within this area would automatically be considered to be subjects of the sovereign ruler. In sum, the territorialization, or spatialization, of politics points to a transition in the relationship of the sovereignty of a ruler from personal relations to a specifically defined space. This process started in the 15th century and became a defining feature of European politics over the following centuries (Figure 1). Following European colonization of the rest of the world, sovereign territoriality became the dominant way of organizing international relations, and following World War II, sovereign equality based on territoriality was adopted as the main principle of the UN charter.

National Identity

Most theories of national identity and expressions of nationalist ideology stress the link of a nation to a specific territory or homeland. Narratives about the special character of a particular land—its beautiful valleys, forests, and so on—serve to link a particular group of people to a particular land. In theories of national identity, it is common to distinguish between articulations of identity associated with blood lineages (where the collective identity is constituted through kinship-like relations) and articulations of identity associated with territory or the land (where residence within a particular territory is constitutive of the collective identity). The former is associated with the historical example of German national identity, and the latter with France. Regardless of whether territory defines the extent of the collective identity, however, the notion of a homeland is crucial. What is significant is the way in which the territory acquires the role of a home for a particular collective. This discourse of the territory as home is strengthened by the feeling of familiarity that
most people have when they return from travel and is associated with being back in a particular territory. In that respect, it is through the discourse on national identity that a population and a territory are tied together into a unit.

**Territorial Conflict**

Territory has often been a source of conflict and war, caused by competition over natural resources, by a general competition for access to land, or by competing notions of national identity claiming the same area as a core aspect of a particular nation. In legal terms, there is a tension in international politics in that territorial sovereignty is expressed through the norm of territorial integrity that seeks to maintain the territories of current states intact, but at the same time, territorial sovereignty is legitimized through a claim to national identity. When a recognized state territory contains what is perceived to be more than one nation, it is logically impossible to sustain both the norm of national self-determination and the notion of territorial integrity. This was clear during the 1990s, when the former Yugoslav Republic was split up into smaller states after a series of bloody wars justified with reference to national and ethnic cleavages. Territorial conflict or competition can also take place in a more peaceful way. In recent years, the Arctic region has attracted increasing attention from the Arctic countries, all of which try to claim large areas of the Arctic

---

**Figure 1** Cartographic representations, such as Blaeu’s map of Europe from the mid 17th century, contributed to the perception of a world divided into neatly bounded territories.

*Source: Public domain.*
seabed. This is done with reference to the UN Convention on the Law of the Sea (UNCLOS) from 1982, which specifies the conditions under which a nation can expand its domain at sea. The countries involved pursue territorial enlargement to get control over the natural resources that might be found there.

Network Versus Territory

In recent years, the significance of territory has been challenged by new approaches to social science. The end of the Cold War and the rise of globalization have led many to believe that territory is becoming less significant. Especially, social constructivist and postcolonial writings have emphasized new “spatialities” coming to play a more significant role and, in doing so, undermining the preeminence of territory. With the advance of communication technology in particular, economic and social transactions can be carried out in an instant across long distances, and it has been highlighted how global networks cut across territorial boundaries and thereby undermine the capacity of the state to exercise sovereign authority within its territory. The main contribution of these writings has been to critically investigate the history and status of territory. By emphasizing the historical development of current territories, and especially contrasting these with non-Western experiences of the territory and spatial behavior, they have shown a range of alternatives to global politics based on a territorial order. For example, poststructuralist studies often stress the existence of alternatives to territorial societies by investigating nomadic traditions and behavior, which they describe as another way of organizing social space. These writings have provided an important contribution by pointing to the limits of viewing the social world from a purely territorial perspective. While it would be a folly to claim, generally, that territory as such no longer matters, it is important to keep in mind that various social practices, such as economic interaction, tend to follow a nonterritorial logic. A useful way to approach this tension is to think about territory and networks as two different social spatialities that often contradict each other while they necessarily coexist.

Jeppe Strandsbjerg

See also Borders and Boundaries; Cross-Border Cooperation; Deterritorialization and Reterritorialization; Geopolitics; Nation; Nationalism; Political Geography; Sovereignty; State

Further Readings


The geography of terrorism refers to the spatial and locational characteristics of terrorist incidents, including the global and regional patterns of terrorism, the physical places where attacks occur, the location and activities of the human victims of attacks, the spatial and operational characteristics of attack locations, the types of land use commonly subject to terrorist attacks, the ways in which terrorist actors intersect in time and space with the intended victims, and, most generally, the extent to which the characteristics of places and the human activities occurring there interact with political, ethnic, racial, social, religious, or other ideological motivations and attack methods to produce terrorism.

The geography of terrorism is complex and multidimensional. It includes a political geography of the nation-states involved in the sociospatial control of various territories and the official public responses to the incidents of terrorist violence within those territories. Terrorism has a temporal geography, in which tribal or communal hatreds and vengeance propel cycles of reciprocal
political violence within a society over time. Terrorism has an urban and rural human geography, in which the spatial arrangements of ethnic, religious, and racial groups set the stage for terrorist violence. Terrorist violence has a military geography, involving the conquest and control of space and the capture and maintenance of territory.

**Definitions of Terrorism**

Definitions of terrorism abound. Terrorism is viewed in this entry as the use of violence by individuals, substate groups, agents of the state, and state authority against innocent victims to achieve political, ethnic, racial, religious, or other ideological objectives. Terrorism can be a broad strategy as well as an individualized tactic used in sociopolitical conflict, practiced by nation-states and substate actors alike. The sociologist Donald Black defines pure terrorism as a form of social control and collective self-help among groups addressing perceived problems—one group wages collective violence on others to get something done or to stop something. Terrorism is also considered to be a tactic of asymmetric warfare.

**Geographical Components of Terrorism**

Every terrorist incident occurs in a physical place in which four necessary elements of terrorism come together: (1) the perpetrator of terrorist violence, (2) the victims of violence, (3) the types of violence (methods and weapons), and (4) the ideological motivations that transform ordinary criminal violence into terrorism. The interactions among terrorists, victims, methods, motivations, and places of attacks produce several geographical dimensions of terrorism.

**Spatial Strategy of Terrorist Violence**

Terrorist behavior has a spatial component when violence driven by political, ethnic, sectarian, or religious motives is perpetuated to control, change, or eliminate the activities occurring within an area or the people occupying that area. Terrorist violence is instigated to (a) drive out the occupants of a particular place, (b) keep other parties away from an area, or (c) stop certain activities from occurring in an area. Alongside these motivations is a desire to create a climate of fear through random violence that sends a message that no place is safe and that the innocent will be targeted to accomplish the terrorists’ objectives. Ethno-nationalist, state terror, and genocidal campaigns commonly include explicit spatial strategies to stop the performance of human activities in a space, drive people out of certain spaces, or simply eradicate them.

The geography of terrorism involves a broader conception of victimization in which the places of terrorist incidents—as well as the humans in those spaces—are an integral part of attacks and their ideological messages. Assaults on government buildings, diplomatic facilities, public markets, clinics, or pristine natural spaces all send direct and indirect messages to intended audiences, based on the characteristics of the places attacked and the human activities they host. The places attacked are part of an informational strategy of terrorism and often reflect multiple layers of meaning. At a minimum, terrorist violence persuades citizens that the targeted spaces are not safe.

**Treatment and Control of Space in Terrorism**

Terrorism can have clear geographical motivations. Land control is at the core of the Palestinian-Israeli struggle. The Irish Republican Army (IRA) used terrorism to dislodge Britain’s occupation of Northern Ireland. Controlling land was the primary motivation in Sendero Luminoso’s violence in Peru, strategically as an example of Maoist guerrilla warfare and tactically as a way of gaining control over coca production. Colombia’s terrorist violence stems from the agricultural sources, production locations, and transport of illicit drugs. The Tamil Tigers use terror tactics to capture and control land in Northern Sri Lanka. The ETA (Euskadi Ta Askatasuna [Basque Homeland and Freedom]) in Spain uses terror to struggle for sovereign status for the Basque land in the Northern Iberian peninsula. In the past 30 years, radical Islam’s interest in the holy sites of Mecca and Medina has produced major terrorist incidents. In Rwanda in 1993 to 1994, the Hutu used mass murder to erase the Tutsi from Rwandan territory. The Sudanese government depopulated...
TERRORISM, GEOGRAPHY OF

the indigenous population of Western Darfur using terror tactics between 2003 and 2008. In all these ways, land and spatial control can be the strategic focus of terrorism.

Location of Terrorist Acts Among Political Jurisdictions

The global geography of terrorism begins with the spatial distribution of terrorist incidents among countries. Individualized terrorist attacks occur, and over time, clusters of incidents appear among sovereign states. Spatiotemporal clusters of terrorism among countries are built on the spatial and sociopolitical context of each country, as defined by its longer histories of political, social, ethnic, or religious conflicts, including not only internal ones but also conflicts with other countries. Terrorism is produced by different actors—it has been executed very effectively by nation-states, by organized and disorganized substate groups, and by grassroots “leaderless” resistance networks. Any of these groups can wage extended campaigns of terror. Furthermore, terrorist groups originate from selected countries and can show specific spatial allegiance to certain areas. Depending on their potency and motivations, groups sometimes wage terror campaigns in other countries or work covertly with public authority when state-sponsored terrorism is involved.

New York City, September 25, 2001: Fragments of the World Trade Center façade that remained after the attacks on the 110-story structures that once dominated the skyline of lower Manhattan.

Source: Mike Rieger/FEMA News Photo.
At a more resolved spatial scale, regional differences in terrorist incidence rates are important. Black (2004) suggests that terrorism arises in places where sociodemographic structures result in (a) long social distances between people in terms of their ethnicity, religion, social class, corporate status, or hierarchical authority and (b) short physical distances between people who are socially distant—that is, there is a large social distance between people who live in close proximity to one another. Terrorist violence frequently generates mass casualties, so population density is an important part of terrorist targeting strategies, creating higher urban risk profiles. Within countries, selected cities and localized regions become repeat hosts of terrorist incidents. Acts of terrorism also occur within a set of local operating environments (e.g., an airport, a public park, an office, a government facility). This means that certain land use classifications become more or less attractive targets. For example, land zoned for public transportation corridors has been the scene of devastating terror attacks over time. Countries hosting “mega-events” (e.g., Olympics, Super Bowl, World Cup) have higher risks of terror attacks during such events.

At a basic level, the target of terror attacks sets up the geography of terrorism. Places targeted are rarely random but are chosen for tactical or symbolic reasons. Physical places are often the targets of terrorist attacks because they host some activity. Medical facilities, timber companies, airline counters, dwellings, and places of business have all been sites of terrorist crimes, from minor vandalism through catastrophic destruction. Public markets, restaurants, meeting halls, hotels, office spaces, transport facilities, and resorts are targets of terrorist violence. Sometimes, the place is a more important targeting dimension, while at other times the functions performed in that space are more important. A terrorist incident can target a women’s birth control clinic, the observation deck of a skyscraper, a parking garage, or an airport ticket counter. Terrorism targets locations that have functional or operational characteristics (e.g., a place where abortions are performed, where Hindus worship, where foreign tourists congregate, or where international business is conducted).

Another geographical component of terrorism comprises the situational aspects of places where terror attacks occur. A detailed analysis of terrorist incidents reveals a wide array of settings. Suicide bombings on public transportation were common in the Israeli-Palestinian conflict and spread to London in 2005. Bombings in restaurants, resorts, and hotels target innocent “occupiers of space” at a particular time. Targeted assassinations occur in residential areas, striking victims in their homes. Firebombings are used in exurban locales by environmental extremists and insurgent groups. Terrorism is often defined based on the characteristics of the attack victims who came together and engaged in routine activities in common places (e.g., a wedding party, a dinner, a shopping center, a station, an airport, or a school).

Terrorist incidents are sometimes designed around the locational and operating characteristics of a target. The Earth Liberation Front firebombs automobile dealers selling Hummers to protest against gas-guzzlers or uses arson to burn partially built houses in undeveloped areas. Mexican narco-terrorists murder an off-duty police official at his residence to demonstrate people’s vulnerability in their homes. The 2006 Mumbai train bombings by a grassroots Islamic group targeted first-class commuters during the evening rush hour.

The targets of terrorism can be comparatively undefended, more accessible to terrorist actors, or difficult to guard and protect. Residential sites and public spaces are relatively undefended. But fortifying the target does not necessarily dissuade attacks. Surprisingly, well-defended places are frequent targets. The multitude of city spaces exhibits higher landscapes of risk. Certain kinds of land use (e.g., public spaces, public transport facilities) are more likely to be the site of terrorism incidents.

At the closest spatial scale where terrorist actors or agents cross paths with victims, terrorism consists of one or more sequential crimes, such as kidnapping, assault, attempted murder, or murder. Each crime is implemented using a method and one or more weapons. The crimes occur together in time and space. The methods and weapons used determine whether the terrorist physically crosses
paths with the victims or instead leaves a device that delivers the attack. The distance from terrorist to victim can be near or far depending on the method-weapon combination. Using a scoped rifle to close the distance between the killer and the victim keeps assassins farther from their victims, as do remotely detonated bombs. At other times, suicide attackers get close to victims. Transportation and communications technologies help create spatial connections between victims and terrorists. Cellular technology and the Internet help coordinate attacks from longer distances. Terrorist groups use technologies (e.g., letter bombs, firearms, computers, airplanes, trains, buses, car bombs, improvised explosive devices) to deliver attacks, which enable terrorist agents to escape, fight it out, or die at the attack site.

When terrorist actors use biological or chemical weapons, or remote detonations of explosives, a slightly different geography develops. Attackers and victims may not come into direct contact, and often the results are not seen until later, after the terrorist actors leave the scene. Letters and parcels bearing viral or biological agents or explosives can use postal systems to reduce the distance between the victims and the terrorists. The U.S. anthrax terrorists in 2001 were probably nowhere near the victims. In contrast, the 1995 Tokyo subway attacks required Aum Shinrikyo members to intermingle with victims in subway cars prior to piercing the bags of sarin and leaving. The 1993 World Trade Center and the 2004 Madrid train bombings used timed detonators that maintained separation between the terrorists and their victims.

Research Questions

The geographical components of terrorism are far-reaching and suggest various avenues for further research. Key questions include the following:

1. What spatial strategies are embedded in terrorist campaigns?
2. Which countries host large rates of terrorist violence, when, and why?
3. Where within a country do terror attacks occur?
4. What land uses and human activities are underway at the places targeted by terrorist violence?
5. How do terrorist actors or agents intersect the personal space of victims?
6. How do terrorists distribute violent incidents across their activity areas?
7. What does the risk profile of a region look like?
8. How do public responses to terror affect people’s movement through space?

Samuel Nunn

See also Antiglobalization; Crime, Geography of; Fear, Geographies of; Hate, Geographies of; Justice, Geography of; Military Geography; Political Geography; Resistance, Geographies of; Risk Analysis and Assessment; War, Geography of

Further Readings


TEXT/TEXTUALITY

There is no clear consensus as to what constitutes a text or how the term should be defined. Instead, the term falls victim to a wide array of interpretations and applications across and within
various disciplines; however, it is often associated with the pioneering work of Roland Barthes and other literary theorists and cultural anthropologists such as Paul Ricoeur, Clifford Geertz, James Clifford, George Marcus, and Stephen Tyler. Here, text is regarded as a sociocultural product and/or process and is expanded from its traditionally narrow definition of being a mere printed medium to include things as wide ranging as paintings, photographs, maps, electronic media, landscapes, as well as economic, political, and social institutions.

A text, in the broadest sense of the word, can be regarded as a configuration of signs that is coherently interpretable by some community of users. Implicit in the definition is the view that something can only qualify as a text if it is void of anonymity, randomness, and illogic. Hanks (1989), for instance, distinguishes the senseless cacophony of a crowded street from the sound exchange of words between two mutually oriented interactants, or the noise of rush hour as opposed to the concerted dissonance of a dramatic passage in a musical score. Texts are therefore innately communicative and are part of an ongoing discourse produced, received, and interpreted by various social actors and agents.

The reading of a text occurs through its textuality. A text is replete insofar as it is grounded in a locally defined social context. To understand a text and make it semantically whole, the reader has to draw on a variety of background information or seek to understand the particular context that gave rise to such text. Even the most rigorous of linguists with their emphasis on textual form and content make reference to a text’s connection with the sociocultural world. Textuality then refers to the attributes that distinguish the text as an object of enquiry. Texts are produced and understood in terms of the broader sociocultural context in which they arise. If read in isolation from the broader social matrix of which it is inherently a part, a text becomes incomplete and indeterminate.

The term intertextuality is also linked to the use of “text” as a concept. Implicit in this is the view that all accounts of the world are highly mediated by preexisting notions and theories. Places are intertextual in that they are shaped by previous texts and practices that are deeply inscribed in their landscapes and institutions. In short, texts shape, and are in turn shaped by, other texts. Therefore, meaning is produced from text to text rather than in and of the texts themselves.

The Discourse on Text

The discourse as to what constitutes a text, and in extension its textuality, has been a long-standing and ongoing one. There are indeed many approaches to the study of text. Approaches to textual analysis can be differentiated according to the scope and extent to which text is seen as an object of enquiry. For a structuralist, texts are seen as products of an ongoing hegemonic discourse. Much of the initial work on texts in structuralism was carried out by Roland Barthes, who believed that the world was made up of signs. By studying these signs, Barthes believed that one could uncover the complexities and the instability that underlie our everyday life. Accordingly, landscapes were perceived as being produced and shaped consciously to represent a particular set of values and belief systems. Landscapes were therefore found to be unnatural and highly ideological and political. In one of his most famous essays “The Blue Guide,” Barthes (1986) critiqued the widely used Hachette World Travel Guide as being an instrument of Western cultural manipulation. Barthes illustrated how, by showcasing a limited range of landscape features, the travel guide plays into Western constructions of place, thus ignoring the familiar (Western) and romanticizing that which is deemed as unfamiliar (the Orient). In fact, Barthes described the travel guide as an “agent of blindness,” one that conceals non-Western realities.

Poststructuralists, on the other hand, challenge the structuralist notion that texts are coherent and self-contained. Instead, advocates of poststructuralism posit that texts are innately contradictory and indeterminate. Poststructuralists therefore shift their focus away from the text itself (as a bounded linguistic artifact) to the interaction between reader, text, and author. The consequence of this change is the expansion of the notion of text to include even social life.

This expanded notion of texts also has its roots in postmodernism. The postmodern view sees
texts as being constitutive of reality rather than mimicking it. For postmodernists, the world is like a text encoded with meaning. Ricoeur, for instance, posits that social life has characteristics strikingly similar to those of a written discourse. For Ricoeur, social life, like text, is detached from the intentions of its original authors, is inherently unstable, and possesses a certain amount of objective fixity. Additionally, social life has an importance beyond the initial context for which it was constructed—again, like that of a written text. Similarly, Clifford Geertz looks at cultures as texts; for him, culture can be “read” by an ethnographer as one might read a book. He extends his point by claiming that this practice is not only academic in its orientation but also one that everyone practices.

### Text, Textuality, and Geography

The bulk of the literature on text and textuality has been confined to a few disciplines—literary studies, linguistics, and anthropology in particular. Most of the initial work focused on issues relating to the organization, production, and interpretation of texts. Throughout the 20th century, competing methods of textual analysis were put forward. Advocates of structuralism have focused on semiotics or text as signs, while poststructuralists have looked at text as being constitutive of larger and more dynamic discourses. The latter mostly adopts a Foucauldian interpretation of text. Here, discourses are seen as connected to knowledge, identity, and power. Society is seen as filled with multiple discourses that are representative of various interest groups. Texts either reflect or shape these multiple and sometimes competing discourses. Over the past few decades, these textual methods of analysis have attracted much attention and interest in the social sciences in general and geography in particular.

It was not until the 1980s and 1990s (during the rise of social and cultural theory in geography) that geographers became interested in textual analysis. This cultural turn saw the promotion of a hermeneutic approach to the study of place and the politics of representation. Most of these studies have focused on landscapes, cultural landscapes in particular. For geographers (new cultural geographers especially), texts represent a valid way of interpreting landscapes. Implicit in this notion is that landscapes are themselves encoded with messages and can therefore be “read” and decoded as texts. Geographers are interested in the way places themselves encapsulate and communicate cultural identity and how these places in turn shape our own perceptions and identities as social beings. People’s interactions with their surroundings are therefore viewed as interactive and dynamic rather than one-dimensional and static. Landscapes are constantly “written” and inscribed with meanings. These meanings can then be “read” or interpreted as signs about the particular values, identity, beliefs, and practices evocative of that particular landscape, place, space, or era. However, to read these signs, one must understand the language in which it was written—in other words, one has to become familiar with the text’s textuality.

Barnes and Duncan’s (1992) *Writing Worlds* illustrates the many ways geographers have used concepts such as text, discourse, and metaphor to explore the dynamics of power in the representation of landscape. Though the landscape representations explored by the authors in the volume varied considerably (from travelers’ writings to propaganda maps), a common theme running throughout the book was that all sociocultural products and practices, including landscapes, social action, paintings, maps, and even language, are susceptible to textual interpretation. McGreevy (1992) showed how written accounts of the Niagara Falls—dating back to the late 19th century—were informed by the metaphor of death. He went a step further to illustrate how this metaphor of death had crept out of the written texts of the area into the very landscape humans created around the Niagara (evident especially in the many acts of suicide carried out in the area). Likewise, Daniels (1990) used a watercolor depiction of Leeds painted by J. M. W. Turner in 1816 to show how even works of art are themselves inscribed with meaning and can be “read” as text. Daniel showed how the painting addressed both the features of Leed’s industrialization as well as the intellectual and political psyche of Turner and his time.

Another study worthy of mention is that of Denis Cosgrove (1998), who applied social and cultural theory to the study of landscapes.
According to him, landscapes are constructed and shaped by sociocultural and political processes and thus represent a “way of seeing.” Ways of seeing are ideological and signify the way in which the dominant class in a society represents itself and its property. In short, landscapes are both constituted by and constitutive of social power relations.

Recent research in subjects such as sociology, anthropology, and human geography has built on these past notions of text—though not explicitly—in exploring issues relating to the politics of place, identity and culture, place making, place/destination marketing, transnationalism, and even graffiti. Studies have shown, for instance, how various media texts (including the Internet, travel blogs, online advertisements, and other promotional literature for instance) have helped to either reproduce stereotypes or challenge dominant images of places. Erjavec (2001) showed how the theme and form of news reports worked to reinforce and legitimize discrimination against the Roma in Slovenia during the 1990s. Morgan and Pritchard (2002) also revealed how destination-branding strategies helped shape Wales’s tourism efforts. Based on their analysis of the marketing campaigns and promotional literature of the Wales Tourist Board in particular, the two concluded that the influence of both repressive and liberating historical, political, and cultural discourses was seen in the way Wales marketed itself as a tourist destination. Both examples—though different in their focus—speak to the relationship between texts, identity politics, and place representation.

Even more recently, Mains (2008) has shown how Latin American transnational identities are inscribed in both the cultural and the physical landscapes around the U.S./Mexico border. In looking at the movements or exchange of music and architecture between both sides of the border, she illustrates how cultural identities shape the way places are constructed and represented. For instance, in both Northern Mexico and California, Mexican hip-hop, ranchero music, and U.S. rock music dominate. These musical forms are often bilingual, thus indicative of the influence of what can be termed transnational or border identities. Similarly, Mains argues that an examination of the built environment of cities such as Los Angeles or Tijuana will show the influence of Spanish colonial plazas and gardens, indigenous adobe materials, as well as modernist office buildings—again reminiscent of a transnational culture but also indicative of the ways in which cultural identities are sometimes manifested in the physical landscape and in turn mapped onto space. In short, the U.S./Mexico border and its associated cultural and physical landscapes can be read as texts, as they embody the interconnectedness with people and places throughout the Americas and have given rise to, and become increasingly shaped by, a number of distinct and competing discourses on mobility, immigration and legality, and transnational identities to name some.

As mentioned before, even graffiti can be looked at as texts and can be used to understand relations and contestations of power in urban space. Here, graffiti are defined as a sort of text that adopts a historically and culturally grounded interpretation of some aspect of the world, shaped by human personalities and actions. Graffiti not only alter or edit the text of the cityscape but also form an independent body of texts that refer to each other as well as to the “canvas” of the city on which they are literally inscribed. Graffiti thus represent a written and visual aspect of language, with their own semiotics of action, that if read properly can uncover the cultural politics of place, as well as various geographies of power and identity.

There are, however, a number of problems associated with the use of text and, in extension, textuality. A major one relates to the issue of representation. There are important epistemological and ethical issues surrounding the notion of representation and its implications for textual analysis. Duncan (2000) points out two such concerns. The first refers to the issue of the translatability of cultural difference, and the second refers to the ethics of speaking for others. The signs that are embedded in a landscape may have different meanings for those who produce them and for those who interpret them. As such, great care has to be taken when interpreting these meanings. Researchers have to be mindful of their own biases as well.
TEXTILE INDUSTRY

The textile industry encompasses a sequence of production processes that transform raw materials into finished textiles and clothing products. Production in these sectors is shaped by two fundamental characteristics. First, cloth is relatively malleable and fragile, so commodity manufacturing in these industries has resisted automation and remained labor-intensive. Second, because the industry’s production processes are divisible and able to be separated or vertically disintegrated into sequential stages, firms are able to locate each stage of production at the most advantageous site. As a result, the sector has developed a globalized organizational structure. Figure 1 provides a simplified view of the textiles production sequence.

The raw materials used to make textiles include natural fibers, human-made fibers, and combinations of the two. Natural fibers include cotton, wool, silk, flax, and hemp. Human-made or synthetic fibers can be obtained from processing petrochemicals (nylon and polyester) or made from...
cellulose, which is derived from wood or cotton (rayon and viscose). Although the actual processes differ depending on the type of fiber, textile production involves spinning thread, weaving or knitting it into fabric, and then dyeing and finishing the fabric in different ways, depending on the intended end use. Technological advances in fiber manufacturing have generated a highly automated and capital-intensive subsector. In addition, a vibrant research sector is developing patentable new fibers that combine natural and synthetic materials for a range of high-technology applications (e.g., the carbon-coated textiles used in the aerospace industry).

Textiles have a wide range of industrial, household, and personal uses. They are the principal material in ropes, sacks, canvases, and fiberglass and have a wide range of industry uses (e.g., in filters and the rollers used in printing mills). Textiles are found in home and office furniture, carpets, curtains, bedding, as well as in the interiors of transport vehicles. Nonetheless, about 40% of textiles are used as inputs to clothing production.

Clothing production involves designing garments; making patterns; cutting cloth; sewing the cloth into garments; adding buttons, zippers, and other accessories; and then checking and packaging the final product. Basic clothing production (i.e., cutting and sewing pieces of cloth) does not require advanced skills, complex equipment, advanced technologies, or large capital investments. Clothing manufacture is therefore characterized by what economists call low barriers to entry and exit, meaning that firms can easily come into or drop out of the industry. As a consequence, the sector has historically been volatile and mobile, changing rapidly in response to the vagaries of the business cycle and shifting its production locations in response to regulatory changes and interregional wage differences.

The sector exemplifies five key theoretical themes in economic geography and development studies: (1) the geopolitics of economic globalization, (2) the tensions between globalized production networks and localized industrial districts, (3) the internationalization of struggles over labor rights, (4) the flexibilization of the labor process, and (5) the contemporary repositioning of “cultural” industries.

The textiles industries were one of the first sectors to develop globalized production structures and are now the world’s most traded commodities after agricultural goods. Textiles industries are the world’s most regulated industries and are unusually sensitive to policy change.

Textiles have played an important role in international trade and national development. Clothing production’s low entry costs, accessible technologies, and modest skill demands make it
the logical choice of industry to “kick start” national development strategies. Numerous industrializing countries have sought to exploit their comparative advantage in abundant and cheap labor by establishing clothing and textiles production industries. Accordingly, the sector has been the centerpiece of export-oriented industrialization strategies in Japan, Korea, and Hong Kong after World War II, in Asia’s newly industrializing economies (NIEs) in the 1980s, and in China since the 1990s.

Clothing and textiles production in the developing countries often occurs in export processing zones set up to attract foreign direct investment. These zones offer a range of incentives to capital, typically low wages, low infrastructure costs, tax holidays, and cheap and nonunionized labor. In the 1970s and 1980s, the growth of clothing production in less developed countries was fuelled by the relocation of production by Western firms seeking to reduce their labor costs or to escape the unionized workforces of factories in their home economies. Thus, the sector has been the archetypal example of the process of relocation of jobs from the developed to the developing world, a process known as the new international division of labor.

In the post–World War II era, Western governments imposed restrictions on textiles and clothing imports with the aim of protecting jobs in their home economies. The most important of these interventions was the 1974 Multi-Fibre Arrangement (MFA), which was an exception to the General Agreement on Tariffs and Trade (GATT), which allowed high-wage countries to impose import quotas that limited textile imports from low-wage countries. The developing countries viewed the MFA as an impediment to their economic development. At the Uruguay Round of GATT negotiations, member nations agreed to discontinue the MFA and bring clothing trade in line with the rules governing trade in other manufacturing sectors. Between 1995 and 2005, therefore, a transitional Agreement on Textiles and Clothing (ATC) was put in place to gradually phase out the sector’s quota restrictions.

Trade liberalization generated major shifts in the global configurations of textiles and clothing industries. Figures 2 and 3 show the principal exporting countries’ shares of world textiles and the clothing export trade for the years 2000 and 2006. Both sets of figures highlight the rapid growth of Chinese exports. India, Turkey, and Pakistan have also benefited from recent regulatory reforms. In textiles, the losers in this process have been South Korea, Taipei, Hong Kong, and the United States. In clothing, Mexico, the United States, Hong Kong, and many small countries with low export volumes have lost market share. Hong Kong’s position as a reexport platform is faltering as Western firms increasingly source products directly from China.

Because trade liberalization has removed the advantage previously enjoyed by smaller developing countries (whose textiles exports were not restricted by MFA quotas), production now appears to be concentrating in and around specialized garment production regions. Both the United States and the European Union negotiated new agreements with China in late 2005 to slow the growth of imports into their markets.

The Commodity Chain Perspective

Commodity chain perspectives highlight the institutional relationships that shape trade flows. They view aggregate trends in textile production and exporting as the outcome of transnational subcontracting arrangements between firms. In textiles, these chains of interconnected firms are usually coordinated by large brand-owning core firms based in high-wage nations. Gereffi has called this form of industrial organization a “buyer-led” commodity chain (Figure 4). The commodity chain worldview assumes that power and profit accrues to core firms located close to consumer markets.

In reality, however, the structure of relationships between firms is complexly contingent on a host of factors, including the costs of production in different places; worker productivity relative to wage levels; the uneven landscapes of global and national regulation; the fashion sensitivity of particular products (which determines the “turnaround” time of the product cycle); transport costs; geopolitical conditions; the relative locations of designers, textile inputs,
accessories, factories, and markets; and, importantly, the power relations among suppliers, intermediaries, and buyer firms. These factors tend to create a product-specific hierarchy in which less complex, high-volume garments are made in low-wage countries while low-volume, fashion-oriented garments are made closer to their final consumption market.

National and global trade regulations are an important influence on the configurations of global production systems. In the 1990s, the growth of regional trade agreements combined with the constraints of the MFA encouraged firms in the United States and European Union to create cross-border production arrangements in nearby low-wage sites. These were usually sites with preferential or unrestricted trade access to Western markets. Mexico’s maquiladora exports to the United States, for example, were facilitated by the North American Free Trade Agreement (NAFTA). This arrangement created markets for American-made fabrics and, thereby, protected American textiles jobs. In Europe, “outward processing” similarly links European brands and European-made textiles to clothing manufacturing sites in Turkey, Eastern Europe, and North Africa.

In recent years, commodity chain analysts have focused attention on the opportunities for less developed countries to upgrade their production capacities and move to higher-value-added activities by learning from their buyers. This view has stimulated research into the nature of the relationships among firms, especially the relationships between core buyer firms and their suppliers. In theory, core firms

Figure 2 Leading textile-exporting countries

in the textiles sector are able to choose where and how different tasks are performed. As buyers in a global industry that is overcrowded with sellers, they enjoy a significant bargaining advantage. In practice, however, firms’ options are limited. To ensure the timely supply of garments of the required quality, core firms tend to develop close relationships with reliable “preferred” suppliers. In recent years, the capacity of large retail firms to micromanage their suppliers has been enhanced by the standardization of accounting, auditing, and stock control technologies. These technologies have enabled large global retailers (such as Walmart and the Gap) to consolidate their relationships with their key suppliers and increase the range of tasks required of suppliers. These innovations tend to raise entry barriers and lock the less technically sophisticated producers out of global supply networks.

**Figure 3** Leading clothing-exporting countries


**Figure 4** The structure of global commodity chains

Labor Rights, Gender, and Business Ethics

The International Labor Office (ILO) has estimated that the sector’s worldwide workforce was about 30 million workers in 2000. About three quarters (72%) of these workers live in Asian countries. In high-wage nations, textile employment has fallen relentlessly since the 1970s, but it is still a major contributor to manufacturing employment.

The textiles sector has been an important source of employment for women, who often work in onerous circumstances and are consistently paid 20% to 30% less than men. Home-based work and work in small factories or “sweatshops” is commonplace even in high-wage locations. This work is often insecure or “precarious,” reflecting the intermittent nature of intermittent production. The sector has therefore featured prominently in studies of gender and development that highlight the hardships faced by women in these industries, as they negotiate the boundaries between waged and unwaged work and between workplaces and households.

The combination of globalized production structures and low wages place the textiles sector at the forefront of global labor rights campaigns. Activists informed by global commodity chain theories have successfully argued that Western buyer firms should be responsible for the labor conditions in their supplier factories. In response, the core buyer firms have introduced corporate social responsibility, corporate philanthropy and employment, and codes of practice that seek to protect their brand’s reputation by ensuring that suppliers comply with minimum labor standards. Activists claim that in practice, these voluntary codes are often ignored. However, in countries such as Australia, the codes of practice have been formally incorporated into clothing industry regulation.

Reworking the Labor Process

In the long distant past, whole garments were crafted by skilled dressmakers and tailors. In the factories that emerged after the popularization of sewing machines in the 1880s, production was segmented so that a worker might perform a single task, such as attaching collars or making buttonholes. Most of this labor was designed as women’s work. The vertical disintegration of the labor process increased the efficiency of production but deskill the clothing workforce and reinforced its gendered division of labor. Nonetheless, the range of styles, sizes, and colors required in clothing markets meant that clothing production was never standardized in the post–World War II Fordist mass production model.

During the 1970s, increasing competition from garments made in low-wage countries forced manufacturers in high-wage contexts to restructure their operations. Firms shifted toward less price-sensitive, niche markets and targeted higher-income consumers’ desire for variety, design excellence, and quality. Firms also aimed to offset the advantage of low-wage producers by increasing labor productivity, focusing on quick-turnaround fashion production and on reducing the time and distance between the conception of designs and the delivery of finished goods.

The inherent uncertainty of fashion-oriented markets encouraged manufacturing firms to adopt strategies variously known as “quick response,” “just-in-time,” or “lean” manufacturing. These involve a set of related innovations, including increasing the number of stock turns per year (equivalently, accelerating the circuit of capital), minimizing inventories, streamlining production to reduce labor costs, and increasing the productivity of individual workers (i.e., work intensification). New technologies of stock control such as Electronic Data Interchange (EDI, which links factories to retailers), computer-aided design, and computer-controlled laser cutting also increased productivity by eliminating many of the low-skilled jobs that once supported the core activity of sewing cloth. Because of this fragmentation, clothing production has come to be seen as exemplifying the numerical and task flexibility associated with post-Fordist production systems.

Reorienting to fashion production encouraged the development of small, specialized firms and altered the relationships among firms in vertically disintegrated supply chains. Modern
“fast-fashion” systems further accelerate the production cycle as their constant design innovations disconnect fashion from seasonal rhythms. Since fast fashion is organized around time imperatives, it encourages localized production “close” to target markets, brings retailers and manufacturers into close alliances, and promotes the integration of fashion-related manufacturing and service activities across multiple sectors.

In the 1980s, the specialized and flexible clothing production sectors of districts such as Emilio-Romagna in Northern Italy became the prototypes for a new paradigm of industrial production based on specialization, flexibility, and agglomeration. In this model of industrial organization, subcontracting strategies favor small, specialized establishments able to quickly adjust their production profiles to changing market trends. This format generates localized networks of highly specialized small firms with complementary expertise. External economies emerge as firms share innovation-promoting “ways-of-doing” knowledge and develop shared infrastructures, which encourages place-based agglomerations. Because firms gravitate to places that are able to supply their labor requirements—both highly skilled design workers and basic sewing machinists—clothing districts are found in the world’s richest cities, especially places with large immigrant communities such as New York and Los Angeles.

Fashion, Agglomeration, and Place

Because clothing and textiles adorn the body, the textiles sector is deeply linked to the worlds of fashion, consumption, and lifestyle. Rapidly changing fashion styles mean that clothing is increasingly regarded as a perishable commodity. In advanced capitalist economies, anticipating and shaping consumers’ fashion preferences is therefore an increasingly important aspect of clothing and textiles businesses. The crucial role of fashion in structuring the global production system exemplifies the increasing importance of symbolic knowledge in regional economic competitiveness. Within places, the cultural embeddedness and the design intensity of fashion promotes links among fashion-oriented industries, creating agglomerative tendencies that are increasingly associated with “creative city” and “cultural economy” discourses.

Conclusion

The textiles sector is characterized by international commodity flows but also features extensive spatial agglomeration. It appears that these globalizing and localizing forces are operating together in a mutually reinforcing way so that the industry is concentrating at the nodes in the global networks. As regulatory barriers are relaxed, the sector appears to be increasingly characterized by complexes of competing and cooperating agglomerations.

Sally A. Weller

See also Commodity Chains; Economic Geography; Export-Led Development; Export Processing Zones; Flexible Production; Globalization; Industrialization; Industrial Revolution; New International Division of Labor; Newly Industrializing Countries; Trade

Further Readings


Thales, born in Miletus, was a pre-Socratic Greek philosopher, the first natural philosopher who belonged to the Milesian school along with Anaximander and Anaximenes. Unfortunately, we do not have any of his writings; however, his importance in the field of geographic studies is due particularly to his views about the nature of Earth and his search for rational explanations through the observation of natural phenomena and avoidance of mythological beliefs.

According to Herodotus, Thales predicted the solar eclipse that occurred on May 28, 585 BC, but he is also said to have calculated the length of the seasons, the solstices, and the lunar phases; to have learned from sailors how to orient himself thanks to the stars (especially those belonging to the constellation Ursa Minor); to have conceived of diverting the Halys River (now called the Kizilirmak); and to have studied the yearly floods of the Nile, wrongly believing, however, that they were caused by seasonal winds.

In Egypt, Thales studied geometry and then introduced it to Greece. During his journeys through Egypt, where he visited the Nile delta, Thales observed the areas where water encounters land and elaborated a peculiar cosmological theory based on the idea that water is the origin (arche) of all things and that Earth rests on this substance. According to Aristotle, he may have found support for his idea in the fact that humidity can be found almost everywhere in the world and that moisture provides living beings with nourishment.

Regarding his idea of the shape of Earth, there are two schools of thought: Some commentators argue that he imagined a circular, flat, and thin world, whereas others support the theory that he believed that the planet was spherical. The explanation that he gave of a natural phenomenon such as earthquakes is strictly related to the theory of water as the fundamental principle of the world. In his opinion, in fact, lands fluctuate and shake because of the rough motion of the oceanic sprawl on which they float.

Susanna Servello

See also Anaximander; Aristotle; Herodotus; Human Geography, History of

Further Readings


Thermal Imagery

Imagery produced by the sensing of thermal energy emitted or reflected from the objects that are sensed is called thermal imagery. Thermal energy or thermal infrared radiation refers to electromagnetic waves in the 3.5- and 20-µm (micrometer) portion of the spectrum. Most thermal remote sensing applications make use of the 8- to 14-µm range. Earth’s surface and atmosphere radiate thermal energy outward owing to heating by solar irradiation and by Earth’s internal heat flow. By measuring and recording such emitted radiation in parts of the thermal region of the spectrum, sensors can produce very informative data (as imagery) that provide both distinctive signatures and/or indirect indications of properties of materials, which are sensed, such as vegetation, soil, rock, water, and people. Thermal imagery can be acquired by thermal remote sensing techniques.

Thermal Radiation Principle

Any objects on Earth’s surface and in the atmosphere at a temperature above absolute zero in
degrees Kelvin can emit thermal radiation due to kinetic energy of molecules within the objects. They are sources of thermal infrared radiation. The thermal radiation obeys Planck’s function, which describes the relationship between the object (blackbody) temperature and its spectral radiant exitance. A blackbody is an object that is a perfect emitter and absorber. Theoretically, two physical laws can be used to describe the behaviors of thermal radiation: the Stefan-Boltzmann law and Wien’s displacement law. The former is related to the Planck’s function and is used to calculate the maximum spectral radiant exitance with a known blackbody temperature, and the latter describes the relationship between the true temperature of a blackbody in degrees Kelvin and its peak spectral exitance or dominant wavelength. However, no objects in nature are true blackbodies, but rather are graybodies such as vegetation, soil, rock, and so on. Therefore, when applying the two physical laws to describe the thermal radiation, an emission efficiency factor called emissivity (ε) should be considered. The ε is generally a function of wavelength, and it is a factor that describes how efficiently an object radiates energy compared with a blackbody. When ε = 1, the object is a true blackbody. So ε for all graybodies is less than 1. When sensors record the thermal radiation emitted by objects, thermal infrared atmospheric transmittance has to be considered because of its absorption. Those wavelength regions that allow the major portion of thermal energy to pass through the atmosphere are called atmospheric windows. Currently, there are two major thermal infrared atmospheric windows that can be used for imaging thermal energy: (1) 3 to 5 μm and (2) 8 to 14 μm; especially the 8- to 14-μm window is used by most orbital thermal sensors.

Thermal Imagery Acquisition

Thermal imagery can be acquired by two types of remote sensing sensors: (1) across-track thermal scanners and (2) pushbroom linear and area-array charge-coupled device (CCD) detectors. The thermal scanner became commercially available during the late 1960s. It is an optical-electronic scanning system. Quantum or photo detectors are typically used for this purpose. These detectors are capable of very rapid response. They operate on the principle of direct interaction between photons of radiation incident on them and the energy levels of electrical charge carriers within the detector material. The
earlier models directly recoded thermal energy on the film to form an image. Newer systems record thermal data digitally. Both analog (film) and digital scanners measure and record temperature variation of an object in two dimensions. The modern scanning systems are capable of imaging temperature resolution on the order of 0.1 °C. An across-track thermal scanner image is a pictorial representation of detector response on a line-by-line basis.

So far, most thermal data were collected with a single detector and a scanning mirror as discussed above. It is now possible to make use of both linear and area-array (sometimes referred to as “staring” focal-plane arrays) CCD detectors for acquiring thermal imagery. Detector arrays comprising more than 1,024 × 1,024 elements are now available and provide low noise and state-of-the-art sensitivity for extremely low variation of object temperatures. The individual CCD detectors also operate on the same principle as a single detector working for the across-track thermal scanner. But due to the capability of CCD detectors to view the ground resolution element for a longer time, the thermal imagery has improved significantly in terms of both radiometric and geometric resolution.

**Thermal Imagery Application**

The prominent remote sensing platforms collecting thermal imagery include Landsat Thematic Mapper (TM) band 6 (120-m spatial resolution) and Enhanced TM Plus band 6 (60-m spatial resolution), Terra/Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) bands 31 and 32 (1-km [kilometer] spatial resolution), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) bands 9 to 14 (90-m spatial resolution), and National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) bands 4 and 5 (1-km spatial resolution). The prominent airborne platforms collecting thermal imagery include the Advanced Thermal and Land Applications Sensor (ATLAS) instrument flown on the NASA (National Aeronautics and Space Administration) Stennis Lear jet (ATLAS thermal bands 10–15) and the Itres, Canada, Thermal Airborne Broadband Imager (TABI). Thermal imagery has been successfully applied in diverse tasks such as determining the rock type and structure, locating geological faults, mapping soil type and moisture, detecting and mapping the extent of active wildfires, studying evapotranspiration from vegetation, detecting and mapping the extent and characteristics of thermal plumes in lakes and rivers, and determining urban heat islands.

**Ruiliang Pu**

See also Aerial Imagery: Interpretation; Atmospheric Remote Sensing; Image Interpretation; Remote Sensing; Remote Sensing: Platforms and Sensors; Remote Sensing in Disaster Response

**Further Readings**


**THORNTHWAITE, C. WARREN (1899–1963)**

Charles Warren Thornthwaite was one of the most influential climatologists of the 20th century. His work on the water balance concept remains a legacy today in environmental and scientific disciplines. Scientists used his water balance methods to depict regional climates and to solve environmental and geographical problems specifically related to agriculture and water balance. Thornthwaite realized that a more logical approach to the moisture factor in climate was needed. As a result, he developed the concept of potential evapotranspiration (PE)—evaporation and transpiration from a uniformly covered ground surface of vegetation that would be adequately supplied with water. Empirical relationships were developed to determine PE based on...
simple measures of air temperature and a latitude factor to adjust for day length and variables either measured at numerous weather stations worldwide or determined from Earth-sun relationships. Thus, PE, expressed as a depth measure, can be directly compared with precipitation to arrive at estimates of surplus and deficits for the soil-vegetative system and in hydrology to determine runoff.

Thornthwaite had a major impact on the field of climatology through his development of a rational classification of world climates based on water balance principles and the concept of PE. His career spanned several positions, from which he crafted ingenious applied analyses and contributions: Chief of the Climatic and Physiographic Division of the Soil Conservation Service in the Department of Agriculture, a consulting climatologist for Seabrook Farms in New Jersey, and an originator of a consulting company, C. W. Thornthwaite Associates. He also established the Laboratory of Climatology in Centerton, New Jersey. Thornthwaite was elected as the first president of the World Meteorological Organization’s Commission on Climatology in 1951. He received the prestigious Cullum Medal of the American Geographical Society and the Outstanding Achievement Award from the Association of American Geographers. In The Task Ahead, published in 1961, Thornthwaite provided young scholars with a vision of the task ahead in climatology—a vision valid to this day and one that included scientific grounding in energy and water budget theory and analyses. Last was his contribution to urban geography through his dissertation under Carl Sauer. Thornthwaite’s approach was a classic one in what was later to become a strong spatial tradition in the discipline.

Anthony J. Braze

See also Climatology; Physical Geography, History of

Further Readings


THREE-DIMENSIONAL DATA MODELS

Three-dimensional (3D) data models focus on portraying the third dimension of physical objects and phenomena through the integration of semantic, geometric, and spatial data relationships. Fundamentally, this is a perspective different from the static, 2D or bird’s-eye perspective on the world in traditional spatial data modeling. There are two approaches to modeling the third dimension in geographic information systems (GIS): (1) quasi-3D data modeling and (2) true 3D data modeling.

In the first approach of quasi-3D data modeling, a geographic phenomenon can be constructed as a surface in which a given geographic location is defined by a set of x and y coordinates, and a single value z can be assigned to this location. The value z can be elevation above sea level or any other abstract value associated with the represented phenomenon, for example, population density. In the elevation example, the displayed land surface in a model would be close to what we actually see in the real world (Figure 1). In the population density example, the height of the displayed surface would be the population density at a location at a particular time. This type of approach can efficiently handle 3D visualization through a number of ways, such as generating the surface from value z, draping raster images onto
THREE-DIMENSIONAL DATA MODELS

As this type of approach is insufficient to represent data with multiple \( z \) values, it cannot be regarded as true 3D data modeling. In addition, this approach is not capable of representing the space above, beneath, and between surfaces in data structure. It is therefore known as quasi-3D data modeling or 2.5D data modeling. Quasi-3D or 2.5D data models are not suitable for 3D solid objects that are continuously distributed in the 3D space, such as ore bodies. From another point of view, quasi-3D or 2.5D data models are mainly used for visualization purposes and cannot support full-3D data querying and analysis, which require geometric and topological relationships.

Given the limitations of conventional 2D and quasi-3D (or 2.5D) data models, a different approach is needed for true 3D data modeling. In true 3D data models, a geographic phenomenon can be constructed as a 3D object, such as a solid cube. Any point in space is specified by three locational values of an \( x \) coordinate, a \( y \) coordinate, and a \( z \) coordinate (e.g., height or depth) and one or multiple values related to the phenomenon, for example, different geological layers (Figure 2). It should be noted that in true 3D data models every pair of \( x \) and \( y \) coordinates with multiple \( z \) coordinates allows the presentation and manipulation of full information relevant to 3D solid objects.

For 3D data model design, topology is considered the most important concept. Topology can be specified as a set of rules that model how adjacent or neighboring spatial features connect and link to each other in spatial data models. These spatial features can be points, lines, polygons, surfaces, or bodies (volumes). Past studies have reported several 3D data models. For example, Carlson (1987) developed the simplicial complex, including 0-simplex, 1-simplex, and 3-simplex, to describe point, line, surface, and volume. Molenaar (1990) proposed a model of 3D Formal Data Structure, which contains nodes, arcs, edges, and faces to denote points, lines, surfaces, and bodies. Pilouk (1996) introduced the Tetrahedral Network (TEN) to model 3D objects with vague boundaries based on the 2D Triangular Irregular Network (TIN). Coors (2003) designed the Urban

Figure 1  Three-dimensional display of digital elevation model for the county of Greene, Missouri
Source: Author.
THREE-DIMENSIONAL DATA MODELS

Data Model, using planar convex faces to represent bodies and surfaces. Lee (2007) proposed the 3D Navigable Data Model, which is a network representation of building factoring pedestrian movements based on a 3D Geometric Network Data Model (GNM) that he developed. In the 3D GNM, a set of nodes denote 3D objects in primal space, and a set of edges denote the spatial relationships between 3D entities in primal space. These models adopted different ways to define topological relationships, that is, spatial relationships between spatial objects, such as intersection, connectivity, direction, containment, and adjacency. The clearly defined spatial relationships enable researchers to describe spatial objects with either heterogeneous or homogeneous properties, using different basic elements in their specific models. Moreover, the clearly defined spatial relationships provide a basis for data manipulation, data analysis, and other functionalities, such as computation-based queries, editing and examining specific objects, geometric calculation of volume, overlay, and buffering.

The potential application areas of 3D data models include environmental monitoring, geological and mining analysis, 3D urban mapping, disaster management, transportation planning, hydrological analysis, and military operations. For instance, a 3D geologic and seismic model may assist researchers in predicting the shaking

Figure 2  Three-dimensional geologic and seismic velocity model of the Santa Clara Valley area

levels of possible earthquakes. It is worth noting that visualization is the most common usage of 3D data models for practical applications.

The development of true-3D data models has been relatively slow. To date very few commercial software packages provide an analytical environment for true-3D data, and 3D functionality is absent. Three-dimensional functionality may include creating 3D objects, editing and organizing 3D data, querying 3D data, processing 3D data, and analyzing 3D data, including 3D data overlay, 3D data buffering, and 3D network routing. Research efforts are needed to extend the uses of 3D data models beyond visualization by resolving issues related to functionality. These issues may include the use of scalable information according to the problem needs instead of aggregated information, designing better data structures, spatial indexing and database management system (DBMS) that are suitable for 3D data representation and analysis, incorporating dynamic or real-time spatial-temporal data into 3D models for decision making and planning, and developing automated approaches to 3D model construction for large areas.

Xiaomin Qiu

See also Digital Terrain Model; Dynamic and Interactive Displays; Exploratory Spatial Data Analysis; GIS, Environmental Model Integration; GIScience; Land Use and Land Cover Mapping; Map Animation; Models and Modeling; Multitemporal Imaging; Spatial Data Models; Viewshed Analysis; Virtual and Immersive Environments; Virtual Globes

Further Readings


the reactor core to become partially uncovered and severely damaged. The major consequences of the accident unfolded over the next week, and it took 1 month to bring the reactor to a cold shutdown.

During the first several days of the accident, communications between the NRC and the site were problematic, which made it extremely difficult for the NRC to obtain up-to-date information from the plant and the utility. The suggestion by the NRC of a possible large-scale evacuation out to 20 mi. (miles) was quite different from the 5-mi. planning requirements imposed by the NRC and Pennsylvania before the accident.

On March 30, midmorning, Pennsylvania Governor Richard Thornburgh’s press secretary told reporters that there was no need for evacuation and that people in a 10-mi. vicinity of the plant could remain inside for a while. The only official warning to the public to evacuate came at approximately 12:30 p.m., when the governor advised pregnant women and preschool children to leave the area within a 5-mi. radius of TMI until further notice. He also ordered schools to close. The advisory to pregnant women and preschool children was lifted on April 9. The governor’s warning was the only official warning issued by the government. People in the vicinity of the plant were bombarded by media coverage, which suggested that a major evacuation was imminent. As a result, many people decided to evacuate despite the limited recommendation made by the governor. Approximately 144,000 people within a 15-mi. radius evacuated.

John Sorensen

See also Chernobyl Nuclear Accident; Natural Hazards and Risk Analysis; Nuclear Energy; Vulnerability, Risks, and Hazards
Nigel Thrift has long been recognized as one of geography’s most imaginative, articulate, and productive scholars. In an exceptionally lengthy series of papers and books, Thrift has made major contributions to the history of geographical thought; introduced a variety of new perspectives ranging from structuration theory to poststructuralist concerns for identity and performativity; advocated a renewed role for regions in geographical analysis; explicated the contingent, contradictory nature of globalization and its implications for regional development; and consistently argued for the centrality of human consciousness, however bounded, in the construction and reproduction of social and spatial relations.

Born in 1949, Thrift earned his PhD from the University of Bristol in 1979. He was stationed briefly in Leeds (1976–1977), spent 4 yrs. (years) (1979–1983) as a research fellow at the Australian National University, and served 3 yrs. (1984–1987) as a lecturer and reader at Saint David’s University College, Lampeter, Wales. In 1987, he returned to Bristol, where for more than two decades he was a professor in the School of Geographical Sciences. Between 2003 and 2006, he served as pro–vice chancellor for research at Oxford University. In 2006, he joined the University of Warwick in Coventry as vice chancellor.

Thrift’s career both reflected and spurred the enormous intellectual changes in human geography in the late 20th and early 21st centuries. Between 1975 and 2009, he authored or coauthored 110 refereed journal articles and 100 book chapters and wrote, edited, or coedited 39 books. His career began conventionally as an economic geographer with analyses of industrial linkages and markets and multinational corporations, originally focusing on the specific instance of Australia. This thread has continued in an ongoing form through a sustained interest in organizational theory, which maintained that the specifics of individual corporations were fundamental to the understanding of how markets behaved and changed. Throughout his works runs a nonstructuralist Marxist concern for class, a position that he later extended to a variety of non-class-based forms of social determination. Thrift’s worldview takes seriously the complex conditions under which human beings take the world for granted and give meaning to it.

Thrift exhibited a sustained interest in questions of time. No longer could geographers be content with the static geometries of chorology and positivism; social theory had become self-consciously dynamic, portraying every place as a time and integrating into spatial analysis an understanding of how time was socially constructed and, thus, experienced differently under varying historical and spatial circumstances. This work exhibited strong linkages to time-geography, which concerned itself with the movements of individual bodies through the rhythms of everyday life. Thrift also studied the restructuring of time consciousness in contexts ranging from the medieval to the contemporary, including in particular the imperatives of commodity production and capital accumulation. Thrift also played a key role in introducing Giddens’s concept of structuration into geography. His paper, “On the Determination of Social Action in Space and Time,” published in 1983, was a landmark that both situated structuration theory within the broader intellectual context of “micro-macro” divisions in the social sciences and pointed toward the emerging reconstruction of regional geography.

In the 1990s, Thrift played an influential role in moving geography to new frontiers of poststructuralism, including a variety of concerns with subjectivity, language, representation, discourse, and identity. Although he has never referred to himself as a postmodernist, his theoretical orientations include similar qualities, such as a distrust of broad metatheories, an appreciation for local uniqueness, and an emphasis on social structures and change as inherently opened-ended and contingent.
Throughout his career, Thrift has been fascinated by cities as dense nuclei of economic and social transactions, the changing possibilities for economic development afforded by globalization, and the mutations in urban form and life that such transformations entailed. Cities, particularly in the knowledge-driven economies of “soft capitalism,” both reflect and constitute the changing dynamics of social life as contingent constellations of meaning.

If there is any theme that permeates Thrift’s multitudinous works, perhaps it is his sustained interest in connectivity of one sort or another. His papers addressed the relations among bodies and individuals, the diffusion of information, the reciprocal relations between knowledge and power, and the increasingly globalized exchanges of human, symbolic, and financial capital. Thus, he exhibits a consistent concern for the flows of information and knowledge that shape individuals’ conceptions of themselves and one another and that play a major role in the routinized reproduction of social relations. Such linkages reflect and constitute the changing face of capitalism at a variety of spatial scales, ranging from the most intimate and local (e.g., the body) to the international and global.

Thrift’s concern with the differential regional effects of globalization was materialized in a variety of case studies. He has worked extensively on the restructuring of the British space-economy in the face of globalization and mounting social and regional polarization, including the rise of the Greater London region and the nature and impacts of various services such as accounting, property and real estate, and surveying. He also examined other European regions in various contexts, including the rising role of dense human networks in leading innovative regions characteristic of advanced post-Fordist production systems. Thrift also worked extensively on Pacific Asia, particularly Vietnam. These empirical analyses complemented his insistence that regions mattered not only ontologically, that is, as units of empirical analysis, but also epistemologically—that is, no social process was manifested in the same way in different places.

The latter line of thought appealed to geographers who insisted that local uniqueness mattered, many of whom sought to recover regions from the dustbin of traditional chorology. Throughout the 1980s, the “new regional geography” developed growing linkages to top-down global political economy and to “bottom-up” concerns for living actors and everyday life. Thrift played a key role in articulating this vision of geography, defending it against both positivist and Marxist critics, for whom regional analysis could, by definition, amount to little more than reconstituted empiricism. Unlike chorology, however, the reconstituted regionalism was both theoretically informed and paid great attention to the connections among regions, their linkages to the global division of labor, and the sticky issue of the production of spatial scale. The new regionalism made local uniqueness a valid object of scholarly scrutiny, demonstrating that the local mattered in ways that broad models could never discover and that no social process played out exactly in the same way in different time-space contexts. The recovery of regions for social theory obligated the discipline to delve into the intricate dynamics of the local actors who populated them and “made them work”: Thus, the localities school and structuration theory’s focus on everyday life were mutually complementary. This concern with the local extended to his work on the most abstract and globalized of economic sectors, finance.

With Andrew Leyshon, Thrift generated a series of works concerning the international financial system, British financial capital, and banking networks in London. These papers both elucidated the impacts of electronic money and national deregulation and simultaneously demystified money by stressing the key roles played by interpersonal relations predicated on trust and face-to-face contact, including the critical but often overlooked roles played by local milieu, trust, and “institutional thickness,” that is, the cultural context in which financial transactions are always and everywhere embedded. Money, even in its most rarified electronic form, is thus much more than an abstract economic relation, for its real power lies in its symbolic value and links to national and global distributions of social power. Like all social relations, financial systems are inevitably discursively constituted through particular social-cultural practices in different times and places. Such an approach brought a badly needed human quality to a topic dominated
by ethereal understandings devoid of actors and is vital if the new forms of “soft” managerial capitalism are to be understood in all their complexity. Thrift’s writings reveal an understanding that the contemporary forms of capitalism, dominated as they are by finance and information, simultaneously reflect the historic tendency toward increasing commodification of all activities as well as the emergence of a historically unprecedented form of production and consumption, a perspective that eludes the naive optimism and technological determinism of postindustrial theory. The “symbolic economy” calls for new forms of performativity for actors for it to function successfully.

Thrift has exhibited broader concerns for the implications on individual subjectivity of information technology and electronic communications, which are representative of the post-Fordist, digitized “soft capitalism” and its attendant digitized, virtual dimensions. The massive time-space compression unleashed by digital globalization has thus altered the field of possibilities for both nation-states and individual actors in everyday life: The renewed regionalism and reconstituted rhythms of daily life are two sides of one coin. At the level of the corporation and everyday life, Thrift has also taken an interest in the possibilities extended by the widespread use of computational technology and mobile telecommunications. In sum, the contingent, simultaneously determinant interactions between culture and technology form a recurrent theme that runs through his writing.

Thrift has long insisted that geographies are produced by people in prediscursive, practical ways, and he has been one of the discipline’s foremost advocates of theoretical stances that emphasize the contingency of human action. This position stands as a hallmark of the contemporary “cultural turn” in the social sciences, which has led numerous researchers to embed economies in social relations, blurring the artificial distinctions between the “economic,” the “cultural,” the “social,” and the “political.” More broadly, the profound role played by systems of signification, including discourses, language, texts, and representations of all kinds, has led him to forge a nonrepresentational theory of action that stresses performative embodied knowledges; more recently, he became a leading advocate of nonrepresentational theory. Yet this relational materialist perspective maintains that the global “space of flows” does not float in a disembodied space: Rather, global flows and connections are constructed by human beings who are always embedded in networks of power and knowledge that are themselves part of an ever-changing structural context. Invoking actor-network theory, Thrift effectively abandons the distinction between agents and structures. This view focuses on the exercise of power by actors rather than just the embeddedness of power in networks. Throughout his career, Thrift has worked assiduously to portray geographies as embodied, embedded, contingent, and ever changing, harnessing the fluidity of spatial relations to demonstrate how they are imbricated in changing human relations of power.

Barney Warf

See also Actor-Network Theory; Finance, Geography of; Nonrepresentational Theory; Postmodernism; Pred, Allan; Structuration Theory; Time-Geography

Further Readings


Thunderstorms are convection storms comprising cumulonimbus clouds that are accompanied by lightning and thunder and moderate to heavy precipitation. Additional attributes may include strong winds, hail, and/or tornadoes. In terms of the hierarchy of atmospheric scales of motion, thunderstorms are classified as mesoscale systems, the second smallest after microscale systems. Mesoscale systems have a typical life span of 1 hr. (hour) or more and range in size from a few kilometers to 100 km (kilometers) in diameter. Based on system duration, structure, and formation, thunderstorms are classified as ordinary cell, multicell, or supercell and may or may not be considered severe.

Also known as air mass thunderstorms, ordinary cell thunderstorms have the simplest structure and formation conditions of the three major thunderstorm categories. These storms materialize within warm, humid, and unstable air mass environments amid often weak vertical wind shear (i.e., wind speed and direction do not change greatly with height). Ordinary cell thunderstorms are usually compact (<1 km in width), nonsevere, and not associated with mechanical lifting mechanisms (e.g., frontal uplift). Ordinary cell thunderstorms typically undergo a three-stage sequence of development: cumulus, mature, and dissipating. The cumulus stage is characterized by rising air parcels or thermals that result from differential surface heating. Updrafts dominate this growth stage, and lightning and thunder are absent. As the cloud particles enlarge and become heavier, the updrafts may not be sufficiently strong enough to sustain their suspension, and the cloud particles begin to fall as precipitation. The manifestation of a precipitation downdraft ushers in the mature stage, the most intense phase typified by strong updrafts and downdrafts, heavy precipitation, lightning and thunder, and gusty surface winds.

The air mass thunderstorm begins to dissipate as the warm, humid air source inflow supplying the thunderstorm’s energy is suppressed by the precipitation downdraft. The final stage is marked by light precipitation, weak downdrafts, and cloud evaporation. Since the entire development cycle may be completed in less than 1 hr., these scattered storms may be referred to as “popup showers,” for their ability to mature and disperse quickly. Of the approximately 50,000 thunderstorms that occur each day across the world, most are of this ordinary cell variety.

Multicell thunderstorms contain several ordinary thunderstorm cells under various development stages, appearing as a continuous, long-lasting storm. A single thunderstorm cell may initiate new cell development or “daughter cells” along the precipitation outflow boundaries (known as gust fronts) and form a larger cluster of thunderstorms. If the thunderstorms align linearly, this configuration is known as a squall line. Not all squall lines, however, are formed along gust fronts. Frontal and prefrontal squall lines are longer lasting than their ordinary squall line counterparts and are frequently associated with severe weather. Fast-moving squall lines may also produce especially enduring and widespread wind storms called derechos, which can produce wind speeds in excess of 100 mph (miles per hour).

Instead of a linear configuration, multicells may also cluster and expand over an extensive
Approaching thunderstorm with lead gust front. Rain-cooled air from the storm moves out ahead of the storm. It ploughs under the warm moist air, forming a flat “shelf cloud.”


region and intensify. Mesoscale Convective Complexes (MCCs) are long-lasting (>12 hrs. or more), nocturnal multicell storm systems that develop in high-moisture environments with weak vertical wind shear, a situation common during the midlatitude summer on the tropics. These slow-moving storms are thousands of times larger than ordinary cell thunderstorms and can produce copious amounts of precipitation. In the maritime tropics, a concentrated thunderstorm cluster around a rotation center may signify the potential for hurricane development.

Supercells are the most intense, most destructive, and rarest thunderstorm type. These storms appear as large isolated cells often ahead of an approaching squall line and can produce large hail, heavy precipitation, and/or tornadoes. In contrast to multicell thunderstorms, supercells are differentiated by a deep, continuously rotating updraft or mesocyclone tilted away from the primary precipitation downdraft region. This tilted updraft structure enables the continued inflow of moist, humid air into the storm even after precipitation commences, thereby sustaining the latent heat energy supply and enabling the storm to continue for several hours. Supercells may be categorized into three main types, classic, low precipitation, or high precipitation, depending on the updraft and downdraft configuration. Environments with strong contrasts in temperature, moisture, and vertical wind shear support supercell development. These ambient conditions are most commonly found in the North American Great Plains region in spring and early summer; however, supercells are also known to occur occasionally in other midlatitude locations across the world.

The global distribution of thunderstorms is linked to the proximity of maritime tropical air
mass source regions that support prolonged uplift and warmth, conditions largely found in the tropics. In particular, locations in the vicinity of the Intertropical Convergence Zone (ITCZ) are areas repeatedly favored for deep convection. Resulting from the surface convergence of the northeast and southeast trade winds, the ITCZ initiates widespread thunderstorm development in the equatorial region and also in the extratropics depending on its movement relative to the changes in solar intensity. The seasonal migration of the ITCZ creates distinct wet and dry periods in the tropics, but commonly more than 200 days per year are associated with thunderstorm occurrence in regions around Central Africa, Northern South America, and Indonesia/Northern Australia. In East Asia, the ITCZ migration is linked to the monsoonal circulation, referring to a seasonal reversal in wind direction that during summer promotes the inland movement of unstable, warm humid air into the continent.

Thunderstorm activity is also prominent in the midlatitudes, especially in locations that promote air mass interaction. In the conterminous United States, the highest average annual frequency of thunderstorm days (>100 days) occurs in the central Floridian peninsula primarily due to regional sea breeze convergence during the late spring and summer months; a secondary maximum along the Eastern Colorado Rockies occurs as a consequence of summertime convection and leeside cyclogenesis. Although not common, thunderstorms do appear occasionally in high-latitude locations (e.g., Northern Canada) during the warm season if sufficient moisture and an uplifting mechanism are present.

Jill S. M. Coleman

See also Air Masses; Derechos; Fronts; Lightning; Precipitation Formation; Tornadoes

Further Readings


THÜNEN MODEL

One of the first and most influential conceptions of relative location was proposed by Johann von Thünen (1780–1850), a German estate owner interested in economic theory and local agricultural conditions. From his experiences as an estate manager, he observed that identical plots of land would be used for different purposes depending on their accessibility to the market. His book *The Isolated State*, published in 1826, proposed one of the very first models in economic geography. von Thünen’s aim was to uncover the laws that govern the interactions of agricultural prices, transport costs, and land uses as landlords sought to maximize their profits.

The concept of economic rent, also called location rent, a relative measure of the advantage of one parcel of land over another, is central to von Thünen’s model of agricultural land use. Differential rents may result from variances in productivity of different parcels of land and/or variances in the distance from the market. von Thünen demonstrated that rent is the price of accessibility to the market. In other words, rents decline with the distance from a market center because transport costs rise accordingly.

To explain agricultural land use, von Thünen described an idealized agricultural region about which he made certain assumptions. He envisioned an isolated state with a large city serving as the only market. A uniform plain surrounded the city. There were no extraneous disturbances in this idealized landscape; social classes and government intervention were absent. The cost of transport to the central town increased at a rate proportional to the distance. He concluded that near the town will be grown those products that are heavy or bulky in relation to their value and that are consequently so expensive to transport.
that the remoter districts are unable to supply them. With increasing distance from the town, the land will progressively be given over to products that are cheap to transport in relation to their value. Farmers near the central market pay lower transport costs than farmers at the margin of production. Farmers recognize this condition, and they know that it is in their best interest to bid up the amount that they will pay for agricultural land closer to the market. Bidding continues until bid rent equals location rent. At that price, farmers recover production and transport costs, and landowners receive location rents as payments for their land. Competitive bidding for desirable locations cancels income differentials attributable to accessibility. The bid rent, or the trade-off of rent levels with transport costs, declines just far enough from the market to cover the additional transport costs; hence, farmers are indifferent to their distance from the market.

Location rent for any crop can be calculated by using the following formula:

\[ R_k = e(p - a) - efk, \]

where

- \( R_k \) = location rent per unit of land at distance \( k \),
- \( e \) = output per unit of land,
- \( p \) = market price per unit of output,
- \( a \) = production cost per unit of product (including labor), and
- \( f \) = transport rate per unit of distance per unit of output.

When the rent gradient is rotated around the market town, it becomes a rent cone, the base of which indicates the extensive margin of cultivation for a single crop grown at a single intensity.

---

**Figure 1** The von Thünen model’s bid-rent lines and associated land uses. Given that transport costs erode profits with distance from the market, the Thünen model describes a simplified agricultural system in which land uses change according to prices and transport costs.

*Source:* Adapted from Wikimedia Commons.
Concentric rings or belts will form around the town, each with its own particular staple product. From ring to ring, the staple product will change.

von Thünen was acutely aware that many conflicting factors—physical, technical, cultural, historical, and political—would modify the concentric patterns of agricultural land use. He modified some of his initial assumptions—equal transportation costs in all directions, for example—to approximate actual conditions more closely. Although he retracted the condition of a single-market town, he did not elaborate on the effects of several competing markets and a system of radiating highways. We can presume, however, that the tributary areas of competing markets would have a variety of crop zones enveloped by those of the principal market town and that a radiating highway system would have produced a “starfish” pattern.

*Barney Warf*

**Further Readings**


**Timber Plantations**

There are approximately 140 million ha (hectares) of tree plantations worldwide, of which 78% are classified as “productive” and are used primarily for wood and fiber production, while 22% are “protective” and are established primarily for soil and water conservation. The extent of both types of plantations has grown over the past two decades, with productive plantations increasing by approximately 2.2 million ha/yr. (per year) and protective plantations increasing by 380,000 ha/yr. between 1990 and 2005. In both types of plantations, pines are the most commonly planted species. Where tree plantations have been established, they have created both benefits and negative consequences, with the balance varying from one location to another.

**Benefits**

While tree plantations constitute only 3.5% of the world’s forested area, they are approaching 50% of global wood production. In addition to timber production, tree plantations are an important source of fuelwood in many parts of the world and can provide income from the sale of nontimber forest products (NTFPs) harvested from plantations. While NTFPs account for a much smaller portion of the revenue from plantations than timber, they can be locally important. For example, in the Ecuadorian Andes, an edible mushroom that grows in association with planted pines is harvested and provides an additional source of income. In recent decades, tree plantations have also been valued for their ability to sequester carbon in tree biomass, thereby playing a role in decreasing atmospheric carbon dioxide concentrations. In some cases, tree plantations can also sequester carbon in the soils where they grow. However, this depends largely on the land use prior to plantation: When plantations are established on croplands, soil carbon generally increases, while conversion of pastures or native forests to plantations generally causes a loss of soil carbon.

**Costs**

Although tree plantations can provide many benefits, there is increasing evidence that they can also cause the deterioration of ecosystem services, in particular water provision. Plantation establishment can decrease stream flow and groundwater recharge, cause acidification of stream...
water and soils, and produce soil salinization. In many parts of the world, timber plantations have caused additional problems where the exotic species used have become invasive. The invasive spread of commercial plantation species has been recognized as a major threat to native biodiversity in South Africa, New Zealand, Australia, South America, and Hawaii.

**Conclusion**

The balance between the benefits and costs of tree plantations depends largely on the location in which they are planted. In particular, the type of soils, hydrology, and prior land use, as well as the condition of the landscape prior to plantation establishment, play an important role, as do the kinds of species used and the way in which the plantations are managed. The degree to which tree plantations can be considered a land use that contributes to environmental sustainability depends on how they influence the provision of ecosystem goods and services, including not only timber and fuelwood but also carbon, water, and biodiversity.

*Kathleen A. Farley and Leah Bremer*

See also Carbon Cycle; Environmental Services; Forest Land Use; Plantations; Sustainable Forestry; Tree Farming; Woodfuel
The fast pace of modern life and the complex uncertainties of environmental change have led both human and physical geographers to question their understanding of time. Since the 1960s, there has been a significant shift away from chronological, linear conceptions of time toward understandings that examine it as nonlinear and chaotic, something experienced as dynamic and interconnected with different spaces and places. An increasing range of conceptions and debates is emerging under the heading “geographies of time.” Of particular interest from a human geography perspective are ideas concerning social time, such as geographies of rhythms and lived time, which explore people’s everyday experiences of time. Critically, scholars are increasingly debating whether time should still be conceived independently from space, a dualism prominent throughout geography.

**Social Time: The Geographies of Rhythms**

Social time essentially focuses on social content, recognizing that the way in which people experience time is dictated by a range of social processes. Jon May and Nigel Thrift provide a comprehensive discussion of social time, identifying four domains that interact to produce people’s experience or sense of time. These domains invoke a way of interpreting experiences through considering the rhythms they generate. Rhythm is used in its widest sense to identify anything from a repetitive process to a recurrent pattern. Anne Buttimer provides an in-depth discussion of time-space rhythms, emphasizing the complex interactions of people’s sensations and representations of time and space.

The first domain considers the variety of cycles and timetables people are subject to, some of which are fixed, such as tidal movements, while others are relatively applied, for example, a woman’s menstrual cycle. Most, however, are constantly under negotiation; take, for instance, the socially constructed pressure of shift work, which requires people to adjust their circadian rhythms to fit in with factory hours or differing time zones in order to meet the demands of the job.

The second domain relates to the regulation or demarcation of time for specific activities. For example, in many Western societies, the prescribed Monday to Friday working week is closely monitored by time sheets and surveillance mechanisms, while the weekend is often equated with family or leisure time. When either time interferes with the other, for instance, taking work home, these norms are broken, disrupting the regulation of social time and demonstrating the combination of forced and voluntary rhythms that make up daily life.

The third domain involves the increasing array of tools and technologies designed to expressly monitor, inform, or direct how people allocate time. Many of these have been around for millennia, from the calendar to various forms of the clock, both of which reinforce the sensation of time moving forward in a linear fashion. The advent of mass transportation and communications led to what is termed the standardization of time, as clock time became uniform the world over. These technologies are often described as leading to time-space compression, perpetuating the perception of an increased pace of life. They often dictate rhythms of particular representations associated with saving time, or being more productive with the time available.

The final domain relates to the influence of particular texts in demarcating what should be done at particular times of the day, year, and so on. From the Julian calendar of AD 1020, which dictated everything from when to pray to when to plough, to Benjamin Spock’s *Common Sense Book of Baby and Child Care* (1946), which...
told mothers when to feed and put their children to bed, there has been a proliferation of texts advising people of a particular geography of rhythms around the appropriate time to perform different tasks.

**Lived Time**

Modern information and communication technologies are proliferating people's capabilities within the moment through instant real-time interactions. Geography is now turning its attention to understanding this and conceptualizing the present or lived time. Many commentators identify the way time has been turned into a product that can be bought and sold, often called the commodification of time. There is a debate around both how to express the present and to what degree it is influenced by past experiences and future intentions. Attention is turning to how individuals perform or what they choose to do in any particular moment, given a world that is transitory and full of multiple possibilities of action.

**Time-Space**

Human geographers are increasingly arguing that time and space need to be conceptualized interdependently, raising the question of whether there should be an entry dedicated purely to the geographies of time. Doreen Massey argues that this interdependence does not signal the removal of the differences between the two dimensions and that they still require defining but not in the dualistic sense of space not being time and vice versa. Social time, geographies of rhythms, and lived time are all implicitly spatial, as how time is experienced depends on the spaces and places in which the experience is lived. In today’s world, there is a much more complex restructuring occurring than simply the acceleration of life and collapse of space, and geography’s constantly evolving dialogue on time and space puts it in a strong position to begin critically analyzing this process.

*Phillippa Marlis Mitchell*

See also Everyday Life, Geography and; Thrift, Nigel; Time-Geography; Time-Space Compression

**Further Readings**


**TIME-GEOGRAPHY**

Time-geography refers to a set of concepts and a way of thinking that offer a notational system to describe and analyze individuals’ and populations’ existence, coexistence, constraints, and conflicts in time-space. The time-geographic approach was originally presented in the late 1960s by Torsten Hägerstrand, a well-known professor of human geography at Lund University, Sweden. Time-geography captures complex processes of change on different scales in time and space and is therefore useful for analyzing various topics and problems.

The time-geographic lines of thought are directly linked to Hägerstrand’s experiences as the son of an elementary schoolteacher who sought to impart “knowledge about their home district.” Hägerstrand found the prevailing academic thinking, which grouped phenomena according to their degree of similarity, to be deficient; his alternative approach was to group phenomena according to their proximity in time and space.

The theoretical roots of time-geography are found in Hägerstrand’s thorough empirical fieldwork in Asby parish in Southern Sweden. He and his wife spent several summers biking there searching for houses (or their remains) abandoned by emigrants to the United States during the 19th century. Then, the dominant understanding...
among researchers was that each empty house had been the home of an emigrant family. The Asby fieldwork made Hägerstrand question this view, since the resource base surrounding the empty houses was too poor for subsistence—much less for buying a ticket to America. By studying the population in the Asby parish books, individual by individual, he concluded that the emigrant families were those that were relatively well-off but still too poor to find in Asby a place better than their American dream. They sold their houses, and a chain of movements started, with poorer families moving from low-income houses to better ones. As a result, farms that operated under the subsistence level were left empty. Following the individual inhabitants of the houses was the only way to find out who left which house for a better life in America. Houses and people come in many different kinds, but they must be considered together to reevaluate the dominating theory.

In time-geography, the two dimensions of time and space (place, region) are united into a time-space in which processes involving different phenomena can be discerned, irrespective of whether such phenomena are living or nonliving. Each individual is born or created at some point in time, exists during a time period, and dies. This process describes a time-space biography of an individual human being, but since time-geography also includes nonliving phenomena, the more general concept of individual path (trajectory) is introduced. Individuals of the same bounded region (time-space) constitute a population. A bounded region can be defined at different scales: the globe as a whole, a continent, a country, or any locality on the globe. In each region in time-space, individuals (from one or more populations) get in touch with other individuals, and when they move (or are moved), they decouple from one bundle of individuals with whom they were in touch and couple with another bundle. Time-geography facilitates analysis of opportunities for individuals to get in touch with one another and of the constraints on and consequences of such coupling, and it provides tools for dynamic life cycle analysis. For example, environmental problems may be described by the extraction (decoupling) of raw materials in a region and their transportation to a place where they are manufactured (put into new combinations). Manufacturing is performed at a place by labor, using tools and machines according to procedures that steer the work process, constituting a pocket of local order. Then the product is decoupled from the manufacturing location, transported, and sold. Through the sale, the output is coupled with the customer, who uses the product for reaching the goals of his or her projects. Eventually, the output is worn out, decoupled from the customer, and put in touch with other worn-out individual products at a waste collection center or maybe recycled.

Human individuals performing activities in their projects meet three types of constraints: (1) coupling constraints (they must be able to get in touch with another individual at a specific location in time-space in order to fulfill their obligations; e.g., parents have to get their children from day care in the afternoon); (2) capability constraints (knowledge, skills, and tools available); and (3) authority constraints (regulations, laws, and power relations in social bundles). All these shape the individual’s trajectory through time and space in the rhythms of everyday life. Opportunities for individuals to get in touch with one another are revealed by their time-space prisms. Individuals whose time-space constraints prohibit their prisms from intersecting are never afforded the opportunity to meet in person. Geographers such as Alan Pred used this model to describe regional systems of social and economic activity, in which the composite trajectories of individuals reproduce larger social structures in time and space. Time-geography thus became a means of representing and analyzing how social relations were manifested through everyday life in all its temporal and spatial boundedness. Critics of time-geography often argued that it lacked a sufficient account of power and social relations, as well as an adequate theory of human subjectivity.

The time-geographic approach is sometimes taken to be synonymous with its notational system. The notational system is a way of describing the concepts of time-geography, and it is the outcome of Hägerstrand’s struggle with the shortcomings of common language to explain his thinking. The notational system is simple and powerful. It can be applied to show how individuals from different populations are born/produced, couple, decouple, move, stay at a
place, and die/are destroyed—in short, the elementary occurrences in an individual’s life.

Time-geography is used for researching environmental problems, energy use, virtual and physical mobility/communication, migration studies, time-use studies, and people’s rhythms in daily life. Hägerstrand’s time-geography includes the basic principles behind the development of geographic information systems and was influential in the formulation of structuration theory.

Kajsa Ellegård

See also Behavioral Geography; Everyday Life, Geography and; Hägerstrand, Torsten; Kwan, Mei-Po; Pred, Allan; Structuration Theory; Thrift, Nigel; Time, Geographies of
TIME-SPACE COMPRESSION

If geography is largely concerned with how human beings are differentially located over the Earth’s surface, a vital part of that process is how we know and feel about space and time. Although space and time appear as “natural” and outside of society, they are in fact social constructions; every society develops different ways of dealing with and perceiving them. Time and space are thus socially created, plastic, mutable institutions that profoundly shape individual perceptions and social relations. The sociologist Anthony Giddens uses the term *distanciation* to describe how societies are stretched over time and space and how this process itself varies temporally and geographically. Because the economy cannot be detached from other realms of social life, time-space compression is more than simply an economic phenomenon. By changing the time-space prisms of daily life—how people use their time and space, the constraints they face, the meanings they attach to them—time-space compression is simultaneously cultural, social, political, and psychological in nature. This issue elevates the analytical significance of relative space, in which distances are measured through the changing metrics of time and cost, above that of absolute space, the traditional Cartesian form that characterized most Enlightenment forms of geography, which portrayed distance in fixed, unchanging terms devoid of social roots.

The Concept of Time-Space Compression

Time-space compression involves the myriad ways in which human beings have attempted to conquer space, to cross distances more rapidly, and to exchange goods and information more efficiently. The analysis of time-space compression places emphasis on the connections and interactions among places (and the people who live within them, for connections are always embodied) rather than on individual places per se. For example, in the simplest sense, using the maximum transportation speed at various historical moments as a measure, the world became 60 times smaller between 1500 and 1970, when we compare the speed of airplanes (say, 600 mph [miles per hour]) with that of medieval sailing vessels (10 mph) (Figure 1). By increasing the velocities of people, goods, and information, the world is made to feel smaller even as interactions are stretched over larger physical distances. The term *compression* is therefore misleading: Every round of time-space compression involves an expansion in the geographic scale of social activities. This idea is often taken to mean that space ceases to have relevance. Despite the fashionable use of unfortunate expressions such as the “death of distance” or the “annihilation of space,” the fact remains that geography is a stubbornly persistent feature of human life. Rather than the “annihilation of space,” it is healthier to talk of how one space-time regime displaces another. Far from shrinking the world evenly, successive revolutions in the structure of time and space have left it misshapen, as some places were brought together relationally more than others. Moreover, reducing time-space compression to simple reductions in transport times fails to do justice to its deeply phenomenological dimensions and the complexity with which these two dimensions

Further Readings

Figure 1  Time-space compression reflects and generates a shrinking world. Historically, rising velocities of transportation have reduced relative distances across the globe.

Source: Author.

are wrapped up in social life and their political and ideological origins and associations.

Time-space compression occurs at multiple spatial and temporal scales, all of which interact with one another, including long-distance networks of trade that historically sutured cities, empires, and, later, nation-states together into interactive wholes; political formations in which the state integrated diverse peoples and places under a single authority, often through tribute, taxes, or conscription; and the ideological and psychological dimensions of how ideologies perceive and represent Others, the discursive and symbolic representations of foreign or distant places that define community, identity, and the here and now. This process, of course, depends heavily on the relative and differential abilities of social formations to link places together or, in an older nomenclature, to conquer the “friction of distance.” Whenever the consequences of actions in one area spill over into others, time-space compression is at work. Whenever new networks of trade or migration appear, tying together places through flows of commodities and innovation, time-space compression can be detected; whenever a new
medium, communication technology, or widespread ideology, whether it be the book or a religion or the Web, brings together subjects into epistemic communities bound together over vast distances, time-space compression is in the making; whenever the spatial scale of social relations expands, such as from the city to the nation-state or from states to empires, time-space compression is evident; whenever new technologies expand the conceptual horizons of people or social institutions bind them together in a novel manner (such as “citizenship”), time-space compression occurs; whenever the division of labor collapses people into dense wads of humanity, such as the city or the factory, time-space compression can be detected. One way to approach time-space compression is by looking at how external shocks to a society—diseases, invasions, technological innovations, wars—reverberate through local social relations of class, gender, and ethnicity to change inhabitants’ views of time and space and their fabric of daily life. Conversely, locally generated changes may scale-jump to become regional, national, or global in scope. Time-space compression can be studied by examining the changes in daily life that ensued as new technologies, cultures, and forms of social cohesion were introduced and older ones concomitantly annihilated.

The Evolution of Time-Space Compression

Time-space compression is as old as human civilization itself. Early changes in transportation technology, such as the wheel and keel, were instrumental in the development of centralized empires. Many cultures (e.g., the Romans) developed road or canal networks to shuttle people and goods between places. The Mongols and the Incas created messenger systems using horse riders and runners, respectively. The Renaissance and the Enlightenment exemplified the intellectual changes of early modern time-space compression, including the Copernican revolution and perspectival painting. Printing greatly enhanced the distanciation of social intercourse, allowing widespread contacts and diffusion of ideas without face-to-face contact. These changes were important moments in the scalar jump from the city-state to the nation-state, the most important social and political unit of the modern era, homogenizing local cultures and economies by incorporating them within even larger units of social and political control.

The rise of capitalism, and the Industrial Revolution in particular, generated enormous improvements in transportation and communications that significantly reduced travel times between places. For example, the travel time between Edinburgh and London, a distance of 640 kilometers, was roughly 2,000 min. (minutes) by stagecoach in 1658. By the 1850s, with the arrival of the steam locomotive, travel time had been reduced by two thirds, to 800 min. In 1988, the rail journey between Edinburgh and London took 275 min. When the line was electrified in 1995, travel time was reduced to less than 180 min. By airplane, it takes less than 60 min. today. Thus, while the absolute distance between the two places remained the same, the relative distance was reduced by 1,940 min. over 350 yrs. (years), or roughly 5 min./yr.

Air transportation provides spectacular examples of time-space convergence. In the 1930s, it took a plane between 15 and 17 hrs. (hours) to fly over the United States from coast to coast; modern jets now cross the continent in about 5 hrs. In 1934, planes took 12 days to fly between London and Brisbane, Australia; today the Boeing 747 is capable of flying any commercially practicable route nonstop. The result is that any place on Earth is within less than 24 hrs. of any other place, using the most direct route.

Closely related to time-space compression is cost-space compression, the steady reduction in the cost of moving goods, people, or information between places. For example, the opening of the Erie Canal in 1825 reduced the cost of transport between Buffalo and Albany from $100 to $10 and, ultimately, to $3 per ton. Railroad freight rates in the United States dropped 41% between 1882 and 1900. Between the 1870s and 1950s, improvements in the efficiency of ships reduced the real cost of ocean transport by about 60%. Within the discipline of geography, time-space compression was first theorized in terms of the friction of distance imposed by high transportation costs. Closely associated with the friction of distance was its measurement in terms of travel time and cost, which tend to be more useful in explaining travel patterns than are absolute distances.

In the 1960s, Donald Janelle introduced the notion of time-space convergence, the rate at which places drew closer to one another over time in relative space due to rising transport speeds even as
the absolute distance between them remained constant. One example concerned the changing travel time between Lansing and Detroit, Michigan, which was approximately 1,300 min. by stagecoach in 1840. By the 1870s, with the arrival of the steam locomotive, travel time had been reduced by two thirds, to 180 min.; with the introduction of the automobile, the journey was further reduced to only 80 min. Thus, while the absolute distance between the cities remained the same, the relative distance was reduced by 1,220 min. over 120 yrs., or roughly 10 min./yr. Similarly, between 1800 and 1965, travel times between Boston and New York declined from 4,800 to 300 min., or 27 min./yr. Janelle also introduced the notion of time-space divergence, such as when urban infrastructures become so overloaded with traffic that significant delays occur due to congestion.

In the context of late-20th-century globalization and technological changes, falling transport times created a steadily “shrinking world” that changed the suite of opportunities and constraints faced by places, firms, and individuals. Because markets are shaped by the distances beyond which goods and information cannot circulate in a timely manner, transport and communication costs limit their geographic size. For competitive firms, the steadily declining friction of distance was a significant economic benefit. For other firms, the benefits were not so clear: As transport costs dropped and the spatial division of labor became broader, once protected local industries lost their monopoly status and were forced to compete with other producers in neighboring and then in increasingly distant regions. For individuals, the benefits of time-space compression include increasing mobility to a wider horizon of potential destinations. As the transportation literature demonstrates, mobility levels tend to rise proportionate to income; however, transport times remain essentially stable, indicating that the ability to conquer distance is purchased primarily through increasing velocities.

In the 1960s, the shrinking world was a popular theme among technocrats such as Daniel Bell and Alvin Toffler, who approached the topic from the perspective of “postindustrial” society, the decline of manufacturing, and the rise of an information-based service class. Technocratic views of communication were widely promoted by Marshall McLuhan, whose enormously influential works portrayed a progression from the limited spatiality of preindustrial societies and orality as the dominant form of communication to the influence of printing, to the global networks of modern telecommunications. Each age, he maintained, saw a dramatic increase in the scale of human extensibility. Technocratic theorizations of time-space compression, informed primarily by technological determinism, tended to present space and time as lying outside of social relations; they ignored or minimized the social inequalities and power relations that the process inevitably entails. This rosy, utopian view, with its impoverished sense of politics and inequality, nonetheless spoke to the profound time-space compression that telecommunications unleashed, and it decisively entered popular consciousness on the subject.

Because it is fundamentally an expression of power, time-space compression is always uneven among groups and places. Time-space compression, thus, does not affect all places or peoples equally. Spatially, this process endlessly generates new geographies of centrality and peripherality, bringing some places closer together and others relatively less so. Generally, the elites tend to enjoy the earliest and often the greatest advantages from reduced costs and transmission times of transportation and communications. Time-space compression is intimately associated with the ways in which capitalism generates new geographies over time. Globally, cheaper, more efficient modes of transport widened the range over which goods could be shipped profitably, allowing regions and countries to realize a comparative advantage and stimulating large-scale production and an increasingly internationalized geographic division of labor.

Within countries, transportation improvements contributed to changing patterns of urban accessibility. Cities in the industrialized world grew from compact walking and horsecar cities (pre-1800 to 1890) to electric streetcar cities (1890–1920) and, finally, to dispersed automobile cities in the recreational automobile era (1920–1945), the freeway era (1945–1970), the edge city era (1970–1990), and the exurban era (1990 to present).
of time-space compression, effectively reducing the communication time between places to zero. The telegraph in the 19th century, for example, connected the global economy’s expanding networks almost instantaneously, allowing news to travel at the speed of light, reducing uncertainty for producers, allowing multi-establishment firms to connect headquarters and branch plants, and allowing markets to expand over ever larger spatial domains. The telephone had similar effects throughout the 20th century, and declines in the cost of telephone service generated considerable cost-space compression, with multiple economic, social, and psychological impacts. Starting in the 1980s with the microelectronics revolution, a worldwide skein of fiber-optic lines has come to form the nervous system of the international financial economy, creating the time-space compression of the flexible, post-Fordist, digitized global economy. Electronic funds transfer systems allow financial institutions to switch vast sums of capital from one place to another instantaneously, in the process arbitraging interest rate differentials, speculating in foreign exchange, and investing or disinvesting in a wide variety of instruments in a diverse array of markets. The Internet represents another dimension of this process. Connecting roughly 1.7 billion people in 2009, the interlinked series of computers that comprise the Internet and the World Wide Web allow almost instantaneous time-space compression. Yet even within the best connected of global cities, for example, there are substantial pockets of “off-line” poverty.

Globally, in a shrinking world, distant strangers become less and less distant or strange. David Harvey attributes the growth of postmodern culture—the fragmented set of discourses emphasizing difference and heterogeneity that flourished in the late 20th century—to the compression unleashed by digitized, globalized time-space compression. It is critical to emphasize that time-space compression is not inherently beneficial to all those affected but results in uneven gains and sometimes losses: For some, it represents a rise in efficiency and an increased ability to master space; for others, it consists of a loss of control as their worlds are enveloped within wider divisions of labor controlled by powerful strangers. Because the structures of time and space are wrapped up with relations of power, domination, and subordination, the shrinking world does not shrink in the same way or equally for everyone; time-space compressions always simultaneously empower and disempower different social groups. Often the process accentuates existing social inequalities, as when, for example, the wealthy deploy new technologies that leave the poor further behind. Indeed, time-space compression for some may be time-space expansion for others.

Barney Warf

See also Harvey, David; Relative/Relational Space; Spatial Fix; Telecommunications and Geography; Time, Geographies of; Transportation Geography; Virilio, Paul

Further Readings


The label T-in-O maps, or simply “T-O maps,” is the modern name given to a simple world map found in a variety of sources during the Middle Ages. They appear as explicit graphics (i.e., diagrams made with circles and straight lines with
names attached), as the structure underlying far more complex maps (e.g., the Hereford mappa mundi has one as its underlying structure for the continental landmasses), and as symbolic representations of the earthly, human, sublunar world (e.g., it inspired the “royal orb” that is or was part of the regalia of European royalty, and in that form, it can be found linked to many Christian statues). In form, the T-O map is a circle with its horizontal diameter marked and with a radius perpendicular to that diameter running down to the lowest point on the circle. The diagram looks like a “T” inscribed in an “O,” hence its modern name. East is at the top of the circle. The upper half represents Asia, the lower quarters Europe (left) and Africa (right). The outer circle is the Ocean; the left radius represents the Danube (although it is commonly misidentified as the Don); the right radius represents the Nile and the lower radius, the Mediterranean. It portrays the whole of the inhabited world, in the northern temperate zone, as it was known to the Europeans.

Other details are often added to the basic map. There is a more elaborate form showing the Danube’s mouth; often the continents are shown with the names of the children of Noah (see Genesis 10) from whom the African (from Ham/Cham), Asian (from Shem/Sem), and European (from Japhet) nations were believed to have descended; and often one or two local details (e.g., the Pillars of Hercules [Gibraltar] or the British Isles) are shown.

The map has to be read in conjunction with other geographical diagrams to appreciate it fully. The most important of these other drawings is the zonal map, which has a torrid zone at the equator, frigid zones at the poles (both uninhabitable), and between them a northern temperate zone (which is the area covered by the T-in-O map) and a southern temperate zone, in which it was assumed that there was a corresponding landmass but there was a debate as to whether or not it was inhabited (the antipodes were its putative inhabitants). When this consideration is taken into account, the T-in-O map can be seen not as that of a “flat Earth” but as an attempt to portray lands on a sphere as seen from a great distance. As such, it embodies elements of an orthographic projection; however, insofar as it has the eastern end of the Mediterranean at its center and the ocean as the circumference, it has elements of an oblique azimuthal projection. It was this aspect of this map, when read in conjunction with certain biblical passage (e.g., Ezekiel 5:5) that led to the practice of placing Jerusalem at the center of many medieval maps.

The origins of the map lie in antiquity. In Homer, the shield of Achilles had a depiction of Earth, and around its edge ran the “Ocean river,” while errors in orientation in Roman sources show that they thought of their lands in a way remarkably similar to the way they are laid out in the T-in-O map. Likewise, Luke’s account in the Acts of the Apostles of the travels of St. Paul are far easier to follow on a T-in-O map than on the modern maps now found in bibles. However, the earliest evidence of the map is to be found in the writings of Isidore of Seville (ca. AD 560–636). Evidence points to the copyists having imported the map from Isidore to give clarity to the descriptions. Isidore produced two distinct forms of the map: The simpler one is just the T in the O with the continents’ names found in his encyclopedia, the Etymologiae; the more complex map is found in his treatise on the material creation, the De natura rerum, which contains additional details of the mouths of the Nile and the Danube, while the linear text mentions other geographical information.
that occasionally was depicted on the map (e.g., the cardinal directions placed outside the O). These two forms were subsequently imported into many others texts as distinct items of common knowledge (e.g., Lucretius’s textbook De natura rerum [On the Nature of Things]). Also, the two forms were often merged, or merged and combined with other “facts” of geography, such as that Paradise was in the east.

There is hardly a Western European map from before the 15th century that is not influenced by the T-in-O form. It fitted with the experience and travels of people from that region (e.g., one can travel across Europe using a 12th-century map by Giraldus Cambrensis, which is based on a T-in-O map), it conformed to all their classical authorities (e.g., it helped in reading Sallust), and it supported the image of the world they used in reading the Bible (e.g., the division of the Earth to Noah’s sons or the travels of Paul). It finally disappeared from use with the revival of interest in Ptolemy’s Geography and its very different world map.

Thomas O’Loughlin

See also Biblical Mapping; Cartography, History of

Further Readings


Toblere, Waldo (1930–)

Waldo R. Tobler is a geographer and cartographer who has done much to expand ideas about what can be mapped and how. He was closely associated with the quantitative revolution in the 1960s, leading the move to computer mapping, developing new map projections, and applying mathematical techniques to practical questions. His interests led him to consider issues in geographical information science, and he was part of the Santa Barbara team in the National Center for Geographic Information and Analysis.

Tobler was born in 1930 in Portland, Oregon, to a Swiss family. His father was the Swiss consul, with responsibility for the Pacific Northwest. Tobler completed his undergraduate degree at the University of Washington, having drifted into geography because he enjoyed reading maps. He proceeded to a master’s degree, specializing in cartography. He left Washington and returned after 2 yrs. (years) to do his doctorate. He was at the University of Washington in the late 1950s, at the same time as many of the future leaders of the quantitative revolution. Geographer William Garrison was a junior faculty member, and the graduate students included Brian Berry, William Bunge, Michael Dacey, Arthur Getis, Duane Marble, and Richard Morrill. Tobler says that he “learned just as much or more from fellow graduate students as from the faculty.” Graduate students were encouraged to learn computing as well as to take courses in mathematics and econometrics; ideas from such courses could often be applied in cartography. His PhD dissertation, Map Transformations of Geographic Space, developed new ways of mapping based on time or cost distances and investigated the mathematical basis of cartograms.

After leaving the University of Washington, Tobler became a faculty member at the University of Michigan, where he worked for 16 yrs., moving to the University of California, Santa Barbara, in 1977. Although still primarily a cartographer, he kept up his interests in many aspects of spatial analysis. His work on migration is distinctive. While most geographers modeling human behavior do so using statistics, Tobler uses other branches of mathematics, such as vector analysis and partial differential equations. He was also a leader in the development of animated maps, for example, the
Roger Tomlinson played a key role in establishing geographic information systems (GIS) from their earliest years. He is one of the very few who merit the title “father of GIS.”

Born in Cambridge, Britain, Tomlinson was a flying officer in the Royal Air Force before attending Nottingham University. He obtained an honors degree in geography (1957) and then moved to Canada for another BSc in geology at Acadia University in Nova Scotia (1960). He continued with an MSc in geography at McGill (1961), while starting work at Spartan Air Services on various forms of terrain evaluation. This work led him to investigate the use of digital computers to store and analyze geographic information. In the 1960s, he joined the Canadian government as head of the development program for an information system to be known as the Canada geographic information system (CGIS). While others around the world began to use GIS terminology at about the same time, CGIS was conceived at a continent-spanning scale from the start. His paper on CGIS in 1968, presented in Australia, may have been the first use of the term GIS in a reviewed publication. The analytical objectives of CGIS were as challenging as the sheer effort in digitizing four map layers across Canada at a scale of 1:250,000.

He obtained a PhD in 1974, writing a thesis that described CGIS in detail. Tomlinson’s vision of GIS attracted international attention during the 12-year period in which he chaired the Commission on Geographical Data Sensing and Processing of the International Geographical Union. Since the early 1970s, Tomlinson has worked as a consultant to government and industry around the world. His important achievements come largely from the critical appraisal of actual needs and his commitment to pushing the technology forward. At the critical juncture when the commercial software sector was emerging (around 1980), he and his associates rejected all tenders for the Saskatchewan Natural Resources project. This action held the developers to high standards that were not met until a few years later. In this role, as much as at CGIS, he directed the future of what became the GIS industry and practice.

Tomlinson has been a tireless campaigner for geographic awareness and geography as a discipline and a profession. He has received many awards for service to geography and GIS and was appointed to the Order of Canada in 2001.

Nicholas Chrisman

See also Business Models for Geographic Information Systems; Geographic Information Systems; GIS, History of; GIScience

Further Readings

TOPOLOGICAL RELATIONSHIPS

Topological relationships are the qualitative relationships of geographic objects that are not affected by continuous distortion, such as translation, rotation, scale, or skew. These relationships are said to exhibit a property known as topological invariant. In other words, topological relationships describe the spatial interrelationships among geographic objects, and how they are linked together, without reference to their geographic locations, dimensions, or orientations. Some examples of topological relationships are (a) touch—a point touches a line (e.g., a bridge on a river); (b) cross—a line crosses another line (e.g., a road across a river); and (c) within—a region is completely contained by the boundaries of another region (e.g., an island in a lake). In addition to topological relationships, geographic objects can also have projective relationships, such as orientation (left or right), and metric relationships, such as distance, which can be measured quantitatively. These geometric relationships are fundamental predicates for geographic representation and reasoning.

The definition of topological relationships derives from how geographic objects are understood and represented, or, more broadly, from ontology. One way to define topological relationships is Egenhofer and Herring’s nine-intersection scheme, which uses discrete points, lines, and regions to represent the geometries of geographic objects. The scheme uses the interiors, boundaries, and exteriors of two geometric objects to construct a $3 \times 3$ matrix, in which every entry denotes whether the intersection of the two object parts is an empty set or not, tested under the topologically invariant condition. Each distinctive set of nine intersections represents a different topological relationship. Out of the $512 (2^9)$ possible combinations of the $3 \times 3$ matrix, the nine-intersection scheme identifies, for example, 8 relationships between two regions with connected boundaries (i.e., no holes or disjointed parts) and 33 relationships between two simple lines (i.e., lines without branches). Some topological relationships are illustrated in Figure 1.

![Figure 1](image.jpg)

**Figure 1** Examples of topological relationships

The nine-intersection scheme provides a formal definition of topological relationships, and as part of the Open Geospatial Consortium specifications and ISO/TC 211 standard, some of the relationships have been implemented in commercial geographic information systems and spatial database systems to formulate qualitative queries about the connection properties of spatial objects. Its reasoning framework facilitates finding new relationships from a set of geographic objects. As the geometric representations of geographic objects become more complex and additional object properties, such as nonplanar geometry, movements of objects, or vagueness of their boundaries, are considered, the task of defining the topological relationships becomes more difficult and sometimes intractable. Many topological relationships identified in the framework have no corresponding natural-language equivalents, making them not applicable in qualitative spatial reasoning that is based on the semantics of natural languages. Given these practical purposes and concerns, topological relationships have become a topic of interdisciplinary research involving the fields of geography, geographic information science, linguistics, artificial intelligence, and cognitive science.

Jiunn-Der Duh

See also GIScience; Network Analysis; Ontological Foundations for Geographical Data; Ontology; Open Geospatial Consortium (OGC); Spatial Cognition; Spatial Data Models

Further Readings


Toponymy is a discipline that developed in the linguistic sciences. It studies the proper names of places from different points of view and according to different perspectives. This research seeks to find the essence of proper names through their evolution from a single instance of a common name to a final proper name. In the final situation, the proper name is a classically opaque “sign” in which the sound (or the grapheme, in its written form) cannot be directly linked by the user to a meaning, inasmuch as the name has lost its direct link to the designated place. For this reason, the study moves in the direction of etymology, which investigates the semantic origins of names. Research into the etymological origins of a name presupposes that the researcher has knowledge of the language or languages from which the common name emerged and of the forms that this name took in the various stages of its evolution. Historical testimonies are thus fundamental instruments in toponymy research, in particular archival documents for historical names and field research through inquiry with witnesses and direct users of the name.

These characteristics place toponymy at the crossroads of disciplines that are to a greater or lesser degree linked; among these, the most closely linked are the history of populations, ancient languages, and the historical and geographical evolution of languages. The links with geography are strong: Toponymy is a fundamental part of geographic study inasmuch as it studies the names of geographic entities.

Links With Geography

It is important to remember that by its very nature (viz., its focus on the longevity and conservation of original traits), the study of the names of places represents an important part of various aspects of geography inasmuch as the name of a place is testimony to its characteristics and modifications of its territory. Aspects that are particularly enhanced include the spread of different types of flora and the identification of territorial characteristics (physical geography, territorial conformity, spread of fauna, aspects of the territory as interpreted by the population that inhabits it, etc.).

Furthermore, toponymy also sheds light on aspects linked to the economic and social geography of a specific place, for example, the institutional and organizational aspects of territories. From a historical perspective, the analysis of
names can contribute to tracing the history of geographic settlements and migration. Finally, toponymy represents a fundamental part of cartography inasmuch as it can contribute to the identification of names to be written on maps and the most appropriate form of their transcription.

To realize its intentions, toponymy proceeds through the systematic collection of names of places. These names are then analyzed with the intent of making generalizations through observation. Parallel to this approach, other study directions are involved in researching the spread and characteristics of toponymic types in detail.

**New Applications**

In addition to historical and diachronic investigations, toponymy developed applications that are less strongly linked to its founding discipline. Inherent in this direction is the inquiry into the formal choice of toponyms, the relationships between the name of a place and the community that inhabits it, sociological and legal statutes pertaining to the name, the creation of new names, the replacement of old names, and the links between names of places and people. In this way, toponymy has developed links with disciplines such as sociology, sociolinguistics, cultural history, ethnography, anthropology, philosophy, urban studies, political science, and literary criticism.

Particular attention is given to the definition of a place name inasmuch as it can assume vastly different forms: For example, it can be indicative of a field or a small holding, a settlement, a city, a nation, a continent, water courses, mountain elevations, buildings, and so on. Over time, toponymy has developed research into aspects related to the nomenclature of common geographic names and, in so doing, closely collaborated with geography. In this regard, a recent direction of analysis strives to observe tendencies related to the interlinguistic aspects of a name: translations of names, the use of names in their original form in a different language, and so forth.

*Stefano Vassere*

*See also Place Names*

---

**Further Readings**


---

**TOPOPHILIA**

Topophilia lies at the intersection of geography and environmental psychology, describing the human emotional experience of the physical environment, including sensory perceptions, attitudes toward nature, and valuations of specific components or composites of the landscape. Topophilia generally implies an affection for specific places, but the term involves a spectrum of responses that may include disaffecting experiences for disliked or less preferred locations. Hence, since its original expression by the geographer Yi-Fu Tuan in the mid 1970s, the meaning of *topophilia* has evolved, and additional related terminologies have emerged. For example, the term *topophobia* has been used to describe the fear of specific geographical features. Furthermore, it is difficult to disentangle topophilia and topophobia—which are often associated with the nonliving components of nature—from the human emotional response to the living components of nature, which is captured separately by the terms *biophilia* and *biophobia*.

When confronted with images or direct experiences of different landscapes such as rain forests, sandy deserts, meadows, ocean fronts, and urban landscapes, most individuals do not find it difficult to declare ranked preferences, although they may not be able to articulate the rationale for such preferences. Attempts to deconstruct responses to specific components of natural or built landscapes are rare, but recent research to elucidate topophilia have revealed four domains within which human emotional attachment or detachment from the physical environment can be categorized: (1) ecological diversity, including the natural composition of vegetation, animals, and insects and the presence of water bodies;
(2) synesthetic tendency, described as the comin-
gling of the senses of sight, smell, texture, and
temperature; (3) cognitive challenge, including
geometrical shapes, landscape complexity, and
opportunities for solitude and contemplation;
and (4) familiarity, according to the level of
comfort experienced by repeated exposure to the
same or similar places.

Understanding the determinants of individual
or group preferences for specific components of
natural and urban landscapes has been proposed
for facilitating the design of restorative environ-
ments such as hospital landscapes, where resi-
dents hope to recover from diseases, or urban
landscapes, where the pressures of daily survival
can contribute to subnormal mental health condi-
tions. Additional research may assess variations
in individual preferences based on community
expressions of topophilia.

*Olaide Ogunseitan*

See also Built Environment; Environmental Perception;
Everyday Life, Geography and; Home; Humanistic
Geography; Phenomenology; Place; Sense of Place;
Tuan, Yi-Fu

---

**Further Readings**

Gonzalez, B. (2005). Topophilia and topophobia:
The home as an evocative place of contradictory

Ogunseitan, O. (2005). Topophilia and the quality of
life. *Environmental Health Perspectives, 113*,
143–148.

and topophobia: Reflections on twentieth-century

environmental perception, attitudes, and values.*

---

**TORNADOES**

A tornado is a violently rotating column of air in
contact with the ground. It usually forms under
a cumulonimbus (thunderstorm) cloud and is
visible as a condensation funnel or by the dust
and other debris incorporated into the rotation.
About 1,500 tornadoes are recorded annually
around the middle latitudes of Earth, and they
typically cause 100 to 300 deaths.

---

**Regional Occurrences and Frequencies**

Tornadoes occur in many regions of the world
but are most frequent in the middle latitudes,
especially in the Central and Southern United
States, but with the most loss of life and livelihood occurring in Central Bangladesh. The
United States records about 1,100 tornadoes
annually. This count has doubled since the
1950s, but the increase is thought to be due to
better reporting and recording of tornadoes
rather than an actual increase in the number of
tornadoes. Canada records about 60 tornadoes
annually; the United Kingdom and Australia
each about 30; Germany, France, and Italy each
about 20; and Argentina and Bangladesh each
about 10. A substantial number of tornadoes
also occur in other European countries and in
India, South Africa, China, Japan, and New Zea-
land. Tornadoes are undercounted in many
countries because small tornadoes are not
observed and recorded. The number of torna-
does seems to increase in these regions as report-
ing efficiency and record keeping improve.

The occurrence of tornadoes is restricted to the
regions where conditions are favorable for their
formation. Thus, they are most common in the
middle latitudes, where a contrast of air masses,
vertical wind shear, instability, a strong jet stream,
and strong cyclonic storms and fronts most com-
monly occur. Although tornadoes may occur
more frequently over flat terrain, they are known
to occur in hilly terrain and to cross large moun-
tain ranges and descend into deep valleys. No
terrain is “protected” from tornadoes.

Seasonal patterns of tornado frequency exist,
with a spring and summer peak in the United
States. The occurrence of tornadoes generally
coincides with the annual peak in thunderstorm
frequency. On the diurnal scale, tornadoes most
often form during the afternoon and evening
hours when atmospheric instability is greatest
and thunderstorms are most violent.
Tornados are classified into two broad categories, supercell tornadoes and nonsupercell tornadoes. A supercell tornado forms within supercell thunderstorms that contain mesocyclones in the middle levels of the atmosphere. Mesocyclones are rotating updrafts that may persist for several hours. They form in a moist, unstable environment with strong vertical wind shear. A supercell thunderstorm may produce several tornadoes, called a “tornado family,” with one tornado forming as the previous one dissipates. Rotation develops in the thunderstorm updraft due to the change of wind speed and wind direction with height above the ground, called vertical wind shear. This wind shear causes horizontal vorticity. Stronger winds aloft cause a tilting and stretching of this horizontal vorticity, and this results in a rotating cloud with vertical vorticity, the mesocyclone.

Not all supercell thunderstorms produce a tornado. The mechanisms that create rotation at ground level, that is, a tornado, are poorly understood. Large vertical vorticity must arise at the ground. This may develop when horizontal vorticity near the ground is tilted into a vertical rotation. Vertical vorticity near the ground may also arise through the transfer of vertical vorticity toward the ground by a rear-flank downdraft from the mesocyclone. The rear-flank downdraft is dry air that descends from midlevels in the atmosphere and wraps around the back of a mesocyclone. The rear-flank downdraft may tilt horizontal vorticity into vertical vorticity, transfer vertical vorticity from the mesocyclone toward the ground, or enhance existing vertical vorticity near the ground, and any of these may lead to a tornado.

Nonsupercell tornadoes occur with the growth stage of a parent cloud and originate from near-ground convergence and rotation, or vertical vorticity, in the lower layers of the atmosphere. Although they are dangerous, they tend to be smaller and weaker than supercell tornadoes. Gustnadoes and landspouts are examples of nonsupercell tornadoes. A gustnado forms along a gust front or other storm outflow boundaries and is visible as a swirl of dust or debris. A landspout appears as a long, narrow rotation, similar to the waterspouts seen along the Florida coasts, and does not require a preexisting boundary.

A waterspout is a tornado over water. These include supercell tornadoes that form over land and then pass over a body of water. More commonly, however, a waterspout forms over warm waters as a nonsupercell tornado with low-level convergence. They are most common over the waters of the Florida Keys but also occur with cold air advection across the warmer waters of the North American Great Lakes and elsewhere.

Tornadoes may occur over land in association with tropical cyclones (hurricanes). Tornadoes that form in rain bands more than 200 km (kilometers) from the cyclone center are called “outer-region” tornadoes and may touch down near the coast well before landfall of the tropical cyclone. They show a diurnal cycle, with most occurring during the afternoon. Inner-region tornadoes, within 200 km of the center, occur less than 12 hours prior to landfall and tend to be weaker, with no diurnal cycle. About 60% of tornadoes associated with tropical cyclones occur within 100 km of the coast, but the threat persists 2 to 3 days after landfall and extends 400 km inland and 500 km from the cyclone center.

Most tornadoes rotate cyclonically (counterclockwise) due to the direction of rotation in the parent thunderstorm cloud. Some tornadoes have smaller secondary rotations, called suction vortices, within their broader rotation. The suction vortices are cycloidal swaths of stronger winds and create local gradations of wind damage caused by tornadoes.

Damage and casualties result from the strong winds in tornadoes and the impacts of the debris carried in those winds. Damage to buildings and other structures increases with stronger wind speeds but depends also on the strength and quality of the construction and the anchorage of the building to the ground. These characteristics of building quality vary geographically according to traditions, customs, and wealth. Contrary to popular notions, buildings do not “explode” from differences in pressure inside and outside the tornado but from the forces exerted by the winds on the walls and roofs.
Wind damage begins with the roofing materials, gutters, windows, awnings, and canopies. These destroyed materials are then carried in the wind and, by their impacts, cause additional damage to structures downwind. With stronger winds, sections of the roof are lifted from the structure, and exterior walls collapse. These building failures can be mitigated by making strong attachments between the roof and the walls that will resist the uplifting forces of the wind. At the higher wind speeds, which are rare, structures are totally destroyed, and all interior walls collapse.

The Enhanced Fujita Scale is used in the United States to rank the intensity of tornadoes and to relate the damage to the estimated wind speeds (e.g., a 3-second gust at 10 m [meters] height) over a range from EF0 (65–85 mph [miles per hour]) to EF5 (more than 200 mph). In Britain, a similar scale for calculating tornado wind speed and damage, the TORRO Scale (Tornado and Storm Research Organisation), is used. Wind speeds of about 75 mph break large branches from trees, and winds of 100 mph cause trees to snap or be uprooted. A typical family home in the United States will sustain roof damage at about 80 mph, but exterior walls remain intact up to about 130 mph (EF2). Mobile homes, where most tornado-related deaths occur in the United States, are rolled over and destroyed at wind speeds of about 100 mph (EF1). Apartments and condominiums lose roof covering at 100 mph, but walls remain intact to about 155 mph (EF3). Large retail buildings suffer the loss of roof and walls at about 135 mph. About 14% of tropical cyclone tornadoes are ranked EF2 or stronger on the Enhanced Fujita Scale, with maximum winds over 110 mph.

Injuries and deaths occur when people are exposed to the high winds and flying debris of the tornado. Some are injured in collapsed buildings, while others are caught outdoors and struck by debris or carried some distance. The very young
and the elderly suffer more deaths and injuries than youth and middle-aged persons.

Weak structures are easily collapsed by the wind or penetrated by debris and offer little protection to the occupants during a tornado. In the United States, about 45% of deaths due to tornadoes occur among residents of mobile homes, yet only 7% of the population resides in these structures. A stronger building offers more protection, especially if people seek a small interior room for shelter and stay away from windows. An underground shelter or basement is the safest location during a tornado. A vehicle may offer more protection than being outdoors or in a mobile home, but motorists should seek shelter in a sturdy building during a tornado. Death tolls from tornadoes decreased during the 20th century in the United States, from about 300 deaths annually to about 50 per year, due to better warning and communication systems, stronger buildings, and education about the risks and proper shelter.

The deadliest tornadoes in recent decades have occurred in Bangladesh, where 1,300 people were killed by a tornado on April 25, 1989, and 700 were killed on May 13, 1996. The deadliest tornado in the United States was on March 18, 1925, when 695 people were killed in Missouri, Illinois, and Indiana.

Injuries and deaths can be reduced by storm surveillance and early-warning systems. Government weather services can give a warning 5 to 15 minutes before a tornado strikes by receiving a report of a tornado on the ground or by observing strong rotation in a cloud with Doppler radar. The warning and information about the storm are disseminated to the public by radio, television, neighborhood sirens, or other electronic devices. Risks of injury are reduced if persons in the path of the storm become aware of the warning and take immediate action to move to the safest shelter. Where personal shelters, such as a sturdy house, basement, or underground storm shelter, are not available, community shelters can be provided to allow many people to take temporary refuge from the storm. These may be functions of wealth, education, class, race and ethnicity, gender, age, disability, and other social factors.

Further Readings


Tourism is defined as travel to a place outside the usual residential environment, involving a stay of at least one night but no more than 1 year, with varying motivations, such as business, pleasure, visits to friends and relatives (VFR), and education. It is one of the world’s largest industries. Tourism has long been of interest to geographers,

See also Climate: Midlatitude, Mild; Climate: Midlatitude, Severe; Cyclones: Extratropical; Disaster Prediction and Warning; Disaster Preparedness; Hurricanes, Risk and Hazard; Natural Hazards and Risk Analysis; Thunderstorms; Vulnerability, Risks, and Hazards; Wind

*Thomas W. Schmidlin*
given its spatial, temporal, and activity patterns and given its major economic and environmental impacts, ranging from the local to the global.

Geographers have been influential in developing conceptual models for explaining tourism development. Some of the most important models are resort morphology, the tourist-historic city, and the tourist area cycle. Douglas Pearce’s work on resort morphology has helped explain the resort’s particular urban form and its evolution in response to new recreational demands. Pearce found that many older beach resorts first developed around a traditional waterfront; later, parallel developments, including a road or highway, high-end accommodation and retail, and interior residential zones, were built as one moved inland. Given environmental degradation and traffic hazards with this traditional resort model, newer shore resorts have increasingly integrated accommodations with the sea via yacht moorings. Likewise, modern integrated ski resorts similarly physically integrate the snow front (slopes and uphill facilities) with concentrated resort buildings. As with new urbanist developments, these new resort models allow for greater integration of accommodations and activities, reduce the amount of land developed, and promote more efficient service provision (e.g., heating, water, sewage). However, equity issues have arisen since integrated development generally favors a single developer, often from distant metropolitan areas and having the needed capital and technical expertise, over smaller local or regional entities.

Another key model in tourism geography is the tourist-historic city model, which represents the fusion of a tourist city with a historic one. The tourist-historic city has attractions, dining services/restaurants, and accommodations in the historic core. Tourists’ action spaces and impacts tend to be concentrated within a small portion of the entire city. This model, which was based on medium-sized, older historic cities in Europe, has
been modified to explain tourism in other parts of the world. In settlements of the American West, historic and reconstructed tourist attractions and accommodations can be found in the equivalent historic cores, which are the old central business districts containing train stations. However, with the dominance of the automobile, a newer, secondary concentration of lodging and dining services for tourists can be found along interstate highways.

The tourist area cycle model developed by the geographer Richard Butler has influenced and spurred much research, application, and debate. The underlying concept, which is based on the product cycle, is that tourist areas, their attractions, and the number and type of their tourists evolve over time. Tourist areas move through the following stages: (a) exploration, in which there are a small number of tourists who are attracted to unique natural and cultural-historical features, use the local facilities, and have high contact with the local residents; (b) involvement, with increasing visitation; (c) development, in which the number of tourists during peak seasons exceeds the local population and locally developed infrastructure and original attractions are supplemented and increasingly supplanted by human-made attractions and facilities developed by external entities;
(d) consolidation, in which tourism is a major component of the economy and thus marketing and advertising efforts increase to expand the visitors’ season and market area, particularly as the rate of increase in visitation is declining (while the total number of visitors continues to increase); and (e) stagnation, in which the peak number of visitors and carrying capacity levels are reached, natural and cultural attractions are superseded by created ones, and the less fashionable area relies on repeat and convention visitors. At this point, tourist areas can continue to stagnate, or they may move into a stage of decline, with reduced visitation and number of tourist facilities but often with increased permanent settlement or retirement. Alternately, they may undergo rejuvenation by completely changing the tourist attractions or by capitalizing on previously untapped resources.

While this model has been much examined and debated regarding its fit to real places, it has important implications for planning, as it confronts the assumption that tourist areas are unchanging and will always attract an increasing number of visitors. Butler notes that the competitiveness of tourist areas could be sustained longer if proactive policies were enacted to maintain development within capacity limits.

Geographers have also played an important role in infusing critical perspectives into tourism research. In his seminal 1991 article integrating critical theory and political economy into the study of tourism, “Tourism, Capital, and Place: Towards a Critical Geography,” Stephen Britton called attention to the fact that tourism is an
manifested in travel and tourism. Critical political economy/ecology perspectives on tourism have also been used to examine topics such as imbalances in consumption, impacts on host communities, environmental justice, and sustainable development. The political ecology framework is particularly suited to looking at the impacts of nature protection for economic development and struggles to maintain customary land use, livelihoods, and access to natural resources.

Given economic restructuring and the recent crises in capitalism, Britton also argued that the geographical analysis of tourism could contribute to the analysis of territorial competition and the rejuvenation of depressed regional economies. Britton’s call is relevant to the ongoing challenges to reposition deindustrialized downtown areas for consumptive activities such as leisure and tourism and for corporate services. Cites worldwide have developed tourist entertainment districts that typically contain an atrium hotel, a festival mall with restaurants and bars, a convention center, a restored historic neighborhood, a domed stadium, an aquarium, new office towers, a redeveloped waterfront, and casinos, which attract tourists, daytime professionals, and suburban evening and weekend visitors. When such tourist entertainment districts are developed in areas surrounded by high crime, poverty, or urban decay, they may be secured and isolated “tourist bubbles.” Such tourist entertainment districts and bubbles often are sites for festivals and spectacles to attract suburban visitors as well as tourists in the ongoing territorial competition. For instance, Detroit, which has experienced the loss of industrial facilities, jobs, and population since the 1950s, has developed a downtown tourist entertainment district anchored by two new sports stadia, has landed mega sporting events, and has

important avenue of capitalist accumulation. Places are symbolically marketed as desirable experiences that impart status to those visiting or consuming them. As such, Britton argued that geographic theorization of tourism requires consideration of how social representations and materiality of leisure and touristic experiences and places are incorporated and commodified in the accumulation process. As part of viewing tourism as a mechanism for capital accumulation, geographers have looked at power relations and issues such as social equity, identity, authenticity, and social attachment to space as these are

Rejuvenating the city with tourism and entertainment: Movement 2009, Detroit’s electronic music festival, with GM headquarters in the background

Source: Author.
hosted festivals (e.g., Movement, Detroit’s electronic music festival, which draws a regional, national, and international audience) to foster its claims of being a world-class city. With the recent bankruptcies of Chrysler and General Motors, Mayor David Bing stressed the city’s culture and entertainment (sports, gaming, music) as a means of keeping the city competitive for population, jobs, investment, and industries such as tourism, which are key for its postautomotive future.

In addition to flows of capital, tourism can be investigated in terms of its relation to migration tied to broader economic and social changes. Volatile labor markets since the 1970s in more developed countries, changing income streams (e.g., pensions, capital accumulation through property), and aging of those societies have spurred early retirement and retirement migration to rural areas. Rural lands in advanced industrialized countries have increasingly shifted from a production orientation to a consumption one. The amenity-based, tourism and housing countryside appeals to those romanticizing nature, the past, and the rural; amenity seekers; second-home owners; and/or entrepreneurs cognizant of the marketable attributes of the rural landscape. In addition to rural, domestic migration, others may choose to migrate overseas to retirement communities or for lifestyle and business prospects (e.g., British immigrants to the Costa del Sol serving travelers from their country of origin). For others, the globalization of labor markets has opened up doors for skilled labor/expatriates in developing countries. Other forms of tourism-related migration include VFR and seasonal labor flows differentiated by ethnicity, race, and gender.

While tourism has been a way to address the challenges resulting from the shift from Fordism
to post-Fordism and from production to consumption, tourism production itself has remained remarkably varied. The travel industry has provided post-Fordist, individually tailored experiences (e.g., specialized luxury ecotourism excursions). However, in neo-Fordist tourism, which is marked by industrial concentration of airlines, transnational hotels, cruise companies, tour operators, and computerized booking systems and by high sales volume, standardized vacation packages appealing to a mass audience continue to be provided. Neo-Fordist tourism employment consists of both highly skilled, well-paid permanent professionals and flexible, low-wage seasonal labor. At the same time, the travel and tourism industry also includes pre-Fordist or artisanal businesses such as bed and breakfasts. Thus, given the coexistence of different production systems in both time and space, there has not been a clear shift from Fordism to post-Fordism in the tourism industry.

Tourism can benefit the discipline of geography. Tourism geography education can increase course enrollments and majors in departments that develop tourism majors or concentrations. It can raise the discipline’s visibility as geographers bring content on sustainability, cultures, heritage, and geospatial analysis to interdisciplinary tourism and hospitality programs. Research on tourism can contribute to applied and theoretical developments in geography. For instance, tourism provides an ideal lens for investigating transnational spaces, as it highlights multiple ties and interactions linking people or institutions across borders of nation-states (i.e., migration of tourism workers, transnational business structures, and tourists and local residents reshaping identity, landscape, and social networks). Tourism can aid in conceptualizing the flexibility and fluidity of capital, complex ownership, and globalization. Likewise, tourism can help in the theorization of border spaces, which can be deterrents or attractions but also can be “non-places” or “in-between spaces.” Cross-border cooperation, which ties into geopolitics, peace, and international treaties, is important to tourism and can be investigated in terms of how it varies by scale (i.e., being greater at the interlocal and international scales than at the larger global, regional, and bilateral scales). One major research outlet has been the journal *Tourism Geographies*. Given the geographical aspects of tourism, including how it transforms the environments of destinations, entails movement over space, and provides a distinctive way for people to relate to the world, *Tourism Geographies* would incorporate these aspects through geography’s unique synthesis of the social and physical sciences in understanding places, regions, and the world. Geographers continue to contribute to research on topics as varied as indigenous tourism, amenity/retirement migration, mountain tourism, mobilities, protected areas, tourism and climate change, heritage tourism, tourism landscapes, and tourism planning. Geography and tourism will continue to be mutually enhancing in the future.

*Deborah Che*

**Further Readings**


The U.S. Public Land Survey System is a township and range pattern of land division that was imposed across the United States west of Pennsylvania’s western boundary in territory deemed “public domain” as the early nation expanded to the Pacific Ocean. It is the foundation of a cadastral survey that defines boundaries for land ownership. It forms a gargantuan checkerboard of surveyed grid-squares defining millions of parcels of land that served literally as the framework for colonizing and developing the vast new country.

Reminiscent of Roman land centuriation, at least in its geometry, the American system was first proposed by Thomas Jefferson, who saw it as the most democratic way to create a great agrarian commonwealth of independent farmers based on freehold land ownership. Neither he nor anyone else at the time foresaw the rugged Western terrain that the system would confront.

The system had its origin in the Land Ordinance of 1785, which provided for the systematic survey and monumentation of public domain lands, and the Northwest Ordinance of 1787, which established a rectangular survey system designed to sell and grant federal lands to private owners. From a modest beginning in the Seven Ranges area of Eastern Ohio, the system grew to encompass most of the nation’s territory and to stamp the American landscape with its unique, mechanistic imprint of seeming dominance over the continent’s natural environment. The chief exclusions from this federal system of land division are portions of Ohio that were surveyed and alienated from the public domain before the system was fully institutionalized; land in Texas, which remained under state control as a condition of annexation; lands granted to private interests under Spanish, French, and Mexican dominion prior to American sovereignty; Native American reservations; and certain highmountain areas in the Far West that have never been officially subdivided.

Earth’s curvature required that the extension of the system be tied to periodic benchmarks of longitude and latitude, known as prime meridians, and baselines defined for specific regions, so that the theoretically flat two-dimensional grid pattern could be laid out on the spherical surface with necessary corrections made at intervals. The basic areal unit is the survey township, a square 6 miles on each side, comprising 36 square miles, each square-mile subunit (640 acres in area) being called a section. Within townships, sections are numbered sequentially from the northeast corner to the southeast corner. Townships have distinctive locational identities, expressed as so many townships north or south of a particular baseline and so many ranges east or west of a particular prime meridian—downtown Chicago, for example, lies in T39N.R14E, that is, the 39th township north of the Centralia Base Line and the 14th range east of the third principal meridian.

Each section of land may be further subdivided into quarter sections (160 acres) and quarter-quarter sections (40 acres), the latter being one of the smallest standard land units sold or granted to private interests, apart from the irregular fractional sections formed by intersecting watercourses, coastlines, survey correction lines, or, in the rare cases of government townsites, townsite lots. Recipients of land in the township and range system have generally been free to select land parcels in almost any geometrical combination of subunits within the checkerboard consistent with purchase and payment requirements that have varied with federal land policy over time. Every discrete land unit within this national survey system is described by a unique geographical reference system, expressible in alphanumeric shorthand. Land descriptions are read from the smallest division to the largest (e.g., the NW1/4 of the NW1/4 of Sec. 9 of T39N.R14E). Such geometrically simple description facilitated land reconnaissance and purchase by intending pioneers and distant purchasers alike; it has greatly simplified the registration of billions of land parcels in this continental-scale nation and constitutes the basis of most land transfers and ownership today. Since 1785, almost 1.5 billion acres have been surveyed into townships and sections.

The spatial regularity of the township and range system at every geographic scale—whether viewed locally on the ground or synoptically from the air—is extraordinary. This order is especially remarkable considering the relatively crude surveying instruments available and the sometimes
severe environmental conditions under which much of the original surveying was done, most of it accomplished during the 19th century across terrain regarded as utter wilderness. In many localities, small departures from cardinal orientation of lines and from strict acreage results occurred due to errors caused by these circumstances and also by other factors, including, for example, the presence of ferrous metals in mountainous locations that threw off surveyors’ compass readings. Other departures from the strict checkerboard occur when the surveyed lands border prior land grants that, if recognized by the U.S. Congress, were left intact, embedded within the U.S. surveys that wrapped around them.

The influence of the township and range system on the settlement geography and cultural development of the United States has been profound. It created the largest gridded landscape in the world, and its rigid imposition on the land, regardless of relief, drainage, soils, and other natural features bearing on sustainability, produced a sometimes awkward fit with the natural environment. Its very layout, coupled with the federal government’s policies of acquisition, encouraged the wide spatial dispersion of individual farm settlements across the land rather than community-based, group settlements focused on village life. The inherent physical isolation this built into the pattern of rural colonization had deep, enduring consequences for the development of the American social character, even after the balance of the nation’s population shifted largely from rural to urban environments.

Michael P. Conzen

See also Cadastral Systems; Coordinate Systems; Cultural Landscape; Environmental History; Environmental Impacts of Agriculture; Environmental Management; Jefferson, Thomas; Landscape Design; Land Tenure; Public Space; Settlement Geography; Surveying

Further Readings


Trade is usually defined as the exchange of goods and services among countries. That exchange is a type of spatial interaction, or movement, that has long been a fundamental component of the study of geography. The analysis of trade is often split into two basic parts. One part, largely the interest of economists, concerns the structure of trade or the selection of goods and services that a country produces for exchange with other countries. The second part concerns the pattern of trade, or the geography of the exchange of those goods and services. It is the pattern of trade that is of primary interest to geographers, who have long studied the flows between countries. In studying those flows, geographers have also considered their institutional context, including government policy, and their effects at both the national and subnational regional scales.

What Is Traded?

The spatial pattern of trade is of primary interest to geographers, but flows among countries are often viewed as the result of their relative efficiencies in production. In the 1770s, Adam Smith argued for the economic benefits of trade based on specialization of production between countries. That specialization argument was advanced further by a contemporary of Smith’s, David Ricardo, in what is called the law of comparative advantage. That law is derived from an analysis of two countries in which each is able to produce the same two commodities. Even a slight difference in the relative costs of production between the two countries can be shown to be the foundation for trade between them that will result in an overall increase in production and, by implication, lower costs for producers. The law of comparative advantage is a common foundation for many arguments in favor of free (or liberal) trade and of neoliberalism in general. Working in the early to mid 20th century, economists described the sources of comparative advantage in terms of the factor endowments of places and the factor intensities of industries. According to their requirement, factors of production such as labor or capital are unevenly distributed from place to place; some industries are labor intensive, and some are capital intensive in production. When factor intensities of production and factor endowments of places are matched, then comparative advantage arises, and trade can produce benefits. For example, one country well endowed with labor would produce labor-intensive goods to trade for capital-intensive goods produced in a country well endowed with that factor.

Comparative advantage/factor endowment theory is focused on differences in supply conditions between countries as the basis for trade, but more recently, market similarities between countries have been theorized as trade inducing as well. If consumers in different countries have similar incomes and tastes, according to this approach, then producers in those countries will find ready markets for their goods in trade because they produce goods that are attractive in each other’s market in terms of their basic characteristics and also because consumers will enjoy the variety that such trade affords. Even if goods are produced for other industries, and not for consumers, the argument holds. Different countries will have producers of specialized goods that can be sold in other countries with similar industrial composition. Similarities in consumption preferences seem easily applicable to trade in services, such as those provided in professional and financial markets and in transportation. Another major component of service trade, however, is tourism, which may conform to differences in “factor” endowments such as good weather, beaches, and cultural attractions.

Geographical Patterns

Actual geographical patterns of trade are likely the inspiration of trade theory. Comparative advantage and factor endowment theory suggests that trade will most likely occur between countries that are economically very different from each other, which was the most noticeable pattern of trade during the colonial and late imperial eras. European countries imported raw materials from their colonial possessions, which were well endowed with natural resources, or they imported other primary products such as sugar and cotton produced by large numbers of slaves or, later, by very low-cost labor. In turn, the Europeans sold
manufactured goods in their colonial monopolies. More recently, the flows of trade between countries that are similar in their high incomes are easily observed, which is why trade theory has focused on market similarities between countries rather than on differences in production costs. In fact, trade among similarly wealthy countries is so prominent that trade is often described using a gravity model, which typically ignores production costs in its specification.

The typical gravity model is specified as $T_{ij} = f(G, I_i, I_j, 1/D_{ij})$, where $T_{ij}$ is trade between two countries $i$ and $j$, $G$ is a constant defined with respect to what is being traded, $I$ is income, and $D$ is some cost of transporting $G$. Such gravity models have been used frequently to describe trade, indicating that the major factors promoting trade are the incomes of trade partners, not differences in production cost, while a factor in reducing trade is the cost of transportation. In short, the gravity model describes a pattern of trade that is most readily observed between wealthy countries located in close proximity to each other. It also describes trade as least likely between poor countries that are distant from each other. In general, the gravity model is correct. Measured by value or volume, trade in both goods and services tends to be greatest among the world’s wealthier countries, followed by trade between wealthy countries and poorer countries, while trade among low-income countries is a distant third. That general pattern has been roughly stable for a long time, but the place of individual countries changes. A notable example of changing trade is that between China and Brazil. Both have experienced significant income growth recently, and the trade between them has increased significantly as well.

**Policy and Customs Unions**

Trade theory assumes that trade is liberal, that is, devoid of government restrictions, and at the same time is the justification for liberal trade policies. Actual trade, however, occurs in an institutional
framework in which government-directed commercial policy plays an important role. Common instruments used by governments to inhibit imports, for example, are tariffs and quotas. Tariffs are taxes on imported goods that governments have used both to raise revenues and to protect domestic producers from trade competition by offsetting other countries' advantages in production costs. Quotas are limitations on the physical quantity of imports; only so many square meters of cloth can be imported, for example, or so many automobiles. Such a physical limitation not only raises the price of the imported good by inducing its scarcity, it also allows for domestic monopolies to form among a country's own producers. Recent multilateral trade agreements have had the general trend of reducing tariffs and quotas in the interest of promoting more trade, under a neoliberal mindset. Such agreements have also encouraged the reduction of other means of limiting imports, such as the requirement that they meet certain environmental or safety standards in their production.

While much commercial policy is focused on limiting imports, some of it is aimed at promoting exports or supporting high prices for export goods in other countries' markets. Export processing zones have been established by many countries as geographical areas in which producers enjoy special tax rates and other benefits as long as they are engaged in producing goods for export. Governments also try to manipulate exchange rates in such a way that the goods produced in their own country are relatively inexpensive in other countries, while imported goods remain highly priced. Export prices in some markets are encouraged to remain high if demand can still be sustained. The Organization of Petroleum Exporting Countries, for example, is a cartel of suppliers that uses internal production quotas to target prices in the global oil market.

More general trade agreements among several countries are referred to generically as customs unions, but those agreements can take many forms. Some countries combine into free-trade areas, in which goods and services may pass across common borders (nearly) without restriction as long as the member countries are the places of production. The North American Free Trade Agreement establishes a free-trade area that includes Canada, Mexico, and the United States. Actual customs unions act as free-trade areas with the additional characteristic that the member countries have common trade policies, including tariff rates, toward nonmember countries. The European Union that emerged in 1993 was developed from a customs union called the European Common Market, which was completed in 1968. There are many variants of customs unions in places around the world, including Mercosur in South America and the Economic Community of West African States.

Geographical Effects of Trade

Trade policies are developed and customs unions are formed because trade has economic effects on countries that are of interest to governments. Going back to the theory of comparative advantage, there is a strong argument that trade can lead to economic growth. Most governments, however, are not usually encouraging of trade in general but rather of exports in particular. Several East Asian countries are often used as examples of export-led economic growth, including Japan, South Korea, Taiwan, and, especially, China. Policies that promoted exporting have been employed in each of those countries over time, and each of those countries has experienced very high growth rates from very low starting points in recent history. At the same time that governments usually encourage exports, however, they also tend to discourage imports. Increases in imports can often lead to problems for domestic producers of the same good or service. While the law of comparative advantage indicates benefits of trade in aggregate, it also indicates that any country should expect both winners and losers as industrial specialization among countries develops along with increased trade. Wage and profit declines or even significant loss of employment and income can occur in some industries as their country opens its doors to more imports, and governments are often petitioned by the injured parties for protection. Protection is also sought by groups before imports are allowed to increase by groups that anticipate injury.

The effects of trade can also vary geographically within countries. Some geographical effects are felt in those parts of a country in which an
industry injured by trade is concentrated, while positive effects typically arise in those parts in which more highly competitive industries are located. Policy often has geographical effects. China’s economic liberalization, for example, especially targeted export production along its coast. That strategy has led to an uneven distribution of the benefits of trade, with much higher incomes on the coast than those that prevail in the interior. Many parts of a country, regardless of policy, seem to have a locational benefit with respect to trade—border regions, for example, with respect to lowering transport costs—while less accessible parts of countries are often less favored by positive trade impacts or more inclined to have a disproportionate share of the costs of trade.

Dean M. Hanink

See also Antiglobalization; Aviation and Geography; Comparative Advantage; Competitive Advantage; Development Theory; European Union; Export-Led Development; Fair Trade and Environmental Certification; Foreign Direct Investment; Globalization; Gravity Model; Neoliberalism; North American Free Trade Agreement (NAFTA); Organization of the Petroleum Exporting Countries; Ports and Maritime Trade; Supranational Integration; Transnational Corporation; World Trade Organization (WTO)

Further Readings


**TRANSHUMANCE**

See Nomadism

**TRANSNATIONAL CORPORATION**

The term *transnational corporation* (TNC) is used to describe firms with overseas operations and is often used interchangeably with other terms such as *multinational corporation* or *global firm*. TNCs play a significant role in processes of globalization and are collectively a key actor in the global economy. A qualitative shift in the nature of the global economy since the 1970s has seen processes of globalization accelerate, and transnational firms are both a cause and an outcome of increased global economic integration. The unevenness of global economic activity is in part a result of the investment decisions made by the world’s largest firms. Interest in TNCs—from academics, policymakers, and governments—focuses on their growth, geographies, investment decisions, and impacts on national economies.

**Definition and Measurement**

There are many definitions of TNCs, ranging from the simple notion of firms that have operations in more than one country to more sophisticated conceptualizations that acknowledge the complexity of firm internationalization. The most widely used definition in geography is by Dicken (2007), who defines a TNC as “a firm that has the power to coordinate and control
operations in more than one country, even if it does not own them” (p. 106). This definition offers an important qualification that transnational corporations are not simply “present” in more than one country. Their transnationality results from the nature of their presence in different markets and their organizational structure. TNCs are engaged in a wide range of different industrial sectors ranging from resource extraction to services such as banking. They share three basic characteristics:

1. Operations within and between different countries, coordinated and controlled through transnational production networks
2. The ability to use such networks to exploit global geographical differences in the distribution of resources
3. Flexibility to shift their geographical locations

Transnational firms can be measured in a variety of ways, for example, overseas revenues, number of employees, transnationality, geographical spread, overseas profitability, and many more. In 2005, the biggest company in the world (as measured by total revenues) was ExxonMobil, the world’s largest employer was Walmart, the firm with the greatest foreign assets was General Electric, and the United Nations Conference on Trade and Development ranked Canadian media firm Thomson Corporation as the most transnational and Deutsche Post as having the greatest geographical spread. The total number of TNCs is growing yearly. Between 1970 and 1998, the number of TNCs worldwide grew from 7,000 to an estimated 53,600, with some 449,000 foreign subsidiaries.

**Evolution of TNCs**

The geographical expansion of firms outside their home territories is not a new phenomenon. Historically, companies such as the East India Company and Hudson’s Bay Company developed extensive geographical networks to trade over large distances. However, the modern transnational firm emerged in the second half of the 19th century as part of a dramatic increase in international economic activity. Processes of globalization accelerated after 1945, and increased internationalization and integration were enabled by two interrelated processes: first, the rapid development of technologies of time-space compression—travel was quicker, cheaper, and possible over greater distances, and developments in telecommunications facilitated transnational communication—and second, the introduction and development of flexible systems of production and organization in firms. By the 1970s, firms were increasingly investing in overseas markets and integrating production and distribution across a range of different territories.

There are two main types of international production. *Market-oriented production* sees foreign direct investment (FDI) in production facilities inside a new market. Firms are attracted to particular markets for a number of reasons, but the most common are market size (such as the large markets of the United States and China) and/or markets with particular demands for products based on national income levels (e.g., the increased demand for consumer goods in the newly emerging economies). *Supply or cost-oriented production* sees TNCs locating production at the site of supplies of particular commodities. These commodities could be raw materials (such as timber, minerals, energy resources) or labor (to exploit geographical differences in labor costs, productivity, and skill levels).

As business firms began exploiting the new global opportunities offered through technological advancement, they reorganized and restructured in response to the challenges faced by their internationalization strategies. Organizational structures are forced to change as traditional models are unable to respond effectively, or quickly, enough to the demands of operating not only in more locations but with greater links between each location. Barlett and Ghosal (1989) suggested four major ideal types of TNCs that help trace the development of a firm’s organization as it internationalizes. First is the “multinational” organizational model, in which, as a firm internationalizes, it establishes offices in new national markets. These branches are fairly autonomous, and headquarters maintain control over finance. Second is the “international” organizational
model, in which overseas operations are more integrated into the domestic corporation. Third is the “classic global” organizational model, in which the headquarters act as a centralized hub and coordinate most decision making. Overseas operations are treated as input and output points feeding the firm’s global market. Fourth is the “transnational” organizational model, in which headquarters oversee a complex integrated network, coordinating components, products, resources, people, and information. This model is an outcome of the dilemma facing TNCs in today’s turbulent, competitive global economy. Firms need the best features of each of the four types at the same time: They need to be globally efficient, flexible over a number of geographical territories, and capable of transferring knowledge across their global networks.

A key part of TNC restructuring has been a shift in the coordination of supply chain inputs to gain cost and time efficiencies. Firms continue to review the degree to which certain functions are retained within the firm or outsourced to other companies. Recent decades have seen a substantial increase in externalized supply relationships, with firms outsourcing functions such as information technology, back offices, logistics, human resource management, and production. For example, Dell, the world’s second largest maker of personal computers, outsources customer service functions to India and Latin America and manufacturing to contractors predominately based in Asia. Such examples of outsourcing often occur over large geographical distances. However, the adoption of “just-in-time” production techniques and technologies has encouraged the colocation of firms and their suppliers as closer geographical proximity aids flexibility and responsiveness to demand. In the automotive sector, for example, large production plants include the original equipment manufacturer (e.g., General Motors), a large number of supplier firms producing components (e.g., car seats, windshield wipers), and even branch offices supplying temporary labor to work on the production line (e.g., Adecco). Therefore, as a result of the realignment of supply relationships, the scale at which firms coordinate their production chains has shifted to the regional or global scale. However, the resulting geographical “footprint” of the firm (i.e., where it actually conducts production, final assembly, and delivery to customers) is highly dependent on the management and strategies of the firm and, crucially, on the sector in which it operates.

Factors Influencing the Geography of TNCs

While TNCs share many characteristics, there is great variety in the shape and size of TNCs, both within and across different industry sectors. No two firms are the same, and even closely competing firms make (sometimes radically) different strategic and locational decisions. TNCs should be understood as inherently complex, constantly evolving, and unique. The sector in which the firm operates, the national context, and the ownership structure are among the key factors that shape the TNC.

Sector

First, the sector of which the firm is part plays a decisive role in determining its geography. For example, British Petroleum’s production sites are dictated by the source of raw materials and extraction technologies. Many of these sites are located in lower-income nations such as Kazakhstan, Botswana, and Bolivia. In comparison, in labor-intensive industries such as garment manufacturing or call-center operations, firms seek sources of cost-effective labor. The majority of the world’s garment manufacturers have production sites in Asian economies, including China and Cambodia.

National Context

Second, the “nationality” of the firm shapes and influences the geographical contexts in which they are situated, and this is especially true of their country of origin. The national context in which a TNC is headquartered influences the firm culture, the nature of supplier relationships, and the regulation of finances. In addition, the size of a firm’s home market determines the drive to internationalize as firms in large markets such as the United States may expand overseas later than a firm based in Belgium.
Ownership Structure

Third, the ownership structure of a TNC can affect its management and corporate strategies, particularly internationalization and sourcing decisions. The majority of TNCs answer to shareholders, which may result in short-term demands for return on investments. However, some TNCs are privately or government owned, which can have a significant impact on competitive decision making, imposing limitations on accessing finance for expansion and, in the case of government-owned enterprises, regulatory restrictions on operations.

Impacts of TNCs

Much rhetoric surrounding TNCs credits the firms with immense powers and omnipotence. TNCs are viewed by some, particularly in the popular media, as renegade entities scouring the globe for investment and exploitation opportunities to generate vast profits. While such views are often overstated, they reveal two key debates surrounding TNCs: their “placelessness” and the impacts of their location decisions. First, the suggestion that TNCs operate completely freely across the global economy is refuted by geographers. In many ways, the importance of place is confirmed by the location decisions of TNCs—the global economy is not an even playing field. Huge differences in the distribution of raw materials, labor, and transport infrastructure result in a complex, shifting, and uneven mosaic of local and national economic spaces, and it is these disparities that TNCs seek to exploit through their internationalization strategies. While nation-states are attracted by FDI from TNCs, the scale and extent of TNC activity does pose some problems for national economies. For some, TNCs have surpassed nation-states as the key actors in the global economy. This status raises concerns for nations regarding their ability to shape and guide their economies and compete internationally. However, the relationship between TNCs and national governments is not as one-sided as it may seem at first glance. The nation-state creates the geographical contexts in which TNCs operate. With the exception of some supranational regulation (e.g., through the European Union or trade agreements), the conditions in which TNCs are embedded in any context are regulated by the national government. This covers aspects of business such as labor regulation (wages, terms, and conditions) and finances (taxation, investment incentives).

Second, the impacts of TNCs in host economies are contested. Some suggest that TNC investment in lower income countries keeps economies relatively backward and dependent on advanced capitalist nations for investment, jobs, and technology, while others argue that FDI by TNCs is an instrument for dispersing the production of goods and services to those locations where they can be most efficiently produced. Many geographers are situated in between these dichotomous viewpoints and suggest that FDI has both benefits and costs to host economies. Benefits can accrue through a number of mechanisms. For many countries, FDI by TNCs is an important source of capital and employment. The TNC may use local suppliers, thereby increasing benefits as employment increases and knowledge is transferred from the TNC to the local firms. The costs of FDI include the financial incentives offered to the TNC (such as tax incentives and/or the provision of infrastructure), the degree of revenues generated as the foreign operation remits earnings and profits back to its parent company, and the quality of jobs created. A key concern is whether the host economy is able to capitalize on the benefits of FDI to “upgrade” local industry, skills, and work standards and connect further into the global economy. If the costs outweigh the benefits, the host economy may find itself as a temporary low-cost location for the TNC in which low-skilled labor is provided without tangible benefits accruing. Not all FDI impacts are related to the economy, as TNCs are also important transmitters of social, cultural, and political change, particularly in developing countries. Again, these changes can be both positive and negative and vary depending on the TNC and the host economy in which it is located.

Jennifer Johns

See also Economic Geography; Foreign Direct Investment; Globalization; Neocolonialism; Neoliberalism; Trade
Transnationalism denotes processes and practices through which contemporary international migrants forge and maintain ties across national borders to their countries and places of origin. The acceleration of economic globalization has enabled these migrants to create new transnational social and cultural spaces that span multiple polities and societies. Migrants create these new social spaces by, among others, sending money home to family members in the form of remittances; they influence the political lives and well-being of their home places through hometown associations, contribute to economic development projects in their countries of origin, or participate in religious and cultural organizations that span national borders. While these new social spaces are similarly facilitated by innovations in transportation and communication technologies, migrants’ “transnationalism from below” differs from globalization from above in that it is individual migrants’ and groups’ social practices rather than the economic power of transnational corporations that create new ties between places.

The terms transnational migrant or migrant transnationalism were made popular by Nina Glick Schiller, Linda Basch, and Christina Blas-Szanton, whose observation of migrants’ continued engagement across borders through multiple practices led them to suggest that contemporary migrants differ from previous waves of immigrants in that they no longer need to give up ties to their home places and face less pressure to assimilate to the host nation. Glick Schiller, Basch, and Blas-Szanton initially suggested abandoning the term immigrant in favor of transmigrant to reflect that migrants live their lives across borders and in multiple nation-states. Emphasizing migrants’ resistance to changing political and economic conditions in a globalized economy, they proposed rethinking conceptions of ethnicity, race, and nation. Such assumptions were echoed in postcolonial and cultural studies that suggested that transnationalism, aided by new mass media such as satellite television, was fostering new cultural identities that stretched beyond national and local contexts and undermined nation-state and nationalist projects.

This initial enthusiasm seemed to overshoot the conceptual and explanatory power of transnationalism and prompted criticism from scholarship in the social sciences that has since sought to refine several aspects of the initial conception proposed by Glick Schiller and colleagues. Some of these extensions and refinements constitute attempts at creating types and taxonomies of transnationalism aimed at better defining what does and does not constitute transnational processes and practices. These taxonomies distinguish economic, sociocultural, and political practices with low and high levels of institutionalization. In a taxonomy proposed by Portes, Guarnizo, and Landolt, hometown associations are considered political transnational practices with a low level of institutionalization, whereas cultural events organized by foreign embassies are considered highly institutionalized sociocultural practices. The frequency and regularity of transnational practices in question receive additional consideration in such typologies. There is debate about the usefulness of such typologies, and more recent work has instead sought to examine migrant transnationalism in relation to multiple axes of difference.

The extent and intensity of transnational practices vary according to the socioeconomic positionality of migrants and the conditions in sending and receiving societies that limit or enable transnational mobility. Among the factors facilitating and constraining transnational mobility are gender,
class, and migration status. So-called hypermobile migrants, or “astronauts,” travel with ease across borders, for example, the Hong Kong Chinese business executives who bought property on the Pacific Coast of Canada. These “transnational elites” are able to take advantage of the globalizing economy by maintaining investments and economic interests in Hong Kong while raising their families in Vancouver. In contrast, poorer migrants’ transnational practices often remain limited to sending remittances to family members or making phone calls, especially if these migrants’ mobility is constrained due to their insecure status as refugees and asylum seekers. Undocumented migrants face even more restrictions because they lack the proper papers that would allow them to travel across borders with ease.

Rather than juxtaposing the home and host countries, geographic research instead shows how migrants forge complementary local, national, and transnational ties. This research questions claims that assimilation is no longer necessary for contemporary migrants. Geographers have examined the complex spatialities of migrant transnationalism as they emphasize how identities are constructed in relation to both home and host places, as migrants negotiate the contexts of both. The analysis of the daily practices of Salvadoran migrants under Temporary Protected Status in the United States demonstrates the difficulty of migrants’ struggles to create and maintain transnational (social) spaces in efforts to connect to their places of origin while coping with status insecurity in the United States. This research grounds migrants’ transnational ties in the lived experiences of their everyday lives and shows that transnational spaces are created, in part, through place-making practices and the creation of local ties.

Migrant transnationalism presents new challenges and opportunities for sending and receiving states. Restrictions imposed on refugees and other migrants demonstrate that transnational mobility is facilitated, regulated, and limited by sending and receiving states. Because migrant remittances form an important revenue source for them, sending states have increasingly been creating provisions for extraterritorial voting, dual nationality, or dual citizenship to bind their citizens abroad to the state of origin. These legal changes also affect receiving states, which increasingly allow dual citizenship. Such changes in citizenship law prompted by the transnational realities of contemporary migrants are frequently accompanied by fierce public and political debates. The attacks of September 11, 2001, in particular, have prompted debate about migrants’ transnational practices, citing security and border control issues while highlighting the potential for terrorism among migrant populations. This is particularly salient for Muslim migrants, whose religious faith is portrayed as undermining liberal democratic values. More generally, the political attachments, loyalties, and activism of contemporary migrant populations have moved to the center of public debate and of researchers’ attention. As numerous migrants remain citizens of their country of origin and engage multiple polities across national borders, hosting states and societies question their loyalty to the receiving polity. Migrants’ collective political identities, activism, and practices of citizenship are thus part of the study of transnationalism as they challenge and change a state-centered approach to politics.

Patricia Ehrkamp

See also Citizenship; Cross-Border Cooperation; Globalization; Immigration; Migration; Mobility; Remittances; Transnational Corporation

Further Readings


Transportation geography is the subfield that deals with the movement of people and goods across space, as well as the social and material infrastructures that enable or constrain those movements. More than most subfields of geography, transportation geography has strong connections with outside disciplines, including economics, engineering, planning, and landscape architecture. On the one hand, these linkages have led to a greater engagement with policy making than in most areas of geography. On the other hand, the subfield has also come under criticism for its somewhat narrow focus and isolation within geography. That said, transportation geography has made significant contributions to the discipline in demonstrating the importance of gender, the integration of economic and environmental concerns, and the need to engage with policymakers, among other areas. Particularly in the current era of globalization, connections between distant peoples and places are of growing importance, and transportation geography is key to understanding how those connections happen (or fail to happen). In terms of researchers, practitioners, and productivity, this is a subfield that is on a positive growth trajectory.

This entry is organized according to a series of categories into which most transportation geography research can be sorted. However, many of these categories have begun to merge as the transportation industry and the study of it have become more integrated across modes and places. Significant opportunity exists to draw from emerging areas within geography and related disciplines to further strengthen this subfield and for other geographers to incorporate insights from the study of transportation nodes and networks.

**Passengers and Freight**

At its most basic level, transportation geography is concerned with the movement of people and goods. With respect to the former, this includes the travel choices and constraints of individuals over long and short distances: how mode choice, trip length, and destination are constrained or enabled by the available networks. With respect to the latter, the movement of people and goods includes the choice of mode and route with an eye toward minimizing cost. With respect to both, it includes the broader social and economic contexts, including cost as a decision factor, as well as the impacts on land use.

The main focus of transportation geography is on the movement of people, ranging across modes and scales. Much early work focused on the policy implications of suburbanizing metropolises, later evolving into a significant literature on excess commuting that tried to explain the long average distances between home and work. Long-distance and international travel have also been key areas of study, from tourism and migration to more recent work that uses flights or passengers as a proxy for connections between world cities in a global network. New cultural and social approaches explore the consumption of transportation in terms of the symbolic meanings of vehicles and of motion itself.

Research on the geography of freight transportation has evolved along with the industry. The early focus was on freight rates, linear programming, and the “transportation problem” from economics, in keeping with the regulated nature of freight transportation in the mid 20th century. Connections between freight transportation and land use focused on cities as historical break-of-bulk points, with general conceptual models describing evolving relations between colonial
cities and their home ports, the relations among colonial cities, and the relations between ports and their surrounding cities. As the industry deregulated and became more entwined with globalizing economic activity, the research focus shifted to containerization, logistics, and the ensuing changes in all transport modes. More recent approaches include global commodity chains, logistics and supply chain management, and the new landscapes of distribution centers and intermodal terminals.

### Accessibility/Mobility

One of the most basic distinctions drawn within transportation geography is between the concepts of accessibility and mobility. Generally speaking, accessibility refers to the presence and extent of infrastructure networks, while mobility refers to the movements of people and goods along those networks. Both have important implications for social equity and economic impact.

von Thünen’s classic model of economic activity as concentric rings around the city is based on accessibility, measured as proximity to the city center. Accessibility is also at the core of models of the evolution of North American urban form at the regional and metropolitan scales, respectively, as the predominant modes of long-distance and commuting travel changed over time. More recent models of urban form take into account the polycentric form of the modern North American city and the need to access multiple locations for work, shopping, and so on. Accessibility can also be measured through network analysis, as has been done for airports to show changes across time due to deregulation, airline mergers, and political change. It can also be studied in terms of the effects it has on land use. For example, the impact on urban land prices of introducing fixed mass transit (such as a light rail line) is a subject of much debate.

However, the simple fact that infrastructure exists does not mean that all people have access to it. The classic example is the limited-access highway, with the evacuation of New Orleans after Hurricane Katrina as a more recent demonstration. The mobility aspect of transportation geography focuses on how easily people can get to and use transportation infrastructure: proximity to a highway or bus stop, vehicle ownership, or wheelchair access, for example. Of particular interest is the “spatial mismatch” problem, where locations with a surplus of jobs (often in the suburbs) may not be easily accessible to the unemployed (often in central-city neighborhoods).
because of poor transit connections and low vehicle ownership.

The concept of “mobility” is not to be confused with the recent work coming out of sociology and related disciplines on “mobilities.” The most prominent work in this regard has been the concept of automobility, describing how modern society is inextricably intertwined with the production and consumption of automobiles and the mobility they provide (and followed more recently by aeromobility, velomobility, and other modes). Much of this work focuses on the need to examine everyday spaces and journeys to understand how people, places, and mobility construct each other. Geographers are just beginning to incorporate this theoretical approach into research on the construction of space, place, and policy.

Aggregate/Disaggregate Approaches

Planners and geographers alike generally approach transportation systems from one of two ways: (1) in the aggregate, based on territories such as census tracts or counties, (2) or in the disaggregate, focused on individuals or households. In particular, planners tend to take the former approach, looking at flows of commuters or travelers at a large scale. However, while a disaggregate approach may be more time-consuming in terms of data collection and analysis, it offers a better understanding of the opportunities and constraints individual travelers experience, as well as the reasons behind their travel decisions.

Aggregate flows are generally broken down into five categories of study: trip purpose, trip time, modal split, trip length, and spatial patterns. Within the United States, trip purpose has experienced a major shift in recent decades, with the majority of trips now being made for non-work purposes and with a concomitant shift in spatial patterns. Trip time and length have increased on average, with both contributing to the worldwide increase in vehicle miles traveled (VMT) at a much faster rate than population growth. Modal split continues to be heavily biased toward the automobile in developed countries, and increasingly in developing countries as well. The spatial pattern of trips can be used to characterize different urban areas, from the strong bidirectional flow of traditional commuters that enables a mass transit system such as New York City’s to capture a majority of commuting trips to a multinodal space such as Los Angeles, with automobile congestion in all directions.

The disaggregate approach to transportation is exemplified by Hanson’s work on the different transportation experiences of men and women, which led not only transportation geography but the discipline as a whole to consider the role that gender plays in the production of space. This work has since been expanded to include differences based on class, race, age, disability, and other markers of social differentiation. Travel diaries and interviews are the most common methods for disaggregate analysis. More recently, Kwan and Miller have revived time-space maps with the use of geographic information systems to visually represent the daily travels of individuals throughout a city or region. While data collection is often a limitation of the disaggregate approach, it involves fewer simplifying assumptions than aggregated studies and can lead to richer results.

Public/Private Dimensions

Public versus private financing of transportation is one of the major distinctions among modes and places. A significant contribution of transportation geography has been close examination of the impacts of deregulation and privatization since the late 20th century. For example, Goetz’s study of U.S. airline deregulation clearly demonstrates the importance of a geographical approach, as the average decrease in airfares following deregulation is more properly described as a price savings in places benefiting from competition as against a price increase in cities where one airline holds a monopoly or near monopoly. Similarly, the ongoing privatization of airlines and airports in Europe and Asia is changing air travel patterns in those regions, most notably by increasing accessibility for the average traveler. The deregulation and privatization of railroads, trucking, and buses, however, have received less attention.

On the public side, a considerable amount of work has examined the economic impact of public investment in transit and other transportation infrastructure. As North American cities have inaugurated or revived light rail in the past few decades, geographers have studied the impact on
land values, ridership, and residential and other types of development. The results demonstrate weak or strong spatial connections between public investment in transportation and economic and social outcomes, depending on the scale of analysis. This follows a long tradition of examining the impact of public financing of highway systems in both rural and urban locations. The role of investment in transportation infrastructure in promoting economic development is the central concern of transportation geography in the context of developing countries.

In recent years, transportation funding worldwide has shifted to a model of public-private partnerships and joint ventures. Transportation geographers have explored the broader impacts of projects such as the Channel Tunnel in terms of the economic development implications at multiple scales for the cities and regions along the route. They are also beginning to study the spatial impacts of mechanisms such as congestion pricing on metropolitan equity and traffic congestion.

**Economy, Environment, and Sustainability**

Because of transportation geography’s origins within economic geography, transportation geographers have long had an interest in the connections between mobility and economic development. This connection has been explored, for example, in terms of the timing of development relative to highway improvements in both urban and rural areas, teasing apart the chicken-and-egg question to show that the type and location of development matters in answering the question. The connection between transportation and land use is also relevant here, with geographers modeling the interactions between multiple transportation users and land uses, from the neighborhood scale to the national. The economic impact of terminals (including ports, airports, and intermodal facilities) has also been studied, including the broader regional and national impacts.

On the other hand, transportation can have serious environmental impacts, and geographers have contributed by analyzing the impacts on both human and biosphere health in terms of waste generation and pollution, resource use, and the physical presence of transportation infrastructure. The widespread impacts of transportation are clear, from individuals suffering from asthma to the worldwide effects of global climate change, to which transportation contributes as the source of one fifth to one third of global carbon dioxide emissions. Road building in developing areas of the Amazon has been shown to reduce biodiversity and increase deforestation, while runoff from roads has negative effects on ecosystems all over the world. On a different note, recent U.S. research has shown a possible connection between living in a low-density suburb and being overweight among both children and adults. This connection between the built environment and human health is an important topic of current debate within both geography and planning.

These two areas of economy and environment are slowly being brought together through the concept of sustainable transportation. Incorporating the larger definition of sustainability as having economic, environmental, and social components (in roughly that order), sustainable transportation is one of the fastest-growing areas of study within transportation geography. International collaboration on ways to reduce vehicle emissions and energy consumption (including alternative fuels), to alter land use patterns in order to reduce vehicle miles traveled, and to move people rather than cars is currently one of the most exciting frontiers of this subfield. As automobile ownership and per capita vehicle miles traveled continue to rise around the world, this is also one of the most important areas of study.

**Modes and Intermodalism**

Traditionally, transportation geographers have tended to focus on one mode at a time, whether road, rail, water, air, or (occasionally) pipelines. Because of the different economic, social, and financial contexts of each of these modes, work on one mode has tended to remain largely separate from others. However, recent trends within the freight industry in policy and planning indicate that multiple modes and intermodalism are becoming more important topics of study.

While the transportation system itself remains dominated by the automobile, transportation geography is more equivocal. Significant work exists on the causes and consequences of automobile use for commuting and recreation, particularly
within the history of suburbanization. As the consequences of exclusive reliance on the private auto become more and more clear, researchers have tried to identify alternatives, explain why individuals make the choices they do, and demonstrate how current policies promote unsustainable outcomes. For example, while telecommuting and e-commerce were expected to reduce the need for travel, studies have shown that telecommuters do not necessarily make fewer trips and goods still need to be delivered to the consumer whether or not they pass through a store first.

Although research on rail in North America has declined in tandem with the decreasing use of this mode in the 20th century, the recent increase in freight traffic may signal an upsurge in academic work as well. Passenger rail has been well studied in Europe, particularly as competition for air travel on short-distance trips. Rail in the form of public transit is also well studied, particularly with regard to the land use implications of new and expanded metropolitan networks both historically and in the present (such as property values, job attraction, and residential density).

Maritime studies have generally focused on changes in the shipping industry as a result of containerization. An early period of centralization among North American port cities is being supplanted by some decentralization in response to port congestion. While books in the popular press have emphasized the importance of containerization to globalization, transportation geographers have focused on shipping lines and terminals and only recently looked at inland ports and connections to industrialization in places such as the Pearl River delta. As inland waterways become more important in Europe and elsewhere, attention is turning to that mode as well.

Similarly, studies of air transportation have tended to focus on the vehicles and terminals themselves rather than the broader environmental, social, and economic impacts of air transportation. Nevertheless, there have been significant contributions in terms of the impact of deregulation and low-cost carriers on air transportation networks around the world. Additionally, recent work has studied the diffusion of SARS (severe acute respiratory syndrome) across airline networks and the consequent health implications. The growing mobilities literature has placed special emphasis on aeromobility in defining and constructing the modern era. However, of the four main modes, air transportation’s connections to land use remain the least understood.

Finally, as the freight industry has become intermodal, thanks to containers that can travel by land, sea, or air, geographers’ attention has turned toward intermodal facilities as well. Metropolitan areas face challenges in terms of retrofitting or adding infrastructure to accommodate the growth in freight traffic and its intermodal requirements, and geographers are well positioned to explain the importance of context in shaping logistics networks. Research is also examining the rail-airport connections that are growing across Europe, where intermodalism is relevant to passenger travel as well.

**Conclusion**

In keeping with general trends in the social sciences, geography has become more oriented toward networks and flows rather than places and territories. Transportation geography has always had this orientation, based on its subjects of study. The incorporation of places with networks, territories with flows, has long been a strength of this subfield, positioning it well within the discipline as a whole. On the other hand, while it was at the forefront of the quantitative revolution, transportation geography has been criticized in recent years for not having moved beyond that point in terms of methodology and subject matter. While it is true that transportation geography remains one of the most quantitative areas of geography, it has used that to its advantage in terms of close connections with related disciplines and with policymakers. Nevertheless, there is considerable room as well as opportunity for transportation geographers to incorporate broader processes and discourses, such as globalization, neoliberalization, and the cultural turn of its parent, economic geography. Because transportation enables most economic activity and social activity, it is of vital importance for geographers and others to be aware of and incorporate the work being done in this subfield. The processes of globalization have only strengthened the importance of transportation geography, and the ever-increasing movement of people and goods,
combined with a growing concern over energy and environmental costs, ensure that it will continue to be key for many years to come.

Julie Cidell

See also Accessibility; Automobile Industry; Automobility; Aviation and Geography; Commuting; Economic Geography; GIS in Transportation; Gravity Model; Hanson, Susan; Infrastructure; Kwan, Mei-Po; Location Theory; Miller, Harvey J.; Mobility; Ports and Maritime Trade; Railroads and Geography; Time-Space Compression; Trade

Further Readings


Trap streets is a term used to refer to the cartographic convention whereby mapmakers deliberately insert fake places (such as streets and street names) into their maps so as to later be able to demonstrate plagiarism by other cartographers.

For well over a century, the U.S. court system has dealt with copyright infringement lawsuits brought when a cartographer or publishing company believes that their maps have been directly copied by a competitor. Because maps are widely assumed to be depictions of reality, it is difficult to determine whether mapmakers have compiled original research or copied directly from another cartographer in creating their maps (what the cartographer Mark Monmonier has referred to as “editing the competition”). Hence, map companies will at times add streets, street names, towns, or other features, often in out-of-the-way places, so as to later detect copying by competitors. Such deliberate errors are not confined to cartographers. Similar copyright traps have been found in dictionaries and encyclopedias as ways to detect later plagiarism.

While map companies are hesitant to point out their trap streets, such “errors” have been reported in the media in both the United States and the United Kingdom. A detailed discussion of the use of trap streets is found in a 1997 U.S. District Court decision, Alexandria Drafting Co. v. Amsterdam, in which Alexandria Drafting Company sued Franklin Maps for copyright infringement alleging that Franklin plagiarized Alexandria Drafting Company’s maps in Franklin Maps’ Philadelphia-area road atlases. One way that lawyers for Alexandria Drafting Company demonstrated this plagiarism was that numerous trap streets that Alexandria Drafting Company had earlier inserted into their maps subsequently appeared in Franklin’s maps. However, the use of trap streets to legally demonstrate copyright infringement was called into question in the court’s ruling in this case, which found that “false facts,” such as trap streets, are not copyrightable elements.

Jonathan Leib

See also Cartography
Travel writing, by definition, is geographic. It narrates the experiences of observing places and moving through space and links travel with representation. A translation of what is seen into what is read, travel writing is of interest to geographers for its description and representation of different parts of the world. This entry discusses what constitutes travel writing, how human geographers have studied it, and what role travel writing has played in both the history of geography and the historical geographies of colonialism and imperialism. Although travel itself—whether long or short distance, temporary or permanent—is a nearly universal human experience, studies of travel writing have focused primarily on 18th- and 19th-century European and North American travelers, leaving much room for future work.

As a genre, travel writing ranges from books and serialized accounts published by well-known authors to unpublished diaries and journals kept by ordinary travelers, from texts by explorers and scientists traveling under the auspices of governments and crowns to letters by men and women traveling for pleasure. Over time, travel writing’s meaning has changed. In the early 16th century, travel writings were considered forms of art and education, while in the late 17th century, they were central to the production of scientific knowledge about the “New World.” By the late 18th century, being well versed in travel writing was a sign of good taste among the European public. Across these shifts, travel writing’s popularity grew, and by the 19th century, travel narratives were bestsellers.

As transportation technologies reduced the costs and difficulties of travel throughout the 18th and 19th centuries, travel writers tried to distance their work from the growing number of tourism publications. Pointing to tourism’s supposed crassness, travel writers went to great lengths to show their commitment to uncovering the “authentic” character of the sites they visited and to demonstrate the value of their own first-hand experience of places. In doing so, however, travel writers did not simply “uncover” the places discussed but, instead, actively constituted them, often through comparison with familiar landscapes. In comparing, for example, the American
West with an English landscape, British travelers textually produced the new through images of the old, even as they faced the challenge of ensuring that the unfamiliar, whether Egypt or the Amazon, remained different enough to maintain travel’s exotic allure.

Within human geography, travel writings have been used in various ways. In some cases, they have been treated as valuable firsthand accounts of places, such as colonial South America, or events, such as the U.S. Civil War. In other instances, travel writings have been analyzed as literary texts; and geographers have interrogated the discursive and intertextual strategies through which travelers both represented places and peoples and were in dialogue with genres from scientific and military writings to novels and political texts. More recently, geographers have used travel writings to examine how travel writers’ own senses of self were differently affected by the acts of traveling and writing.

Across these approaches, geographers have studied travel writing most intensely in two areas. First, travel writing has played an important role in the history of geography as both a formal academic discipline and a broader interest in the human and physical world. Through geography’s role in European colonial expansion and the impulse to map colonial territories, travel accounts of European explorers and geographers helped bring “science” and the New World to a reading public. Narratives by travelers such as Alexander von Humboldt provided detailed geographic information about the physical, social, and cultural features of colonized holdings and peoples, helping translate unfamiliar lands into territories ripe for commercial exploitation and settlement and bringing rich descriptions of these “new” places to eager readers.

In their writings, European and North American travelers often discursively erased humans from colonial landscapes, presenting lands across Africa, South America, and elsewhere as “empty” spaces awaiting European investment and definition. Such descriptions, it is important to note, frequently had material consequences, as their representations of colonial lands as latent resources fed into and justified subsequent European exploitation of these sites. Through their depictions of “native” peoples, colonial travel narratives also illustrated what Mary Louise Pratt calls “contact zones,” where groups and cultures met and interacted. In many cases, these interactions were deeply asymmetrical, and travel writers not only relied on native knowledge to maneuver and understand the places they observed but also were complicit with an “othering” that rendered colonial subjects both different from and inferior to European subjects.

Travel writings have also been central to geographic studies of colonialism and imperialism, particularly vis-à-vis gender. Through studies of
travel narratives by European white women in various colonial settings, feminist historical geographers have shown how gendered analyses of travel writings blur the lines between imperial, public spaces and domestic, private spaces. As they demonstrate, the inclusion of women travelers often calls into question monolithic narratives or understandings of colonialism and highlights the complexity of interactions among European and native women and men.

As this last example shows, the specifics of the social, economic, and political relations of colonialism and imperialism can be most effectively seen when travel writings by men and women, by known and obscure writers, are analyzed alongside one another. This comparative approach enriches understandings not only of the geographies and practices of colonialism but also of the transformative nature of travel itself. In the process, it offers an exciting model for subsequent work on travel writings from other historical and geographic contexts.

Jamie Winders

See also Colonialism; Discourse and Geography; Gender and Geography; Geographical Imagination; Gregory, Derek; Historical Geography; Orientalism; Representations of Space; Text/Textuality; Writing

Further Readings


Tree farming, or plantation forestry, is a system of cultivated forests established by planting or seeding in the process of afforestation (converting bare or fallow land into forests) and reforestation (planting once forested land with trees or other woody plants). Tree farms are established for several reasons, for example, to produce wood biomass, especially where natural timber stands are depleted; to meet the demand for high-quality species (e.g., mahogany, cedar); to develop export markets; to conserve or restore soil and water; to protect biodiversity; and to supply potential markets for carbon sequestration. While tree farms provide numerous benefits, critics note a number of ecological and socioeconomic defects; these are summarized below.

While tree farms existed throughout the world for centuries, their incidence increased dramatically in the mid 20th century. This is largely due to the expansion of commercial timber harvesting, the growing strategic importance of the pulp and paper industry, and the depletion of merchantable natural timber stands. Tree farms are relatively inexpensive to implement and maintain, produce cash crops in greater volumes and shorter periods of time than natural forests, require little infrastructural investment, and can provide jobs in underdeveloped regions. Tree farms are intensively managed, which simplifies production and reduces silviculture and harvesting costs as well as loss of time and resources due to inclement natural phenomena. According to Roger Clapp, the shift from natural to plantation-based systems of forestry is conceptually equivalent to the agricultural revolution. Most large-scale tree farms rely on species that grow rapidly and are resistant to drought. The most common are pine, which mature in between 15 and 30 yrs. (years), and eucalyptus, which mature in as few as 7 yrs. (see photo). Acacia is also commercially grown in southeast Asia.

The inception of large-scale plantation forests occurred in the 1960s, primarily on easily accessible fallow agricultural lands in Spain, Portugal, the southeastern United States, and the Canadian province of Ontario’s St. Lawrence Valley. The Weyerhaeuser Corporation also
played a leading role in developing successful tree farms in the northwestern United States during this era. Brazil and Chile developed large-scale plantations in the 1980s that demonstrated the economic viability of commercial tree farming. Many of South America’s first large-scale tree farms were established by Japanese pulp and paper firms in response to elevated North American fiber prices and the depletion of timber stocks in and the ensuing ban on log exports from southeast Asian countries. More recently, Indonesia, Malaysia, Thailand, China, India, Russia, South Africa, Australia, and New Zealand have developed large-scale plantations. According to a recent report by the Food and Agriculture Organization of the United Nations, commercial tree farms account for roughly one half of the global total while nonindustrial plantations and unspecified plantations each account for approximately one quarter of the global total. Four countries house more than 60% of the world’s tree farms: China, India, Russia, and the United States.

Commercial tree farms can alleviate pressures on natural timber stocks and reconcile the interests of environmental advocacy groups and proponents of timber-based economic development. In fact, some major timber-producing countries or regions—most notably New Zealand and the southeastern United States—derive the majority of their commercial wood fiber from tree farms, while natural forests are set aside for conservation or preservation. The spatial consolidation of timber supplies through tree farming also reduces the financial and environmental burden of transportation, which has historically been a major impediment to profitability, rationalized production, and ecological sustainability in forest-based industries. Additionally, the environmental benefits gained through tree farming are often used as a justification to access public funding for such endeavors.

Casuarinas growing in dunes, Zululand, South Africa. Casuarinas are planted in coastal sand dunes for the stability they provide to the ground and for their timber.

Source: © Anthony Bannister; Gallo Images/Corbis.
Recent Debates and Controversies

Tree farms are a valuable ecological and socioeconomic component of the world’s forest resources. However, recent debates and controversies highlight the shortcomings of commercial plantation forests. These shortcomings are classified as either ecological defects or socioeconomic defects, but there is often notable overlap.

The absence of multilayered canopies, the depleted water tables, the inability to protect soils, the lack of habitat for wildlife and livestock, and microclimates altered by nonnative tree species are some of the most pressing ecological defects associated with tree farming. The lack of biodiversity on tree farms also draws criticism. Because the primary objective of most tree farms is to maximize the output of timber, monoculture crops are common. Critics, however, are skeptical that such crops are sustainable in the long run and claim that the aforementioned ecological defects are the result of monoculture plantations. Additionally, monoculture plantations are disproportionately susceptible to damage by invasive or parasitic insects and florae. Many point to small-scale and nonindustrial tree farms as the best means of balancing the need for long-term ecological sustainability with the need for efficient and profitable timber production.

The socioeconomic defects of commercial tree farming are most prevalent in underdeveloped nations or regions, particularly southeast Asia and South America. Three predominant defects exist. First, commercial tree farms rarely provide high economic multipliers to local or regional economies. This is especially the case where work systems are highly mechanized and capital intensive or where production is export oriented and devoid of value-adding processing facilities such as pulp or lumber mills. Second, profits are often distributed unevenly and fall into the hands of multinational firms, corrupt governments, or military juntas. Third, the conversion of land into plantations displaces peasants and indigenous cultivators from common lands that supply pasture and fuel.

Brendan Sweeney

See also Agroforestry; Community Forestry; Deforestation; Forest Restoration; Indigenous Forestry; Plantations; Social Forestry; Sustainable Forestry; Timber Plantations

Further Readings


TREWARTHA, GLENN

(1896–1984)

Born in southwestern Wisconsin in 1896, Glenn Trewartha was an influential 20th-century American geographer. Trewartha’s academic career was impressive in both its length and scope. His publication career covers seven decades, from his first publication in 1923 to his last in 1982 (just 2 yrs. before his death in 1984). Most impressively, Trewartha was a recognized leader in three distinct areas of geography: (1) weather and climate, (2) the geography of Japan, and (3) population geography.

Trewartha was hired as an instructor at the University of Wisconsin, Madison, in 1922, and received his PhD there in 1925. After receiving his doctorate, Trewartha was promoted to assistant professor at Wisconsin in 1926 (and later to associate professor and professor). He spent the next 40 yrs. at Madison before retiring in 1965 as the Finch Research Chair in Geography.

First and foremost, Trewartha was a leading expert on weather and climate. He published the very influential textbook *An Introduction to Weather and Climate* in 1937. The book went through five editions over the next 40 yrs., the
last edition being published in 1980. Trewartha is best known for his introduction of and modifications to the Koppen climate classification system. Also, Trewartha is credited with coining the term greenhouse effect in 1937.

In addition to his work on climate, Trewartha was also a leading American scholar on Japan. One of the first American geographers to specialize in the regional geography of Japan, Trewartha published his first book on the country in 1934, with subsequent editions published in 1945 and 1965. As a leading American scholar on Japan during World War II, Trewartha served as a consultant to the U.S. government during the war and afterward during the Allied occupation government’s reconstruction efforts.

Trewartha is also remembered as the founder of the subdiscipline of population geography. As president of the Association of American Geographers, Trewartha used his 1953 presidential address to advocate for population geography as a distinct and prominent subdiscipline. He believed that population geography had long been ignored by geographers and argued that the study of population should be central to the discipline. He proposed that geography had three main elements: (1) the “physical earth,” (2) the “cultural earth,” and (3) population. Trewartha saw the study of population as a central organizing principle of geography and as the key linkage between the human and physical sides of the discipline.

Jonathan Leib

See also Population Geography

Further Readings


**TRIANGULATED IRREGULAR NETWORK (TIN) DATA MODEL**

The Triangulated Irregular Network (TIN) is a data model that describes surfaces, especially terrain. It has been developed as an alternative to the two other data models for surfaces, the Regular (Rectangular) Grid and the Contour Model. The summary term is digital terrain model (DTM).

The philosophy that underlies TIN is that triangles are a good approximation of terrain that is less than smooth (i.e., has breaks such as ridges). TIN needs a fraction of the units of regular grids and is computationally faster than contour modeling.

A triangle has three components: (1) one area, (2) three edges, and (3) three vertices. It shares each edge with one other triangle and each vertex (node) with an average of five other triangles. This sharing allows the linkage of the triangles into a network. The resulting relationships are usually identified under the term topology.

All structures have topology. For the regular grid, topology is implicit; that is, each vertex in the network is given by its numbered location, the northwest corner usually being the position 0,0. The neighbors of vertex \((i, j)\) are \((i \pm 1, j \pm 1)\). For the contour structure, contours often have with them stored the labels of the contours above and below (the “contour tree”). This we could call a “partially explicit” topology.

The implementation of the TIN model into a data structure can happen in different ways.

- The first structure stores in one array the triangles together with their edges and, in a second array, the edges with their limiting vertices. A third array would have the vertices
with their coordinates. All topological relations are stored explicitly.

- The second structure is based on the edge as the main carrier. With each edge are stored the labels of the two endpoints and the labels of the two triangles that are bordering the edge, leading, again, to an explicit topology. A separate array holds the coordinates of each vertex.

- A third structure has the edges as the basis. Each record stores the label of the “leading vertex” or node and the labels of all vertices that are linked to the node. The edges are arranged in clockwise order around the node, starting due north. There is a record for every node in the network. Another array stores the coordinates of all nodes. This structure is different from the other two in that the node records are of variable length and the topology is partially given implicitly through the sequence of neighboring edges. This is likely the structure that needs the smallest amount of storage and is fastest for searches across the network.

So what is a data structure such as TIN good for? First of all, to enter a set of data points into a structure with all the topological attributes gives the points accuracy and solidity. Second, a structure allows for the production of a variety of applications. Most operations that involve surface networks are searches across the surface with one or two of the dimensions (x, y, and height, or z) kept constant. The most frequent application is likely the creation of regular, rectangular grids, because a number of geographic information systems use TIN only for storage purposes, and as soon as something is done with the data, they are converted into the regular grid. These grids are the result of searches across the network with first the y dimension kept constant (horizontal lines) and then the x dimension (vertical lines). The drawing of contours means searching the network with the z dimension kept constant.

TIN is a structure on the way to a better understanding of terrain. Terrain is given by its rivers (channels) and ridges, and TIN is a very good approximation. “TIN is the thinking man’s DTM.”

See also Digital Terrain Model; Landscape Interpretation; Terrain Analysis; Topological Relationships

**Further Readings**


**TROLL, CARL (1899–1975)**

Carl Troll was a German geographer who developed the concept of landscape ecology and made significant contributions to the study of high-mountain geography. He also served as president of the International Geographical Union from 1960 to 1964.

Troll was born in Bavaria, Germany, on December 24, 1899. He studied at the University of Munich, obtaining a doctorate in botany (1921) and another in geography (1925). Between 1926 and 1929, he undertook an extensive research journey through the Andes, during which he expanded on the concepts and research of his famous countryman, Alexander von Humboldt. His mountain studies were extended to Eastern and Southern Africa in the 1930s, and he was a member of the disastrous German expedition to Nanga Parbat in 1937. In 1930, he was appointed professor of colonial and overseas geography in Berlin. He moved to Bonn University in 1938.

His major achievements prior to the outbreak of World War II include the application of air photography to the analysis of landscape and formalization and adaptation of the concept of *Landschaftsökologie* (landscape ecology) to the study of *Hochgebirge* (high mountains); he applied the theory of altitudinal zonation to both the physical and the human and cultural aspects of mountains. However, his numerous publications in German made little impact on the English-speaking world until after the war. Yet
his treatise on patterned ground and frozen/periglacial phenomena at high altitude (1944) attracted U.S. military intelligence. It was republished in English translation (1948), thereby introducing his work to a worldwide readership.

At enormous personal risk, Troll protected his Jewish colleague, Professor Alfred Philippson, and his family from death in a concentration camp, through his contact with the pro-Nazi Swede Sven Hedin, a confidant of Hitler. After the war, Troll played a crucial role in reintegrating German geography into the international community, which was recognized by his election as president of the International Geographical Union in 1960. This led to acceptance of his proposal for an IGU Commission on High-Altitude Geoecology in 1968, which he chaired until 1972, when ill health forced him to resign.

Troll used the vehicle of what developed as the “Mountain Commission” to interest international scholars in working together to expand mountain research worldwide. He attracted to the commission younger scholars, many of whom became leaders in the field, from Poland, Russia, Switzerland, Kenya, Japan, Canada, New Zealand, and the United States, as well as his own students and colleagues throughout Germany. Thus, he created a powerful research network. While he did not live to see this infectious concept and effective teamwork develop as a force for creating worldwide awareness about mountains, his life’s contribution provided the vital catalyst.

One of Troll’s special interests centered on the explanation of the factors affecting the position of the upper timberline worldwide. He also exuded an enthusiasm for terminology. His pre-war development of climate diagrams was outstanding for its time. In 1947, he founded and edited the quarterly journal Erdkunde (Earth Study). Many of his students became leaders in mountain research, including Olov Hedberg, Masatoshi Yoshino, and Frederich-Karl Holtmeier. His enthusiasm and charisma were overriding personality characteristics that did much to extend his influence. He died in Bonn in 1975.

Jack D. Ives

See also Landscape Ecology; Physical Geography, History of

Further Readings


**TROPICAL RAIN FORESTS**

See *Biome: Tropical Rain Forest*

**TSUNAMI**

The devastating tsunami in the Indian Ocean of December 26, 2004, alerted the world to one of the most terrifying natural phenomena on Earth. Few will forget the scenes of carnage and destruction wrought by the floodwaters as they swept across coastal areas. In fact, tsunamis have been known about for generations. The word *tsunami* is derived from the Japanese word meaning “harbor wave.” Tsunamis are frequently described as tidal waves; however, this view is erroneous, since they have nothing to do with tides. Tsunamis are generated by offshore earthquakes, submarine slides, and, occasionally, subaerial landslides that enter water bodies. Asteroid impact is an additional but much rarer mechanism. With the exception of asteroid impacts, the displacement of mass, whether through submarine sediment slides, the collapse of a volcanic edifice, or an earthquake that induces faulting of the seabed, leads to a large-scale displacement of water. Although most tsunamis are phenomena associated with the open ocean, some tsunamis can be generated within lakes and/or fjords due to rockslide failures. An attempt is made here to explain the processes of tsunami generation and propagation as well as what happens when tsunamis strike coastlines. A description is also given of how societies have responded to the perception of tsunami risk.

**Tsunami Mechanics**

When a tsunami is generated, the initial water movement is generally characterized by a rapid
drawdown and a lowering of the sea surface at the coast as the water moves into the area of seabed displacement. Thereafter, due to the build up of momentum, large kinematic waves are propagated outward from the zone of seabed disturbance. The waves travel across the ocean at very high velocities, often in excess of 280 mph (miles per hour), and possess very long wavelengths and periods. Tsunami velocity is mostly a function of water depth. Thus, as the waves approach shallow water, the wave velocity decreases, and the wave starts to break. At the coast, the tsunami flood level (run-up) is partly a function of the dimensions of the propagated waves but is also greatly influenced by the topography and bathymetry of the coastal zone, and as such, the waves can reach considerable elevations, causing widespread destruction and loss of life.

It is a mistake to think of a tsunami as a single wave. All tsunamis consist of a train of waves that can strike a coastline over time periods ranging from a few minutes to several hours. Often, a large incoming wave can be followed by a much smaller one. However, the backwash from the first wave can interfere with the wave motion of the second incoming wave. In many cases, this interference can act to amplify the dimensions of the second wave, causing it to increase in size beyond the first. From this description, it can be easily appreciated that the dimensions of individual tsunami waves striking a coastline are greatly influenced by wave resonance, refraction and diffraction effects, and local near-shore bathymetry.

Geography of Tsunamis and Warning Systems

The majority of tsunamis occur around the Pacific Ocean, but many are also known from other areas. The frequency of Pacific tsunamis is due to the high occurrence of severe earthquakes under or close to the seabed as a result of the subduction of oceanic crust adjacent to continental margins. Such geological processes are a characteristic feature of Japan, where there is a long history of devastating earthquakes and tsunamis. Between 1596 and 1938, the Japanese islands were struck by 15 major tsunamis. One of the worst of these took place on June 15, 1896, as a result of a large submarine earthquake centered under the ocean floor 93 mi. (miles) offshore. Since the epicenter of the earthquake was located beneath the ocean floor, the inhabitants on nearby coasts, although they knew that an earthquake had taken place, were unaware that a dangerous tsunami had been generated.

Long before the tsunami of December 2004, the long history of tsunamis known to have affected coastlines bordering the Pacific Ocean led to the development of warning systems designed to alert the public in advance of the arrival of individual tsunamis. Following the Aleutian Trench earthquake and tsunami of April 1, 1946, together with the destruction of the Scotch Cape Lighthouse on Umnak Island and the devastation of Hilo, Hawaii, a case was made for the establishment of a tsunami warning system designed to protect life and property.

The Pacific Tsunami Warning System was developed by the U.S. Coast and Geodetic Survey (since 1970, the National Geodetic Survey) and has its center of operations on the Island of Oahu, Hawaii. The center, known as the Pacific Tsunami Warning Center (PTWC), became operational in 1948 and is linked to seismographic stations throughout the Pacific Basin. These provide data on Pacific earthquakes whose magnitude and epicenters make them tsunamigenic (capable of producing tsunamis). When an earthquake has taken place, the PTWC issues a tsunami watch to all receiving stations. The PTWC is also linked to more than 50 tide-gauge stations located throughout the Pacific. Any tsunami that has been generated by an earthquake is automatically recorded in the tide-gauges closest to the epicenter. If a tsunami has been detected, then the tsunami watch is upgraded to a tsunami warning. At this stage, the estimated times of arrival of the first waves are computed for all stations across the Pacific. Once the PTWC has issued a tsunami warning and has provided information on the times of arrival of the first waves, it is the responsibility of the local police, military, and civil defense agencies to decide on whether or not particular areas should be evacuated.

The accuracy of PTWC tsunami warnings is well illustrated by the famous Chilean earthquake and tsunami of May 21, 1960. Once the earthquake epicenter had been calculated and a brief study of local tide-gauge data had been completed, it was estimated that the velocity of the tsunami was 440 mph and that the tsunami would reach
the Hawaiian islands 14 hours and 56 min. (minutes) after its generation off the Chilean coast. The prediction was that the first wave would strike Hilo at 9:57 p.m.—it arrived 1 min. late.

In areas where the coast is located close to the epicenter of a tsunamigenic earthquake, the time that elapses between the generation of the tsunami and its arrival on the coast is often frighteningly short. For example, the first tsunami waves that struck the Chilean coast on May 21, 1960, arrived only 15 min. after the main earthquake shock. Similarly, there was only a relatively short time interval between the March 27, 1964, earthquake in Alaska and the arrival of tsunami waves at the coast. In both cases, loss of life occurred because the tsunamis struck coastlines long before any PTWC warning could be given. In the case of the 2004 Indian Ocean tsunami, since the Pacific tsunami warning system did not extend as far afield as Indonesia, it was not possible to generate an instant warning to countries bordering the Indian Ocean. Instead, the first indications that a tsunami was likely to be generated came from the global array of seismic monitoring stations that were recording the occurrence of a huge earthquake beneath the Indian Ocean.

The presence of a tsunami warning system is essential for the Pacific region due to the large number of tsunamis that are known to have occurred. However, large tsunamis are also known to have taken place in other parts of the world, albeit less frequently. The Indian Ocean tsunami of 2004 is a good example of this, but there have been many other catastrophic events. In Europe, for example, the most destructive historical tsunamis were those that accompanied the Lisbon earthquake of November 1, 1755; the earthquakes in Sicily and Calabria on February 5, 1783, and December 8, 1908, respectively; and the Aegean Sea earthquake of July 9, 1956. Of these, the most destructive event was the Lisbon earthquake in 1755.

### Prehistoric Tsunamis

In recent years, it has become increasingly clear that many large prehistoric tsunamis can be recognized in coastal sediment sequences, since such tsunamis frequently result in extensive coastal erosion and sediment deposition. The recognition that specific prehistoric tsunamis can be identified using geological methods has provided the scientific community with very valuable information on the long-term frequency of tsunamis in particular areas of the world. For example, it is now known from geological studies along the Pacific coastline of the United States and Canada that a large, severe, destructive tsunami took place about 300 yrs. (years) ago. The geological evidence for this tsunami, associated with a large offshore earthquake, is supported by historical data from Japan, which suggests that this particular tsunami caused severe flooding throughout the North Pacific region. The recognition that such destructive floods associated with former earthquakes have taken place in the relatively recent geological past has alerted governmental organizations that if a similar event were to occur in the future, there would be widespread destruction in many of the cities that border the Pacific coastline of the United States and Canada.

Geological investigations have similarly shown that one of the most destructive tsunamis to have affected northwest Europe took place as a result of one of the world’s largest submarine slides, which occurred in the Storegga area on the continental slope west of Norway. The second Storegga slide is believed to have occurred around 8,000 yrs. ago and involved the movement of about 400 mi.³ (cubic miles) of sediment and rock across the seafloor over a distance in excess of 300 mi. The magnitude of this slide is demonstrated by the movement of two blocks, 500 to 650 ft. (feet) thick and up to 6 to 20 mi. wide, that were transported as far as 125 mi. downslope, over seabed surfaces with average slopes of no greater than 1° to 2°. The tsunami generated by this landslide caused extensive flooding of coastlines bordering the Norwegian Sea and northeast Atlantic Ocean. For example, in the North Sea, flood levels reached up to 13 to 20 ft. above the contemporary high-water mark, while along the coastline of Western Norway and the Shetland Isles, the tsunami locally reached up to 30 meters (about 90 ft.) above former sea level (see photo).

### Conclusion

The occurrence of this giant tsunami in prehistory teaches us an important lesson. It tells us
that there are few coastlines of the world that are not at risk from tsunamis. With this realization comes the need to be able to quantify tsunami risk. It highlights the need for tsunami scientists to be able to inform planners and politicians of the probability of occurrence of future destructive event in specific areas. This task is exceptionally difficult, since the database of past events in history and in prehistory is always bound to be incomplete. Sadly, it has taken a catastrophic event such as that which occurred in 2004 to accelerate the pace of tsunami research to help find answers to these questions.

Alastair Dawson

See also Coastal Erosion and Deposition; Coastal Hazards; Earthquakes; Natural Hazards and Risk Analysis; Oceanic Circulation; Tsunami of 2004, Indian Ocean

Further Readings


TSUNAMI OF 2004, INDIAN OCEAN

A major tsunami took place on December 26, 2004, which was the deadliest tsunami in recent history. On that fateful day, the tsunami left more than 225,000 people dead or missing, with many millions made homeless in a total of 11 countries. Indonesia, Sri Lanka, India, and Thailand were the hardest hit.
Figure 1  A regional map of those countries most affected by the tsunami. This map also illustrates the approximate land coverage under 20 m in elevation as a zone of potential tsunami damage.

Source: Courtesy of UNOSAT, the UN Institute for Training and Research (UNITAR) Operational Satellite Applications Programme, implemented in cooperation with the European Organization for Nuclear Research (CERN). Map based on data provided by International Charter Space and Major Disasters.
The tsunami was caused by an offshore (undersea) earthquake of magnitude 9.2 that was triggered along an area of plate collision where the India Plate, an oceanic plate, is being subducted beneath the Burma-Sunda plate across a subduction zone in the area of the Sunda Trench. The epicenter of the 9.0-magnitude quake was under the Indian Ocean off the western coast of Sumatra, Indonesia. The earthquake was associated with the rupture of the seafloor along a length of 1,000 km (kilometers; 620 miles). Along this zone, the land surface was displaced both laterally and vertically by several meters. This event led to the sudden displacement of the overlying ocean water and the production of the tsunami.

Along the coast of Northern Sumatra, tsunami waves up to 30 m (meters; 100 ft.) in height destroyed everything in their path. The tsunami traveled across the Indian Ocean, causing devastation along coastlines as far as away as Somalia, Kenya, and the Maldives. Some of the most destructive flooding took place along the coasts of Thailand, Sri Lanka, and India, where many thousands of people lost their lives and many more lost their livelihoods.

Alastair Dawson

See also Coastal Hazards; Natural Hazards and Risk Analysis; Tsunami; Vulnerability, Risks, and Hazards

Further Readings


in human geography,” though it is erroneously believed that he coined the neologism *topophilia* (W. H. Auden and Gaston Bachelard used the word before him). However, there is no doubt that he popularized a concept that has been subsequently applied to a wide range of themes that deal with the “sense of place,” or the cognate idea of *genius loci*. A study of “negative” senses of place (“topophobia”), *Landscapes of Fear* (1979), is less well-known. He returned to the power of place in *Space and Place* (1977), another definitive work that sees place as inhabited space.

Although Tuan is considered by some as an academic “outsider,” it is possible to see in his work illuminations of writing by Michel Foucault and other eminent scholars. For example, Tuan’s *Segmented Worlds and Self* (1982) stresses the changing spatial structures in society in relation to society’s varied forms of control. Later work saw Tuan define geography as a “moral science”; for example, in *Dominance and Affection* (1984), perhaps his most pessimistic book, his foci are pets and gardens. In this fascinating work, he wrestles with the possibility that affection—indeed, love—may be seen as an extreme form of domination.

Two terms characterize Tuan’s oeuvre: *humility* and *vitality*. He continually seeks to explore the “good life.” As he seeks it in many of his works, he draws extensively on literature and self-reflection. To be sure, he has had his critics (though they are few and far between), yet he returns and modifies his examples by testing and editing his findings.

Tuan is a scholar who wishes to engage with his readers. Hence, in *Dominance and Affection*, facts and ideas are carefully, but with responsibility, displayed and explored, and the author necessarily focuses further on a specific problem and its detailed examination. Additionally, for many years, he has disseminated weekly letters to his colleagues and students that provide a “verbal outlet” to his thoughts.

Tuan has published a large number of papers and books, most of which have been acclaimed. His works *Escapism* (1998) and *The Good Life* (1986) are examples where taken-for-granted subjects are explored through Tuan’s philosophical lens, through which he seeks understanding and appreciation without being seduced by surface phenomena. Indeed, he regards a humanistic approach as seeing ordinary objects afresh, delighting in them for what they are and, as they appear, excavating hidden relations and meanings and then, in conclusion, presenting surfaces and depths—the seen and the unseen.

Tuan’s work has been appreciated in a wide variety of disciplines, including geography, history, architecture, psychology, philosophy, and sports studies. He has received many honors, including the Callum Geographical Medal from the Association of American Geographers and the Laurat d’Honeur of the International Geographical Union.

*John Bale*

**Further Readings**


**TURNER, BILLIE LEE, II (1945– )**

Billie Lee Turner II helped reinvigorate a science orientation to human-environment relationships, initially by steering cultural and historical geographical topics shared with anthropology into the
subfield of cultural ecology and subsequently by leading the development of land change and sustainability science. Of his scholarly contributions, including the role of geography as a human-environment research endeavor, three deserve special consideration. First, his field research in Mexico and Middle America paved the way for a new understanding of ancient Mayan human-environment relationships by demonstrating the various cultivation and landscape practices employed by this civilization. His work provides the basis by which questions on the rise and fall of the Mayan civilization must be set. Second, he and his students helped develop the induced intensification thesis of smallholder cultivation in the contemporary tropics, demonstrating how outcomes linked to both Boserup and Malthus are possible. This thesis demonstrates how the ambient environment alters the outcomes of different levels of pressures on land use and how household response to these pressures is predicated on a fusion of market and subsistence factors. Third, he has been an international leader in the development of global environmental change and sustainability research, through the lens of what has become land change science. His team of researchers has advanced remote sensing and modeling assessments of tropical deforestation, demonstrating that vulnerability must address a coupled human-environment system and pointing the way toward the research challenge of discovering sustainable land architectures.

Turner earned his PhD from the University of Wisconsin–Madison in 1974. In 1980, he joined the Graduate School of Geography, Clark University, where he remained for the next 28 years, mentoring 40 PhD students and serving as the Higgins Professor of Environment and Society. For several years, he was director of Clark’s Graduate School of Geography and the George Perkins Marsh Institute. He served as a fellow at the Center for Advanced Studies in the Behavioral Sciences (Stanford) and was elected to the National Academy of Sciences (1995), American Academy of Arts and Sciences (1998), and Massachusetts Academy of Sciences (2008). In 2008, he became the Gilbert F. White Professor of Environment and Society, School of Geographical Sciences, Arizona State University.

Robert Gilmore Pontius Jr.

See also Agricultural Intensification; Agriculture, Preindustrial; Cultural Ecology; Human Dimensions of Global Environmental Change; Land Use and Cover Change (LUC); Malthusianism; Political Ecology; Shifting Cultivation; Sustainability Science

Further Readings


Typhoons

See Hurricanes, Physical Geography of

Typography in maps refers to symbols and signs in maps. Since maps are graphical representation of spatial relationships that essentially reduce the permutations of space into a two-dimensional topological construct, the role of typography is limited to labeling points, arcs, and polygons (referred to as features) with appropriate and efficient form, style, and weight factors.

In 1990, John B. Harley redefined maps as more than mere efficient representations of physical surfaces. Through a postmodernist reinterpretation of map typography, Harley viewed maps as representations of power. Thus, maps have joined the ranks of other graphical pursuits, such as architecture and design, that encounter such ontological
The impact on typography has been evident ever since the stability of ideas, as Plato imagined it, was challenged in the past two centuries with concepts such as semiotics and deconstruction. Ferdinand de Saussure (1857–1913), a Swiss professor of linguistics and a contemporary of Sigmund Freud, Émile Durkheim, Charles Darwin, and Karl Marx, revolutionized the field by introducing the concept of semiotics. The broader epistemological basis for semiotics is contained in structural and poststructural philosophy.

The history of symbols and signs since antiquity has evolved separately in the fields of art, architecture, and cartography, but there are signs of convergence, at least epistemologically.

Since all relevant information cannot be printed on maps, the field of cartography developed a sophisticated ontology. The way the cartographer represented symbols and signs depended on what was viewed as important and appropriately signified the signifier (semiotics). Therefore, the symbol for “north” is interpreted as the direction north, but the orientation of north (up, in most maps) is historically a result of maps mostly constructed as a cultural legacy of the Northern Hemisphere. Therefore, the semiotics of typography is in what it implies and is more complex than functional issues such as what it represents.

With the advent of computer cartography and the possibility of dynamic labeling (through artificial intelligence and haptic manipulations such as “zoom” and “mouse over”), a strict cartographic hierarchy need not be followed; instead, map typography can be dynamically “programmed” to satisfy a large community of map users. The resulting flexibility does not eliminate the complex power structure that Harvey implied earlier but allows for improved efficiency. With artificial intelligence algorithms, the complex demands on map typography can now be better handled than was possible in the earlier era of analog maps.

Since traditionally, map making and mapping software have usually represented feature-based maps (i.e., maps that contain discrete and finite elements that can be represented by points, arcs, and polygons), the representation of “fields,” or continuous objects, has been neglected. However, the dynamic representation of time and space through digital technology now allows for field-based typography. Examples include traffic and weather simulation, as seen in some geographic information software such as Transmodeler.

Aniruddha Banerjee

See also Cartography; Harley, Brian; Map Design; Map Visualization

Further Readings


Underdevelopment refers to a condition characterized by undiversified primary sector production for export (usually agriculture), wide income disparities typified by a small upper class where wealth is concentrated, and a small internal market. The state of underdevelopment, in which poorer nations have market relations with industrialized countries, must be distinguished from those without development, which do not have market relations with industrialized countries. Discussions of underdevelopment typically
focus on the spatial scale of the individual state and its trade relations with developed economies. Two categories of underdeveloped states are distinguished: (1) those that were nation-states before they were integrated into the world economy and (2) those that transitioned from colonies into states at independence but without any change in their social or economic relationships with their ex-colonial administrators. In either case, underdevelopment is a historical legacy of colonialism and a process directly attributed to the historical spread of capitalist structures: The center-periphery (or metropolis-satellite) relations that were forged during colonialism resulted in formal colonies depending on developed countries to purchase their raw materials. Thus, any growth or development in countries dependent on raw materials depends on expansion of the market in developed countries.

Radical underdevelopment theory and the dependency school of development have their origins in the early 1950s. As early as 1950, the Argentine economist Raúl Prebisch, head of ECLA, recognized the inadequacy of the conventional global division of labor, in which regions such as Latin America produced raw materials and commodities for export to developed regions such as North America and in turn received manufactured goods from these regions. Prebisch argued that the dependence on commodities and raw materials exports was at the root of the poor economies’ problems and that capital accumulation was impossible under those conditions because it was inhibited by disadvantageous terms...
of trade, that is, exports of low-priced foods and raw materials and imports of expensive manufactured goods. In response to this realization, Prebisch promoted a new strategy for Latin American economies. The strategy was based largely on protectionism and import substitution industrialization, but it also retained a focus on the export of raw materials and food commodities. Even as integration into the world economy was seen as detrimental to the development of Latin American economies by ECLA, the argument for continued focus on raw materials export was that it would finance the importing of capital goods, supporting economic growth through technology transfer. Governments would play an active role in implementing the ECLA strategy.

After a period of growth in Latin America in the 1950s, nation-states participating in the ECLA program faced economic stagnation attributed to the failure of the ECLA strategy. It essentially proved overly ambitious and inadequate for the problems facing Latin America and other poor regions, as it did not attack structural disadvantages but, instead, worked from the assumption that industrialization would fix other obstacles of development in the developing economies. In fact, import substitution industrialization fell short of producing a favorable balance of trade for underdeveloped countries because it neglected the diversification of the export sector from raw materials and commodities.

The failure of the moderate ECLA strategy prompted more radical thinking on development in the 1960s among Latin American intellectuals. At the same time, Latin America was experiencing a crisis of orthodox Marxism. The Cuban and Chinese revolutions inspired the theory that societies did not have to pass through the requisite stages of bourgeois revolution and then socialist revolution, as Marxist theory asserted; instead, worked from the assumption that industrialization would fix other obstacles of development in the developing economies. In fact, import substitution industrialization fell short of producing a favorable balance of trade for underdeveloped countries because it neglected the diversification of the export sector from raw materials and commodities.

The failure of the moderate ECLA strategy prompted more radical thinking on development in the 1960s among Latin American intellectuals. At the same time, Latin America was experiencing a crisis of orthodox Marxism. The Cuban and Chinese revolutions inspired the theory that societies did not have to pass through the requisite stages of bourgeois revolution and then socialist revolution, as Marxist theory asserted; instead, they could proceed directly to socialist revolution without the evolution of the bourgeoisie. This neo-Marxism also provided the basis for the radical critiques of the ECLA program and shifted the thinking of Latin American development theorists in the 1960s from economic structures to inclusion of the social implications of the center-periphery division of labor.

Andrew Gunder Frank developed key critiques of the modernization school of development that significantly contributed to the development of dependency theory and thinking about the processes and implications of underdevelopment. First, modernization theory is based on the experiences of First World countries, which never experienced colonization—a process that effectively set in place the structures of Third World economies. Instead, modernization theory attributes underdevelopment to internal factors such as culture or a lack of investment. Frank offered an external explanation in place of the internal one, with the reasoning that societies such as China were advanced before experiencing colonization, which effectively reversed these societies’ development. Frank further theorized the mechanisms of underdevelopment, proposing a metropolis-satellite model in which complex systems of economic surplus extraction and transfer span the globe, flowing from Third World economies to First World countries. These critiques led Frank to a series of hypotheses that theorize “the development of underdevelopment”—a famous term coined by Frank that signifies underdevelopment as a historical process rather than a normal or inevitable condition of Third World societies. Essentially, Frank hypothesized that satellites that had the closest historical relationships to metropolises are the most underdeveloped and that there is a direct correlation between their relationship with the metropolis and the extent of their underdevelopment. Furthermore, reintegration of satellites into the economic system after a crisis reverses any previous industrial development those countries might have achieved. Frank also played a key role in communicating and disseminating the ideas of radical underdevelopment theory and the dependency school to the English-speaking world, where it resonated with the ideas of radical young researchers who were in the midst of overturning their own establishment.

Cardoso and Faletto added nuances to the radical underdevelopment theory in the early 1970s, further critiquing modernization theory’s modern-backward dichotomy and adding internal factors such as national-scale class relations to the external explanation. They argued that the dominant socioeconomic class imposes through political action a set of social relations that is most in its own economic interests and that elites’ relationship to international metropolises
facilitates the flow of wealth toward the metropo-
lises. In other words, the internal economic rela-
tions between the classes, as well as elites’ ties to
the core economies, actually limit political action
and thus restrict social change. Hence, polariza-
tion between the classes can occur internationally,
regionally, as well as nationally—the result of the
historic evolution of capitalism; however, how it
has played out in each country depends on the
economic and class structure of the specific coun-
try and the elites’ relationships. The evolution of
oppositional ideas and theories of development
was not restricted to Latin America; scholars such
as Samir Amin in the early 1970s drew from the
experience of African societies and their struggles
for sovereignty, creating further iterations of the-
ory under the rubric of neocolonialism.

Critiques of Underdevelopment
and the Dependency School

Critiques of the radical underdevelopment theory
and the dependency theory (often considered syn-
onymous) address a variety of issues. First, the
primary unit of analysis used by dependistas
(early proponents of the dependency theory) is
the nation-state, which was not the sole actor and
is arguably no longer the primary actor in eco-
nomic globalization. Instead, transnational cor-
porations and international institutions bring
with them distinct dynamics of domination, even
as they continue the work of extracting economic
surplus from underdeveloped countries. Second,
the dependency school cannot explain Third
World capitalist development; in fact, it effec-
tively ignores it. A third critique of the underde-
velopment and dependency theory is its strict
developmentalist approach, arguing that societies
had to go through some kind of socialist revolu-
tion followed by a process of autonomous devel-
opment. Another important critique of underdevelopment spoke to its oversimplification
of metropolis-periphery relations: It did not
acknowledge that even as the core economies
extracted surplus from Third World countries
during the process of underdevelopment, the situa-
tion was often much more complex in that capi-
tal often flows in the other direction as well, that
is, from the metropolis to the periphery. For
example, transnational corporations invest in
industrialization and production infrastructure
since they have an interest in promoting develop-
ment as it opens new markets for their goods and
services. The problem of dependency persists,
however, since developing countries depend on
developed countries for technology and invest-
ment. Put in other terms, development and
dependence exist simultaneously, and the exact
manifestations are varied and complex, in con-
trast to the simple scenario presented by depen-
dency theorists.

Current State of Underdevelopment
and the Dependency School

Although theories of underdevelopment and
dependency are often considered today to be
defunct or obsolete, it must be recognized that
the evolution of thinking on underdevelopment
took place in the context of the Cold War. The
Cold War was a period of instability and turmoil
in which intellectual opposition was part of wider
political and social opposition movements that
fed into the development of oppositional thinking
that is still relevant today as underdeveloped
societies continue to struggle against foreign
economic, social, and cultural domination. Con-
temporary issues, including the foreign debt cri-
sis, only reinforce the argument that the basic
precepts of underdevelopment still hold and can
be further developed to integrate new develop-
ments and phenomena of contemporary global-
ization. Furthermore, scholars such as Milton
Dos Santos in the late 1990s pointed out that
underdevelopment and dependency theories are
still given much scholarly attention and underde-
velopment discourses are still widely used, espe-
cially in Third World intellectual circles. Others
argued that the ideas proposed by scholars of
oppositional theories in the 1960s and 1970s are
still relevant to today’s world as part of a larger
movement to revitalize the inclusion of opposi-
tional narratives of economics and history, espe-
cially in light of the contemporary dominance of
neoliberal ideas.

Heather R. Putnam

See also Colonialism; Dependency Theory; Developing
World; Development Theory; Import Substitution
UNEVEN DEVELOPMENT

Uneven development is a general term for the measurement and explanation of spatial patterns of variation in the quality of life among human beings, or in a more restricted sense within Marxist theories, the concept is a fundamental and inescapable part of capitalism. The definitions of development are varied and contentious. Even given a particular definition, the patterns observed will vary widely depending on the chosen spatial scale. It is more challenging still to uncover the causes of any pattern and to situate these causes within a theory with explanatory power for larger areas and longer time periods. This entry discusses the definition and measurement of uneven development, the problem of scale, neo-Marxism and neoliberalism within the context of uneven development, and the subaltern and current trends.

Geographers and other social scientists have tended to approach uneven development through the lens of theories that, despite their varied emphases, overlap considerably: world-systems theory, dependency theory, neoliberalism, and, especially, neo-Marxism. Each approach grapples with the question “To what degree is uneven development an inevitable, even desirable, consequence of the spatially unequal comparative advantages inherent in a global capitalist system?” Another question is, “To what degree is uneven development a consequence of physical geographic endowment, and to what degree is it due to the chance contingencies of history?” Since the refutation of environmental determinism in the 1920s, this second question is asked less often; it is now generally taken for granted that uneven development is a complex intertwining of both factors. The subfield of cultural ecology, influenced by anthropologists such as Eric Wolf, has continued to examine the particulars of this intertwining, as have geographers such as Philip Porter and Eric Sheppard and, for a broader audience, Jared Diamond.

Work since the 1990s has tended to question assumptions regarding structure and agency and has inquired how spatial disparities may be mitigated, or redefined, by individuals or groups often considered its passive victims—the so-called subaltern. Postcolonial and Marxist geographers observe how neoliberal experiments have played out in various regions of the world and have reworked some Marxist ideas to better explain uneven development in the rapidly globalizing 21st century.

Defining and Measuring Uneven Development

Except with case studies for the smallest areas, much geographic analysis depends on the availability of spatial data. The most commonly used measure is gross national product (GNP)—the total final output of goods and services produced by an economy—and its derivatives, especially GNP per capita. While in some cases, this may be quantified for subnational regions or supranational blocs, by definition GNP privileges the nation-state scale. GNP may be considered as a static measure (e.g., to compare “more developed” and “less developed” nation-states) or as a dynamic rate of change (e.g., to identify “rapidly developing” nation-states).

Even if we accept “income” as an appropriate proxy for “development,” there are many practical problems with this measure, such as its failure...
to capture the informal economy, which is often considerable in developing nations. Another option is the Human Development Index (HDI), popularized by the United Nations Development Program, which combines life expectancy at birth, adult literacy, mean years of schooling, and income sufficiency for an adequate quality of life.

Some studies use other variables such as human right indices to analyze development. Most, however, assume that income is a fairly reliable proxy. This assumption may be explicit, as in studies based on world-systems theory, or implicit, as in studies based on capital flows and in most feminist work. While they may agree on little else, Marxist geographers and neoliberal advocates both tend to rely on income as a useful indicator. The few who contend it directly are those, often postcolonialists, who question the entire idea of development.

On occasion, “development” has been examined as a sort of industry unto itself. The Colombian anthropologist Arturo Escobar has shown how the identification, professionalizing, and institutionalizing of development “problems” by rich nations and their allies in poorer ones increase the power of both at the expense of those they claim to serve. Escobar advocated indigenous, autonomous social movements and localized, place-based strategies of development, a strategy compatible with certain geographic methods such as participatory research mapping.

The Problem of Scale

In one way or another, analyses of development study human beings, individually or grouped at various spatial scales. It could be argued that ever-increasing mobility makes it less important to map and analyze people, and groups of people, as if they were fixed points in space. However, three facts work against this argument. First, labor and, to a lesser degree, capital and ideas are less mobile than is often assumed; nation-state boundaries are still generally strong barriers, and those who do migrate are often considered “temporary” workers without full rights in their host nations. Second, many geographers analyze “space” in a sense that goes beyond mere coordinates on the Earth’s surface; for example, Ashraf Ghani sees space as an “arena of represented practices,” where social constructions of gender may underscore less apparent inequalities of development. Third, some geographers (often “transnationalists”) study mobility itself as a vector for both amelioration and worsening of uneven development at different scales.

At the scale of nation-state blocs, the groundwork for much geographic study of uneven development was laid by world-systems theory, formulated in the 1970s by the sociologist Immanuel Wallerstein. World-systems theory examines the economic conditions of nation-states within the global system, which in its most basic form is seen as having a core (the most developed nations, with 20% of the world’s population but 80% of its GDP), a semiperiphery (Mexico, the Newly Industrializing Countries, and the “BRICs,” i.e., Brazil, Russia, India, and China), and a periphery (including Africa, the poorer parts of Asia, Oceania, Latin America except for Mexico and Brazil, and the Caribbean). This world system originated in 16th-century Europe, when the core was England, Northern France, and the Netherlands, although its membership has changed over time. A global labor pool is linked through commodity chains, and in the periphery, labor is generated through some threat of force. Even if shirts are made in the Honduras of cotton from India, the patent holders, the designers, the marketers, and the ultimate controllers of labor and capital investment are mainly in the core. In these and other ways, world-systems theory supports Marxist assertions.

World-systems theory is well suited for examining supranational political-economic entities in the core (such as the European Union), as well as international trading blocs, such as the North American Free Trade Agreement (NAFTA), which facilitate the flow of goods and capital in and out of the core. It helps explain why the nation-state is becoming less important in the core (e.g., the United States now shares economic dominance with countries such as Japan) and in the periphery (where ethnic ties often dominate, reinforced through 19th- and 20th-century European colonial practices), while the nation-state continues to be strong in the semiperiphery (in large-population “emerging markets” such as Mexico).
Geographic studies directed toward other scales are consequently less top-down or Eurocentric than world-systems theory. Some multiscale studies have their roots in dependency theory, which acknowledges relationships between local elites and dependents—even between village leaders and other villagers—up to and including global nation-state blocs. At each level, unequal terms of trade lead to self-perpetuating unequal exchange, another basic tenet of Marxism.

Subnational regional patterns of uneven development have been examined throughout the world, including in Mexico (the indigenous south vs. the developed north), England (the richer southeast vs. the poorer north), and China (the industrialized coast vs. the impoverished interior). The Brazilian economist (and later president) Fernando Cardoso has influenced many such studies. Often, more developed regions are centered on urban centers of finance, academic research, or government, themselves often located in former or current places of commercial trade (e.g., ports or important international borders) or colonial loci of centralized bureaucracy.

The Marxist geographer Neil Smith (2008) wrote that “city building has become a motive geographical force of capital accumulation, a source of massive surplus value production” (p. 263), especially in Asia, in part fueled by massive rural-to-urban migration. Recent urban geography work builds on earlier studies of uneven development (many contrasting inner cities and suburbs) to focus on alternative models in developing nations as well as on gentrification.

Neo-Marxism, Neoliberalism, and Uneven Development

The writings of Marx contain little about the spatial implications of the theories he espoused, but throughout the 20th century and into the 21st, Marxist geographers developed a large body of literature on the subject. To explain uneven patterns of development, these writers have departed from the teleological predictability that infuses orthodox Marxism. Instead, they emphasized how Marxism regards the global capitalist system as a zero-sum game, and consequently, we should expect to find entrenched spatial concentrations of “winners” and “losers.” This idea is paralleled in world-systems theory, which argues that increasing linkages tend to perpetuate inequalities rather than ameliorate them, as neoliberalist thinkers contend. Also, as in world-systems theory, the nation-state is seen as having played a key role in protecting and expanding systems of surplus extraction.

Since the 1980s, Neil Smith and David Harvey have been the most prominent neo-Marxist geographers. In their works, capitalism seeks to equalize the conditions of production over space while simultaneously taking advantage of, and so accentuating, those differences—as capital “seesaws” between the developing world (the source of cheap raw materials and cheap labor) and the developed world. This view helps explain recent phenomena such as the global rise in remittances and the decrease in food security in the late 2000s, as once self-sufficient countries such as Mexico and Nigeria devote ever-increasing amounts of land and labor to the production of foodstuffs for export.

Spatial patterns of uneven development are perpetuated because capital, even in the era of instantaneous global financial transactions, still seeks to “park” itself somewhere; capital can only circulate if some part of it does not. This process can be analyzed at many scales. The geographer Don Mitchell analyzes specific small landscapes as loci of regional and global inequalities. A strawberry farm in California, for example, is a fixed node in space where capital is invested; the products of that landscape, and the landscape itself, hide the unjust labor conditions that allow it to exist. Others examine subnational regions, showing how, for example, the continued importance of face-to-face contacts influences corporate decisions. At the world-system scale, Federal Reserve Chair Ben Bernanke suggested that money generated during the real estate bubble in Japan in the 1990s (during a downturn in southeast Asia) eventually found its way into the U.S. debt market, thus helping set the stage for the economic collapse of 2008.

The global slowdown of the early 1970s, along with the expanded foreign debt of semiperipheral countries such as Mexico and Thailand in the 1980s, set the stage for neoliberal experiments in the 1990s. Neoliberal theory contends that uneven
UNEVEN DEVELOPMENT

development can be ameliorated by removing state regulation and barriers to free flow of goods, capital, and (sometimes) labor. Marxist geographers such as David Harvey argue that this has made some countries more internally uneven than before, while separating the semiperiphery into two groups: (1) those that have generally benefited (e.g., China and India) and (2) those that have not (e.g., Mexico).

The neoliberal experiment has faced practical difficulties, including the following: (a) it may be perceived as a disguise for accelerated capitalist accumulation to benefit developed nation-states and local elites, (b) the nation-state bureaucracy and power structure often remain as strong as before, and (c) the “temporary” hardships produced by “structural adjustments” have led to many rightist governments of the 1990s being replaced by leftist ones in the 2000s. In the 2000s, most neoliberal advocates have recognized these deficiencies while remaining optimistic that the underlying principles are sound.

The Subaltern and Current Trends

To what degree do the causes of uneven development come from privileged, centralized decision makers (e.g., supranational organizations such as the World Bank, rich nation-states, and transnational corporations), and to what degree can they be mitigated by the less transparently powerful “subaltern” entities (e.g., poor nation-states, “progressive” nongovernment organizations, and individuals)? As Marxism is rooted in the potential for dynamic disequilibrium and revolt in human societies, neo-Marxist thought on uneven development has found commonalities with postcolonialist and post-structuralist thinkers such as Homi Bhaba, who criticize both world-systems theory and dependency theory for their failure to acknowledge the power of the subaltern in intellectual, cultural, and sometimes political realms.

In part, such criticism is a reaction to the assumptions of modernization theory, which in geography grew out of Eurocentric studies of innovation diffusion in the 1960s. Many geographers now recognize how the Internet, for example, permits relatively low-cost links to be formed between people in the global periphery and global NGOs; others, however, point out that even Internet access is spatially uneven.

One implication of this turn from Eurocentric attitudes is a revised understanding of history. Eric Wolf showed how, well before the 16th-century European global expansion, multiscale spatial inequalities in development existed in Asia, Africa, and the Americas through the buildup of hegemonic political and military systems and long-distance trade linkages.

“Development” can be thought of as an unfolding of something that was in some sense there to begin with (this is its etymological root meaning) or instead as the intervention of an outside force on a region and its people. Geographers today consider local actions and global processes as mutually constitutive. While flexible accumulation and globalized commodity chains and capital flows allow development to happen in some places where it had not occurred before (e.g., Ireland and parts of India and China), it still must happen in some places and not in others.

Discussion of uneven development continues among neo-Marxist geographers, as well as others who explore the complexities and contradictions of postcolonial globalization. At the nation-state scale, these complexities include the incomplete adoption of neoliberal tenets by countries such as Mexico (where deregulation of land and water markets has been contested) and the perpetuation of extractive and elite-benefiting practices by some postcolonial governments (e.g., Indonesia) with roots both in European colonialism and before it. Geographers of uneven development are well positioned to analyze the global economic downturn of the late 2000s, wherever it tends to reduce spatial inequality, so as to “lower all boats” equally while maintaining patterns, or to exacerbate inequalities as capital flees from a periphery now with reduced options for local and regional development.

John Kelly

See also Dependency Theory; Development Theory; Gross Domestic Product/Gross National Product; Harvey, David; Justice, Geography of; Marxism, Geography and; Modernization Theory; Neoliberalism; Peet, Richard; Radical Geography; Smith, Neil; Social Justice; Transnational Corporation; Underdevelopment; World-Systems Theory
The United Nations (UN) is an international organization created in the aftermath of World War II to promote peace and prosperity among and within nations and states. Its formal existence began on October 24, 1945, with the ratification of the UN Charter by China, France, the Soviet Union, the United Kingdom, the United States of America, and other signatories.

The UN is generally considered to be the successor to the League of Nations, which was established in 1919 to promote international cooperation, peace, and security. As the league’s international role faded in the 1930s and 1940s, various national governments agreed to form a new organization. They met in San Francisco in 1945 to draw up the UN Charter. As of December 2009, the UN had 192 member states; Montenegro (which joined in 2006) is its newest member.

The charter is the constitution of the UN, detailing rights and obligations of member states and establishing and describing UN organs and procedures. According to its charter, the purposes of the UN are the following:

(1) to maintain international peace and security . . .
(2) to develop friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples . . .
(3) to achieve international cooperation in solving international problems of an economic, social, cultural, or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms . . .
(4) to be a centre for harmonizing the actions of nations in attaining these common ends.

The following principles guide the work of the UN (2004, p. 5):

1. All its members have sovereign equality.
2. All members are to fulfill in good faith their Charter obligations.
3. They are to settle their international disputes by peaceful means.
4. They are to refrain from threat or use of force against any other state.
5. They are to give the UN every assistance in any action it takes in accordance with the Charter.
6. Nothing in the Charter is to authorize the UN to intervene in matters that are essentially within the domestic jurisdiction of any state.

Countries that accept the obligations and responsibilities entailed in the UN Charter may apply for membership; the General Assembly admits new members on the recommendation of the Security Council. The charter also allows for expulsion of a member, but this has never occurred.

The UN has six principal organs: (1) General Assembly, (2) Security Council, (3) Economic and Social Council, (4) Trusteeship Council, (5) International Court of Justice, and (6) Secretariat. There are also numerous UN programs and funds (e.g., UNICEF [United Nations Children’s Fund], UN-Habitat, UNDP [United Nations Development Programme]), specialized agencies (e.g., UNESCO [United Nations Educational, Scientific, and Cultural Organization], WHO [World Health Organization]), and thousands of nongovernmental organizations associated with the UN in a variety of ways.

These UN organs are heavily dependent on data, methods, theories, topics and practices, many of them specific to the field of geography.
Like the discipline of geography, the work of the UN is broad in scope but integrative in nature, with an emphasis on education and capacity building. The work requires definition and understanding of place and its dimensions.

Since the UN is run for and by the people of the world, data come from all over the world, are qualitative and quantitative in nature, and are subject to technological change. For example, originally, country tabulations of censuses used to be collected in filing cabinets, but today sophisticated databases, ETL (extract, transform, and load) processes, and Web-based exchange with statistical offices are common. The demographic data collected by the UN, for example, are used for global population projections—the only such projections in the world still regularly produced based on a consistent set of methods, tools, and data. These data are used for a worldwide demographic assessment of past, current, and future demographic trends.

Cartography is also crucial to the work of the UN and has undergone significant technological changes. For example, maps are essential to peacekeeping missions as well as to aid organizations, which need to know where to distribute food for the needy or where to vaccinate sick children. Often, the UN itself is the principal authority over the definition, collection, and distribution of worldwide data on various topics (see, e.g., the Principles and Recommendations for Population Housing Censuses [UN, 2008] or the Technical Reference Manual for the Standardization of Geographical Names [UN, 2007]). Several UN entities provide technical expertise, logistical support, and material aid intended to strengthen the capabilities of member nations in these fields.

The UN Charter lists maintaining international peace and security as its primary goal. The UN monitors and assesses global political developments and actively engages in peacemaking and preventive diplomacy. The charter also entails work on economic and social development and humanitarian affairs, all of which
involve geographical matters. Sustainable development, climate change, urbanization, and HIV/AIDS are among the core issues on the UN’s current agenda. At the 2000 Millennium Summit, member states reaffirmed their support for the UN and declared it as the focal point through which all governments should seek to realize common goals of peace, security, and development. The eight Millennium Development Goals, supported by a number of specific and attainable targets, were agreed on as the framework to achieve common development goals: (1) the eradication of poverty; (2) universal primary education; (3) the promotion of gender equality; (4) reductions in child mortality; (5) improvements in maternal health; (6) combating HIV/AIDS, malaria, and other diseases; (7) ensuring environmental sustainability; and (8) developing a global partnership for development.

The work of the UN is ultimately defined by the world’s people. Their governments vote on resolutions, in the General Assembly or the Security Council, affecting lives all over the world. Over the years, nongovernmental organizations have also become partners in the day-to-day activities of the UN, forming a “valuable link to civil society” (UN, 2004, p. 13). The staff of the UN (generally referred to as the UN Secretariat) come from all over the world. Personnel are recruited to meet certain region- and country-specific quotas; they speak at least one of the official six UN languages and have taken an oath to be solely responsible to the UN and not to any government or other authority external to the organization. Although much of the work of the UN is political, the critical inputs are often scientific, based on common data, methods, theories, and topics, many of which are intimately related to the field of geography.

Sabine Henning

Author’s note: The views and opinions expressed in this paper are those of the author and do not necessarily represent those of the United Nations.

See also United Nations Conference on Environment and Development; United Nations Environmental Summits; United Nations Environment Programme (UNEP)

Further Readings


UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT

The United Nations (UN) Conference on Environment and Development was convened between June 3 and 14, 1992, in Rio de Janeiro, Brazil, 20 years after the first global environmental conference in Stockholm. The primary focus of the Rio conference was to reconceptualize the global development agenda to include the sustainable use of natural resources. World leaders attempted to ameliorate the world’s most pressing environmental issues by agreeing on a comprehensive strategy. This strategy aimed to meet current socio-environmental needs while ensuring a healthy and viable world for future generations. The Rio Summit boasted unparalleled representations from 172 governments, including 108 heads of state, and the participation of 1,400 nongovernment organizations (NGOs).

The 1984 Brundtland Commission (named after the chair, Norwegian Prime Minister Gro Harlam Brundtland) laid the foundations of the
Rio Summit. The commission published a provocative and widely circulated document titled *Our Common Future*. Lauded by the international environmental community, it derogated the world’s failure to achieve development goals sustainably and outlined visionary actions for reversing anticipated environmental catastrophes. This document helped propel international support among world leaders for the Rio Summit and generally outlined the topics for discussion.

The main plan of action developed and adopted by the 178 governments at the Rio Summit is known as Agenda 21. It is a comprehensive blueprint for global, national, and local actions by UN organizations, governments, and major environment and development stakeholders. Ten years later, the World Summit on Sustainable Development (WSSD), held in Johannesburg, attempted to affirm UN commitments to the “full implementation” of Agenda 21, alongside the achievement of the Millennium Development Goals and other international agreements.

One of several other important achievements of the conference was agreement on the UN Framework Convention on Climate Change (FCCC), which aimed at stabilizing greenhouse gas concentrations at a level that would prevent dangerous interference in Earth’s atmosphere. The FCCC later led to the Kyoto Protocol, a legally binding agreement among countries to reduce carbon emissions. Another key agreement adopted at Rio was the Convention on Biological Diversity. It established three principal goals: (1) conservation of biological diversity, (2) sustainable use of its components, and (3) fair and equitable sharing of the benefits from the use of genetic resources.

The Rio Summit was sharply criticized for its failure to include the regulation of businesses, financial institutions, and transnational corporations in Agenda 21 despite their central role as carbon emitters. Furthermore, several accords were left unmet after Rio, largely due to the United States’ unwillingness to sign key treaties.

Presaging a growing civil society influence in UN covenants, 18,000 representatives attended a parallel summit specifically for NGO participants (a number that has swelled at consecutive UN summits). However, civil representation remained geographically unbalanced, and civil society organizations remained ancillary collaborators to states and largely remained distant from the central politics shaping Agenda 21.

Anna Carla Lopez, Emma Norman, and David L. Carr

See also Climate Policy; Environment and Development; Sustainable Development; United Nations; United Nations Environmental Summits; United Nations Environment Programme (UNEP); World Summit on Sustainable Development

Further Readings


for international environmental cooperation and led to the creation of the United Nations Environment Programme and related global and regional environmental-monitoring networks. It also paved the way for civic engagement in the global arena. However, the actual number of civilian participants was low by contemporary standards, with fewer than 300 nongovernmental organizations (NGOs) attending.

Following Stockholm, the Brundtland Commission published a provocative and widely circulated document in 1984 titled Our Common Future. Lauded by the international community, it railed against the world’s inability to achieve development goals sustainably and outlined visionary actions for preventing environmental catastrophes. It rallied international support among world leaders for another global environmental conference and generally outlined the topics for discussion.

The subsequent global conference was the 1992 United Nations Conference on Environment and Development (Earth Summit), held in Rio de Janeiro. By the time of the Rio Conference, the global environmental movement had gained momentum, and political will on behalf of governments to address environmental issues had grown substantially. Fourteen hundred NGOs were officially registered, and 18,000 representatives attended a parallel summit for NGOs. The main plan of action developed at the Rio Earth Summit is known as Agenda 21. It was adopted by 178 nations and is an all-inclusive outline of actions to be taken at all scales by UN organizations, governments, and key groups in all areas in which humans affect the environment.

The most recent of the UN global environmental summits was the World Summit on Sustainable Development (WSSD), held from August 26 to September 4, 2002, in Johannesburg, South Africa. Its main objective was to reinforce an intergovernmental commitment to sustainable development and natural resource use. It also took stock of developments since Rio. More than 20,000 participants from governments and NGOs, the private sector, and the scientific community participated. The large number of unmet accords inherited from the 1992 Rio Summit called for a novel approach to include civil society in global agreements and action plans:

the UN Stakeholder Forum Implementation Conference (IC). The IC was designed to mobilize stakeholder participation and facilitate the implementation of commitments established in Rio as embodied in Agenda 21.

While the UN summits have received increasing attendance and media recognition, concrete results have consistently fallen short of international agreements. Consistent summit shortcomings, leading to a sense of “summit fatigue,” shifting geopolitical coalitions, and struggling financial markets, will continue to challenge the accomplishment of summit accords.

David L. Carr, Emma S. Norman, and Anna Carla Lopez

See also Civil Society; Environment and Development; Sustainable Development; United Nations Conference on Environment and Development; United Nations; United Nations Environment Programme (UNEP); World Summit on Sustainable Development

Further Readings


**UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)**

The United Nations (UN) Environment Programme (UNEP) was created by UN General Assembly resolution 2997 (XXVII) on December 15, 1972, to act as the global and regional voice
for environmental policy within the UN system. This action followed the recommendation of the June 1972 UN Conference on the Human Environment, held in Stockholm, Sweden. The UNEP Secretariat was established in Nairobi, Kenya, and is headed by an executive director, who also serves as UN Under-Secretary-General. The executive directors included Maurice Strong (1973–1975), Mostafa Tolba (1975–1992), Elizabeth Dowdeswell (1993–1998), Klaus Toepfer (1998–2006), and, most recently, Achim Steiner (2006–present). The UNEP is funded by trust funds and funds allocated by the UN regular budget, by special earmarks, and by a voluntary Environment Fund. The largest contributors to the Environment Fund are the United Kingdom, Germany, the United States, and the Netherlands. There is a professional staff of around 500 working at the UNEP and a total of almost 1,000 employees. Several of the professional staff members are nationals from the United Kingdom, the United States, Germany, France, the Netherlands, Canada, and Japan, as well as Kenya. In addition to its Nairobi headquarters, the UNEP has regional offices in Washington, D.C., New York, Mexico City, Brasilia, Geneva, Brussels, Vienna, Moscow, Bangkok, Beijing, Cairo, Addis Ababa, and Manama (Bahrain). There are several additional liaison offices, division offices, and outposted offices around the world.

The UNEP’s mandate is to coordinate the development of environmental policy consensus by keeping the global environment under review and bringing emerging environmental issues to the attention of governments and the international community for action. Its mission and objectives have been strengthened by several actions taken since the early 1990s. These include Agenda 21, adopted by the 1992 UN Conference on Environment and Development; the 1997 Nairobi Declaration on the Role and Mandate of the UNEP; the 2000 Malmo Ministerial Declaration and the UN Millennium Declaration; and the recommendations related to international environmental governance approved by the 2002 World Summit on Sustainable Development and the 2005 World Summit of the UN. The UNEP has five priority work areas: (1) environmental assessment and early warning, (2) development and implementation of policy instruments, (3) enhanced coordination with environmental conventions (treaties), (4) technology and knowledge transfer, and (5) special support for Africa.

The UNEP is also one of three implementing agencies of the Global Environment Facility (GEF), along with the UN Development Programme and the World Bank. The GEF was set up to assist developing countries and those with economies in transition to pay for the incremental costs of measures and technologies designed to achieve global environmental benefits in six areas: (1) climate change, (2) ozone layer protection, (3) biological diversity, (4) international waters, (5) land degradation, and (6) persistent organic pollutants. This program, based in Washington, D.C., has provided more than $7.5 billion in grants from donor countries for more than 2,000 projects in more than 165 countries since 1991 and has leveraged more than $30 billion in cofinancing. It is also the financing mechanism for a few of the environmental conventions that are listed below.

The UNEP hosts several environmental convention secretariats, most of which are located outside Kenya. Among these are the Ozone Secretariat and the Montreal Protocol’s Multilateral Fund; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the Convention on Biological Diversity; the Convention on the Conservation of Migratory Species; the Basel Convention on the Transboundary Movement of Hazardous Wastes; the Rotterdam Convention on Prior Informed Consent (for international trade in banned or severely restricted chemical products); the Stockholm Convention on Persistent Organic Pollutants; and six Regional Seas Conventions and Action Plans. It also established the Intergovernmental Panel on Climate Change (IPCC), along with the World Meteorological Organization (another UN agency based in Geneva). The IPCC publishes special reports on topics relevant to the implementation of the UN Framework Convention on Climate Change. In 2007, the IPCC won the Nobel Peace Prize, which was shared with the former U.S. Vice President Al Gore Jr., for its work over the past two decades to build up and disseminate greater knowledge about anthropogenic climate change and to lay the foundations for the measures that
are needed to counteract such change. The UNEP first called for the negotiation of a climate change convention in 1985, which led to international agreements in 1992 and 1997.

Important accomplishments of the UNEP have been achieved in six areas. First, and most fundamental, are stronger international arrangements to enhance global environmental protection and security. Second, it has conducted periodic assessments and made forecasts to support decision making and international consensus on the main environmental risks and the responses to them. Third, it has provided support for more effective national and international responses to environmental risks, including policy advice to governments, multilateral organizations, and others to strengthen environmental protection and incorporate environmental considerations into the sustainable development process. Fourth, it has enabled a more effective coordination of environmental affairs within the UN system. Fifth, it has promoted greater awareness and institutional capacity for environmental management among governments, the private sector, and civil society. Last, the UNEP has promoted better understanding of the connection between the natural environment and human security, poverty eradication, and prevention and mitigation of natural disasters.

Barry D. Solomon

See also Climate Policy; United Nations Environmental Summits

Further Readings


The Census Bureau is an agency of the U.S. federal government that produces a wide variety of statistical information for the public and private sectors. It has done so since the first federal census of population in 1790, in accordance with the provision in Article I of the Constitution that an “actual Enumeration shall be made within three years after the first Meeting of the Congress of the United States, and within every subsequent Term of ten years, in such Manner as they shall by Law direct.” This constitutional requirement has served as the basis for conducting a census of population at 10-year intervals ever since. In response to increased governmental and private sector demands for statistical information, the Census Bureau has become the federal government’s largest statistical agency and now produces many statistical series in addition to those derived from decennial censuses.

Regulations governing the collection of statistics by the Census Bureau, formally codified in the U.S. Code, Title 13, Census, require that statistical information remain confidential, meaning that the identity of individuals, households, or organizations that have provided information must not be revealed to any user. Important consequences for the geographic presentation of statistics derive from these regulations, particularly when the capabilities of modern geographic information systems (GIS) are taken into consideration. Data confidentiality safeguards often result in the loss of place-specific geographic detail; nonetheless, statistical information from the Census Bureau provides one of the primary empirical bases for understanding the nation’s human geographies, especially with regard to settlement, the characteristics of residents, and a wide range of economic topics.

A variety of geographic requirements are associated with each phase of collecting, processing, and presenting statistics. In the data collection phase, generally referred to as enumeration, one must locate and then obtain information from a person, household, business firm, or other unit of observation at a specific location, usually a street address. In the processing phase, geographic
identifiers are added to responses obtained in the collection phase that will be used to report the tabulated statistics. These requirements have remained essentially unchanged since the first census of 1790, but the manner in which they are operationalized has altered radically since then. The transformation of the nation from 4 million residents situated along the Atlantic Seaboard in 1790 to 305 million residents spread over a continent-scale country of 3.5 million mi.² (square miles) today has dramatically increased the geographic operational demands. Changing societal demands have brought about increased types of statistical information, with more thematic type-of-area identifiers, for ever more specific locales. Still more dramatic, in terms of their impacts on geographic operations within the Census Bureau, are the technological transformations wrought by modern high-speed computers and the electronic processing of information during the latter 20th and early 21st centuries.

Geographic operations in the data collection stage have always included the necessity for producing innumerable local-area maps for in-the-field data collection. In the data-processing stage, enumeration areas—the basic spatial unit for

The U.S. Census Bureau began updating its address list of the nation’s approximately 130 million housing units in spring 2009. Census workers used confidential and secure GPS-equipped handheld computers to verify, add, and delete addresses. An accurate address list ensures that every household receives a census questionnaire in 2010.

Source: U.S. Census Bureau, Public Information Office (PIO).
internal geographic operations—are created. They enable all subsequent spatial bookkeeping operations to occur. From the census of 1790 through 1870, the administrative districts of federal marshals served this purpose. With the 1880 census, Henry Gannett (1846–1914), the bureau’s first professional geographer, established a geography program to produce field maps and enumeration areas that took into account both the physical features of the environment and the existing patterns of human settlement. These enumeration areas were then aggregated into geographic units for tabulating statistics. By the 2000 census, the number of these enumeration areas—the basic spatial units from which all geographic units for tabulating statistics are formed—had increased to 8 million.

Geographic operations for acquiring and processing responses always present formidable challenges in terms of maintaining the accuracy of place-specific geographic information associated with each response. Prior to high-speed computers, the Census Bureau produced detailed local-area maps from the best available sources, including local governments and topographic quadrangles, for such operations—a series of exceedingly tedious paper-based tasks. Beginning with the 1970 census, detailed geographic information was digitized to create reference maps to display geographic tabulation units in the Metropolitan Map Series, which covered 100,000 mi.² of the most intensively settled portions of the country. With the 1990 census, the Census Bureau introduced the TIGER® (Topologically Integrated Geographic Encoding and Referencing) database for managing its internal geographic operations and for creating reference maps that display the geographic units in which statistics are tabulated. This GIS has served as the basis of geographic operations of the Census Bureau ever since.

The historic evolution of geographic units that have served to report statistical information mirrors American society’s increased expectations for data, which demand an ever-increasing variety of units with ever-greater geographic specificity. In 1790, the states themselves were the only formal geographic units required for reporting statistics, as the census was conducted explicitly to allocate seats in the U.S. House of Representatives and apportion the Revolutionary War debt among the states. Since then, the number of geographic units provided by the Census Bureau for presenting statistics has increased dramatically, coming to include, among many others, various subnational regionalizations, units representing residential settings as small as city blocks (with at least 300 residents), units representing forms of settlement that range from urban and rural locales to metropolitan areas, and units that represent school districts and voting districts for state legislatures and the U.S. Congress. Today, users can create their own customized geographic units of analysis and have statistics tabulated online in real time via the Internet.

The Census Bureau has collected statistics, which were then made publicly available, from the initial decade of the federal government’s existence. Today, the topics covered by this agency’s statistics range from geographical mobility, foreign trade, and housing to hundreds of other topics. Frequency of issuance ranges from monthly to once per decade. The operational challenges faced by the Census Bureau to produce national-scale statistical data sets have resulted in countless innovations in geographic operations and in the tabular and the geographic/cartographic representation of statistics. Once instituted by the Census Bureau, these innovations have readily crossed over into the private and public sectors outside the federal government. They not only underlie the statistical base of knowledge provided by the federal government but also enable users of Census Bureau products to statistically analyze the processes that transform the nation’s human geographies and how they relate to its physical environment.

Donald C. Dahmann

See also Census; Census Tracts; Metropolitan Area

Further Readings


U.S. Census Bureau: www.census.gov
The United States Geological Survey (USGS) is a nonregulatory scientific research agency housed in the U.S. Department of the Interior employing scientists in five scientific disciplines—geology, hydrology, geography, biology, and geospatial information science—at more than 400 U.S. locations. USGS scientists provide decision makers with timely and relevant information on the nation’s landscape, natural resources, and hazards. The USGS is the country’s largest civilian mapping agency, providing online access to base data, map products, and geospatial Web services derived from satellite imagery, aerial photographs, and the 7.5-min. (minute) topographic maps of the United States.

The USGS was established by Congress on March 3, 1879. John Wesley Powell, its director from 1881 to 1894, initiated a plan for the topographic mapping of the entire United States. USGS scientists contributed to the war efforts during World Wars I and II, trained the astronauts who landed on the moon in 1969 in geology, and helped launch the first civilian Earth-observing satellite in 1972, which evolved into the Landsat program that provides a continuous historical record of medium-resolution satellite imagery to the public.

USGS geologists study the causes and effects of geologic hazards such as earthquakes, volcanoes, and landslides; map the basic geology of the United States; investigate coastal change; provide assessments of energy and mineral resources; and contribute to an understanding of global climate change.

USGS hydrologists pioneered techniques for gauging the discharge in rivers and streams and modeling the flow of complex groundwater systems. USGS hydrologists provide information to minimize loss of life and property from water-related hazards such as floods, to manage groundwater and surface water resources, and to protect water quality.
USGS geographers and cartographers developed topographic mapping techniques using aerial photography during the 1930s, and they led the revolution in automated cartography and geographic information systems in the 1970s and 1980s. The 7.5-min. topographic map series of 55,000 quadrangles covering the United States was completed in 1992, and geographic data from these maps are the basis for The National Map, which provides online access to data from the USGS and its partners in federal, state, and local governments. Researchers in geography study the causes and consequences of land use and land cover change and hazard vulnerability, and they provide land use and land cover data through the Multi-Resolution Land Characteristics Consortium.

Biologists in the USGS provide scientific understanding and technologies to support the management and conservation of the nation’s biological resources. Biologists study ecosystems, contaminants, aquatic resources, genetics, and endangered and invasive species. The USGS has developed the National Biological Information Infrastructure, a collaborative online system providing access to data and information on the nation’s biological resources.

Barbara S. Poore

See also Aerial Imagery: Data; Cartography, History of; GIS, History of; Land Use and Land Cover Mapping; Powell, John Wesley

Further Readings


The University Consortium for Geographic Information Science (UCGIS) is an organization of universities and colleges, federal agencies, industry partners, and international affiliates whose purpose is to foster research and education in the field of Geographic Information Science (GIScience). UCGIS was founded in the early 1990s based on the recognition that a diverse and broad-based organization was needed to sustain growth in GIScience within the United States.

As described on the UCGIS Web site, the UCGIS mission and its associated goals are organized in three main thrusts:

Unify:
1. Provide ongoing research priorities for advancing theory and methods in GIScience.
2. Assess the current and potential contributions of GIScience to national scientific and public policy issues.

Facilitate:
1. Expand and strengthen GIScience education at all levels.
2. Provide the organizational infrastructure to foster collaborative interdisciplinary research in GIScience.

Benefit Society:
1. Promote the ethical use of and access to geographic information.
2. Foster GIScience and analysis in support of national needs.

Governance of UCGIS is conducted by an executive committee (made up of the president, the president elect, the past president, and the executive director) and a board of directors. The activities of the UCGIS are performed by the chairs of committees (research, education, policy and legislation, communications, and membership), who organize the work of the delegates. Delegates from the UCGIS 75-plus institutional members are scholars representing disciplines, including
cartography, cognitive science, computer science, engineering and land surveying, environmental sciences, geodesy, geography, landscape architecture, law and public policy, remote sensing and photogrammetry, and statistics. Each year, delegates and partners participate in a summer assembly and a winter meeting to coordinate research and education activities of national need.

Special workshops create significant products to advance GIScience research and/or education. Recent UCGIS products include the following:

- A GIScience research agenda developed from convening a 10-year diverse representation of delegates (McMaster & Usery, 2005)
- A monograph describing a GIScience and technology body of knowledge for education and research (DiBiase et al., 2007)
- A research agenda (Yuan & Stewart Hornsby, 2007)
- A research monograph (Stewart Hornsby & Yuan, 2008) about the topic of geographic dynamics

Each year, UCGIS conducts a search for a published research contribution that is worthy of national recognition and for an educator who has made outstanding contributions to GIScience education worthy of national recognition.

Current information about UCGIS activities can be found on the organization’s Web site at www.ucgis.org.

Timothy Nyerges

See also Geographic Information Systems; GIS, History of; GIScience

Further Readings


until there is a statistically insignificant change in the location of class means or in the number of pixels that switch class membership or until a maximum number of iterations is reached.

The two most commonly used unsupervised classification algorithms are K-means and the Iterative Self-Organizing Data Analysis Technique, or ISODATA. Both are iterative processes that, in general, operate as described above. K-means, however, requires the analyst to specify a fixed number of desired classes and then minimizes the within-class variability by optimizing the sum-of-squares error between individual class means and member pixels. ISODATA is more flexible, in that spectral classes can be merged or split. Classes are merged when two or more class means are located in close proximity. A class is split when its standard deviation exceeds a threshold value.

Relative to supervised approaches, a primary advantage of unsupervised classification is that the potential for human error is reduced. That is because there is less input required from the analyst and because of the high likelihood that each unique spectral class in an image will be identified. Unlike supervised classification, no prior knowledge of the study area is required to initiate an unsupervised process. However, detailed knowledge of the study area is needed to accurately label the resultant spectral classes. The primary disadvantage is that matching spectral classes to the desired set of land cover classes can be difficult.

*Bradley C. Rundquist*

See also Image Processing; Land Use and Land Cover Mapping; Multispectral Imagery; Remote Sensing; Supervised Classification

---

**UNWIN, DAVID (1943– )**

Born in Chesterfield, Derbyshire, United Kingdom, David J. Unwin was among the first generation of students trained in quantitative geography. With the recognition of geographical information science (GIScience) as a research domain, he became a leading member of that community, having published his landmark text *Introductory Spatial Analysis*, which formed the precursor for *Geographic Information Analysis*, which he coauthored with David O’Sullivan.

Unwin graduated in geography from University College London in 1965 and received his MPhil degree in 1970. By then, he was a lecturer of geography at the University College of Wales at Aberystwyth. In 1973, he moved to the University of Leicester, where he worked until he moved to Birkbeck College, London, in 1992 as professor of geography. He was pro–vice master of the college (2000–2002), before moving to serve as director for learning programmes at UK eUniversities Worldwide Limited. He retired in 2004.

Two principal themes characterized Unwin’s research: (1) teaching and (2) computing/geographical information. He was concerned with improving the quality of teaching in British higher education, especially computer-assisted education, and he served on various geography curriculum committees in both British schools (A levels) and universities. His contributions to research on teaching are also illustrated by his work on the *Journal of Geography in Higher Education*; he was a member of its founding editorial board from 1977 to 1986, and he served as coeditor from 1986 to 1989.

Unwin’s research in the area of computing led to the writing of key books, titled *Computing for Geographers* in 1976 and *Computer Programming for Geographers*, in 1985 and leadership of a number of research grants for computer-based thematic mapping. In GIScience, his principal research contributions have been in cross-area estimation (with Mitchel Langford, University of Glamorgan) and in visualization and virtual reality, which led to coedited books.

The two interests came together in a string of grants such as the Leicester Image Processing...
Suite, Computers in Teaching Initiative Centre for Geography (codirected with David Maguire), Visualisation for the Social Sciences (a Leicester-Birkbeck collaboration), and the Virtual Field Course Project (a Leicester-Birkbeck collaboration). Outside geography, his administrative responsibilities at Birkbeck and UK universities were related to both teaching and technology.

Unwin’s most notable service to the research community was for the Quantitative Methods Study Group of the Institute of British Geographers as the secretary/treasurer (1974–1976), as chair (1976–1979), and as editor of the CATMOG series (Concepts and Techniques of Modern Geography, 1979–1982). He also participated in establishing the first European Colloquium on Theoretical and Quantitative Geography in 1978.

Unwin’s MPhil research was in climatology, and he maintained interest in this area throughout his career. Merging this with a lifelong interest in fell running and mountaineering, in 1978, Unwin authored *Mountain Weather for Climbers*.

*Peter Fisher*

*See also* Geography Education; GIScience; Spatial Analysis; Spatial Statistics

---

**Further Readings**


---

**URBAN AND REGIONAL DEVELOPMENT**

Students of urban and regional development consider the social, economic, and political forces that shape, and are shaped by, the physical and social landscapes of metropolitan areas. Urban and regional development is a multidisciplinary subject of study that draws interest from scholars affiliated with a broad range of social and physical sciences, including planning, sociology, geography, political science, anthropology, and health and environmental sciences. The multidisciplinary nature of urban and regional development should not be surprising given the significance of the city, and more recently the concept of the region, in each of these disciplines. Placing a boundary around the term *urban and regional development* is, consequently, a difficult task. Indeed, given the disciplinary intersections inherent in urban and regional development, any effort at delimiting the literature would unfortunately result in omissions that some may find problematic. Nevertheless, what follows is an attempt to be as inclusive as possible concerning urban and regional development and its theoretical evolution.

---

**Origins of Urban and Regional Development**

Like most academic concepts, the origins of urban and regional development can be traced to broader intellectual pursuits combined with changes in wider economic, cultural, and political conditions. In geography, students of urban and regional development emerged from the subdisciplines of urban and economic geography. Early geographical models of urban development were often econometric. Walter Christaller’s central place theory, for example, focused on the placing and spacing of urban settlements by examining the geographical draw of hierarchies of economic goods that, in turn, produced hierarchies of settlements spaced equidistant from each other by virtue of the mix of goods and services found in them. Brian Berry used central place theory to understand distributions of urban settlements and economic activities in the Midwest of the United States.
Early contributions from sociology include Ernest Burgess’s studies of Chicago, in which he viewed the city as a laboratory for the study of urban form and urban social problems. Cities were seen as organic, expanding and changing in social and physical form in a process similar to the succession of plant life. The structure of urban form and growth appeared to be in concentric zones, with the central business district (CBD) at the center and surrounded by a transition from the CBD to more residential areas, which in turn were structured into concentric zones by levels of affluence. The mobility of citizens, measured in journey-to-work commutes, use of telephones, and land values at strategic locations (and change in the number and spatiality of strategic locations), is couched in terms of a city’s “metabolism” and reflects the “vitality” and “health” of a city’s economic and social life. Additionally, “disorganization” of urban life in the form of vice, poverty, concentrations of minority populations, and disinvestment in the built environment is attributed to the “excess” of actual population growth over natural increase (i.e., immigration). Disorganization along with the demand for labor are seen as natural to urban life and appear to act as “stimulants” for the mobility of citizens, creating pressures for urban expansion and succession of land uses.

Anthropological contributions to urban and regional development focus on the cultural and social life of cities. Urban cultures and subcultures are examined within the context of specific groups navigating and shaping the built environment through everyday life practices, providing “the city” with vibrancy—different smells, ethnic cuisines, cultural and religious activities, markets, tempo, entertainment, and family and social gatherings. Particular groups, whether ethnic enclaves in specific neighborhoods or organizational units such as corporations and civic institutions, are examined to identify the cultural practices that collectively provide individual cities with their unique sense of place.

Planning and health and environmental science concerns arose largely in response to the rapid urban growth associated with industrialization in the 19th century. The need to regulate and spatially segregate various kinds of urban development and provide for infrastructural requirements arose from the rapid and haphazard development of thickly settled tenement housing in cities such as New York in the 1800s. Health and environment concerns drove the creation of infrastructure such as sewage, water supply, and ordinances for the designing and spacing of buildings to allow sunlight to penetrate densely constructed urban areas. The need for such planning became evident after the outbreaks of diseases such as cholera, typhoid, yellow fever, and dysentery in the crowded and unsanitary quarters of industrializing cities such as New York and London.

Following World War II, planning practices shifted toward accommodating the fast-growing suburban populations. Planned private suburban communities such as the Levittowns of New York, New Jersey, and Pennsylvania—along with others scattered about the United States—were aimed at accommodating the high demand for housing for a burgeoning middle class in the postwar United States. In the latter part of the 20th century, public planning became more prevalent in the United States as environmental concerns emerged in the 1970s and 1980s against the backdrop of increasing pollution and other negative externalities associated with rampant leapfrog suburban development. In Europe, where national governments are generally more centralized than in the United States, planning practices largely focused on decreasing densities around public transportation nodes and expanding the public transportation infrastructure. It should be evident here that the United States and Europe diverged in developing their respective transportation infrastructures. The United States focused primarily on constructing and maintaining its interstate highway system to accommodate the growth of privately owned automobiles. Suburbanization, including leapfrog development, generally follows the contours of the interstate highway system. Europe’s preindustrial and pre-automobile cities with narrow streets and high densities were not easily malleable to the kinds of urban structural change required to accommodate limited-access highway systems. Consequently, the major focus in Europe was largely on public transportation such as high-speed trains, subway systems, and light rail systems, which are less intrusive on the built environment. The planning professions in the
United States and Europe thus reflect the social and cultural implications associated with these differing transportation infrastructures.

**Urban Governance**

The 1950s and 1960s saw the publication of a series of works that broadened the scope of urban and regional development to include urban governance. The publication of Floyd Hunter’s book *Community Power Structure* in 1953—a Marxist analysis of a “Regional City’s” (largely understood to represent the city of Atlanta) close ties between the city’s business class and the city government—launched a new theoretical framework for studies of urban and regional development. Rather than viewing the social and built environment as “natural” or organic, the new focus was on how class dynamics (re)produces the social and economic landscape in modern capitalist cities. The business community, for example, was recognized as pivotal in a city’s social and political structure. The leaders of the business community are seen as more than representatives of their particular company or industry; rather, they are seen as representatives of a class of capitalists who police and act on behalf of class interests in addition to the interests of their particular businesses. This is done through the establishment of business policy organizations in which local firms offer their expertise and resources to local government officials to help shape urban policies. In addition, business leaders financially back pro-business candidates for office and tend to head local community foundations, arts councils, and other eleemosynary organizations to merge the resources they command, including social and political networks, for the purpose of fund-raising and/or mobilizing the kinds of support that such organizations require to function.

The work of Robert Dahl effectively launched what in political science is known as the “pluralist school,” which remains a powerful framework for contemporary studies. Indeed, throughout the 1970s and 1980s, urban scholars generally worked within the framework of either the “elite school” of community power structure or the “pluralist school,” with little overlap between the two. The two models are largely separated by epistemology—that is, they differed in their expectations of what can be researched. Pluralists, for example, take a “decisional” approach and analyze actual decisions (e.g., legislation and the decision-making processes behind them) regarding urban policies. They generally conclude that political influence is decentralized but imbalanced among a range of competing interests. Meanwhile, anything beyond concrete decision...
making is, according to the pluralists, beyond the confines of scientific inquiry. Elite theorists, on the other hand, assume that the desires of local elites (usually business elites) guide the political process behind the scenes and limit the scope of the political process to only those issues that are comparatively innocuous to local elites. Methodological approaches in the elite theory tradition—popularized by Floyd Hunter—involves reputation analyses in which decision makers are interviewed to gauge their assessment of the involvement of people who, by the nature of their perceived high social or economic status, possess the potential to tacitly influence the decision-making process. The split between the elite theorists and the pluralists continued into the mid 1970s, until Harvey Molotch’s seminal article on urban growth machines, published in 1976, changed the terms of the debate.

Growth Machine, Urban Regimes, and Regulation Theory

The growth machine hypothesis broadens the scope of urban politics in urban and regional development to include more than political decision making. The sociologist Harvey Molotch’s growth machine hypothesis was laid out in greater detail with the publication of Urban Fortunes in 1987, a book that he coauthored with John Logan. The growth machine hypothesis conceptualizes cities as battlegrounds of competing interests between what they refer to as “rentiers”—a class of people who, as property owners, earn their living from rent—and “users.” Elites are recast as those with a variety of interests favoring economic growth: They include, for example, property owners who seek to maximize the “exchange” values of their properties; newspaper executives who seek to increase readership, which, in turn, increases the demand for advertisements; city government officials who would prefer to see tax revenues increase; local businesses and utility companies desiring more industrial customers; universities seeking increased enrollments; unions seeking to increase the pool of local jobs for their constituents (and increase membership); and the arts, sports franchises, and philanthropy institutions, seeking increased audiences and contributions. These disparate groups of interests ostensibly act as a unified business class that collectively influences urban and regional political decision making by virtue of the myriad financial and social resources at their command.

With growth machines at the heart of political coalitions across a range of U.S. cities, what emerges is a “battle of the growth machines”—that is, competition among cities and places for various forms of inward investment. The geographer David Harvey, for example, observed that city governments had largely transformed during the 1980s from concerning themselves primarily with effective and efficient municipal service provision to, instead, participating as agents of speculative investment making in local land uses with the aim of laying the groundwork for private inward investments. Cities by and large were faced with broader changes in global economic structure with the emergence of data processing and communications technologies in the developed world, which, in turn, intensified global competition and prompted a dramatic shift of the manufacturing sector to the emerging economies. The economies of the developed world, meanwhile, largely transformed into flexible high-technology production and services. In short, as the geographer Kevin Cox details, “capital” has become increasingly mobile across space as a consequence of globalization, prompting a “new urban politics” in which localities must respond by becoming more “entrepreneurial.” This entails investing public revenues into speculative ventures, such as the provision of location and tax incentives to firms that would locate new production or other facilities nearby or to existing locally based firms to prevent them from relocating out of a particular jurisdiction. Furthermore, speculative ventures include the building of new stadiums, convention centers, and arts facilities and developing restaurant-and-bar districts or other “places of consumption” that aim to be a draw for the “creative-class” workers of the new high-technology manufacturing and service-based economy.

The publication of the political scientist Clarence Stone’s book Regime Politics in 1989 brought together the elite and pluralist schools more so than the growth machine concept. Stone’s book was another long-term study of the
city of Atlanta, Georgia, largely covering the years since the publication of Hunter’s work in 1953. The urban regime concept’s breakthrough in bridging the gap between community power structure and pluralism lies in its situating of political leaders within the constraints of the democratic process; that is, regime theory recognizes that urban politicians must be responsive to myriad interests as the pluralists contend. At the same time, however, regime theory also recognizes that business interests appear to wield more influence than others over the formulation of urban policies. In capitalism, business leaders—through no action of their own—are seen as possessing “systemic power” by virtue of their private ownership over the productive assets of society. Particularly in the United States, urban governments are reliant on their business communities for fiscal solvency because of the vital resources they command—namely, jobs and capital. Municipal governments, therefore, have traditionally been more responsive to the long-term needs of business community leaders over the needs of other constituents and have actively engaged with business leaders through informal networks to develop various political platforms. In short, governance is a more apt description of urban management and development given that urban governments alone lack the resources required to effectively develop and implement policies. Therefore, political leaders must reach out to the broader community—typically the business community—to mobilize the necessary resources for effective governance.

The regime concept proved to be problematic when applied to British or other European cities, where governments are more centralized and generally less dependent on local resources for effective governance. In Britain, regulation theory found more fertile academic ground than the concept of urban regimes. Led by the geographer Bob Jessop, regulationists explore the modes of “social regulation” and their roles in urban and regional development. Social relations—labor markets, capitalist competition, consumption, social movements, and so on—are seen as being mediated through governmental, social, and civic institutions at varying and interlocking scales of interaction. How these relations are mediated and directed help shape and direct the forms that urban and regional development takes. Agglomeration economies, deindustrialization, the rise of “cultural” economies, and the like are attributed to specific locally based arrangements of regulatory institutions and social relations. Ash Amin and Nigel Thrift have referred to these arrangements as “institutional thickness” and attribute a locality’s capacity to secure inward investments and “embed” global forces of production in particular places as contingent on a locality’s level of institutional thickness.

Regulation theory brought to the fore the issue of scale that was hitherto undeveloped and largely absent from studies of urban and regional development. The concept of institutional thickness is cognizant and inclusive of various institutions—governmental, economic, social, and otherwise—operating at a range of scales. The “region” as opposed to the “city” is seen as particularly important for harnessing and directing the powers of regulation and social interaction toward embedding global processes in particular places. Authors have drawn from the works of others in the broader discipline of economic geography, including the concept of the “city-region,” for a better framework for understanding institutional thickness across scales. Others have called for a new politics of the “region” as opposed to the “city” so that cities and regions be better equipped to respond to the changing scales of global production and exchange.

Conclusion and Future Directions

The multidisciplinary field of urban and regional development is a rich and dynamic field of study. Although much of the work has been presented somewhat in a linear fashion, it should be noted that the various approaches to urban and regional development outlined above continue to flourish both independently and with much cross-fertilization of concepts, insights, and methodologies. Each approach offers promising insights for future directions of inquiry.

One particularly promising approach to urban and regional development has emerged from the broader discipline of human geography. The attention to issues of scale as outlined above has permeated much of social inquiry in human geography and other social sciences. The concept
of scale as networks and the “return” of graph theory in broader social science, along with new software technologies created specifically for network analyses, offer interesting methods for isolating specific interests identified in models such as urban regime theory, regulation theory, and “institutional thickness” in urban and regional development. Recent work, for example, seeks to identify specific business interests that enjoy centrality in urban regime coalitions through social network analysis. Others demonstrate the utility of viewing previously “amorphous” concepts such as globalization as economic transactions mediated through specific social relations and networks across space, linking regions and localities to “global” capital. Social networks and relations take the form of potential suppliers and business partners bridging global capital with local or regional markets and of customers representing forward and backward linkages up and down the production chain. This new thrust of inquiry promises to situate urban and regional development amid specific social, economic, and political actors that, collectively, constitute “coalitions,” “institutional thickness,” and other structures of social relations. By teasing out specific actors from these broader social forms, new possibilities emerge, with implications for human agency, urban social movements, and political action.

Mark de Socio

See also Agglomeration Economies; Central Business District; Chicago School; Circuits of Capital; Deindustrialization; Economic Base Analysis; Economic Geography; Environmental Impacts of Cities; Environmental Planning; Growth Machine; Growth Poles; Housing and Housing Markets; Industrial Districts; Infrastructure; Innovation, Geography of; Knowledge, Geography of; New Urbanism; Postindustrial Society; Public Policy, Geography of; Public-Private Partnerships; Regional Economic Development; Regional Environmental Planning; Rent-Gap; Rural-Urban Migration; Squatter Settlements; Suburbs and Suburbanization; Transportation Geography; Uneven Development; Urban and Regional Planning; Urban Geography; Urban Hierarchy; Urbanization; Urban Spatial Structure; Urban Sprawl; World Cities; Zoning

Further Readings


Think of the things one sees in a city or region that everyone wishes were otherwise. They might have been otherwise if there had been careful planning in the past. The periodic confrontations over the building of new shopping centers, high-rise apartments, airports, landfills, and highways; the demolition of historic buildings; or the failure to conserve open space are a measure of the regard with which planning is held. In these contentious situations, the subject under debate is not the need for planning but rather the need for better planning, not whether but how it should be done.

Planning is a systematic process of thought and action intended to contribute to effective decision making for the welfare and integrity of communities and the sustainability of the natural environment. It involves forethought and the judicious or systematic use of scarce resources to attain a desired goal. The primary objective of planning is to make an informed decision. This entry reviews the history of planning, its development in the areas of both urban and regional planning, and the characteristics of the planning process itself.

**History**

Planning has been going on throughout history, and it is tempting to explain it away by merely stating that humans have a natural urge to plan; it is part of humans’ organizational makeup. Historians and anthropologists have uncovered evidence of planning from the classical civilizations of Greece and Rome to the nation-states and mercantile empires of the 19th century; in America, from the Iroquois confederation to the Inca and Aztec empires in Mexico; in Africa, from the tribal empires of the Ashanti and Mali in West Africa to the Zulu Empire and the kingdom of Zimbabwe in Southern Africa; and in the East, from the early cultures of Japan and China to the Persian Empire. The roots of planning extend to the first emergence of structured societies at the dawn of human history. Indeed, the planning of common activities, in the sense of deliberate anticipation, and the development of strategies for action are evident in all primitive human societies.

Planned cities were at the core of all great pre-classical civilizations. Evidence lies in the layout of early Roman and Greek cities and in the civilizations that developed in the Indus River valley. Greek cities were based on a grid system layout, and they included standard elements such as a temple complex or Acropolis, a marketplace or Agora, and a recreational complex made up of an amphitheater (for theater and performances) and a hippodrome (for sports events and chariot races). Such was the plan for the city of Miletus, which was planned by Hippodamus, the father of town planning, in 480 BC. In North America, early urban settlements were generally preplanned in Europe before the settlers set off for the New World. For instance, Savannah, Georgia, planned in 1733 by James Oglethorpe, was inspired by the layout of London’s residential squares. Each square contained 40 residential lots laid out on a modified grid around a central square.

In addition to the traditional role of designing a city’s physical form, planning expanded in the 19th century to include slum clearance, urban renewal, suburban development, transportation planning, urban growth management, and environmental planning. Today, planning has become so complex that it is useful to categorize it into three forms: (1) substantive planning, (2) contextual planning, and (3) spatial planning. Substantive planning refers to the functional areas of planning interest, and specific types include environmental planning, health planning, transportation planning, and physical or land use planning. Contextual planning refers to the context of planning, and specific examples include comprehensive planning, regulatory planning, policy planning, and strategic or long-range planning. Finally, spatial planning refers to the spatial aspect of planning, such as rural, urban, and regional planning.

**Urban Planning**

Urban planning is also referred to as city, town, or community planning. In Britain, the term *town planning* has been used since the late 19th century. “Community planning” entered the Canadian lexicon not long after World War II, when
the Community Planning Association of Canada was formed. In the United States, the comparable term is city planning, and it emerged shortly after 1900. However, in both Canada and the United States, “urban planning” has also become the accepted term since 1960. Urban planning is defined as a systematic process of identifying community goals and specific land use objectives, exploring and assessing the options available to the community, and choosing and implementing the best option. Its purposes are to fulfill the following:

1. Minimize or avoid an unsatisfactory state of affairs such as urban sprawl, traffic congestion, and environmental degradation
2. Protect the health, safety, and welfare of the urban society
3. Ensure efficient allocation of scarce public resources

Most of the urban planning activities involved reconciling private and public preferences to solve problems caused by growth and development. The planning profession has evolved over the past century.

Urban planning in the decades following World War II was concerned with how to accommodate vast population increases by providing housing, public utilities, parks, schools, and public transportation. Cities and towns in this era were often subject to epidemics of diseases and prone to extensive fire hazards. Their new populations needed adequate housing, water, and sewage systems. The 1960s began with major concerns over the physical deterioration in communities. Hence, urban renewal became the focus of planning efforts until the “bulldozer approach” used to achieve it was called into question by Jane Jacobs in her famous book *The Death and Life of a Great American City*. In the 1970s, urban planning concerns focused on the effects that large-scale projects such as airports, shopping centers, and apartment complexes might have on the existing community environments.

Another response to urban problems in the early 1960s was the emergence of a cadre of professionals who gradually codified their ideas and experience about solving urban planning problems. The urban planning profession emerged during this period and has since generated a rich array of planning concepts, theories, and processes that continue to be drawn on heavily in contemporary planning practice. Modern planners have mastered the techniques for preparing plans and are able to involve a wide range of people in the planning process. Besides, today’s planners understand the legal foundations and techniques for plan implementation and are able to articulate planning issues to a wide range of audience.

### Regional Planning

Few planning problems are confined within individual communities. The reasons stem from the interrelationships of various socioeconomic and natural processes in a community and the ways in which the effects of development are transmitted through space. For instance, the drainage of storm water from a subdivision located on a watercourse has the potential of causing pollution to areas downstream. Hence, it is often necessary to undertake planning for areas larger than a single community and large enough to encompass the major effects of a single development project. When large areas are distinguished by identifiable unifying characteristics, they are called “regions.”

Regional planning is concerned with many different facets of the physical and human environment over large areas that may or may not have well-defined political boundaries. Regional planners attempt to visualize a better future for a region and recommend steps to achieving a desired vision.

One of the first planners to advocate the need for larger-area planning was Patrick Geddes. After observing a rapid spread of urban development in 19th-century Britain, Geddes coined the term *conurbation* to capture the interdependent nature of linked cities. He drew attention to the independence of all activities within a geographic unit such as a watershed to emphasize the need for regional planning. Ebenezer Howard also deserves credit for the emergence and development of regional planning. His publication titled *Garden Cities of Tomorrow* (1902) helped initiate the Garden City movement. The movement was not only concerned with planning single new towns but was also based on the concept of
organizing a territory around large cities to minimize sprawl and conserve natural resources far beyond the city.

The trend toward regional planning is buttressed by the following developments: (a) urban space has become a series of interconnected districts that stretch across a vast geographical area, (b) economic relationships exist between residents in towns and those in the country, and (c) there is a need to avoid wasteful duplication of planning efforts or facilities in several local jurisdictions. Regional planning recognizes the need to take a synoptic approach to areawide problems and the planning of each jurisdiction in coordination with adjoining areas. A successful example is the river-basin-planning activities of the Tennessee Valley Authority (TVA). The TVA is a regional planning authority that transcends the jurisdictions of seven states, including Virginia, Georgia, Mississippi, Kentucky, Virginia, North Carolina, and Alabama. In establishing the TVA in 1933, the U.S. Congress showed its awareness of a growing trend toward regional planning and an understanding that many of the problems of the Tennessee Valley could hardly be solved by individual states acting alone.

Regional planning is also done at a metropolitan level. Metropolitan regions often have a core city and hinterlands that have noticeable economic and social links. A typical metropolitan region in the United States contains multiple local governments—an average of 104 jurisdictions, which include (a) general-purpose governments in counties, municipalities, and townships and (b) special-purpose governments such as school districts, fire districts, and industrial districts. Regional planning minimizes duplication of public services and development efforts by forging partnerships with local governments as well as the business and nonprofit sectors. Given the autonomy accorded to local government units, regional planning blends their competing aims for development in the interest of all citizens of a metropolitan region. This requires special organizational arrangements, such as the Regional Council of Governments, Regional Planning Commissions, or the Metropolitan Planning Organization (MPO) in the United States. For instance, MPOs serve as the decision-making body for federally funded transportation projects within a metropolitan area. They also prepare and maintain long-range transportation plans with input from the general public.

### Process

A traditional planning process is used in urban and regional planning practice. The process begins with problem diagnosis or dissatisfaction with a status quo situation. Planners work with the general public to articulate a common goal or vision. Next, the vision or goal is refined into a set of objectives that are specific, quantifiable, and measurable. The objectives serve as milestones toward the desired goal. A study is undertaken to assemble facts and figures that enable planners to develop alternative courses of action consistent with the stated goal and objectives. The study may involve the survey, analysis, prediction, and projection of future needs or a future state of affairs. The best course of action is chosen, implemented, and monitored for consistency or unintended consequences. Public participation is essential at each stage of the planning process because it helps (a) incorporate public concerns and values in the planning process, (b) minimize opposition by developing a consensus among stakeholders, and (c) build credibility between planners and the general public. Overall, the traditional planning process is seen as a systematic, rational, and comprehensive decision-making tool.

*Seth Appiah-Opoku*

See also Community-Based Environmental Planning; Environmental Planning; GIS in Urban Planning; Land Use Planning; Participatory Planning; Regional Environmental Planning; Urban and Regional Development; Urban Geography; Urban Land Use; Urban Planning and Geography; Urban Policy; Urban Solid Waste Management; Zoning

### Further Readings

Urban ecology has traditionally been considered a field of inquiry emphasizing ecological processes and organization under the conditions of industrial urbanization. There is a growing interest in interdisciplinary, urban theoretical and scholarly research among the natural, social, and planning sciences, especially within the context of rapid global urbanization, population concentration, and industrial and environmental change. As a field of academic inquiry, urban ecology reflects and embodies changes and transitions in both urban theory and ecological theory over the past half-century.

Early Developments

Early urban ecological exploration and explanation in the mid 20th century reflected contemporary ecological thinking and theory involving the supposed linearity and directionality of ecological change (or succession) and the relative stability, efficiency, and coherence of ecological structure and organization. To this end, early academic interest in the effects of urban industrial growth on natural environments and ecological processes emphasized the degrading character of cities, with urban form and function critiqued and characterized as anathema to the form and function of “healthy” environmental systems. Industrial pollution, human waste, landscape fragmentation, and the growing and spatially concentrated demand for natural resources by industry and urban consumers were—and to a large degree still are—implicated in declines of air, water, and soil quality at local and regional scales, with broad environmental, social, and economic implications. Similarly, the replacement of native local and regional fauna and flora with nonnative, or invasive, species of plants and animals was implicated in the overall and generalized diminishment of urban landscapes, where local and regional biodiversities were being replaced by more homogeneous, weed-based ecological communities.

Because “nature” was, from this perspective, abolished by the city, then—by implication—its study, in the form of ecology, was antiurban, both in theory and in practice. The nonurban, or rural, remained the principal domain of “true” nature and, thus, of ecological inquiry throughout most of the 20th century. The implications for subsequent constructions of and distinctions between urban and rural—that is, the city (and urban society) as degrading and degraded and the hinterland (and rural society) as a more ecologically uncontaminated place—have been the topic of sustained critique and debate.

The Role of Human Ecology

By the late 20th century, urban ecology had emerged as a key object of explanation and academic inquiry among an interdisciplinary population of, principally, North American scholars. Equipped with a new set of ecological principles and concepts, and integrated theories of human-environment interaction, these human ecologists—ecologists, anthropologists, sociologists, and resource managers, many trained in rural or developing regions of the world—brought to the study of urban ecology a more sophisticated and nuanced appreciation of human-environment relationships in cities, whereby urban society and urban environments were understood as coregulated and codependent systems whose
interaction was nondeterministic, dialectical, and involving dynamics of feedback and change along multiple axes and gradients, from the purely physical to the socioeconomic. Anthropogenic environmental change, it was theorized, resulted in new sets of material and spatial conditions to which urban society responded and adjusted, which, in turn, resulted in further environmental change, future adjustments, and so forth.

This new systems approach of urban human ecology (not to be confused with the Chicago School of Human Ecology, developed in the 1920s, which focused on social and cultural relations within cities) replaced the ecological principles of balance, linearity, and stability (i.e., those concepts that fed accusations of environmental degradation) of earlier critiques with new models emphasizing the impacts of change, nonlinearity, and chaos on ecological structure, form, and function. The result was a new emphasis on the humanized urban ecosystem, one in which urban society was a fundamental organizational component and agent of nonnormative and nonlinear environmental change at various spatial and temporal scales. Urbanization, from this perspective, amounts to a form of environmental disturbance to which the natural system and, subsequently, human systems respond in dialectical fashion. This model of urban human ecology thus disposed of earlier nature-society, urban-rural dualisms to argue that cities are, in fact, fully functioning and viable ecosystems and that the politically charged “degradation” is better understood and explained as a form of systemic change to which urban societies respond and adapt. The 1997 emergence of the flagship journal Urban Ecosystems and the parallel development of the, traditionally nonurban, Long-Term Ecological Research (LTER) Project sites (funded by the U.S. National Science Foundation) in Baltimore, Maryland, and Phoenix, Arizona, signaled the legitimacy and success of this new, more interdisciplinary model of systems-based urban human ecological thinking and scholarship.

**Urban Environmental Services**

Parallel to the emergence of urban human ecology in the 1990s was a growing interest in the economics and social value of ecosystem services, sometimes called environmental services. The services perspective argues that healthy urban ecological communities provide myriad unintentional benefits that justify environmental protection, management, and/or restoration. These services include the removal of pollutants and toxins from air (via photosynthetic activity and soil respiration) and water (via root uptake, soil filtration, and plant transpiration), soil stabilization (via root structure), and temperature regulation (via shade from trees and forests or heat absorption by urban water sources). On the one hand, scholarship in the area of ecosystem services argues that “healthy” and intact urban ecological systems, if protected and managed properly, have the capacity to absorb much of the effluent and wastes of industrial production and social consumption. This perspective calls attention to the—largely unaccounted for and unappreciated—economic benefits of healthy urban ecosystems that accrue at multiple scales, from the household to the municipality to the region. Urban ecological degradation, thus, does not simply represent a future expenditure (i.e., through technological investment, environmental remediation, restoration, or containment) but entails an opportunity cost of likely significant magnitude. On the other hand, the services perspective advances the argument that the benefits provided by “healthy” urban ecosystems fall under the category of quality-of-life indicators demanded by urban residents, whereby healthy ecosystems promote urban social and economic health and a healthy, happy, and productive urban citizenry.

To this end, insofar as they meet certain quality-of-life criteria and satisfy public demand, healthy urban ecosystems are said to help produce the conditions of economic development, including the attraction of tourists, jobs, and full-time residents. Borrowing principles that are reminiscent of Frederick Law Olmsted’s ideas a century ago, this language of urban sustainability and the sustainable city has its origins in the fields of urban landscape architecture and design. In doing so, and in recognizing and representing the city as the container of (potentially) viable and healthy ecosystems, the services perspective strongly refutes earlier arguments and perspectives that alluded to cities as a priori environmental abominations.
Critical Urban Ecology

Apolitical and ahistorical urban ecological thinking and analysis generally characterized both the human ecology and the ecosystem services perspectives of the late 20th century. A response to this has been a more critical inquiry into the structural underpinnings of urban ecological change, the unequal distribution of ecosystem services and their quality-of-life and economic benefits, and the unequal distribution of degraded urban ecological landscapes and their potential risks. This emerging critical urban ecology, or urban political ecology, is based largely in the discipline of geography and is a nascent, if growing, area of interest among, especially, urban theorists and scholars, rather than ecologists, per se. Closely allied with urban environmental justice, urban political ecology emphasizes the modern urban environment as a historical construct of industrial urbanism and fragmentation, one whose patterns and rights of access, use, distribution, and change are contested and (re)negotiated along myriad axes of political and economic power. A hybrid of Third World political ecology and critical urban theory, urban political ecology reframes urban human-environment relations as the product or a reflection of unequal social relations and seeks opportunities for urban ecological inclusion, the right to urban nature, and thus the right to the city.

Alec Brownlow

See also Energy and Human Ecology; Environmental Services; Greenbelts; Green Building; Green Design and Development; Human Ecology; Political Ecology; Suburban Land Use; Urban and Regional Planning; Urban Environmental Studies; Urban Green Space; Urban Metabolism; Urban Solid Waste Management; Urban Water Supply

Further Readings


Urban Environmental Studies

Urban environmental studies are emerging as an integrated science aiming to understand extended urban areas that include not only biological and physical features but also economic and social components. These studies improve our
understanding of urban climate, hydrology, ecosystems, and environmental conditions and help us gain critical knowledge of how human and natural environments have interacted to motivate past urban environmental changes. The crux of science in urban environmental studies concerns the fluxes of energy, water, and carbon, how these fluxes are related to one another, and how they have changed over space and time. A better understanding of these science questions contributes to building a conceptual framework for sustaining the urban environment and thus enhancing the quality of life of its residents. The complexity of urban environmental issues calls for a systematic approach by interdisciplinary teams. This introduction reviews most important concepts and research methods in urban landscape, climate, water, vegetation, and sustainability.

Urban Landscapes

Urban landscapes are typically a complex combination of buildings, roads, parking lots, sidewalks, garden, cemetery, soil, water, and so on. Each of the urban component surfaces exhibits unique radiative, thermal, moisture, and aerodynamic properties and relates to its surrounding site environment to create the spatial complexity of ecological systems. To understand the dynamics of patterns and processes and their interactions in heterogeneous landscapes such as urban areas, one must be able to quantify accurately the spatial pattern of the landscape and its temporal changes. It is necessary to have a standardized method to define theses component surfaces and to detect and map them in repetitive and consistent ways.

Various approaches have been developed in the studies of landscapes in general and urban landscapes in particular in the fields of geography, planning, landscape ecology, natural resources, environmental science, and so on. The land use and land cover approach is a predominant one, especially in geography, planning, and landscape ecology. Land cover can be defined as the biophysical state of Earth’s surface and immediate subsurface, including biota, soil, topography, surface water and groundwater, and human structures. In other words, it describes both natural and human-made landscapes of Earth’s surface. Land use can be defined as the human use of the land. Land use involves both the manner in which the biophysical attributes of the land are manipulated and the purpose for which the land is used. However, the relationship between land use and land cover is not always direct and obvious. A single class of land cover may support multiple uses, while a single land use may involve the maintenance of several distinct land covers.

Urban areas are composed of a variety of materials, including different types of artificial materials (concrete, asphalt, metal, plastic, glasses, etc.), soils, rocks, minerals, and green and nonphotosynthetic vegetation. Remote sensing technology has often been applied to map land use or land cover. Each type of land cover may possess unique surface properties (material); however, mapping land covers and materials have different requirements. Land cover mapping needs to consider characteristics in addition to those coming from the material. The surface structure (roughness) may influence the spectral response as much as the intraclass variability. Two different land covers, for example, asphalt roads and composite shingle/tar roofs, may have very similar materials (hydrocarbons) and thus are difficult to discern, although from a material perspective, these surfaces can be mapped accurately with hyperspectral remote sensing techniques. Therefore, land cover mapping requires taking into account the intraclass variability and spectral separability. On the other hand, analysis of land use classes would nearly be impossible with spectral information alone. Additional information, such as spatial, textural, and contextual information, is usually required for a successful land use classification in urban areas.

Traditional methods of land use/cover classification based on detailed fieldwork suffered two major common drawbacks, (1) confusion between land use and land cover and (2) lack of uniformity or comparability in classification schemes, resulting in difficulty in comparing land use patterns over time or between areas. The use of aerial photographs and satellite images since the late 1960s does not solve these problems, since these techniques are based on the formal expression of land use rather than on the actual activities that gave rise to land use patterns. In fact, many land use types cannot be identified
from the air. As a result, mapping of the Earth’s surface tends to present a mixture of land use and land cover data, with an emphasis on the latter. Another major problem in urban land use/land cover classification is related to so-called mixed pixels. It is rare that urban land classification can yield an accuracy of greater than 80% by using per-pixel classification (i.e., “hard classification”) algorithms. The low accuracy of land use/cover classification in urban areas is largely attributed to the mixed-pixel problem, where several types of land use/cover are contained in one pixel. The mixed-pixel problem results from the fact that the scale of observation fails to correspond to the spatial characteristics of the target. Therefore, the “soft/fuzzy approach of land use/cover classifications has been applied, in which each pixel is assigned a class membership of each land use/cover type rather than a single label. It has been suggested that characterization and quantification, rather than classification, should be applied to provide a better understanding of the compositions and processes of heterogeneous landscapes such as urban areas. Merrill Ridd proposed a conceptual model for remote sensing analysis of urban landscapes, that is, the vegetation/impervious surface/soil model. It assumes that land cover in urban environments is a linear combination of three components—namely, (1) vegetation, (2) impervious surface, and (3) soil. It has been suggested that this model can be applied to spatial-temporal analyses of urban morphological, biophysical, and human systems. While urban land use information may be more useful in socioeconomic and planning applications, biophysical information that can be directly derived from satellite data is more suitable for describing and quantifying urban structures and processes.

Impervious surfaces are anthropogenic features through which water cannot infiltrate into the soil, such as roads, driveways, sidewalks, parking lots, rooftops, and so on. In recent years, impervious surface has emerged not only as an indicator of the degree of urbanization but also as a major indicator of environmental quality. Impervious surface is found to be inversely related to vegetation cover in urban areas. In other words, as impervious cover increases within a watershed/administrative unit, vegetation cover would decrease. The percentage of land covered by impervious surfaces varies significantly with land use categories and subcategories. Detecting, monitoring, and analyzing impervious surface is valuable not only for environmental management, for example, water quality assessment and storm water taxation, but also for urban planning, for example, building infrastructure and sustainable urban growth.

Urban Climate and Air Quality

The most remarkable feature of urban climate is the urban heat island (UHI) effect. Urban climatologists have long been interested in the phenomenon that observed ambient air temperature differs between cities and their surrounding rural regions, to which the UHI effect refers. The urban-rural temperature differences are usually modest, averaging less than 1 °C, but they occasionally rise by several degrees when urban, topographical, and meteorological conditions are favorable for the UHI to develop.

Two types of UHI can be distinguished pertinent to the methods of temperature measurement: (1) the urban canopy layer heat island and (2) the urban boundary layer heat island. The former consists of air between the roughness elements, for example, buildings and tree canopies, with an upper boundary just below roof level. The latter is situated above the former, with a lower boundary subject to the influence of urban surface. The spatial pattern of the canopy layer heat island corresponds closely to the distribution of surface cover characteristics. The myriad component surfaces and the spatial complexity when they are mosaicked create a limitless array of energy balance and microclimate systems, preventing urban meteorologists from drawing any generalization. Most of the previous UHI studies have been conducted at the mesoscale using an energy budget approach, which separates the energy flow into measurable interrelated components for simulation modeling. Because the morphological characteristics of urban landscapes that modify urban climate occur at the microscale, it is imperative to have a good understanding of urban morphology.

Knowledge of urban surface energy balance is fundamental to the understanding of UHIs and
urban thermal behavior. If the net horizontal heat advection is not considered, the surface energy balance of a city can be expressed as

\[ R_n + A = H + LE + G \, (W/m^2), \]

where \( R_n \) is the net all-wave radiation, \( A \) the anthropogenic heat flux, \( H \) the sensible heat flux, \( LE \) the latent heat flux, and \( G \) the net storage heat flux. To quantify the urban surface energy balance, in situ measurements (largely tower based) can be obtained to estimate accurate heat fluxes at the roof level. However, because of the diversity in size, shape, height, composition, and spatial arrangement of the urban “canopy” components, it is difficult to define a surface datum for such measurements, especially for an entire city. Moreover, the sites of the measurements are frequently not associated with meteorological stations. To date, most of the urban heat flux observations have been conducted in a limited number of residential areas. Several experimental studies were conducted in European cities but did not analyze specifically the different components of surface energy balance. Because direct observation of heat fluxes is rare, many efforts have been made to parameterize the terms by using more routinely measured data.

A fundamental problem with the in situ measurements of energy fluxes lies in the great difficulty of selecting a representative site for a larger adjacent region due to the complexity of urban material composition. Sue Grimmond and Catherine South outlined the method to extract surface cover information for the Multi-City Urban Hydrometeorological Database (MUHD). The most noticeable recent advance in terms of instrumentation relates to the use of stand-alone sensors, with which observational data can be recorded for a network in a city. Even with the MUHD and the new sensor technology, siting criteria for urban locations are still hard to define for documenting local-scale heat flux variability. It is extremely difficult and expensive to investigate the detailed spatial pattern of energy fluxes in a city, if cost, time, instrument, and data calibrations are considered all together. Furthermore, the surface energy balance approach has met with mixed success in documenting the temporal variability of energy fluxes in urban areas. Most of the in situ measurements are used to determine the diurnal variability, but they are less used for evaluating the seasonal and the interyear variability.

Remote sensing studies of urban thermal landscapes and UHIs have been conducted mostly by using NOAA AVHRR data. However, in all these studies, the 1.1-kilometer spatial resolution AVHRR data were found suitable only for large-area urban temperature mapping, not for establishing accurate and meaningful relationships between image-derived values and those measured on the ground. The 120-m (meter)-resolution Landsat Thematic Mapper’s (and later the Enhanced Thematic Mapper Plus [ETM+] data of 60 m) thermal infrared data, as well as Terra’sASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) images (with spatial resolution of 90 m in thermal infrared bands), have also been extensively used to derive land surface temperature and to study UHIs. Most recent advances include the development and use of quantitative surface descriptors for assessing the interplay between urban material fabric and urban thermal behavior and the use of the landscape ecology approach to assess this interplay across various spatial scales and identify the operational scale of an urban thermal landscape. Because the ASTER sensor collects both daytime and nighttime thermal infrared images, analysis of land surface temperatures has also been conducted for a diurnal contrast. Studies using satellite-derived surface temperatures have identified surface temperature heat islands, which are believed to correspond more closely with the canopy layer heat islands, although a precise transfer function between land surface temperature and the near-ground air temperature is not yet available.

In addition to the UHI phenomenon, rainfall is often higher in the urban area by a margin of 5% to 10%. This increase is attributable to the thermal-induced upward movement of air, increased vertical motions from mechanically induced turbulence, increased cloud and raindrop nuclei, and industrial increases in water vapor. Urban wind speeds tend to be lower because of the rougher surfaces, frequently higher temperatures of the urban fabric, and reduced duration of sunshine due to air pollution.
Urban Air Pollution

Urban areas are associated with sources of a variety of air pollutants and regional pollution problems such as acid rain and photochemical smog. Cities are also major contributors to global air pollution related to ozone depletion and carbon dioxide warming. Within an urban area, the level of pollution varies with the distance to pollution sources, including both stationary and mobile sources (e.g., vehicles). Local pollution patterns in cities are mainly related to the distribution of different land use and land cover categories, the occurrence of water bodies and parks, building and population densities, the division of functional districts, the layout of transportation network, and air flushing rates. Pollution levels tend to rise with land use density, which usually increases toward a city center. Therefore, there is generally an urban-rural gradient in the concentrations of air pollutants. For example, the concentrations of particulates, carbon dioxide, and nitrate ion (an oxide, as in acid rain) in the inner city are typically two to three times higher than in the suburban areas and five times higher than in the rural areas.

Furthermore, urban areas experience another type of pollution—heat pollution. Because of the construction of tall and closely spaced buildings, the flushing capability of the air at the ground level is largely reduced. However, the relationship between air pollution and urban heat has not been fully understood, although both relate to the pattern of urban land uses. UHIs favor the development of air pollution problems but are not indicators of air pollution. Higher urban temperatures generally result in higher ozone levels due to increased ground-level ozone production. Moreover, higher urban temperatures result in increased energy use, mostly due to the greater demand for air conditioning. As power plants burn more fossil fuels, the pollution level is driven up. A few studies have so far examined the correlation between land surface temperature and air pollution measurements.

Urban Water

The process of urbanization has a considerable hydrological impact in terms of influencing the nature of runoff and other hydrological characteristics, delivering pollutants to rivers, and controlling rates of erosion. One of the most notable impacts is the way in which urbanization affects flood runoff. Because urbanization replaces land surface with nonevaporating and nonporous materials, there is a trend for flood runoff to increase in comparison with rural areas. Urban drainage densities may be greater than the rural densities, and the installation of sewers and storm drains accelerates runoff. As a result, the rainfall-runoff process in an urban area tends to be quite different from that in natural conditions depicted in classical hydrological cycles. Peak discharges are higher and occur sooner after runoff starts in basins. It should be noted that this effect of urbanization varies according to the size of flood. As the size of flood becomes larger and its recurrence interval increases, the effect of urbanization tends to decrease.

Urban warming changes the moisture characteristics, precipitation amount, and storm characteristics in the urban areas. Higher air temperatures hold more moisture, and warmer water increases the moisture content of storms. Urban warming often increases precipitation amount and storm frequency and intensity. Global warming relocates precipitation globally, so that some places may experience unusually wet and others unusually dry conditions. Moreover, watersheds with large amounts of impervious cover may experience an overall decrease in groundwater recharge and baseflow and an increase in storm flow and flood frequency. Imperviousness is also related to the water quality of a drainage basin and its receiving streams, lakes, and ponds. Increase in impervious cover and runoff directly affects the transport of nonpoint source pollutants, including pathogens, nutrients, toxic contaminants, and sediment. Increases in runoff volume and discharge rates, in conjunction with nonpoint source pollution, will inevitably alter in-stream and riparian habitats, resulting in the loss of some critical aquatic habitats. Some measures for mitigation have been suggested, including the construction of porous pavements and neighborhood detention ponds and wetlands to collect storm water. To increase evapotranspiration, various types and shapes of green spaces, green roofs, and green walls are advocated. In sum, urban areas have a unique feature in water balance.
Urban Vegetation

In the process of urbanization, natural vegetation cover is largely replaced by paved surfaces. Open spaces are maintained for recreational or ornamental purposes rather than for the production of food or timber, so that the ecosystem dynamics of the remaining “green” areas of the city are usually quite different from those of the open countryside. The use of exotic species in urban areas seems to suggest an increase in species diversity, but many of these exotic species are very rare and restricted to certain locations. Moreover, the levels of use of fertilizers and pesticides per unit area in cities are usually much higher than on agricultural land, with corresponding environmental effects. Species diversity is kept low by the ruthless pursuit of weeds and pests. The contribution of exotic species to urban ecological complexity is thus insignificant. Furthermore, urban vegetation grows in an environment remarkably different from natural vegetation. Impervious surfaces prevent rainwater from recharging the groundwater, making less water resources available for urban vegetation. In the meantime, impervious surfaces are easy to heat up due to low specific heat capacity. Recent studies based on satellite observation found that the UHI effect changes vegetation phenology. Intensive management can significantly enhance carbon storage by urban vegetation.

Urban Environmental Sustainability

To define various strategies for urban sustainable development in the context of accelerated urbanization and global climate change, urban planning, resources, and environmental management and governance strategies need to be examined and evaluated. Among the key challenges of the current era are the range, complexity, and intertwining nature of environmental problems in the urban areas and the limited response capacity and capability of cities, in developed countries as well as in developing ones. It is imperative to understand fully the science, technology, and policy issues in urban environmental studies and how they interplay in a particular social, economic, political, and cultural context. Policies, regulations, impact adaptation, mitigation, and remediation can intervene in the urban environmental system by reducing or enhancing the negative feedbacks. Technologies such as modeling, statistical analyses, geospatial techniques, and digital cities have effects on both the science and the governance. The interdisciplinary nature of urban environmental problems often requires an interdisciplinary team approach to address them.

Qihao Weng

Further Readings


Urban gardens can be described as private green spaces belonging to a property within towns and cities. They vary in size from a relatively small patch of green space situated in front of a domestic property, often found in inner-city areas to large spaces surrounding an individual property, exceeding several hundred square meters. Urban gardens provide a haven for a wide range of flora and fauna within urban areas. The urban garden is generally not believed to be exceptional in its species richness, yet it has higher plant diversity than is found in the Amazon rain forest. Many bird species also frequent urban gardens, adding a sense of character to a neighborhood, especially during the summer months.

To understand the benefits of urban gardens, it is useful to explore some of their significant characteristics. These include the following:

1. High plant diversity
2. Large number of food chains
3. Large number of unique habitat zones
4. Constant state of succession
5. Disturbed state

The relatively high plant diversity reflects that fact that many gardeners plant as many species as possible. This phenomenon has a knock-on effect, since the numerous varieties of plant species provide the basis for a different food chain. Gardeners are usually keen to create several zones within a garden, such as a water feature, a flowerbed, lawns and hedges, and so on, each of which supports different types of flora and fauna. A constant state of succession is ensured by not allowing a particular plant species to dominate. This has the added advantage of preventing a garden from supporting only a specific plant species such as woodland. Finally, because the garden is continuously subjected to disturbance, it is generally welcoming of foreign species, thus ensuring diversity.

Urban gardens provide a range of benefits to an urban area that are not widely acknowledged. Vegetation is known to have a substantial effect on the temperature, moisture, and precipitation regimes of urban areas. For instance, plants can reduce temperatures by as much as several degrees Celsius in large urban green spaces by increasing the relative humidity of the air, causing it to cool, and counteracting the urban heat island effect. Indeed, a large tree, well supplied with water, has the ability to provide local cooling equivalent to several air conditioners running over much of a day.

Urban gardens have the potential to provide significant benefits to human well-being. In the United States, for example, a study found gardeners consistently reporting the importance of urban gardens in providing an opportunity for exercise and reduction in stress levels. In a U.K. survey, gardeners cited the creation of a pleasant environment and the promotion of relaxation as the two most important aspects of gardens. Other benefits noted were personal satisfaction gained through maintenance and in producing a tidy piece of green space, the health benefits of fresh air and
exercise, a sense of peace and tranquility, and the opportunity to meet and talk with neighbors.

Despite their crucial role in urban society, there is generally a lack of information on the extent of urban garden space because local government is not required to monitor or manage such spaces, yet it is apparent from aerial photography and other sources that they constitute a significant portion of many urban properties and must therefore constitute a sizable proportion of urban areas. This relatively large aggregated green space has the advantage of another very significant feature, namely, flood alleviation. As climate change begins to produce more extreme events such as floods, urban gardens have the distinct advantage of attenuating flood peaks.

Urban gardens form a large part of the public face of a household and its owners and may display a “neighbor mimicry effect,” whereby proximal gardens share significantly more characteristics than distal gardens. Urban front gardens, in particular those that look similar, in terms of their form and the types of vegetation present, may be found close to each other along street sections. This apparent mimicry effect could be very important in deciding important landscape changes in areas where planning authorities have little influence.

Given the numerous benefits of urban gardens, it is surprising to find that they are facing increased threat for several reasons. These include increased car ownership, difficulty of on-street parking,
poor public transport, and a fashion for low-maintenance minimalist landscape. Fear of car crime or robbery while walking from the car to the house has also been cited as a reason to park on front gardens.

Rizwan Nawaz

See also Environmental Services; Greenbelts; Green Design and Development; Urban Ecology; Urban Green Space

Further Readings


The dawn of the 21st century ushered in an era when, for the first time in the history of humanity, the majority of people on the planet live in urban areas. More than ever before, cities are now at the core of defining the human experience, for better or for worse. In this context, urban geography is eminently positioned as a field that can enhance our understanding of the structure, form, and function of cities, explain the process of urbanization and the dynamics of urbanism, and offer valuable insights into an equitable and sustainable urban future.

Indeed, more than ever before, urban geography is one of the most vibrant and productive areas of inquiry in the discipline. The volume of scholarly work that focuses on the multitude of urban-related topics that have attracted the attention of geographers has shown an unabated trajectory of quantitative growth and qualitative sophistication. At the end of the first decade of the 21st century, the momentum not only seems to have carried the subfield to the center of attention of geography as a whole but, in many ways, has been instrumental in the recognition of the contributions of geographers to the broader field of urban studies and affine disciplines such as sociology, urban planning, political science, anthropology, and so on. To take stock of where urban geography stands today and where it might go in the future, it is useful to briefly retrace whence it came, if only in very broad strokes.

**Origins and Growth of Urban Geography**

The emergence of urban geography can be traced back to 19th-century discussions of urban origins and growth. The early emphasis on the site and situation of settlements and their role as centers of civilization was linked to geographers’ overarching interest in the relation of humans to their physical environment. This abiding concern with excavating the rise of cities and the role of environmental conditions—whether physiographic or climatic—in shaping society reflected the broader disciplinary concerns of early geographers in arriving at scientific explanations that bridged the gap between the physical sciences...
and the incipient social sciences. It also hinged on an ultimately flawed reliance on assumptions that the natural environment exerted a determining influence on human society and behavior, as well as on the structure, form, and function of its spatial arrangements. In effect, such geographers would argue that the site of a city determines—not merely influences—the prospects of its social development and economic growth. Two of the more prominent figures in this particular perspective were the American geographers Ellen Churchill Semple and Ellsworth Huntington. Their work and that of their colleagues was challenged in the 1920s as overly simplistic and deterministic. The debunking of environmental determinism acted as a dead end for the sort of human-environment work that had emerged in the early decades of geography’s disciplinary development and that had definitively moved urban geography into a different direction altogether.

Early on, the environmental-determinist paradigm was matched in popularity by a growing interest in the regional patterns of settlement and in the classification of urban structure, form, and function. Early works such as Frederick Emerson’s 1907 study, *A Geographical Interpretation of New York*, or Almon E. Parkins’s 1918 volume, *The Historical Geography of Detroit*, were among the founding texts of this particular tradition in urban geography. In most cases, copious descriptive information was compiled with little attempt made to offer anything more analytical. This empiricist paradigm, too, was ultimately inadequate in providing a sustained analytical framework because of its inherent limitations as an almost exclusively descriptive approach. Nevertheless, the regional description paradigm served the discipline well in preparing the way for more analytically refined approaches that shifted the focus of geographical inquiry from the environment alone to socioeconomic conditions and their spatial patterns.

Key in this regard was the influence of the Chicago School, which became a catalyst in promoting both the growing interest in analyzing cities and the emerging concern with understanding the links between socioeconomic conditions and spatial patterns. This approach was pioneered by researchers in the sociology department at the University of Chicago in the 1920s and 1930s, using the city of Chicago as an urban “laboratory.” A seminal text of this tradition was the famous volume by Robert Park and Ernest Burgess, *The City*, first published in 1925. A core element of the Chicago School approach was the axiomatic acceptance of the proposition that human society reflects natural processes and, as such, is conditioned by “natural laws” that apply to it just as much as they apply to plant communities, for example. Nevertheless, despite the reluctance of the Chicago School to irrevocably sever the threads to the organismic analogy between society and nature, its development signaled the transition to more positivist methodologies, with their emphasis on the “scientific method,” as well as a more nomothetic inclination that sought to determine universal laws. Of special interest is the use of ethnography as a tool in discovering the links between social relations and their spatial arrangements, a method that would gain renewed currency several decades later. Most important, at the time, the focus of the Chicago School on mapping groups and institutions in the urban landscape was well suited to the interests of geographers, who were heartened by this spatial turn in the social sciences and embraced the work of their sociologist colleagues.

In particular, the keen interest of the Chicago School to abstract the spatial patterns of the city into models that captured salient aspects of the social order and urban structure fueled the growth of interest in urban geography. Ernest Burgess’s concentric zone model and Homer Hoyt’s sector model became clarion calls for visualizing the interplay of social and spatial processes. Many young geographers, eager to solidify the credentials of their discipline as a scientific enterprise, immersed themselves with relish in modeling. Chauncy Harris and Edward Ullman’s multiple-nuclei model represented just one of the more sophisticated refinements that geographers contributed to the study of cities. Of special significance is that the work of social scientists—not the least geographers—in this vein of research eventually led to the development of factorial ecology in the 1970s that used multivariate statistical techniques to examine residential differentiation in urban areas. In this sense, the Chicago School was an important antecedent for the robust urban geography that spread across Anglo-American geography departments in the 1950s and 1960s.
The parallel—albeit discrete—development of central place theory in interwar Germany, in the work of the geographer Walter Christaller and the economist August Lösch, was to influence a great number of geographers in the post–World War II period and directly contribute to the rapid expansion of Anglo-American urban geography. The focus of their work, and that of their successors outside Germany, was on modeling the optimal spatial distribution of settlements and, especially, to explain the size, spacing, and function of smaller settlements in the urban hierarchy. The four basic concepts were (1) centrality, (2) range, (3) threshold, and (4) hexagonal trade areas. These were based on assumptions that consumers behave rationally and that they operate on an isotropic plane—a uniform landscape devoid of physical or human-made obstacles or hazards.

The effect of these general tendencies to abstraction and theory development was the inevitable emergence of an urban geography as a full-fledged spatial science by the 1950s and 1960s. With the whirlwind of spatial science unleashed, urban geographers immersed themselves in a matrix of spatial variables and spatial systems. Whereas previous generations of geographers had looked at geology or biology for inspiration, this generation was more focused on mathematical statistics and physics, or “social physics” to use the moniker of the day. The intensive quantification of the work that urban geographers were performing mirrored similar developments in other social sciences, to one extent or another. This particular paradigm culminated, perhaps, with the publication of David Harvey’s *Explanation in Geography* of 1969, widely hailed as a landmark text for the field. Nevertheless, a sustained reaction had

An aerial view of Chicago. Chicago played a key role in the rise of urban studies, including urban geography.

*Source: Morguefile.*
already been mobilized in an effort to counter the abstraction inherent in spatial science and to ground urban geography in a less abstract, albeit still positivist, approach that had human behavior at its core.

**Behavioral and Humanist Perspectives on Urban Geography**

Starting in the mid 1960s, the behavioral thread of urban geography focused on the cognitive processes by which human subjects made decisions. This was less a rejection of urban geography as spatial science than a rescaling of the research conducted to a human dimension rather than the aggregate dimension necessary for work in spatial science. Behavioralism retained much of the positivism of the previous approaches, but the guiding principle was that the analysis of the daily spatial behavior of individuals and the exploration of how individuals experienced and responded to places would provide a deeper understanding of urbanism and urbanization. Some of the core statements of this approach can be found in Julian Wolpert’s 1964 article in the *Annals of the Association of American Geographers*, “The Decision Process in Spatial Context,” and Allan Pred’s 1967 monograph, *Behavior and Location: Foundations for a Geographic and Dynamic Location Theory*.

The behavioral turn was a significant development in urban geography, primarily because it initiated a thread that rejected the aggregate scale of spatial science for a more human orientation. Nevertheless, as would be expected of such a dynamic discipline, right away there were plenty of geographers who argued that the behavioralists were too timid in their critiques of spatial science and that they were not really going far enough to explore the human dimensions of urban life. Inspired by the philosophical currents of phenomenology/existentialism that were quite popular in continental Europe in the post–World War II period, humanist urban geographers sought to break away from the positivist methodologies that dominated the discipline. They favored, instead, methods such as textual analysis and ethnography, the latter having an antecedent in the work of the Chicago School a few decades earlier. Humanistic urban geography embraced the individual as an agent and sought to understand the subjectivities of his or her lived experiences in the city. The notion of space yielded its role as an organizing concept for the discipline to a more subjective notion of place. What mattered to the humanists was to extract the significance that individuals attach to places as the sites of their lived experiences. To do so, the humanist urban geographer must enter the “life-world” of the subject to glean the meanings attached to the places experienced by the human consciousness. Just as important, the humanist seeks to understand the ways by which that human consciousness actively reconfigures places in the lives of human subjects through intersubjectivity. Edward Relph’s 1976 classic *Place and Placelessness* and Yi-Fu Tuan’s 1976 work *Topophilia* became the essential texts of this turn in geography, influencing a generation of urban geographers.

**The Radical Turn**

Parallel to the behavioralist/humanist rejection of spatial science in the mid 1960s was a growing concern with the relevance of the work done by urban geographers. In the spirit of the times, a growing number of young geographers were influenced by the antiwar movement, the civil rights struggles, and the realization that large populations in the inner cities were socially marginalized and spatially segregated. The political upheavals and social struggles of the 1960s were a catalyst for the formation of radical tendencies, especially among urban geographers, that moved more and more to the left, identifying with the emancipatory aspirations and theoretical positions of Marxism. These urban geographers reached back to the work of Friedrich Engels’s 1844 *The Condition of the Working Class in England in 1844* and the voluminous opus of Karl Marx to reject the academic abstractions of spatial science that were increasingly seen as amoral at best or complicit in oppression at worst. Motivated, in part, by the rediscovery of Marx, especially through the interpretive lens of Western Marxism, young radicals took to heart the dictum that philosophers have only interpreted the world in various ways and that the point was to change it.

An important development in the United States was the inauguration, in 1969, of the radical journal *Antipode*, which provided a venue for
radical urban geographers to publish their heterodox work. Another seminal event in the radicalization of urban geography in those early days was the publication of David Harvey’s 1973 _Social Justice and the City_. Confronted with images of crushing urban poverty, racial segregation, widespread public and private disinvestment in the city, clashes in the streets with the police, burning city neighborhoods, and a host of other jarring urban phenomena in the most advanced capitalist economy in the world, it became an urgent preoccupation for radical urban geographers to explain and address what they were witnessing. They rejected what they perceived to be the voluntarism of the behaviorists and humanists with their emphasis on the individual as an agent. They sought, instead, to make use of radical political economy as a method to expose the profligate economic, political, and social structures that underpinned the injustices at the core of the capitalist system, oppressing the working class, women, and minorities, especially in the cities of the United States and other “First World” countries. In 1980, Edward Soja introduced the concept of the “sociospatial dialectic” in an article by that title in the pages of the _Annals of the Association of American Geographers_. The self-evident notion that the social and the spatial are inextricably intertwined and that one cannot be properly understood without the other became an organizing principle for radical urban geographers such as Harvey, Neil Smith, and Soja. Influenced, in part, by the work of the French philosopher Henri Lefebvre, who argued that space is a social product and who asserted the centrality of space in organizing and sustaining capitalism, these radical urban geographers embraced a more nuanced and subjective perspective relative to earlier Marxist analyses. In their work, Marxism was spatialized, and the social relations and spatial practices that constitute the city were subjected to a relentless scrutiny.

In the early 1970s, the terms _structuralist_ and _Marxist_ were used to describe radical urban geographers who engaged with the voluntarists/humanists in a set of protracted disputations that defined the general theoretical and methodological contours of urban geography. Over the years, there have been several refinements and restatements of the respective arguments in a dialectical exchange that has been quite productive and has propelled urban geography to a place of prominence in the discipline and in the broader social sciences. One illustrative example has been the way in which the two camps have engaged the question of gentrification in North American cities during the 1980s and 1990s. On the one hand, the geographer Neil Smith authored a series of articles starting in 1979 and culminating with the publication, in 1996, of his book _The New Urban Frontier: Gentrification and the Revanchist City_. Smith’s arguments were unabashedly of Marxist provenance and emphasized the role of structural forces, including real estate speculation and land prices, as the prime impetus behind gentrification. On the other hand, the geographer David Ley approached the same question with a humanist’s sensibility, insisting on human agency as the driving force behind gentrification. His contributions to the heated discussions through the 1980s culminated in 1996 with the book _The New Middle Class and the Remaking of the Central City_. Geographers were joined by researchers from other disciplines in this academic melee throughout the 1980s and into the next decade, signaling a new currency for urban geography.

### “Post-al” Encounters in Urban Geography

A seminal development during the late 20th century was the emergence of a poststructuralist position that would lead to a number of _post-al_ approaches to the study of cities: postmodernism, post-Marxism, postfeminism, postcolonialism, and so on. Building on humanist disaffection with structural explanations—and heavily influenced by the development in literary criticism of a derivative, Anglophonic reading of translations of what the French called _la pensée 1968_—some urban geographers challenged what they saw as the totalizing, deterministic straightjacket of the Marxist analysis of cities. Part of a “cultural turn” in geography, post-al urban geographers in the 1980s and 1990s delved into the study of culture in the city. Gender, race, ethnicity, and sexuality were very much on the agenda, rectifying the considerable degree of neglect that the silences of earlier urban geographies had bequeathed the field. What emerged was a definitive rejection of
even the hint of positivism, a diligent abjuring of structural explanations, an embrace of multiple perspectives, and a preoccupation with discourse and ideology. Citing French authors became fashionable, with the names of Foucault, de Certeau, Bourdieu, Lyotard, Baudrillard, Deleuze, Guattari, Irigaray, Cixous, and others used liberally in the writings and speeches of a new brood of urban geographers. This change coincided with the “spatial turn” across the social sciences and the humanities, where space and the geographical imaginary were discovered and embraced. This step brought scholars from other disciplines in contact with the work of geographers, creating a vibrant interdisciplinary exchange that focused on urban space and spatiality. All of a sudden, literary theorists, sociologists, anthropologists, and other scholars were assiduously quoting urban geographers, while urban geographers picked up where their humanist predecessors had left off and merrily sauntered further afield into literatures hitherto beyond their range. Literary criticism and psychoanalysis, for example, were no longer distant precincts but, rather, fruitful fields for cross-pollination for work on urban space and spatiality in the postmodern era. This development has coincided with the announcement of the existence of a Los Angeles School of urbanism to replace the void left by the Chicago School decades ago. According to the geographer Michael Dear’s 2001 edited volume From Chicago to L.A.: Making Sense of Urban Theory, the Los Angeles School is characterized by a move away from the modernism of the Chicago approach to a more postmodern vision that draws its inspiration from the fragmented and decentered nature of the sprawling metropolis in Southern California.

The infusion of post-al attitude and latitude invigorated both Marxist and non-Marxist urban geographers and contributed to the further development of the boisterous critical urban geography that one encounters today. What makes urban geography “critical” is a skeptical posture that interrogates what is taken for granted about the social relations and spatial practices in urban areas. It is a big tent under which are accommodated epigones of radical and humanistic geography alike, in a collegial conviviality that bears similarities to a marriage of convenience. Nevertheless, despite the constant spats, the palpable suspicion, and the unmitigated irreconcilability that seems to mark critical urban geography, it has produced an important body of work that has secured, to a substantial degree, its bona fides within the academy. Global city regions, transnational urbanism, the right to the city, spaces of consumption, the embodiment of the urban experience, virtual urbanities, urban surveillance, and the mobilities and materialities of urban space are all common threads of inquiry for critical urban geographers alongside more persistent themes such as urbanization, segregation, governance and urban politics, or the effects of neoliberal economic policies on metropolitan areas.

More recently, the environment reentered the picture after decades of exile, in the form of urban political ecology. Drawing from critical urban geography as much as from political ecology, geographers have rediscovered nature in the city. Unlike the earlier environmental turns of the determinists or human ecologists, however, today’s urban political ecologists do not fasten onto ontological assumptions about nature, nor are they preoccupied with organismic analogies. Rather, they posit nature as the hybrid of human and nonhuman processes that are both physical and cognitive. As such, what emerges is a rigorous analysis that examines the social production of urban environments and the complex articulation of nature and the city, in a project that harkens back to the egalitarian and emancipatory intentions of radical urban geographers. In Nik Heynen, Erick Swyngedouw, and Maria Kaika’s edited volume In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism, one can glimpse the sprawling and ambitious agenda of this paradigm that combines the concerns of a socialized ecology with a spatialized political economy in an era of inexorable urbanization.

Finally, the perennially gnawing question of relevancy has led urban geographers to another seemingly atavistic turn. Just like nature and the environment have found a place in 21st-century urban geography, increasingly a more empirical geography has emerged to reclaim currency and credibility in the discipline. Advances in geographical information technology have fueled an interest in an applied urban geography that, in a way, harkens back to spatial science. This time,
however, the byword is *mixed methods*, diligently integrating quantitative and qualitative approaches. Thus, geographic information systems (GIS) and statistical methods have joined ethnography and other qualitative methodologies to create integrated analyses of urban phenomena that affect the lives of real people in real communities. It is generally thought that this new applied urban geography is better positioned to effect change and affect the lives of urban communities in a progressive direction because it provides needed analysis that can influence policy making.

One recent example of this sort of work has been the research on the effects of subprime mortgages and foreclosures on the working class and people of color done by Elvin Wyly, Dan Hammel, Kathi Newman, and others.

In conclusion, today urban geography is more diverse and spirited than ever. In the Association of American Geographers, and its equivalent professional organizations in Canada and the United Kingdom, urban geography’s preeminence as a popular subfield or specialty is rivaled only by the number of geographers engaged in GIS work. The “spatial turn” in the social sciences and the humanities has clearly given geographers currency among other scholars studying urbanization and urbanism. At the same time, urban geographers have drawn on the rich and varied history of their discipline to forge a dynamic field of inquiry that rightfully claims a central role in the development of geography and its engagement with other disciplines.

*Dennis Grammenos*

**Further Readings**


Urban green space, which is related to, but not necessarily the same as, an urban ecosystem and green infrastructure, comes in a variety of forms and serves a variety of purposes in the urban landscape (see the first set of photos). Various types of urban green space are recognized in the literature: planned or unplanned remnant intact patches of vegetation embedded in the urban matrix, planned spaces such as parks or restored areas, and abandoned or derelict sites that are slowly being colonized by pioneer plant species. The definition might reasonably be expanded to include freshwater and marine environments. Thus, urban green space includes iconic sites such as London’s Hyde Park and New York’s Central Park, large expanses of seminatural vegetation such as Perth’s Kings Park and Botanic Garden, and abandoned sites such as can be found in all cities. Irrespective of their form, urban green spaces are perceived in many ways by those who encounter and use them. For many people, urban green spaces are places that enhance physical and psychological well-being by providing contact with the “natural” world, yet for others they are places of fear or spaces that serve to reinforce social boundaries. This entry first defines ecology in cities and the ecology of cities and examines the contributions urban green spaces can make in terms of environmental services, engineered urban green space, social and cultural services, and health and well-being. Negative outcomes and perceptions of urban green space are then examined. The entry concludes with a look at the future of the many forms of urban green space.

**Ecology in and of Cities**

There is a long tradition of studying and documenting the ecology of urban green spaces in cities, such as the descriptions of the plant species that colonized bombed sites in the aftermath of...
World War II. In the early 1990s, however, urban ecology rose to prominence as a subdiscipline of ecology. Urban ecology has taken two broad approaches: (1) the study of ecology in cities and (2) the study of the ecology of cities. The former is concerned with understanding the composition, structure, and function of the populations of organisms and the habitats in which they live in cities; the latter uses the tools and concepts of ecology, such as the quantification of biogeochemical fluxes and ecological footprints, to study cities as ecological systems.

Ecology in cities faces several challenges, including the loss of habitat; air, soil, and water pollution; the direct and indirect threats of invasive species; and climate change. Despite such threats to biodiversity, many cities are surprisingly “green” and are often extremely spatially heterogeneous. For instance, two thirds of the Greater London area (158,000 ha [hectares]) comprises green space of some type, 20% of the total area is considered to be valuable wildlife habitat, and 16% is protected in some way; many threatened and iconic species can be found within this area, including the stag beetle (*Lucanus cervus*). Similarly, urban waterways, including artificial structures, in Northern New Zealand (e.g., Hamilton and Auckland) contain significant populations of native fish, such as the endemic banded kokopu (*Galaxias fasciatus*). The common view of urban expanses as “biological deserts” does not sustain scrutiny; indeed, per unit area, domestic gardens may have levels of species richness approaching those of tropical rain forests.
Urban green spaces are not simply refugia for rare (or other) plant and animal species. They can also modify and ameliorate biophysical processes and so have become useful tools for urban planning (in which context they are sometimes called green infrastructure). In terms of the physical environment, urban green space can improve local air and water quality, filter wind and sound, and counteract the elevated temperatures produced by the urban heat island. Significant temperature differences between parks and built-up areas have been recorded, with these differences extending over hundreds of meters; bodies of water in the urban landscape provide similar cooling effects. Urban green spaces can also provide environmental services to nonurban parts of the landscape (see wildlife corridor photos). For example, populations of the bird species Tui (Prosthemadera novaezeelandiae) in the Waikato (Northern New Zealand) use urban plants to supplement their food supply. This is particularly important during times of the year when native plants are not flowering. Tui living in remnant patches of native forest outside urban areas commute into urban areas to exploit these nectar sources. Thus, urban green space provides a wide range of valuable environmental services both within and beyond the urban environments within which they are located.

As the environmental services that urban green spaces provide have become increasingly valued, there has been growing consideration of how green spaces can and should be included in urban design and planning. Low impact urban development and design (LIUDD) emphasizes the utility of green infrastructure, with a focus on the amelioration and management of the urban water cycle. The retention of urban green space can reduce the amount of impervious surfaces in urban catchments; these surfaces are associated with (a) dramatic shifts in storm hydrographs (especially increased “flashiness”) and (b) the flux of sediments and undesirable contaminants into waterways. As an example, New Zealand’s largest urban wetland restoration project, Waiauranga wetland in Meadowbank, Auckland, was restored in the 1990s in an effort to trap sediments in storm water runoff from the surrounding catchments; of the 130 metric tons of contaminants and sediment flowing through this system prerestoration, a significant fraction is now retained in the wetland. The project has had other positive effects, such as providing a recreational resource and an increasing habitat for waterfowl (including kotuku, Egretta alba modesta) (see first set of photos). LIUDD also encourages the implementation of microlevel urban

Wildlife corridors in the urban environment: (A) wildlife corridor alongside railway in Wandsworth, southwest London (with Wandsworth Common in the background) and (B) habitat corridor in Central Park, New York (with inset photo of a sign requesting that visitors stay on the walkways and reduce impact on the area).

Source: Author.
green spaces such as green roofs and rain gardens (both designed for increased water retention and/or biofiltration).

Wildlife corridors provide another example of engineered urban green spaces, with their primary purpose being improving ecological connectivity in urban environments but with the added benefit of increasing the quantity of urban green space (see wildlife corridors photo). Wildlife corridors are designed to link isolated populations together, with the goal of facilitating the flow of individuals and genes between isolated local populations, and to allow mobile species to move through fragmented landscapes.

Social and Cultural Services

Urban green spaces are places where ecological and human-social systems come together. Besides their environmental benefits, urban green spaces provide social and cultural services. As well as being associated with improved physical and psychological health and even increased longevity, they also provide valuable resources for recreation and learning. Furthermore, urban green space can also have benefits in the wider community by developing social ties and attachment to the community by promoting individual interactions—this is an indirect benefit of, for instance, community-driven urban restoration projects. Recent studies have even suggested that vegetation may reduce crime levels, despite the fear that urban green spaces are often centers of antisocial behavior.

Health and Well-Being

Urban green space provides many health services, both physical and psychological. Konstantinos Tzoulas and colleagues have suggested that urban green space provides health benefits in two ways: (1) by improving the local environment, they promote physical activity and so physical health and well-being and (2) passive viewing of green space after negative experiences (e.g., hospitalization) can boost psychological health and well-being. The use of urban green spaces for physical exercise and recreation is a visible example of the health benefits such environments provide. Studies (controlled for age and sex) associate the availability of green space with increased exercise levels, although the evidence for the quality and proximity of urban green space alone being directly related to physical activity among local populations is equivocal.

The second mechanism by which urban green spaces provide sociocultural benefits is more subtle. Roger Ulrich reported in 1984 that hospital patients who could see natural environments recovered significantly faster from surgery than those with more limited views. Subsequent research has reinforced the links between exposure to urban green space and psychological health across a broad section of society. Exposure to and interaction with “nature,” which for those living in cities will often be limited to urban green spaces, has been argued by child psychologists as playing a crucial role in children’s cognitive, emotional, and social well-being. There is some concern, therefore, over the diminishing access to nature (as urban green space declines) and the increasingly sporadic (in time) interactions children have with it. As one example of the benefits associated with providing children access to nature, there is a growing awareness that there are links between “attention” and children’s access to and use of green space. The engagement of children who have attention deficit hyperactivity disorder with green space has been associated with the reduction of symptoms.

A Downside?

Despite the many benefits associated with urban green spaces, they are also associated with some negative outcomes and perceptions. In particular, people may see urban green spaces as dangerous places where crimes are likely to occur. In this context, the nature of the green space is particularly important; derelict and/or poorly maintained green spaces are perceived very differently than well-maintained ones.

Rather than strengthening links between different members of the community, urban green spaces can sometimes serve to act as boundaries that reinforce socioeconomic division and segregation. Some authors have argued that the poor park conditions in Roxbury and North Dorchester near Boston imply low levels of local interest and little pressure on local municipalities to maintain
parks and that low levels of local interest are associated with disenfranchisement and segregation.

In terms of human interaction with urban green spaces and the wildlife that use them, problem issues include increased human-wildlife conflict and the potential for urban green space, especially in peri-urban environments, to act as reservoirs for disease. For example, links between suburban expansion, tick abundance, and the growing incidence of Lyme disease in North America are well documented. Interactions between humans and green space in urban environments are complicated, and understanding them is not just a case of “the more, the better.”

The Future

Urban green space encompasses many forms, including remnants of “natural” vegetation, restored environments, and human-made or engineered spaces. These spaces provide important environmental and sociocultural services to organisms, including humans, using and living in urban environments. A growing body of research considers ecology in and the ecology of cities and the many services that urban green spaces provide. Despite the considerable environmental and sociocultural services provided by urban green spaces, how best to integrate such areas into urban planning and design remains an open question. Urban environments are experiencing, at an accelerated rate, many of the environmental changes facing the planet as a whole—elevated temperatures; dramatically altered hydrological systems; air, water, and soil pollution; and habitat loss. We have much to learn from how urban green spaces respond to such pressures and how they can be used to respond to the social and environmental changes such pressures will bring.

George L. W. Perry

See also Energy and Human Ecology; Environmental Services; Greenbelts; Green Building; Green Design and Development; Human Ecology; Suburban Land Use; Urban Ecology; Urban Environmental Studies; Urban Gardens; Urban Heat Island; Urban Land Use; Urban Metabolism; Urban Planning and Geography; Urban Solid Waste Management; Urban Water Supply

Further Readings

Urban heat islands directly affect a number of human and natural systems. UHIs also generate indirect impacts through altering mesoscale circulations such as thunderstorms and urban/country breezes. Urban gardeners are well aware that the UHI alters flowering dates and extends the growing season in cities. Urban warmth can be favorable for many species of plants and animals, particularly during the cool seasons. Conversely, elevated urban temperatures often negatively

May 19, 1998: Hot rooftops shine brightly in a fresh, false-color image of Baton Rouge, Louisiana, taken as part of the Urban Heat Island Pilot Project (UHIPP) conducted by NASA and other agencies. It clearly demonstrates the principle behind UHIPP—that the differences in cooling and heating between the natural and humanmade surfaces can affect city temperatures.

affect human comfort and health during warm seasons. Sensitive demographic cohorts such as the elderly and infirm are at particularly high risk of heat-related illnesses and mortality. Energy demands are also affected by the UHI. In warm climates, the higher number of cooling degree days occurring within cities further increases cooling costs. In cool climates, however, energy savings from reduced heating degree days may offset or surpass the increased cooling bills. Even climate science is affected by the UHI since artificially high temperatures can introduce bias into long-term temperature records. If land use/land cover is changed in the vicinity of a weather station, localized climatic changes could appear in the station’s record and be misinterpreted as a regional or even global signal of climate change. Removing this urban bias requires sophisticated statistical techniques. The influence of urban areas on large-scale temperature trends continues to attract attention among climatologists.

UHIs are not limited to large cities; small towns generate heat islands too. In fact, any place where artificial land cover has replaced natural land cover could have a climate that is different from its surroundings. Replacing natural land covers, such as trees and grass, with artificial land covers, such as concrete and asphalt, alters the local energy balance. First of all, more incoming energy is retained in urban areas than in rural areas. Many urban surfaces have a low albedo (reflectivity) and often absorb more solar energy than the natural land covers they have replaced. In addition, the geometry of street canyons causes multiple reflections within the canyon, allowing multiple opportunities for building materials to absorb energy. Along with the aforementioned characteristics, the physical and thermal properties of construction materials are also different from those natural materials. Many building materials are very effective at retaining absorbed solar energy and radiating heat into the surrounding environment for hours after sunset. By comparison, rural areas generally cool much more quickly. Therefore, differences in urban and rural cooling rates after sunset often generate the UHI. Additionally, maximum nocturnal UHI development typically occurs on calm, clear nights. Calm winds limit the mixing of urban and rural air, and clear skies promote rapid nocturnal cooling through the loss of longwave radiation.

Another alteration of the energy balance in urban areas involves latent heat exchange. Imperious surfaces combined with a low amount of vegetation in urban areas result in little water being available at the surface to absorb latent heat through evapotranspiration. The result is that much of the excess available net energy goes to sensible heat, often making urban areas warmer than the surrounding, unmodified rural areas.

Urban climatology has experienced tremendous growth since Luke Howard’s original study of London’s UHI in the early 1800s. Through documenting the UHI of numerous individual cities, scientists better understand the causes of the UHI. We have also learned that cities having similar populations can experience very different UHI characteristics due to the lifestyles of their inhabitants, the geographic setting, and physical characteristics such as land use patterns and choice of building materials. Field-based studies have become increasingly more complex as observational instrumentation has improved. Remotely sensed data have also been used extensively in UHI research to analyze surface temperature patterns and to track land use and land cover changes over time. Data from field research and remote platforms provide information for computer models that has greatly advanced our understanding of UHI dynamics. Despite the vast increase in our knowledge, numerous questions remain about the relationships between UHI and global climate change. Global warming will likely affect cities primarily by altering regional-scale processes such as wind and precipitation patterns. What is far less understood, however, is how urban climates affect larger-scale processes that create uncertainty when trying to model atmosphere processes.

The number of publications about urban climate in both physical science and non-physical science journals has increased over the past decade. The recognition of urban climate’s importance and relevance to other disciplines indicates the health and vitality of the discipline. This is encouraging since urban sustainability efforts must involve numerous scientists, professionals, and stakeholders working together to achieve common goals.

Donald M. Yow
Urban areas exhibit a large range of population sizes—from hamlets to global cities—each having a corresponding economic role within the urban system. Settlements with larger populations that provide more and diverse services are higher up the urban hierarchy. Settlements with smaller populations and a limited number and type of services are further down the urban hierarchy. The size and distribution of urban areas within this system have important implications for economic development.

The urban hierarchy may be illustrated by a pyramid where the smallest settlements (hamlets) are at the bottom of the pyramid and global cities are at the top (Figure 1). Settlements at the bottom of the pyramid have small, rural populations and...
contain a small number and limited variety of economic services within the system. This type of settlement is the most dominant and widespread. Settlements at the top of the pyramid have large, urban populations and contain a large number and wide array of economic services. Usually, there is one settlement at the top of the urban system. As you move up the urban hierarchy, the number of settlements in each category declines as the populations and the number and diversity of services expand. For example, in the United States, the city at the top of the urban hierarchy is New York, which has the country’s largest population; is a major global financial, transportation, and cultural center; and offers a wide variety of social and economic services. Just below this level would be cities such as Los Angeles and Chicago, both of which have large, urban populations and offer numerous retail, financial, medical, education, and cultural services. One step below on the urban hierarchy, we will find cities such as Atlanta, Denver, Seattle, and Miami. Each has large urban populations, but they are smaller in size than the populations of New York City, Chicago, and Los Angeles. They also offer a somewhat smaller number of services. Below this level, we find cities that might be the largest cities within a state and/or state capitals. These cities serve an important economic and administrative role at a statewide or perhaps regional level. Smaller cities that are not state capitals or are not the largest cities within a state are found at the next level. They supply services to a portion or region of the state and have a significantly smaller population. Towns with smaller populations and a smaller array of services depend on nearby cities for more diverse services. Hamlets have small populations and very limited services, such as gas stations, convenience and/or grocery stores, and restaurants.

In the early stages of development and in agriculturally based economic systems, settlements typically are of similar size and are evenly distributed across the landscape (Figure 2, Stage 1). This pattern minimizes transportation costs and competition. Over time, one city or settlement (the core) gains dominance or power over other settlements in the system (Figure 2, Stage 2). This core or primate city may be centrally located compared with the other cities, or it may have an ideal location as a port city for access to water transportation. Primate cities are the largest and most dominant cities within a system of cities. Primate cities have populations many times greater than the second largest and subsequent cities. Usually, primate cities were once centers of much larger systems (e.g., empires). Over time, city systems tend to move toward a rank size distribution (Figure 2, Stage 3).

When a primate city size distribution exists within a system of cities, negative economic consequences can occur. During Stage 1, settlements are of comparable size and economic well-being
As economic development occurs and/or time passes, one city or settlement dominates the region or has a high degree of primacy—now referred to as the core (Stage 2). The core has a high capacity for generating and absorbing change. The core is technology rich and economically rich and depends on inputs from the periphery (the smaller settlements in the systems). Development in the periphery is determined by the core region institutions and tends to be resource rich but economically poor. The periphery is based on outputs to the core. As economic development increases and/or time passes, the system approaches a rank size distribution, and there is a more equitable distribution of wealth across the region (Stage 3).

The world faces comparable challenges of core and periphery regions as globalization occurs. Developed regions (the core) rely on undeveloped regions (the periphery) for resources and labor. Undeveloped regions must deal with rapid population growth in urbanized areas as an agrarian-based populace seeks the promise of higher-paying factory jobs. As these peripheral regions reach higher levels of economic development, they will become less dependent on the developed world for technology and investment, and the global economic system will likely have a more equitable wealth distribution.

Lisa Theo

See also Central Place Theory; Primate Cities; Rank-Size Rule; Urban Geography; Urbanization; World Cities

Further Readings

The urban world at the dawn of the 21st century has assumed special importance for two principal reasons. First, the world’s population has recently crossed the threshold from being more rural to being more urban. In absolute terms and according to UN estimates, this means that of the world’s population of approximately 6.8 billion, approximately 3.5 billion people (or 51%) are living in urban settings. To put this notion in historical context, consider that 58 yrs. (years) earlier only 29% of the world population lived in cities. The projection for 2050 is 70%. Second, a dramatic change in the urban hierarchy is taking place as the large cities—variously termed global cities, world cities, megacities, and so on—are beginning to dominate the urban landscape. This entry first reviews the historical development of the urban world, from the earliest settlements in Mesopotamia to the present, and the types of explanations researchers have used to describe this process. Problems in measuring the degree of urbanization are then discussed, including the concept of urban degree (the level of a country’s urban concentration, expressed in percentage at a point of time). Although urbanization is occurring around the globe, there are significant differences in this process; some of the global trends are noted here. The entry concludes with a look at the future of urbanization.

Along with urbanization, other changes are taking place concomitantly: The rural-urban and interurban mobility of population is accelerating, the traditional rural-urban dichotomy is blurring, and research and technological innovations in economic development and transportation—along with the relaxation of political-institutional barriers—are growing. Consequently, a diversified and unprecedented mix of urban phenomena, urbanization processes, and urban patterns in global and regional scales is emerging, giving rise to complex issues, problems, and prospects. The concentration of urban populations is manifested in many forms and functions—both historically, through cyclical changes (e.g., urbanization, de-urbanization, and re-urbanization), and spatially, from the monocentric, core-oriented settlements to the polycentric, peripherally focused patterns.

Urban fringe, urban cluster, urban sprawl, “rurban,” and extended urban areas are among the terms frequently used to identify and characterize the spatial patterns of the emerging urban landscapes. Urbanization is linked with social and demographic changes such as smaller family sizes, occupational specialization, and increased population densities. Ideally and typically, urbanization is tied with increasing wealth and improved quality of life. While an urbanizing world has the potential to impart extraordinary benefits—including an enhancement of the quality of life—to its citizens, it also faces significant problems that include the degradation of environment and a challenge to urban sustainability. Urbanists seek to analyze these diverse urban issues from a variety of perspectives and scales in order to understand the spatial processes and patterns.

Early urban settlements were small but iconic representations or symbols of civilization, extensively written about in a number of regional contexts. Even though the concentration of population in settlements can be traced historically, the evidence of urban origin—the where, when, and how of urban concentrations and their subsequent spread—remains uncertain. Scholarly disagreements on the genesis, traits, settlement patterns, and modes of dispersal of urbanization notwithstanding, we know that urbanization has been a nearly continual process throughout human history. The earliest cities, or urban settlements, first developed approximately 6,000 yrs. ago in Mesopotamia. These were followed by cities developing independently in the Nile Valley in Egypt, the Indus Valley in South Asia, the Yellow or Huang He River valley in China, parts of Africa, and Mesoamerica and South America over the next several millennia. These regions are widely cited as the early “urban hearths.”

Of the theories offered to explain urban origin, four broad theories—hydraulic, economic, military, and religious—provide the dominant views. Briefly, a surplus in agricultural production was a critical notion underlying the hydraulic theory, and the notion of cities as the locations for trade was central to the economic theory. In the military theory, the need for concentration was
attributed to the communal defense, while the role of religious leaders in the organization and control of territories for ensuring the safety and security of community dwellers was the basis of the religious theory. Clearly these explanations are not mutually exclusive.

Historically, urbanization has been linked with the progress of society from agrarian to industrial. Most societies before the 16th century were only marginally urban, as the vast bulk of the populations consisted of peasants and farmers. The mode of agricultural production, extraction of natural resources, and trading activities of urban dwellers had distinctive geographical and locational advantages. Subsequently, the progress of the agrarian economy, increased trade in the 16th century, and the onset of the Industrial Revolution in the 18th century laid the foundation of large-scale urbanization. Cities grew in number and population and became interlinked in trade and commerce.

Urbanization as a global phenomenon accelerated markedly with the advent and expansion of European colonialism. This diffusion of urbanization may be broadly depicted in several phases: The earliest phase grew incrementally and most apparently in Latin America, subsequently appearing in South Asia, Southeast Asia, and Africa. Other parts of Asia, such as China, were affected too, though later and not to the same degree. This first phase, lasting until the mid 1800s, was rooted in city-based mercantile colonial activities. During this period, city growth occurred mostly in colonial trading centers.

A second, industrial colonial phase was evident from the mid 1800s through the 1920s. During this phase, urbanization was increasingly tied to the extraction of raw materials for industrial activities and for growing food consumed in the rapidly expanding industrial centers. States were more directly involved in territorial control of their colonies. Colonial urbanization became more complex and more pervasive. Cities grew rapidly, became denser and increasingly segregated, and came to bear the hallmarks of European colonial planning.

The emergence of diversified urban economies and the development of a variety of transportation modes in the 19th century provided the stimulus for urbanization to accelerate, while distinctive patterns of urbanization became evident during the second half of the 20th century, especially during the post–World War II period. Several factors can be attributed to this distinctive pattern. First, many of the so-called less developed countries gained independence from colonial rule and initiated socioeconomic developmental planning emphasizing large-scale industrialization. Second, some of the more developed industrial countries shifted their industrial base from traditional manufacturing to a wide range of tertiary activities. This shift altered the location of activities by prompting regional redistributions of population within countries while spreading industries to new sites outside the core cities and countries. Third, the revolutions in finance, trade, and commercial activities involving both the developed and the developing countries, particularly during the past 25 yrs., gave rise to the process of globalization, which is intrinsically linked to the accelerated growth and development of many larger cities. One prominent outcome of the globalization process is seen in the emergence of the current global city or world city.

Throughout world history, urbanization, industrialization, and societal changes have been closely interrelated. Two key factors, broadly speaking, have shaped the pattern of urbanization over the centuries: the demographic (population base and growth rates) and the economic (resource base, growth rates, and development), making the socioeconomic development path key to understanding urbanization. This intricate relationship makes it imperative to understand, measure, and monitor urbanization, primarily by means of assessing the urban concentrations of population in space and over time.

### Measuring Urbanization

In general, urbanization is described as the process of concentration of a population in space designated as urban—a process that encompasses the migration of populations from rural to urban areas, a natural increase in the urban population, and a reclassification of rural areas to urban. Although the idea of spatial concentrations of population might appear to be simple, it is well recognized that a variety of its correlates manifest
themselves in urban space, reflecting the complexities of the process. Virtually all the countries of the world have designated their urban places or areas, although the conceptual definition of the term *urban* remains variable. Broadly, the following are among the key criteria that have general global acceptance:

- A minimum threshold of population size, built-up area, or density
- Occupational traits of the labor force (primarily nonagricultural)
- Administrative status
- Spatial structure and organizational pattern

In spite of the general agreement on the key criteria, the study of urbanization is fraught with two problems, namely, that the urban concept is not uniformly defined across the globe and that the data on the criteria for urbanization lack uniform definition, stringency, accuracy, or availability. These problems make it difficult to adequately assess and compare the urban status or patterns of individual countries or regions, not to mention the difficulties involving intracountry or cross-country comparability. Traditionally, easily computable demographic data, such as a minimum threshold of population size, are used for determining the urban status of a designated place. This simple approach reflects one of the many urban traits that arise out of population concentration. Wide variations in urban concentrations are apparent across nations, usually related to the countries’ levels of development and industrialization. In this respect, measurement of urbanization becomes a key indicator in assessing the developmental status.

The change in the degree of urbanization (urban degree) can be measured in two ways: (1) urban growth—the difference in the level over a period of time and (2) the relative difference between urban and rural growth rates. If the urban growth rate exceeds the rural growth rate over a specified time period, an urbanizing process sets in, indicating change in the societal status of the country. The measure of concentration and change in a population, as noted in its urban degree, growth, and urban-rural differentials, is related to a host of underlying demographics (e.g., birth rates, death rates), economic (e.g., migration of labor force), and/or administrative (e.g., urban designation policy) factors.

### Global Trends: An Overview

The difficulty in generalizing about global urbanization primarily arises from the complex geographies of countries and regions. First, the geographic patterns of the level of urbanization vary substantially across the globe. By world region, the world’s most urbanized areas are North America (the United States and Canada; 81%), Latin America (78%), Europe (72%), and Oceania (71%). Less urbanized areas are Africa (39%) and Asia (41%). Given their demographic magnitude, it is wise to single out the urbanization levels of China (47%) and India (29%). Notable countries at the extremes are Singapore (100%) and Uganda (13%). Next, the pattern of change across the developed and less developed regions, both in the number of urban populations and in the rate of urbanization, are noticeably uneven (Figure 1). Irrespective of their level of urbanization, during the 25 yrs. following World War II, the urban population steadily increased in both the developed countries and the less developed countries. However, during the next 25 yrs. (1975–2000) both the size and the growth rates of the urban population in the less developed countries significantly exceeded the same in the more developed countries.

The urban structure, depicting the proportion of population distributed in a variety of size groups of places within given geographical and/or administrative territorial boundaries, can indicate important attributes of spatial development as observed in many regions in less developed countries. During the period from 1975 to 2000 (Table 1), the pattern of change in three selected hierarchical size groups of urban population showed a steady rise in the number of urban settlements in the smallest (<1 million population) size group, while they declined in their share of the total urban population. For the intermediate (1–5 million) and the largest (>5 million) size groups, the number of settlements increased, while their proportion of total urban population either increased or remained steady during these years. The structural patterns did not show much variation between the more developed countries and the less developed countries. However, compared
Figure 1  Urban population: uneven growth of MDRs (more developed regions) and LDRs (less developed regions)

with the smallest (<1 million) size group, a rather dramatic growth in the number of settlements for the two larger-size classes in the less developed countries depicts significant changes in the urban system (Table 1).

The emergence of megacities—those with 10 million or more people—marks a milestone in the 20th-century urbanization of the less developed countries. Out of a total of 19, there were only 5 megacities in the developed regions in 2007 (Table 2). It is estimated that by the year 2025, only one more city will be added to the megacity list in the developed region, while the rest, accounting for nearly 80% of the total number of cities, will be in the less developed countries. Over the past two decades, megacities in the less developed countries have experienced significant growth. Some, such as Dhaka in Bangladesh and New Delhi in India, recorded a huge increase of 11.3 million and 11.5 million people, respectively, during the period from 1975 to 2007. The average population of the world’s largest 100 cities now stands at more than 7 million, compared with only 700,000 in 1900. The observed trends are attributed, broadly, to the forces generated from within (e.g., development policies) and/or outside (e.g., economic globalization) the more developed countries and the less developed countries.

### The Urban Future

Urbanization is a universal process. No matter how its evolutionary path is traced or interpreted, the certainty of its steady pace can hardly be disputed. Much social progress and development and economic prosperities are derived from urbanization. The continuity of the pattern of growth and pace, however, also clearly indicated the vulnerability of the urban environment. The basic issue for the future, then, is simple: How should the urban world grow?

While discussing the pros and cons of urbanization in the context of the global urban revolution, there are two major differing views on the state of urbanization. The “urban optimists” are motivated by the notion that the societal benefits of urbanization generate an overall improvement in the quality of life of the individuals as well as in the developmental levels of nations. The “urban pessimists,” on the other hand, worry

---

**Table 1** Urban population: selected size group of cities

<table>
<thead>
<tr>
<th>Region/Year</th>
<th>&lt;1 million</th>
<th>1–5 million</th>
<th>&gt;5 million</th>
<th>&lt;1 million</th>
<th>1–5 million</th>
<th>&gt;5 million</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>67.9</td>
<td>20.9</td>
<td>11.2</td>
<td>237</td>
<td>163</td>
<td>18</td>
</tr>
<tr>
<td>2000</td>
<td>62.8</td>
<td>22.3</td>
<td>14.9</td>
<td>399</td>
<td>334</td>
<td>44</td>
</tr>
<tr>
<td>2025</td>
<td>59.8</td>
<td>23.1</td>
<td>17.0</td>
<td>551</td>
<td>524</td>
<td>75</td>
</tr>
<tr>
<td><strong>MDRs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>67.3</td>
<td>19.6</td>
<td>13.2</td>
<td>102</td>
<td>71</td>
<td>8</td>
</tr>
<tr>
<td>2000</td>
<td>63.6</td>
<td>22.4</td>
<td>14.0</td>
<td>116</td>
<td>98</td>
<td>10</td>
</tr>
<tr>
<td>2025</td>
<td>62.4</td>
<td>20.4</td>
<td>17.2</td>
<td>132</td>
<td>103</td>
<td>17</td>
</tr>
<tr>
<td><strong>LDRs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>68.3</td>
<td>22.1</td>
<td>9.6</td>
<td>135</td>
<td>92</td>
<td>10</td>
</tr>
<tr>
<td>2000</td>
<td>62.5</td>
<td>22.2</td>
<td>15.2</td>
<td>283</td>
<td>236</td>
<td>34</td>
</tr>
<tr>
<td>2025</td>
<td>59.2</td>
<td>23.8</td>
<td>17.1</td>
<td>419</td>
<td>421</td>
<td>58</td>
</tr>
</tbody>
</table>


*Note: MDRs = more developed regions, LDRs = less developed regions.*
about the adverse effects of urbanization, especially in the context of the developing countries, where socioeconomic unrest and urban pathologies such as poverty and slums continue to plague society. People across the globe perhaps see their individual and collective urban futures somewhere along the continuum.

To optimize the benefits of urbanization for societal development while minimizing, or at least coping with, its adverse consequences, it is imperative that research be focused on the global, national, and regional or local scales to understand the divergent paths of the complex urbanization phenomenon. In charting the future course of urbanization, the needs and wants of the people for a desirable urban living environment in a variety of contexts must be incorporated. Just as it is essential that the stakeholders—the citizens, the private and the public bodies—participate in envisioning the urban culture for shaping the future, it is equally crucial to collect, store, and distribute accurate and comparable urban data for ongoing research that would serve as the foundation for effective planning strategies and policies.

Debnath Mookherjee and George Pomeroy

See also Counterurbanization; Gentrification; Rural-Urban Migration; Suburbs and Suburbanization;

<table>
<thead>
<tr>
<th>Urban Agglomeration</th>
<th>Population in Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1975</td>
</tr>
<tr>
<td>Tokyo, Japan</td>
<td>26.6</td>
</tr>
<tr>
<td>New York–Newark, USA</td>
<td>15.9</td>
</tr>
<tr>
<td>Mexico City, Mexico</td>
<td>10.7</td>
</tr>
<tr>
<td>Mumbai, India</td>
<td>7.1</td>
</tr>
<tr>
<td>Sao Paulo, Brazil</td>
<td>9.6</td>
</tr>
<tr>
<td>Delhi, India</td>
<td>4.4</td>
</tr>
<tr>
<td>Shanghai, China</td>
<td>7.3</td>
</tr>
<tr>
<td>Kolkata, India</td>
<td>7.9</td>
</tr>
<tr>
<td>Dhaka, Bangladesh</td>
<td>2.2</td>
</tr>
<tr>
<td>Buenos Aires, Argentina</td>
<td>8.7</td>
</tr>
<tr>
<td>Los Angeles–Long Beach–Santa Ana, USA</td>
<td>8.9</td>
</tr>
<tr>
<td>Karachi, Pakistan</td>
<td>4.0</td>
</tr>
<tr>
<td>Cairo, Egypt</td>
<td>6.4</td>
</tr>
<tr>
<td>Rio de Janeiro, Brazil</td>
<td>7.6</td>
</tr>
<tr>
<td>Osaka-Kobe, Japan</td>
<td>9.8</td>
</tr>
<tr>
<td>Beijing, China</td>
<td>6.0</td>
</tr>
<tr>
<td>Manila, Philippines</td>
<td>5.0</td>
</tr>
<tr>
<td>Moscow, Russia</td>
<td>7.6</td>
</tr>
<tr>
<td>Istanbul, Turkey</td>
<td>3.6</td>
</tr>
<tr>
<td>Kinshasa, Democratic Republic of the Congo</td>
<td></td>
</tr>
<tr>
<td>Lagos, Nigeria</td>
<td></td>
</tr>
<tr>
<td>Jakarta, Indonesia</td>
<td></td>
</tr>
<tr>
<td>Guangzhou, Guangdong, China</td>
<td></td>
</tr>
<tr>
<td>Lahore, Pakistan</td>
<td></td>
</tr>
<tr>
<td>Shenzhen, China</td>
<td></td>
</tr>
<tr>
<td>Chennai, India</td>
<td></td>
</tr>
<tr>
<td>Paris, France</td>
<td></td>
</tr>
</tbody>
</table>

Table 2  Urban population: megacities

Cities across the world are complex mosaics of economic, social, political, and recreational land uses. How and where these land use activities are organizationally patterned reflect not only a city’s primary function (e.g., an “economic engine” in an industrial economy or a “cultural/administrative” center in an agrarian economy) but also at least two other overarching forces—accessibility and territoriality/congregation/segregation. In general, the utility of a designated place or location within a city is defined by its potential usefulness, which, in turn, is often a function of its accessibility. Activities that tend to be land intensive have a propensity for high levels of interaction and serve a necessary and functional purpose that requires accessible locations. Alternatively, low-accessible locations are occupied by those land use activities that are characteristically land extensive (activities that require the use of large tracts of land) and functionally peripheral and independent (Figure 1).

Figure 1  Economic competition, accessibility, and the resultant urban land use patterns in relationship to the central business district (CBD)

Source: Author.
At the same time, land use activities are often organized in clearly demarcated geographic territories so as to define and preserve “group” membership and identity. Typically, this involves the use of both inclusionary and exclusionary practices in an effort to create homogeneous groupings by housing, retail/commercial establishments, professional services, and industry. Of particular significance is the occurrence of congregation—a voluntary territorial and residential clustering of specific groups of people (i.e., language, religion, race, lifestyle, among others) that engenders a sense of place unity as defined by a common electoral power base, a system of reciprocal support, and cultural preservation. However, there also exists an involuntary form of congregation (segregation) that results in territorial and residential clustering involving discrimination and the spatial separation of specific groups of people. In this way, both accessibility and territoriality/congregation/segregation are important place-defining forces that shape the internal structure of cities worldwide and their urban land use patterns. This entry discusses four urban land use models: (1) the concentric zone model, (2) the sector model, (3) the multiple-nuclei model, and (4) the peripheral model, as well as the application of these models.

Urban Land Use Models

Whereas economic competition, accessibility, and the propensity toward social and ethnic discrimination/segregation/congregation are evidenced in many of the cities across the globe, the resultant urban land use varies considerably due to the influences of culture, history, and particularly the functional roles cities have played in the world economy. Since the 1920s, geographers, sociologists, and economists have attempted to identify and examine the ever-evolving geographic placement of people, economic activities, and administrative functions in cities. Within the North American context, four models describing the internal structure of cities have been developed: (1) the concentric zone model, developed by Ernest W. Burgess in 1923; (2) the sector model, developed by Homer Hoyt in 1939; (3) the multiple-nuclei model, developed by Chauncy Harris and Edward Ullman in 1945 (Figures 2A, B, and C); and (4) the peripheral model, developed by Truman Hartshorn and Peter Muller in 1989 (Figure 3).

Traditionally, the city’s center, commonly known as the central business district, or CBD, has served as the principal “hub” for retail, office, and significant administrative/institutional land use activities. In particular, the CBD has not only contained the highest density of all these land use activities but has also been positioned at the nodal point of transportation systems and is visually characterized by an impressive vertical skyline. Typically, the CBD is surrounded by a zone of mixed land uses, including older residential neighborhoods, small factories, warehousing, and multifamily residential complexes, and is often collectively referred to as an urban land use “zone in transition.” Geographically, beyond this zone is a mosaic of residential neighborhoods and suburban territories of various age, social, and ethnic compositions.

Concentric Zone Model

The concentric zone model was the first attempt to explain the distribution of different social groups within cities. Fueled by streams of migrants and immigrants from diverse cultural backgrounds to the North American industrial cities throughout the late 1800s and early 1900s, residential territories of congregation were established to provide a sense of security, communication, and familiarity. On average, these original ethnic communities persisted over one to three generations, after which an increasing number of individuals from these groups were able to obtain better employment and therefore relocated to newer, higher-income housing that was being built at greater distances from the CBD. In this way, the concentric zone model proposed a continual outward expansion of the city (in the form of concentric rings or zones), with the development of ever newer, more spacious and expensive residential neighborhoods (Figure 2A).

Sector Model

In 1939, a second urban land use model was developed by H. Hoyt. Because the key component influencing the geographic placement of land use activities in this model was accessibility,
Figure 2  The three urban land use models: concentric zonal, sector, and multiple nuclei

Source: Author.
Hoyt argued that cities developed in a series of sectors (aligned along transportation “corridors”), not concentric rings (Figure 2B). As a city expanded geographically outward radial, as opposed to circumferential, transportation systems were built (e.g., suburban commuter roads and streetcar and elevated rail lines) to facilitate and channelize growth. And due to economic competition and the compelling demand for accessibility, land use activities located and geographically sorted themselves into clusters or sectors that were congruent with the transportation arteries radiating outward from the CBD. In this way, Hoyt suggested that high-rent residential areas grew outward from the CBD, along major transportation routes, surrounded by middle-income housing, and low-income housing settled in districts adjacent to the CBD near industry. Finally, the dynamism of the sector model is characterized by a “filtering-down process,” as older residential neighborhoods were abandoned by the outward movement of their original high-income occupants and were replaced by households of the next lower-income strata.

Multiple-Nuclei/Peripheral Model

In contrast to the concentric zone and sector models, the multiple-nuclei model views urban land use in cities as being shaped by several nodes of growth, as opposed to the single-CBD assumption (Figure 2C). In 1945, Harris and Ullman suggested that different land use activities have uniquely specific locational requirements; for example, retailing needs accessibility, heavy manufacturing relies on horizontal production spaces near railroads, port functions are best served by waterfront activities, and other nodes, including universities, airports, and parks, may serve as the focal point for other types of land use activities. And basically, both territorial segmentation and segregation were hallmark characteristics for understanding the resultant spatial pattern of urban areas.

While these three urban land use models are somewhat dated for explaining present-day urban land use patterns, they nevertheless continue to provide a historical baseline to the structural underpinnings of land use in contemporary metropolitan complexes. As an extension, Hartshorn and Muller have proposed a peripheral land use model that accounted for the pervasive suburbanization of a multiplicity of CBD functions between 1970 and 1990 (Figure 3).

The peripheral model focuses on the circumferential outer beltway that has redefined the role of suburban nodes, not by their relationship with the traditional CBD but rather with other outlying suburban nodes. Contained within the peripheral model is the notion that households are highly segregated into relatively homogeneous suburban territories, whereby suburban nodes are highly developed and self-supporting employment, retail, and recreation centers. Finally, peripheral models legitimize the occurrence of exurbanization—a “residential appendage”—as the outermost land use activity connected to an urban area.

Application of Models

None of the four models individually and completely explain urban land use patterns. Partly due to their simplistic assumptions as well as the time period in which they were developed, the models do not encompass all the changing forces that geographically shape today’s urban communities. Nevertheless, the four urban land use models collectively provide the structural basis for understanding the social, economic, and political geographies of the contemporary city. While the four models may be particularly useful to describe urban land use patterns in North American cities, adjustments are needed for their application in both European and less developed country (LDC) contexts.

In particular, wealthier people in European cities not only cluster along specific sectors extending outward from the CBD but more prominently occupy places of residence in and adjacent to the CBD. Historical preservation combined with the numerous cultural amenities found in European CBDs, along with high transportation costs (fuel), make living and functioning in or near the CBD in high demand. As such, the poorer European urbanites tend to dominate the outer “suburban” tracts of land. Moreover, there exists an important distinction between Western and Eastern European cities. Namely, Western European cities and their resultant land use patterns are deeply
rooted in their medieval origins, Renaissance restructuring, and level of industrial capitalism. Their geographic compactness, high population densities, and pervasive “apartment”-style residences have fostered the continued reliance on public forms of transportation. Cities in Western Europe often combine places of residence with places of employment; for example, retail/business establishments occupy street-level space, while subsequent upper levels are occupied by households for living space. In many of these cities, the historic core is gentrified, where the middle-income groups, the elderly skilled artisans, and the young entrepreneurs share space and intermingle with preserved historical buildings, monuments, and tourist attractions.

In contrast, Eastern European cities and their resultant land use patterns reflect a different ideological base—centrally administered planning principles. In particular, explicit segregated land use, “intra” neighborhood equality and autonomy, and restrictions on the geographical size of a city were adopted during the communist period, from 1945 to 1990. While none of these objectives ever became fully implemented, they have served as the cornerstones for the geographic
layout of Eastern European cities. Slowly but steadily, as the former Eastern Bloc countries, along with the former Soviet Socialist Republics that are now part of Eastern Europe, increasingly incorporate market principles of land allocation, the land use pattern of Eastern European cities may begin to resemble that of their western counterparts.

By comparison, the fastest-growing cities and the most rapidly growing populations are found in the developing world. Despite the variety of urban structure that abounds in culturally diverse regions such as Latin America, the Middle East, and Africa, there exist at least three common planning principles that underlie their urban land use. First, the lowest-income individuals have and continue to increasingly situate themselves in the outlying areas of the city, away from city services, often occupying the land illegally and forming squatter settlements. Second, there is an absence of adequate urban infrastructure to support the growing population—sanitation, drinking water, roads, electricity, and so on. Third, many of these cities have a colonial heritage that, over an extended period of time, left indelible architectural, religious, political, and cultural imprints on the geography of the city. In much of the developing world, urbanization is driven by massive rural-to-urban migration. In short, urban land use in less developed countries is primarily a culmination of historical origin, colonial imprint, and functional role within its current cultural setting.

**Conclusion**

Urban land use of cities across the world, whether in North America, Europe, or the developing world, is reflective of underlying antecedents for the design and planning of urban space. Whether land use is based on “grid systems” (the remnants of Greek and Roman settlements), position of power or celebrated glory (e.g., the Renaissance), religious edifices (e.g., the mosque, cathedral), military ordinance, or cities that should be designed and function like “machines” (e.g., the modern movement and industrial capitalism), geographical principles play a significant role in all urban landscapes.

*Jeffrey P. Richetto*

---

**See also** Chicago School; Exurbs; Hoyt, Homer; New Urbanism; Rural-Urban Migration; Suburban Land Use; Suburbs and Suburbanization; Urban and Regional Development; Urban and Regional Planning; Urban Ecology; Urban Environmental Studies; Urban Geography; Urban Spatial Structure; Urbanization; Urban Sprawl

**Further Readings**


---

**Urban Metabolism**

The concept of urban metabolism provides a framework for examining natural resource flows and use in urban areas. Urban metabolism studies draw an analogy with the metabolic requirements and processes of an organism. Like an organism, a city requires water, energy, food, and other resources to fuel, grow, and reproduce itself. It also produces wastes and residuals that must be disposed of with minimal hazard. Urban metabolism studies can be used to provide insight into the sustainability of the relationships between a city and its supporting physical environments and have recently begun to include social and economic relationships as well.

The first formal urban metabolism study was prepared in 1965 by Abel Wolman for a hypothetical North American city of 1 million inhabitants to highlight key urban environmental issues of modern industrialized cities: the
provision of a safe and adequate urban water supply, the effective disposal of sewage, and the control of air pollution. Since then, approximately 10 urban metabolism studies of actual cities have been conducted, including Hong Kong, Vienna, Toronto, Tokyo, London, and Sydney. Analysis using urban metabolism as a framework metaphor typically takes the form of a material flow analysis, where researchers take stock of the inputs, storage, transformation, and output of different materials and their residuals across a defined urban system and over time. While some studies look specifically at the flow of a single material such as water or nitrogen, most provide a comprehensive accounting of inputs and wastes.

Taking stock of material flows across an urban system and over time helps draw attention to the need to examine the systemwide impacts of the consumption of natural resources and provides valuable information for decision making and planning for the future of cities. An urban metabolism study may reveal inefficiencies in resource use, opportunities for policy intervention to slow or prevent the exhaustion of resource supplies, and the sources of potential problems from the buildup of potentially hazardous materials and emissions within the urban system and its surrounding environment.

Different indicators describing the metabolic flow of resources can be used to draw conclusions about the sustainability of a city’s urban metabolism and therefore of the city itself. These include the magnitude of and changes in the total and per capita resource use and waste generation and the degree of circularity in resource use.

Most urban metabolism studies indicate that in general the magnitude of the per capita resource use in cities is large and increasing. For example, a comparison of the comprehensive studies of the urban metabolism of Hong Kong in 1971 and 1997 (Table 1) demonstrates increases of 20%, 100%, and 280% in the per capita consumption of food, fossil fuels, and construction materials, respectively. In addition to increased resource use, Hong Kong’s total waste and residual outputs of municipal solid waste, carbon dioxide (CO₂), and sewage discharges have also risen by 245%, 250%, and 153%, but per capita air pollutants emissions have decreased by 23%. A review of urban metabolism studies from eight metropolitan regions across five continents suggests that the trend of increasing total and per capita urban metabolisms is prevalent worldwide, fueled in part by increasing urbanization and material wealth.

### Table 1  Urban metabolism of Hong Kong, 1971 and 1997

<table>
<thead>
<tr>
<th>Material Flow</th>
<th>10^6 Tons/Year</th>
<th>% Change</th>
<th>Kilograms Capita⁻¹ Year⁻¹</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>2.4</td>
<td>5.0</td>
<td>+108</td>
<td>570</td>
</tr>
<tr>
<td>Fossil fuel</td>
<td>4.0</td>
<td>13.0</td>
<td>+225</td>
<td>1,000</td>
</tr>
<tr>
<td>Construction materials</td>
<td>4.0</td>
<td>25.0</td>
<td>+525</td>
<td>1,000</td>
</tr>
<tr>
<td>Other goods</td>
<td>1.0</td>
<td>3.5</td>
<td>+250</td>
<td>250</td>
</tr>
<tr>
<td>Freshwater</td>
<td>390</td>
<td>913</td>
<td>+134</td>
<td>99,010</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total solid waste</td>
<td>3</td>
<td>13.8</td>
<td>+245</td>
<td>762</td>
</tr>
<tr>
<td>Sewage</td>
<td>288</td>
<td>677</td>
<td>+153</td>
<td>73,115</td>
</tr>
<tr>
<td>CO₂</td>
<td>9</td>
<td>31.6</td>
<td>+250</td>
<td>2,285</td>
</tr>
<tr>
<td>Air pollutants</td>
<td>0.26</td>
<td>0.33</td>
<td>+27</td>
<td>65</td>
</tr>
</tbody>
</table>

Hong Kong population: 393,900 (1971); 6,617,100 (1997)

Herbert Girardet, a long-time scholar of the urban metabolism of cities, highlights the shape of a city’s urban metabolism as another key indicator of sustainability (Figure 1). A city’s urban metabolism may be linear, where input is unrelated to output. A city has a linear urban metabolism when it acquires, concentrates, and consumes ecosystem resources and disposes of its...
waste products in a manner such that they cannot be reused or may potentially cause harm to other systems or the city itself. In most cities, the use of fossil fuels is a prime example of a linear urban metabolic process. Fossil fuel resources from beyond urban system boundaries are stored and then consumed as sources of energy, and the waste products of heat such as particulate emissions, nitrogen oxides (NOx), sulfur dioxide (SO2), CO2, and other greenhouse gases are released and contribute to the creation of the urban heat island effect, climate change, acid rain, and air pollution.

On the other hand, a city’s metabolism may be circular, whereby it is able to reuse or recycle its waste products or return them as a source of inputs for other systems. In many North American and European cities, the flow of food and the embodied organic matter, nutrients, and energy within is becoming a more circular urban metabolic process. Food products are brought into or grown within the urban system and consumed by its inhabitants. The waste products of garbage and sewage are increasingly collected and treated by the city. In some cities, innovative waste management practices are used to produce compost and other soil amendments from food wastes that can be reused as inputs for agriculture and horticulture or to capture methane and heat to serve as new sources of energy. A narrowly focused study of food nitrogen flows in Toronto, Canada, from 1990 to 2004, suggests that the degree of circularity in the urban nitrogen metabolism is between 2.3% and 4.7%. This circularity appears quite low, given the number of municipal programs aimed at collecting and composting household food wastes. The accounting revealed that major sources of the linearity of the nitrogen metabolism were in sewage treatment and commercial food waste disposal. This finding emphasizes the ability of an urban metabolism study to identify processes at which to target interventions to increase the sustainability of a city’s relationship with its surrounding environment.

Factors Influencing City Metabolism

There are several factors that influence the magnitude and shape of the urban metabolism of cities. The natural and physical built form characteristics of an urban area, such as climate and surface and groundwater resources, as well as urban form and transportation technology, are key determinants of total and per capita energy and water use. For example, a low-density sprawling city in an interior continental climate is likely to have a larger metabolic energy requirement for transportation, heating and cooling, and water distribution than a compact city of the same population size in a temperate climate.

Municipal policies and practices such as building codes and waste and water management technology, as well as urban residents’ attitudes and behavior, will also influence a city’s urban metabolism, in terms of both its magnitude and its degree of circularity. For example, the degree of circularity of a city’s urban metabolism can be increased through composting and recycling, grey water separation and reuse, and district heating and cogeneration facilities. The success of municipal policies aimed at reducing the magnitude of urban metabolism will require targeting inefficiencies in resource use and reuse and significant participation by urban residents, who also must be supported by appropriate changes in infrastructure and urban form. By taking stock of resource flows, urban metabolism studies can help identify both current and future trends in resource use and track progress toward greater sustainability between cities and their surrounding environments.

Jennifer Forkes

See also Anthropogenic Climate Change; Ecological Footprint; Greenhouse Gases; Industrial Ecology; Urban Ecology; Urban Green Space; Urban Heat Island; Urban Water Supply

Further Readings


Although the world population has historically been rural, there are now more people in urban areas than in the rural hinterlands for the first time in history. According to UN estimates, in 2010 more than 3.5 billion people (50.6%) will inhabit urban centers around the world, with the highest concentration of large urban centers in Asia (Table 1, Figure 1). Typical of this concentration is the metropolitan complex of Tokyo and Yokohama, Japan, with the largest urban population of approximately 36 million people (Figure 2). The growing urban areas need to provide for citizens’ demands for housing, employment, transportation, infrastructure, and the vast array of services and facilities. To meet these demands, it is essential to understand the environmental, social, economic, and political characteristics of the ever-growing urban realm. Urban geography has contributed significantly to this knowledge and continues to expand its role by providing theoretical, technological, and analytical advancements to assist in this effort. Correspondingly, the integration of this knowledge and its implementation into strategies, policies, and programs to meet the needs of the urban population is a task planners have undertaken. The implementation of their plans is a key component to ensure the health, safety, and well-being of urban citizens. The spatial dynamics of the urban area and its growth management create the interaction between urban geography and urban planning and are the focus of this discussion.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Urban</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5,290</td>
<td>2,275</td>
<td>43.0</td>
</tr>
<tr>
<td>1995</td>
<td>5,713</td>
<td>2,554</td>
<td>44.7</td>
</tr>
<tr>
<td>2000</td>
<td>6,115</td>
<td>2,850</td>
<td>46.6</td>
</tr>
<tr>
<td>2005</td>
<td>6,512</td>
<td>3,165</td>
<td>48.6</td>
</tr>
<tr>
<td>2010</td>
<td>6,909</td>
<td>3,496</td>
<td>50.6</td>
</tr>
<tr>
<td>2015</td>
<td>7,302</td>
<td>3,848</td>
<td>52.7</td>
</tr>
<tr>
<td>2020</td>
<td>7,675</td>
<td>4,213</td>
<td>54.9</td>
</tr>
<tr>
<td>2025</td>
<td>8,012</td>
<td>4,583</td>
<td>57.2</td>
</tr>
<tr>
<td>2030</td>
<td>8,309</td>
<td>4,960</td>
<td>59.7</td>
</tr>
</tbody>
</table>

Table 1  World total and urban population (billions), 1990–2050
Source: UN Department of Economic and Social Affairs, 2008.
The thematic dimension of urban research provides the elements of an urban area that are linked together to establish its character. The city is a system either within its own area or as a part of the interconnection between cities, and it is imperative to know the elements of the city or cities to understand how the system works together. The general environmental, social, economic, and political dimensions are the broad characteristics of any city. However, there are many subthemes that are more specific; for example, the social dimension can be subdivided into families, race, ethnicity, or medical history. The number of subthemes can be limitless depending on the specificity of the researchers and their characteristic interest. This notion is made more complex by the investigation of multiple subthemes spanning several major elements. The spatial distribution of environmental quality and its impacts on health and living conditions for the underprivileged of a specific ethnic background are an illustration of this point. Thus, many different subthemes of several elements can be examined at different spatial scales.

Urban research’s analytical dimension has four main components: form, function, process, and structure. Each component represents a different aspect of the urban area that broadens our understanding of the city system or system of cities. The form is generally the arrangement of the urban elements or subthemes and is represented by their spatial distribution at a local, regional, national, or global scale. The functional component of an
investigation explores the purpose, role, or meaning that the subtheme has within the city system or system of cities. A city may have an economic base on which to focus, and the investigation may be concerned with what role that city has within the broader economy of the region, nation, or international system. The process component of this dimension is examined using many different methods based on the subtheme being researched. The importance of process is that it reveals the interrelationships, linkages, and connections between the subthemes. The strengths or weaknesses can be examined, which can provide the cause-and-effect relationships between the social, economic, and environmental issues within the urban area. Finally, the structural component of the analytical dimension is the foundation on which the urban form, functions, and processes are built. The structure presents the assumptions that are the bases on which the urban system operates. Without knowing the underlying rules or assumptions, it is difficult to understand the relationships, linkages, or connections between the subthemes. Urban geography investigates urban areas using all the different analytical components for a better understanding of the overall city system or system of cities depending on the spatial scale and the intent of the research undertaken.

The final dimension of urban geography is the chronological. There are four approaches that urban geography has taken in this dimension—(1) historic time, (2) a progression or sequence in time, (3) the present time, and (4) the future or predictive time. The historic time approach is an investigation of an urban area at a specific date or time span in the past. A study of the spatial distribution of Spanish Moorish cities in the 12th century and their function for western expansion would be an example. The intent is to understand a component of the analytical dimension using the thematic dimension. The progression or
sequence-in-time approach to historic urban geography examines the change over time within or between urban areas. This approach may use several of the analytical components to investigate a specific urban area in order to understand what processes create a change in form or how structural changes manifest themselves in the urban area. The majority of urban geography, however, is concerned with the present or current time dimension. The intent is to know the current factors, situations, and results of contemporary urban society. Data and information are collected and analyzed with the purpose of strengthening the relevance of solving today’s city issues. Finally, the ability to project into the future through analytical and scenario-based computer programs allows urban geography to envision what may be the result of contemporary urban activities based on structural assumptions. The ability to model future urban areas may have great significance to world society because the United Nations has predicted that the proportion of the world population in urban areas will increase to 80% by 2050, totaling almost 7.4 billion people.

**Planning**

Urban areas are generally the result of the landscape’s characteristics, social and economic activities, and infrastructure of historic urban development. To meet the ever-expanding needs of the urban population, urban planners and
engineers incorporate modern design and technologies into this historic context. However, they do not work alone; multiple agencies work together to maintain existing facilities and services and identify, predict, and construct new facilities and expand services for the future population. Local and regional planners apply either reactionary or visionary planning tools and techniques to construct strategies, policies, and programs designed to address the identified issues and needs. The local planner generally works with citizens at the neighborhood or community level to identify problems and examine different policy options to solve both immediate and long-term problems. Citywide or regional planners address the broader issues, incorporating input from multiple areas of the city or its jurisdictions, with the same purpose of examining different strategy and policy options to solve these broad issues and meet the citizens’ needs. Urban planners examine the urban form, functions, processes, and structures that combine to create the urban area. The different scales of the problems are addressed by different levels of planning, local to regional, with coordinated and cooperative goals to assist in making the city a better place for living, working, and recreation.

Planning entails different approaches and techniques based on the scale of the project. Generally, urban plans will be comprehensive in their approach or will address a specific topic or urban area. The most common is the comprehensive plan that is constructed to identify the overall community vision and develop goals, objectives, and policies for specific topics, for example, environmental protection, land use, economic development, and so on, to lead the community in the direction of their choice. The plan then becomes a guiding document for decision makers because it has identified and prioritized those topics that the community believes are important. Policies and programs are then implemented to obtain the goals and objectives stated in the plan. Another type of plan is a more detailed analysis of a topic area, for example, environmental protection or neighborhood, and this type of plan establishes more specific sets of strategies, programs, and policies that will be implemented to reach the plan’s stated goals and objectives. Because they are more specific in either the topic or the scale of the plan, different techniques for obtaining data and information along with the analysis are employed by the planners to reflect the finer detail of the plan. Both types of plans, however, have the same purpose: to address the issues of the urban community and provide for the citizens’ health, safety, and welfare.

**Integration**

Urban geography and planning are not separate activities; they each rely on the results of the other to create a livable, sustainable urban environment. The incorporation of the different urban geography dimensions into the analysis of urban issues is part of the task of the planner, so that they can determine the most feasible strategies, programs, and policies to address the problems. In particular, geographic information systems (GIS) have been of particular usefulness to both activities because they are multidimensional and have the capability to predict future results or scenarios based on differing sets of assumptions. A GIS is designed to analyze georeferenced data at different spatial scales and the complexities of multivariate analysis. GIS have been used at the neighborhood level to organize and provide current information to community organizers for housing and employment problems. At the city level, a GIS is used daily for transportation routing, maintenance, and problem solving. Even at the global scale, GIS is assisting with issues of global warming and pollution control by monitoring environmental conditions and simultaneously evaluating alternative strategies to mitigate the impacts of the increasing urban population. Urban geography and planning provide the theory, applications, and policies that are needed to address the ever-expanding urban world.

*William J. Gribb*

See also GIS in Urban Planning; Public Participation GIS; Suburbs and Suburbanization; Urban and Regional Development; Urban and Regional Planning; Urban Environmental Studies; Urban Geography; Urban Hierarchy; Urbanization; Urban Land Use; Urban Policy; Urban Solid Waste Management; Urban Spatial Structure; Urban Sprawl; Urban Storm Water Management; Urban Sustainability; Zoning
Urban policy refers, broadly, to the numerous ways in which national or federal governments implement programs that affect the nature of cities, including modes and priorities of financing municipalities, strategic planning to stimulate urban economic growth, attempts to combat uneven regional development or encourage cooperation among local governments, control over negative externalities such as destruction of the natural environment, targeted subsidies for specific problems (e.g., homelessness), and political restrictions on the autonomy of the local state. As such, urban policy is closely related—but not identical—to urban and regional planning efforts. There is typically no single national urban policy, but aggregations of many different policies, some of which may work at cross-purposes, with varying effects over space and time. Because the capitalist city is not simply the product of market forces, but also of the state, urban policy plays a critically important role in shaping urban space and the quality of life within it.

Most “urban” policies are not specifically called urban; rather, they affect cities indirectly, such as when they address issues such as infrastructure, transportation, urban labor and housing markets, environmental problems (e.g., water supplies, air pollution), energy use and availability, and so forth. Policies aimed at specific economic sectors, such as protectionism for manufacturing firms, have uneven urban impacts; similarly, immigration controls differentially affect the supply of labor in urban space. Indeed, virtually all government policies have implicit, if not explicit, urban consequences, such as tax laws, land use controls, and anti-poverty programs.

Urban policy is both deeply political and geographical in nature. Far from being politically neutral, urban policies reflect the interests of multiple constituencies and stake-holders, including corporate interests, different social classes, various groups in civil society, and different factions within the state. Although urban policy often caters to hegemonic interests, it is important to view it as a contested arena in which different political interests and discourses jockey for influence. Additionally, because urban policy varies among and within countries, because it shapes urban space in different ways, urban policy is also profoundly spatial in nature.

This entry begins by noting variations in urban policy among countries; next, it briefly summarizes Keynesian urban policy that dominated in the early to mid 20th century; then, it focuses on neoliberalism and its impacts concerning how governments treated urban areas. Next, the entry discusses the implications of these trends for local planning efforts. It concludes with comments concerning urban policy in the developing world.

National Urban Policy Differences

Urban policies vary widely in time and among countries, depending on the global political and economic system, the structure and health of the national economy, their respective degrees of urbanization, national political dynamics (e.g., unitary vs. federal government structures), the relative degree of political autonomy enjoyed by local governments, modes of tax collection and disbursement of public moneys, national and local administrative priorities, the nature and severity of social problems, and popular historical and cultural climates that facilitate or inhibit government intervention.

Compared to Europe, Japan, or Canada, the political culture in the United States is markedly more favorably disposed to presumptions about the primacy and efficacy of the “free market” and exhibits a widespread mistrust of government
intervention. As a result, with most governance effectuated at the local level, urban policy in the United States has always been relatively anemic compared to European states. In the United States, the bulk of tax revenues are generated and most public services are provided at the state and local levels rather than the federal one, and the country lacks national planning systems regulating land use, population, or other policy measures. Thus, despite the importance of the federal government in financing many local measures, American urban policy tends to be relatively ineffectual. In Canada, Germany, and the United States, provincial, Länder, and state governments, respectively, play important policy roles, a dimension lacking in Britain and many European countries.

European urban policy, in contrast, is typified by significantly stronger national governments, stricter controls over local policy implementation and land use (e.g., historic preservation), and more widespread popular acceptance of such measures. In France, for example, a long tradition of a powerful national government has tended to resist many recent initiatives toward privatization and deregulation common in the United States or Britain. In contrast to the United States, where corporate interests tend to figure prominently in federal and local policies regarding urban space, European policy measures tend to leave more room for the interests of the working class and popular political will. Uneven development and attempts to alleviate it via regional development strategies have long been more important to European countries than in the United States. There are wide variations among European states: Germany, for example, retains a much stronger tradition of social democracy and centralized policy making than does Britain, which more closely resembles the United States in this regard. Sweden and Greece both lack explicit national urban policies; however, while Sweden allows almost complete local autonomy for its cities, such independence is almost nonexistent in Greece. However, recent initiatives of the European Union have fostered a gradual, if halting, policy convergence among countries.

In Japan, urban policy has long focused on attempting to encourage growth outside of the major metropolitan regions, in which the bulk of the nation’s population and productive capacity are concentrated. Traditional policy measures in Japan were exceptionally heavy handed, dictated by fiat from the national government to local ones with little opportunity for feedback. Recent economic stagnation and gradual population decline have forced a more relaxed departure from this rigid top-down system of governance. Lax regulatory controls are often widely perceived as diminishing the aesthetic quality of Japanese urban landscapes, and recent legislation has encouraged local governments to address this issue.

Keynesian Urban Policy

As the economies of many Western countries became focused on Fordist mass production in the late 19th and early 20th centuries, urban policy began to assume a focus on regulating growth and minimizing social inequalities that could prove to be disruptive. Although its origins may be traced back to the Progressive Era at the turn of the 20th century, Keynesian urban policy began to be implemented emphatically in the Western world during the Great Depression of the 1930s as a result of that crisis. In part, this set of initiatives included attempts to stimulate aggregate demand, particularly in sectors such as housing. For example, in the United States, the Federal Home Loan Bank was erected in 1932 to subsidize credit for mortgage providers. In 1934, the National Housing Act established the Federal Housing Administration, through which the federal government insured numerous mortgages. It also initiated the policy that allowed deductions of interest paid on mortgages from federal income tax, which subsidized the middle class, encouraged suburban expansion, and persists to this day. Public housing projects also emerged, eventually comprising 20% of the British housing stock but only 2% of that in the United States, where it was pioneered under the Public Works Administration but later passed to the U.S. Housing Authority. In Britain, local authority housing programs witnessed the construction of millions of working class housing units, a system extended by the Building Societies of the late 20th century. Other measures include national government attempts to assist fiscally distressed local governments, stimulation of employment, and massive infrastructure expenditures, all of which powerfully affected urban spaces and social life.
Keynesian urban policies in Western Europe, the United States, Canada, and elsewhere persisted well after World War II throughout the long post-war boom, although they assumed different forms in different countries. Many governments provided assistance to veterans in the purchase of houses, and their policies amplified a long-standing trend toward urban decentralization and sprawl. Their impacts were largely confined to combating poverty and unemployment, taming the effects of business cycles, mitigating social inequality, and controlling negative externalities (e.g., traffic congestion and environmental destruction).

Keynesian urban policy in the United States traditionally focused largely on the problems of inner cities, including the urban renewal programs of the 1950s, the Model Cities Program of the 1960s, and the Housing and Community Development Act of 1974, the centerpiece of urban policy under the Nixon administration. President Johnson’s Great Society programs, including the War on Poverty legislation, were largely concerned with the dire straights faced by the urban underclass, in part responding to the urban riots of the 1960s. In the 1950s and 1960s, under the guise of urban renewal, federal efforts were also aimed at enhancing the commercial viability of downtown areas (e.g., via highway on-ramps and off-ramps), often involving massive displacement of low-income minorities and the obliteration of their neighborhoods. The Urban Mass Transportation Act of 1964 provided federal funds to finance mass transit facilities, which favored low-income areas, and the 1968 Federal Housing Act increased the supply of low-income housing. Under the Carter Administration, the Comprehensive Employment and Training Act in 1978 offered cities fiscal aid, subsidies and public service employment programs and instigated the Urban Development Action Grant program to subsidize the rehabilitation of older industrial and commercial spaces. These programs were augmented by a host of other programs, including Targeted Job Tax Credits and community development block grants.

Neoliberal Urban Policy

Beginning in the United States and the United Kingdom in the 1980s, and subsequently expanding to encompass many other countries, urban policy underwent a pronounced turnabout with the hegemony of neoliberalism. Typically, this shift was characterized by widespread deregulation and privatization, and by the state’s withdrawal from the broad domain of social reproduction (i.e., government financing for public services, especially those aimed at the poor). National governments in many countries altered their funding priorities, eliminated many programs of their predecessors, initiated new ones in keeping with the ideological imperatives of the “free market,” and transformed the national policy matrix within which cities are governed.

The transition from national to global markets, and associated internationalization of economic linkages within many countries, made the viability of nationally based state welfarism increasingly questionable. Even in the bastions of state welfarism such as Scandinavia, where social programs have long been regarded as sacrosanct, neoliberalism has induced attempts to reduce social spending. With the neoliberal demise of the welfare state, urban policy in many countries became increasingly less concerned with the provision of social benefits to the poor and needy and more concerned with budget reductions in such expenditures.

In the United States under the Reagan administration, federal subsidies to localities for mass transit, education, water treatment, medical care, and public housing were sharply reduced. This assault on the welfare state had mixed results: While some domestic programs suffered sharp contractions, others, including social security, Medicaid, Medicare, food stamps, and Aid to Families with Dependent Children were sufficiently popular to escape relatively unscathed. Urban Development Action Grants, initiated by the Nixon administration in 1974 and earmarked for specific purposes, were folded into block grants. This shift in funding strategies gave local political authorities considerably more control over the allocation of federal funds during a period in which interurban competition rose sharply. To a considerable extent, block grants subsidized downtown developments without regulating them, contributing to the surge of gentrification in central city areas. Additionally, the “workfare” reforms of the Clinton administration in the 1990s,
which continued under the presidency of George W. Bush, removed tens of millions of people from the “welfare rolls” of public relief, a burden disproportionately felt by cities. Opposition to such measures was frequently labeled as “anti-growth,” and the costs of such projects in terms of residential displacement rarely entered into discourse about their contribution to a broadly inclusive “public good.” Post-Keynesian urban policy thus successively subordinated social needs to the prerequisites of real estate firms, bankers, the construction industry, and related interests.

Neoliberal urban policy also witnessed a sustained devolution of powers from national to local governments. In the United States, this took the form of Reagan’s New Federalism, which shifted financing for many programs to the states. In the U.K., the collapse of Keynesian policy was apparent in the ascendency of Thatcherism, which centralized many responsibilities formerly controlled by the local state (including the abolition of the Greater London Council in 1985), in contrast to the devolution of governance underway in the United States. However, the U.K.’s City Challenge program spurred competition among the states. Similarly, the Major City Policy in the Netherlands was designed to stimulate local urban economic rejuvenation.

Perhaps the most geographically obvious neoliberal strategy that combined elements of deregulation, privatization, and public-private partnerships was the Enterprise Zone. Originally proposed as a means of unleashing market forces in distressed inner cities through the simple removal of government controls, enterprise zones soon evolved into more complex attempts to generate private investment through active public subsidies (income and capital gains tax breaks, depreciation allowances, labor training programs) in selected urban areas. Enterprise zones, first implemented in the U.K. in 1981, began as an experiment to give inner cities tax relief and freedom from planning restrictions. The British government also created Urban Development Corporations to stimulate property investment, map land uses, and make sites available to developers; in the United States, these assumed the form of Urban Redevelopment Authorities.

A central neoliberal tool in urban policy has been the institution of public-private partnerships. Advocates of this strategy justify it on the grounds that it illustrates an unproblematic mutual interest between the two sectors: Involvement by the public sector allows for supervision and oversight of projects in which private developers would otherwise enjoy autonomy. Public promotion and facilitation of private development are assumed to produce a general public benefit, that is, positive externalities that include improving a city’s economic base and raising real estate values, thereby generating additional tax revenues that in turn permit greater resources for social redistribution. Moreover, the long-term gains outweigh the ostensibly short-term public subsidies deployed. Corporate interests are attracted to cities that deploy powers of eminent domain, assemble and package land parcels, erect new infrastructures, and offer various subsidies. Private interests are held to contribute expertise, experience, financial resources, and technological and managerial efficiency frequently inaccessible to those in the public domain. The involvement of the public sector in such ventures often allow private interests to claim that they have made contributions to civic welfare. The opportunity costs of government spending on such ventures were rarely acknowledged, including funding that might otherwise have been extended to distressed urban areas.

It should be noted that neoliberal urban policy was not implemented to the same extent everywhere. In Japan, for example, privatization and reductions in social expenditures were considerably less prevalent than in the United States or Western Europe. In France and Southern Europe, too, neoliberal urban policies found much less purchase than in other parts of the continent. Finally, neoliberal urban policy was influential in the rise of world cities, large metropolitan areas that play powerful roles in the global economy. As national regulations were portrayed as inhibiting competitiveness in a worldwide market, deregulation tended to accelerate the explosive rise of financial and producer services in cities such as London, New York, Los Angeles, Tokyo, Toronto, and, increasingly, Singapore and Shanghai. The health of many such centers has become increasingly more linked to the global economy than to their national ones, rendering them problematic from the point of view of national urban policy makers.
Local Urban Policy Under Neoliberalism

At the local level, the transition to neoliberalism induced a switch from “managerial” to “entrepreneurial” planning, in which local authorities became increasingly preoccupied with attracting capital and generating economic growth at the expense of long-standing priorities such as social equality, protection of the poor and socially marginalized, and environmental protection. In many countries, bereft public authorities became susceptible to the aggressive overtures of private capital, raising the political leverage of investors over local public authorities. Frequently, interurban and interregional competition sharply accelerated, forcing public authorities to partake in zero-sum auctions to woo increasingly footloose capital. Typically, older industrial cities suffered while service-based urban areas flourished. Levels of inequality rose accordingly. The broad shift in the priorities of local governments led them to become less concerned with issues of social redistribution, compensation for negative externalities, provision of public services, and environmental management and more absorbed with questions of economic competitiveness, attracting investment capital, and the production of a favorable “business climate.” Long-term capital budgeting, master planning, and infrastructure investments have given way to short-term concerns of job generation, looser regulations, and tax relief. Planning is hence concerned more with promoting economic development and less with regulating its aftermath. In the United States, a common result was widespread commercial sprawl, often in the form of ugly strip malls, in which public land use controls are so relaxed as to be negligible.

In this context, neighborhoods assume importance either through their economic significance or through political power. Frequently, planning resources are allocated toward economically influential areas (e.g., the central business district) or politically powerful neighborhoods (including suburbs and gated communities), but not toward the ghettos populated by the urban underclass that command little attention from urban policy makers. In this way, urban policy reproduces and deepens difficulties endured by the poor, ethnic minorities, and the politically disenfranchised. Therefore, despite neoliberal rhetoric about how consumer sovereignty depoliticizes urban development, it has in fact politicized planning to an unprecedented degree.

Urban Policy in the Developing World

Societies, governments, and cities in that vast swath of the planet commonly known as the developing world generally face circumstances that differ substantially from those in the economically advanced countries, and hence urban policies differ accordingly. Levels of urbanization range markedly among developing countries, ranging from the minuscule (e.g., much of sub-Saharan Africa) to predominantly urbanized (as in much of Latin America). Rapid demographic growth, rural-to-urban migration, housing shortages, inadequate public services, and widespread poverty tend to be the norm, although the severity and frequency of such problems vary enormously. Moreover, depending on the country, urban policy initiatives may be hampered by lack of adequate funding mechanisms, foreign interference, widespread corruption, shortages of human capital, or inadequate effective leadership. Some developing countries face political divisions, including ethnic conflicts, or widespread distrust of the state based on long histories of oppression, as in post-apartheid South Africa, that hamper effective urban policy implementation. Finally, in countries in which military expenditures have the highest priority, urban policy may fall well behind in terms of planning efforts and implementation.

Many developing countries feature urban hierarchies characterized by primate cities (e.g., Mexico City, Seoul, Buenos Aires, Lagos), in which both public and private investments, and hence employment opportunities, are overconcentrated within a single megacity. (Notably, France also faces this issue.) Urban policies in such a context may attempt to decentralize some government functions to smaller cities (e.g., in Argentina), although such efforts are typically met with stiff resistance.

In many developing countries, housing shortages and problems of accessibility to clean water and air are important obstacles to development.
Because more people rely upon public transportation and public medical and educational services in the developing world than in economically developed ones, much urban policy is concerned with the provision of such services. In countries with rapid growth in population and/or incomes, rising numbers of automobiles can lead to severe traffic congestion, often a centerpiece of urban policy initiatives. Thus, urban sustainability is often a priority in urban policy measures, although its successful achievement via policy initiatives is questionable.

Rapid rural-to-urban migration, and the consequent swelling of urban shantytowns and squatter settlements, present formidable challenges to the provision of public services and control of crime. In such cases, urban and rural policies are inextricably intertwined. Many governments have attempted to meet such challenges by encouraging rural development, including infrastructure development, as a means of reducing the influx to urban areas; others respond with forcible destruction of such communities. Some governments in the developing world enforce price limitations on essential foodstuffs, a policy that critics hold discourages local farmers but reduces the reproduction costs of urban labor, particularly for transnational corporations.

To some extent, Western neoliberal urban policy initiatives have been replicated in the developing world. In China, for example, most urban areas now enjoy greater autonomy in decision making and revenue collection than they did in the past. Structural adjustment programs implemented by the International Monetary Fund may also limit national or municipal authorities’ ability to assist low-income populations, as with subsidies for mass transit.

Barney Warf

See also Growth Machine; Growth Poles; Housing and Housing Markets; Housing Policy; Infrastructure; Neoliberalism; New Urbanism; Public Housing; Public Policy, Geography of; Regional Governance; Regulation Theory; Rural-Urban Migration; Squatter Settlements; Urban and Regional Development; Urban and Regional Planning; Urban Geography; Urban Hierarchy; Urbanization; Urban Land Use; Urban Planning and Geography; Urban Spatial Structure; Urban Sprawl; Urban Underclass; Urban Water Supply; World Cities; Zoning

Further Readings


Urban solid waste refers to industrial, commercial, institutional (collectively known as ICI waste), residential, and construction/demolition waste generated in urban areas. Current waste management practices emphasize approaches such as recycling that attempt to divert waste from landfills as much as possible. This is a significant reversal from practices that existed during most of the 20th century, when the main role of the waste management professional was to collect and dispose of waste as efficiently as possible by burning or burying it. Waste diversion has been increasing at a steady pace since the mid 1980s, when governments in most industrialized countries responded to landfill shortages and growing environmental concerns about excessive waste production by introducing municipal recycling programs.

Another significant change in urban waste management since the late 20th century is that it is no longer just a local issue. Because of economies of scale at large waste management facilities, the consolidation of private sector waste management companies, and the lack of local facility capacity, waste disposal and treatment can occur hundreds of miles from the point of generation and even in adjacent countries. Recyclables, particularly waste electrical and electronic equipment (WEEE) and recyclables found in the residues from mechanized material recovery facilities, can be shipped even further for processing. These may end up in lower-income countries, where the labor-intensive separation of different types of recyclables from one another, the removal of contaminants, and the breakdown of recyclable items into their component parts are considerably less expensive but often more environmentally hazardous than in industrialized countries. This entry discusses the waste hierarchy, waste generation, and composition; integrated waste management; the informal sector composed of self-employed individuals who participate in waste collection, separation, and recycling; urban waste management facility siting; and policy tools.

Although recycling is probably the most common waste diversion technique in use today, nearly all urban waste management policies subscribe to the waste management hierarchy, of which recycling is only one element. The ordering of elements in the hierarchy is seen as problematic by some, but most governments have adopted the following ranking, in order of environmental performance from best to worst: (a) waste prevention activities (also referred to as source reduction or waste minimization) that reduce the mass, volume, or toxicity of a product or material at source; (b) reuse; (c) recycling and biological treatment; (d) thermal treatment (typically with energy recovery); and (e) disposal. Despite the enormous effort being put into diversion of wastes by governments, a disappointing aspect of current urban waste management practice is the lack of attention paid to the root cause of waste production, namely, consumption.

### Waste Generation and Composition

Within the broader category of urban waste, waste generated by households, municipal governments, and small commercial and retail generators is known as municipal solid waste. Municipal waste excludes industrial waste—waste generated by large commercial and retail generators and construction and demolition wastes—because these categories are usually managed by the generators rather than by municipalities. Much of the data on waste generation in various countries or cities refer to municipal waste because these data are publicly available and well tracked by municipal governments. However, the data may sometimes include ICI waste, so caution should be taken when comparing data across jurisdictions.

The amount of urban waste generated per capita varies considerably around the world. Because of their wealth, industrialized countries produce considerably more urban waste than lower-income countries, generally on the order of two to three times as much per capita. About one third of the urban waste from higher-income countries is paper, one third is organic, and the remainder consists of plastics, metals, glass, wood, rubber, leather, textiles, and miscellaneous materials. In lower-income countries, a much larger portion of the waste stream is organic, typically from half to three quarters, while paper and plastic waste
constitute 5% to 15%. Lower-income countries have a higher percentage of organic waste because residents consume fewer processed foods (much of the organic waste is produced at the point of processing rather than in the home) and have fewer sources of other types of waste, such as packaging and wastepaper from offices. Inert materials, such as ash residues from cooking fuels, can make up a large portion of the urban waste stream in countries where householders lack access to reliable electricity or natural gas distribution networks and rely on coal briquettes for cooking and heating.

The Waste Hierarchy and Integrated Waste Management

Understanding the composition of urban waste is the first step in managing that waste. A waste stream that is high in organics means that biological treatment, such as composting, should be an essential component of waste management. The energy content of the waste stream is also important in determining waste management approaches. Paper and plastics, for example, have high calorific values, while organics, which are high in moisture, have low calorific values. Burning waste to recover energy is not an effective management technique for lower-income countries, where the waste stream has a large percentage of organics.

One way to assess the environmental impacts of alternative waste management options is through life cycle analysis (LCA). LCA enumerates the energy, water, and material inputs and the outputs of airborne emissions, water effluents, and solid wastes at each stage of a waste material or waste product’s life cycle, from the “cradle” to the “grave.” The cradle in LCAs of waste management systems is typically the point at which municipal solid waste is set out for collection, and the grave is disposal in a landfill. Recycling, biological treatment, and thermal treatment occur in between. LCA studies confirm that recycling is better for the environment overall than incineration with energy recovery, and that incineration with energy recovery is better than landfilling. These results are generally consistent across all types of materials. In other words, LCA tends to confirm that the waste management hierarchy is valid in terms of environmental performance, at least in industrialized countries, where most of these studies have been conducted. The one exception is plastics, which a few studies have shown to have higher acidification effects and energy use when they are recycled rather than burned. Another cautionary note in the use of the waste management hierarchy is that it does not consider the social or financial impacts of each option. For example, although incineration with energy recovery may be better for the environment than landfilling, it may also be far more costly and therefore unattractive to municipal governments. An approach known as integrated waste management (IWM) has emerged to address this problem. IWM recognizes the interrelationship of environmental, economic, and social factors in designing waste management systems. It also recognizes that the best system for one location may differ from that in other locations because of geographic variations in, for example, the composition of waste, the availability of markets for recyclables, and the availability of suitable sites for waste management facilities.

The Informal Sector

Almost all countries, regardless of their level of income, have what is called the “informal” waste sector, where waste is collected, separated, recycled, and sometimes reused by self-employed individuals. The sector is unregulated, and individuals do not report their incomes for taxation purposes. Cities in lower-income countries have no formal municipal recycling programs, yet many of these cities divert just as much or more waste from landfills as cities in the industrialized North because of the informal sector. The value of recyclables in the waste stream relative to incomes is much higher in lower-income countries than in the industrialized ones. Householders and other waste generators receive payments at depots or from itinerant buyers, who go from door to door collecting the most valuable recyclable and reusable items. Waste pickers on the street and at open dumps or landfills sort through valuable items remaining in the waste stream. Many people in the informal sector are rural migrants, and most start collecting recyclables because it provides a source of income with few barriers to
entry. Even so, the job is hazardous. Those who pick through waste for recyclables at dumps and on the streets risk exposure to broken glass, pathogens, dust, and other pollutants. It is also a stigmatized profession, whose workers are regularly harassed by police and the public. The informal recycling sector is present in industrialized countries as well. Although much smaller in size, it plays an important role in recycling beverage containers (where deposits exist), scrap metal, and sometimes paper—all collected by picking through garbage and recycling bins or bags. Reuse that occurs at yard sales and car boot (trunk) sales and flea markets are also examples of waste diversion through the informal sector.

In the industrialized world, almost all waste generators receive collection services, but in developing countries, cities often don’t have the financial resources to provide collection services, leaving anywhere from 25% to 50% of the city without service. In the absence of municipal collection services, residents burn their waste, bury it, dispose of it in lakes and streams, or leave it in open dumps. Some communities have responded to this problem by creating community-based collection programs, frequently with the assistance of nongovernmental groups. Community organizers gather fees from residents and pay informal workers to collect waste and deliver it to a centralized municipal collection point.

### Urban Waste Management Facilities

The infrastructure for managing waste includes a range of facilities, from landfills to incineration or energy-from-waste facilities, to biological treatment facilities (for composting and bio-gasification) and transfer stations (where waste is compacted for long-haul transport). Opposition to the siting of waste management facilities is widespread. Some refer to this opposition as NIMBYism (not in my backyard), a contested term that implies that opposition is about self-interest rather than real concerns. Opponents cite many concerns, including odors, groundwater pollution, air pollution, noise, traffic, dust, and property value impacts. Opposition is present not only in industrialized countries. There are many examples of civil disobedience against the siting and operation of disposal facilities in lower-income countries, where weak environmental regulations and lax enforcement can produce severe pollution problems.

### Policy Tools

A wide array of policy tools is being used to divert waste from landfills. They include regulatory instruments, such as landfill bans on recyclable materials; economic instruments, such as landfill taxes; and voluntary instruments, such as agreements by industry to minimize production wastes. One of the most effective policy tools for encouraging waste diversion in the residential sector is a collection, or user fee. Under a user fee scheme, householders pay for collection of their waste by weight, or more commonly by volume, rather than paying a flat fee or hidden fee in general taxes. Householders can reduce their fees by recycling more, by using home composters, and by purchasing products with less packaging or more durability.

Another increasingly popular policy tool for waste management in industrialized countries is extended producer responsibility (EPR). EPR places partial or full responsibility for the postconsumer stage of a product’s life cycle on the producer of that product. A basic principle of EPR is to shift the burden of paying for waste management costs from municipalities and the general taxpayer to the producers and consumers of particular products. Europe has been a leader in EPR, starting with Germany’s 1991 packaging ordinance, in which producers were required to take back and either recycle or recover energy from specified percentages of postconsumer packaging. In 1994, the European Union’s Packaging and Packaging Waste Directive introduced targets for the recovery, recycling, and heavy metal content of packaging waste and stimulated a wave of EPR packaging policies among its member countries. WEEE, waste batteries, and end-of-life vehicles are also subject to EPR policy in the European Union. By placing responsibility for postconsumer products and materials on the producer, EPR is meant to encourage producers to make design changes to their products that will reduce waste management costs. Such changes could include making a product easier to recycle or reuse, reducing packaging, and a variety of similar changes collectively known as design for environment (DfE). Although EPR
has been successful in transferring waste management costs to producers, it has not been as successful in encouraging DfE. There are many reasons for this lack of success, prime among them being that many EPR policies allow producers to meet diversion targets collectively, for the industry as a whole, rather than ensuring that individual producers meet waste diversion targets for their own products. Future generations of EPR policy may be more effective in achieving the DfE goal and at reducing waste at source.

Virginia W. Maclaren

See also Consumption, Geographies of; Informal Economy; Not in My Backyard (NIMBY); Recycling of Municipal Solid Waste; Waste Incineration

Further Readings


Urban Spatial Structure

In economically advanced, postindustrial countries such as the United States, the proportion of people living in towns, cities, and metropolitan areas reached 75% or more by the late 20th century in developed countries. In the world as a whole, the proportion of urban population rose from less than 5% in 1800 to slightly more than 50% of a much larger aggregate world population by the early 21st century. Numerically, world urban residents expanded from perhaps 30 million in 1800 to about 3 billion in 2000. Matters of urban spatial structure, which pertain to the geographical patterns and characteristics of urban places, thus concern a very large and expanding share of the world’s people. This entry examines the factors that influence urban spatial structure and how they contributed to growth in urbanization in the United States. It then discusses the ways in which geographers have conceptualized urban spatial structure through the concentric zone, sector, and multiple-nuclei models and also considers the limitations of these models. The entry concludes with a look at how urban spatial structure may evolve in the future.

One major facet of urban spatial structure involves the overall geographical patterns of urban settlements at regional, national, and global scales, especially in terms of the sizes and locations of towns, cities, and metropolitan areas. Another major facet involves the internal spatial arrangements of activities and land uses within urban settlements. Indeed, one of the most common analytical distinctions made in urban geography reflects a division according to geographical scale into matters that involve, first, “interurban” features of “systems of cities” for cartographically smaller map scales, at which towns, cities, or metropolitan areas are most reasonably represented using point symbols, and, second, “intra-urban” characteristics of city systems for cartographically larger map scales, at which the internal features of towns, cities, or metropolitan areas are most reasonably represented using line or area symbols. In between these are intermediate geographical scales, at which urban land use and activity patterns can be examined for metropolitan regions, which are conventionally subdivided into central city, suburban, and fringe subareas.

Patterns of Interurban Spatial Structure

Economic and environmental considerations usually predominate when one tries to understand the spatial structure of an overall interurban system of cities.

Economic Functions

While differences in the social, cultural, political, or demographic characteristics of cities create
An enormous diversity of urban lifestyles, it is the differences in their economic functions that largely account for geographical variations in their rates of economic growth and levels of economic well-being. Some cities are mainly mining centers, known for their mineral, petroleum, or natural gas industries. Others are mainly manufacturing centers, known for the production of nondurable goods, such as chemicals, textiles, or food products, or durable goods, such as electronic or transportation equipment. Most cities perform trade or service functions, which include the collection and wholesaling of agricultural products, warehousing, retail trade, and the provision of diverse educational, medical, governmental, and other services. Industrial location theory, central place theory, and regional growth theory all help improve understanding of how cities with different economic bases function within a larger system of cities. Cities mainly specialized in goods production or handling have generally grown more slowly than cities mainly specialized in services, especially consumer or producer services. Indeed, at the very top of the world urban system are “global” or “world” cities, such as New York, London, and Tokyo, which owe their elevated status and success to the provision of a wide range of financial and producer services. Major transnational corporations generally have their headquarters located in world cities, even though their production facilities are often dispersed among many smaller urban and rural settlements.

**Environmental Settings**

Even in the modern postindustrial era, the environmental settings of cities remain important. For example, many of the largest cities in the Eastern United States are located along or near a seacoast or lake front, including New York, Chicago, Philadelphia, Washington, and Miami (Figure 1). Other major cities can be found along interior waterways, such as Minneapolis, St. Louis, New Orleans, and Pittsburgh, which originated and continue to function as Mississippi or Ohio River ports. The surrounding fertile agricultural lands, as in the Corn Belt or Great Plains; the nearby deposits of minerals or fossil fuels, including iron ore, coal, oil, or natural gas; or adjacent forest or mountain amenities are of importance to cities.

**Figure 1** Population sizes of Eastern U.S. cities, 2000. The intra-urban morphology of cities is closely bound up with the evolving interurban system of cities.

*Source: Author.*
such as Kansas City, Dallas–Fort Worth, Birmingham, or Houston. Changes in technology and in consumer tastes create continual reassessments of natural resources, causing some cities to experience booms while others lag behind. More leisure time has made amenity-rich locations especially attractive in recent years.

Patterns of Intra-Urban Spatial Structure

While economics and environment usually feature prominently in geographical discussions of systems of cities, much more varied terminologies can be encountered in geographical discourses focused at the intra-urban city system scale of daily urban experience. At this scale, an urban or metropolitan settlement represents the geographical context in which most people live and work. Refined land use specialization usually is regarded as one of the defining characteristics of urban existence in a postindustrial society, such as that of the United States. Nearly two thirds of Americans now live in owner-occupied, single-family detached homes, which increasingly are located in suburban settings. Most other Americans live at higher residential densities in duplexes, apartments, or high-rise condominiums, which mainly are located in inner-city settings. Less than 7% of Americans lived outside the “core-based” Metropolitan or Micropolitan Statistical Areas in 2006, and less than 5% lived on farms or ranches in rural settings.

The Emergence of Urbanization in the United States

In any thoughtful consideration of the spatial structure of urban settlement, it is worth keeping in mind that barely two centuries ago, at the time of the first U.S. Census in 1790, about 95% of Americans lived on farms, and the largest city, New York, had a resident population of only about 49,000 people. In comparison, in 2006, there were 363 urban settlements in the United States, which exceeded the 50,000 population threshold for Metropolitan Statistical Area status, and the New York Consolidated Metropolitan Statistical Area alone contained an estimated population of more than 18.8 million people. These enormous changes in urban demography have been paralleled by equally impressive changes in urban transportation, communications, and construction technologies, which make it possible to move people, goods, and ideas much faster and higher in the modern, machine-powered city than was possible in the earlier, muscle-powered city. The 19th-century city was transformed by electric trams, commuter railroads, landline telephones, and electrically powered elevators just as much as the 20th-century city was transformed by private automobiles, television, wireless cell phones, and high-speed Internet connections. In New York City, in 1790, virtually everyone had to walk to school, workplace, or shop; in New York City, in 2006, there were so many transport choices among so many modes of surface or subway and steel-wheeled or rubber-tired conveyances that some residents regarded walking as a recreational exercise.

Most modern urban geography texts devote at least two thirds of their contents to matters that involve intra-urban spatial structure. When urban geography first supplanted rural settlement geography as a realm of excitedly expanding geographical discourse about the middle of the 20th century, the split between interurban and intra-urban topics was usually about even. But intra-urban topics now predominate to such an extent that their page coverage in a typical urban geography textbook echoes the proportion of the U.S. population that lives in metropolitan areas with populations of 1 million or more, a proportion that noncoincidentally is about 60%. When Metropolitan Statistical Areas of all population sizes are considered, it is found that their areal extent spans about 20% of the total U.S. land area, although Urbanized Areas, which comprise the more densely populated built-up portions of urban clusters, cover only about 5% of all U.S. land.

Models of Intra-Urban Spatial Structure

The question of whether broad geographical generalizations can legitimately be drawn about the myriad, complex, and subtle urban spatial structures to be found within these urban settings is generating tension between urban geographers who tend to view the city from a positivist,
model-building perspective and those who tend to view the city from a softer and more nuanced, postmodern perspective. These poles can be represented, on the one hand, by computer-based quantitative factorial ecologies that mathematica-

cally summarize vast arrays of hard areal statistics and, on the other hand, by eloquent and sometimes adamant descriptions of “street-level participant observations” made in inner-city set-
ing. In between these two perspectives, there are perhaps some commonalities of view among interested urban geographers regarding at least some of the basic features of intra-urban spatial structure.

Virtually every recent urban geography textbook includes a section dealing with the “three classic models” of urban spatial structure (Figure 2). In a way, these three classic intra-

urban models are rather like the three “essential” filters that an aspiring photographer should have handy to photograph through atmospheric haze (haze filter), to avoid reflections (polarizing fil-

ter), or to focus on small subjects (close-up filter). These simplified abstractions scarcely guarantee a “perfect picture” of the city, but they can direct attention to revealing and worthwhile vistas.

Concentric Zone Model

The concentric zone model can be thought of as presenting a view that enables a city or metropolitan area to be visualized as if from a high altitude. Google Earth is a handy Web-based source for high-altitude views of most cities in the United States, as well as elsewhere. Details merge into very broad patterns if a city is viewed from high above, but a dominant geographical core central business district (CBD) usually can be identified by finding the tallest buildings and by observing the convergence of major transportation lines. Dense workday populations, traffic congestion, and high land values also usually characterize the CBD. According to urban “bid rent” theory, commercial or institutional activities are more likely to be able to profit from and hence pay for scarce and expensive sites near a city’s Peak Land Value Intersection. Commercial and institutional activities therefore tend to dominate within the CBD. Outward from the CBD, competition for space among activities with differing capacities to profit from accessibility leads to an overall pattern of concentric zones. As distance from the CBD increases, this pattern can be physically manifested by lower building height and perhaps larger lot size, demographically manifested by lower popu-

lation density and perhaps by different population characteristics in terms of age structure or ethnic composition, and economically manifested by lower land value. With notable exceptions such as New York’s Central Park or Boston’s Common, there usually is very limited green space in most CBDs, but open land becomes more common and finally predominates as the urban periphery is reached.

According to the concentric zone model, most famously articulated by the urban ecologist Ernest W. Burgess for Chicago in the mid 1920s, the CBD is usually surrounded by a zone in transition, within which anticipated land use change discourages maintenance, leading to physically decaying structures occupied by wholesaling or light manufacturing activities unable to afford the high rents of the CBD, followed in succession by “lower-status,” “medium-status,” and finally “higher-status” residential zones. In Burgess’s era, only members of the wealthy elite could afford large peripheral estates and indulge in fashionable midmorning work trips on a comfortable commuter railway line. Economic necessity forced everyone else to live closer to their place of work and to travel by crowded public buses, trolleys, and subway or elevated trains.

Sector Model

The sector model can be thought of as present-

ing a view that allows pronounced directional biases to be detected in urban spatial patterns. The dominance of the CBD remains apparent, but distance decay effects are no longer so uniform as to create perfectly symmetrical zones in any direction outward from the CBD. Instead, transport corridors, water fronts, historical attachments, and other directionally biased influences lead to radial variations in land values, land uses, and neighborhood characteristics in different directions outward from the CBD. Homer Hoyt’s Depres-

sion era research on residential patterns in many American cities showed that appealingly com-

fortable and highly valued residential properties
often dominate along high-status corridors from near city centers outward, as northward from the Loop along Lakeshore Drive in Chicago or north-westward from Capitol Hill toward Georgetown and beyond to Chevy Chase and Bethesda in the Washington, D.C., metropolitan area. Although Hoyt’s generalizations were asserted during the heyday of the streetcar, many continued to be applicable during the late-20th-century freeway automobile era, though at a much expanded...
geographical scale. In the greater Washington, D.C., metropolitan area, for example, the fashionable Northwestern Corridor now extends much further outward along Interstate 270, beyond Rockville toward Frederick, Maryland.

**Multiple-Nuclei Model**

The multiple-nuclei model can be thought of as presenting a view that reveals distinctive and usually rather homogeneous districts of many varieties. On the commercial side, financial districts group banks, stock brokerage firms, and related services near one another; entertainment districts are formed by geographical clusters of theaters, restaurants, and perhaps sports arenas; automobile districts cluster new and used car dealerships and automobile repair shops; warehouse and light manufacturing districts feature clusters of often functionally linked production facilities; airport districts cluster around airfields; port districts line waterfronts; and so on. On the residential side, there are high-rent clusters of luxury townhouses and high-rise condominiums; “zones of dependence,” with geographical concentrations of decaying multifamily private and perhaps public housing units; and so on. On the institutional side, college or university districts cluster academic classroom and research facilities near student housing and college-oriented businesses such as bookstores and bars; medical districts group nearby general and specialty hospitals and physicians’ offices; and so on. As a rule, districts tend to be larger, more highly specialized, and more distinctive in larger metropolitan areas and less distinctive in smaller cities and towns, though a tendency to geographically cluster similar or functionally linked land uses exists throughout the urban hierarchy, as evidenced, for example, by the clusters of feed, fertilizer, and farm equipment suppliers in small rural service communities in the Midwest.

**Diversity, Spatial Specialization, and Urban Futures**

Three final points about urban spatial structure remain.

First, towns, cities, and metropolitan areas are extraordinarily diverse in their geographical patterns, especially when considered at local or neighborhood scales. In any urban settlement, if one were to walk down a street, ride a bus, or look out from an upper-story window, he or she is likely to see a colorful variety of people, land uses, and activities. The three simple classic models described here, and even their more complex and sophisticated counterparts, are abstractions that may generalize but cannot entirely capture the on-the-ground character of a real city.

Second, spatial specialization at an urban or metropolitan scale can have Janus-like implications. Janus, the Roman god of doors, gates, and beginnings, is represented artistically with two opposite faces. On the one side, spatial segregation of people and activities can increase well-being by giving urban residents utility-maximizing choices of geographical settings that most appeal to them, in terms of architectures, public services, shops, neighbors, lifestyles, and so on. But on the other side, service needs and the fiscal capacities to meet these needs can become severely geographically mismatched. This problem is especially conspicuous in larger and older metropolitan settings, where the richer suburban municipalities are politically, administratively, and legally quite separate from the seriously underbounded central cities. In such settings, gated communities quite literally wall service demands out and fiscal resources in.

Third, urban spatial structure is very dynamic through time. The degree of dynamism is especially conspicuous in North America, where small towns grew into giant metropolises in a historical blink of an eye. But in the early-21st-century period of steeply rising energy costs, the future of urban spatial structure seems uncertain. The second half of the 20th century witnessed rural-to-urban land conversion at a prodigious rate, as expanding freeway systems pushed further and further outward from city centers. But expensive gasoline is likely to diminish the appeal of distant suburban commuter zones, affecting building trends and home values throughout the metropolitan regions. Big sedans and SUVs (sport-utility vehicles) with gas-guzzling engines are beginning to filter down through the used car market to congest the parking lots of inner-city public housing projects. Pedestrian-friendly New Urbanism developments are likely to become increasingly fashionable. Privately planned New
Urbanism communities feature mixed land uses, narrow residential lots, and small-town-like neighborhoods with schools, churches, shops, or offices within easy walking distance of homes. Imagine a gaslight-illuminated Victorian-era streetcar suburb but with a small, fuel-stingy hybrid gas-electric car parked in front of each bungalow, and one just might be looking back into the North American urban future.

J. Clark Archer

See also Built Environment; Central Business District; Central Place Theory; Chicago School; Gated Community; Gentrification; GIS in Urban Planning; Housing and Housing Markets; Hoyt, Homer; Los Angeles School; New Urbanism; Public Housing; Rural-Urban Migration; Segregation and Geography; Smart Growth; Suburban Land Use; Suburbs and Suburbanization; United States Census Bureau; Urban and Regional Development; Urban and Regional Planning; Urban Ecology; Urban Environmental Studies; Urban Geography; Urban Hierarchy; Urbanization; Urban Land Use; Urban Planning and Geography; Urban Policy; Urban Sprawl; Urban Sustainability; Urban Underclass; World Cities; Zoning

Further Readings


The term urban sprawl should be understood in the context of a deep-seated and ongoing conflict over differing visions of and priorities for the development of urban regions, between those who see contemporary suburban land development patterns as a good thing and those who see them as a major social and environmental problem. The meaning and image of urban sprawl are contested and are thus continually evolving, but most discussions of urban sprawl identify a number of common characteristics, including low-density residential development on the urban fringe, segregated land uses that give rise to long-distance travel and dependence on automobiles for mobility, and leapfrogging of development over undeveloped areas.

Although critiques of urban sprawl have become increasingly prominent during the past three decades, concern about patterns of urban expansion was a major issue for planning advocates in Western Europe and North America in the early 20th century. Their argument was that planned suburban growth offered a chance to prevent the problems of overcrowding, disease, pollution, and congestion that plagued 19th-century industrial cities and that unplanned urbanization would merely produce more of the same. A major goal of the early planners was therefore to be able to regulate and plan for development on the fringe, to ensure that housing areas were separated from industry; road patterns were well designed; water, sewer, and public transit facilities were built; and parks and natural areas set aside. Although most developed countries had enacted some elements of city planning legislation before World War II, powers were limited, and most development continued to be unplanned.

After the war, increased city-planning powers, rapid economic growth, and a spurt in house building led to the development of expansive new suburban areas with single-family, detached homes. Zoning regulations designed to avoid the problem of mixed housing and industrial areas encouraged the creation of purely residential developments, while the mobility offered by widespread automobile use meant that land was cheap
and housing could be built for all classes at relatively low densities. Early in this postwar residential boom, the term urban sprawl was coined to describe the new patterns of suburban residential development. Early critiques were in part aesthetic, as observers reacted with shock to the enormous scale of the transformation of rural landscapes into homogeneous tracts of single-family homes that were widely seen as ugly.

Over time, however, as the scale of suburbanization accelerated, with ever-larger and more dispersed patterns of development during the past 50 years, the critiques of urban sprawl became more sophisticated and were supported by a growing range of actors. These include many municipal governments and planners, who must deal with the high infrastructure costs of low-density and leapfrog development patterns that leave tracts of land undeveloped; environmentalists, who show that sprawl consumes far more land than necessary and threatens wildlife because scattered development leads to habitat fragmentation; transport planners, who see low-density, segregated land uses as the major cause of traffic congestion even with high levels of investment in roads, because virtually every trip must be made by car; health advocates, who argue that automobile-dependent suburbs contribute to ill health and obesity by making walking and bicycling difficult; those concerned with social equity, who see the high levels of racial and economic segregation of American society as in large part a product of the white flight to affluent suburbs, which left the poor and racialized minorities to reside in the crumbling inner cities; and those concerned with global warming and environmental sustainability, who see automobile-dependent suburbs as unnecessarily wasteful of fossil fuels.

Aerial view of San Jose, California. The intersection of Interstate 280 and California State Route 87 (Guadalupe Parkway) is visible at the bottom of the photograph.

Although some observers dismiss critics of sprawl as elites who merely wish to impose their own aesthetic preferences on the rest of the population, there do appear to be substantive reasons to question the long-term viability of contemporary patterns of extensive suburban growth. And although all developed countries have struggled with the implications of the mobility offered by widespread car ownership, similar conflicts over suburban development played out quite differently in different countries. For example, many Northern European nations have created relatively powerful public controls over suburban development and design, while among the developed countries, the United States and Japan have taken the opposite approach with much weaker regulation and greater freedom for private property developers.

Critiques of sprawl have led to the elaboration of at least three main programs for a different pattern of urban development: (1) new urbanism, (2) smart growth, and (3) sustainable cities, each of which are premised on the idea that sprawl is a major urban problem and that alternative and more compact urban forms should be a major policy priority. It has not proven easy, however, to stop the growth of sprawl, because existing development patterns have a great deal of momentum and are strongly supported by those with vested interests in continued development, such as urban fringe landowners, developers, construction and building material interests, realtors, and the myriad other actors who profit directly from land development and have powerful incentives to resist new regulatory controls and infrastructure obligations. Also resistant of greater regulation, however, are others, including some affordable housing advocates, who fear that increased regulation will drive up housing prices,
and advocates of free markets, who see any state intervention as an infringement on private property rights. Another major obstacle to attempts to limit urban sprawl is the fragmentation of local government in most metropolitan regions, which makes coordination difficult and can promote competition between jurisdictions for desirable development and the exclusion of unwanted land uses, each of which can contribute to further sprawl. It seems highly likely that urban sprawl will continue to provoke controversy.

André Sorensen

See also Counterurbanization; Exurbs; Gentrification; New Urbanism; Smart Growth; Suburban Land Use; Suburbs and Suburbanization; Sustainable Cities; Urban Land Use; Zoning

Further Readings

these systems are overloaded during heavy precipitation events, in an attempt to reduce the pressure on the system, untreated waste may be discharged into the nearest watercourse via a combined sewer overflow (CSO), with an obviously negative impact on the environment. On rare occasions when CSOs do not function properly, wastewater can circumvent the constraints of the system, potentially flooding streets, homes, and businesses.

Developers and water system managers are increasingly under pressure from environmental agencies and local authorities to implement approaches to mitigate the risk of flooding. The management of urban drainage in a sustainable manner has increased in importance in recent years. In North America, these approaches are often considered as best management practices (BMPs); in Europe, they are known as sustainable drainage systems (SuDS); and in Australasia, they are called water-sensitive urban design (WSUD).

The aim of these systems is to reduce the impact of storm water runoff on receiving rivers, as storm water runoff adversely affects the flow regimes, causing river hydrographs to peak sooner, often at higher levels; the runoff may also wash contaminants into the watercourses, such as organic litter, soil/dust, salt, metals, fertilizers, pesticides, chemicals, oils, hydrocarbons, and a range of other substances that may accumulate on surfaces. The approaches applied depend on the specific issues presented at each site: the duration and intensity of precipitation events; the proportional area covered by impervious surfaces; catchment relief; the drainage system, both natural and anthropogenic, and the level of integration between the two; and land use, with urban areas often including residential, retail, and industrial developments and car parks.

Current water management approaches focus on the sources of runoff and pollution and the tools used to contain and reuse the water within parkland, urban housing, and commercial and industrial areas, with the ecological status of the area and the receiving water bodies of particular importance. The water management approaches used increasingly attempt to reproduce the natural processes of infiltration, which do not operate when using impervious surfaces. Examples of this include the wider use of “green roofs” (see Prague photo), which retain the precipitation within planted beds, or replacing impervious surfaces with systems such as porous paving, which
URBAN STORM WATER MANAGEMENT

permits the water to drain through. These approaches, although successful in many areas, are costly and difficult to retrofit, particularly within urban areas, though increasingly these are being seen as key at the planning stage in gaining planning permission, particularly for large developments. Storm water is increasingly treated as a resource that can bring environmental, economic, and social benefits to urban areas; with capture, treatment, and reuse, storm water can provide an important contribution to water use within urban communities.

Urban storm water management in developing countries is of particular importance with these areas currently facing the greatest challenges to public health resulting from the meager provision of potable (drinking) water, inadequate drainage, and rapid urban expansion. The greatest challenge within developing countries is balancing the demands to provide sanitation and water supply with financial constraints and environmental management. In developing countries, specific challenges exist, with relatively few resources given to infrastructure development and often relatively poor planning of new developments. Rapid growth often takes the form of informal settlements, with little management of basic infrastructure, as a consequence of which developments are often constructed in unsuitable areas, such as the floodplain or on high gradient slopes. Often, the administrative requirements for successful storm water management are not present, with limited coordination between bodies and across administrative boundaries, leading to poorly integrated drainage systems. The challenges faced by developing urban centers are not new, but the opportunities are also challenges, particularly from a financial and resources perspective.

Historically, drainage has been perceived to be the domain of the civil engineer, but the successful implementation of modern-day urban storm water management requires an integrated approach involving an interdisciplinary team of groups and individuals, including engineers, hydrologists, urban planners, environmental scientists, economists, social scientists, and
developers, who engage with communities and local bodies.

Neil Macdonald

See also Floods; GIS in Water Management; Public Water Services; Surface Water; Urban Water Supply; Wastewater Management; Water Management and Treatment; Water Needs; Water Pollution; Watershed Yield; Water Supply Siting and Management

Further Readings


As a concept and a field of study, urban sustainability emerged out of the sustainable development movement that took off in 1987 with the publication of the Brundtland report, Our Common Future. Via the Brundtland report and the subsequent 1992 United Nations Conference on Environment and Development (Earth Summit), held in Rio de Janeiro, sustainable development brought together the international priorities of poverty alleviation and environmental conservation, creating an agenda for simultaneous improvement in both situations worldwide. Sustainable development has since been defined in terms of the quest for a balance between economic, social, and environmental conditions and, in the form of “sustainability,” as the achievement of a state of living that can be continued long into the future without deterioration of any of these three. The field of urban sustainability can be viewed from the perspective of international development and prescriptions for global and intergenerational equity and from the perspective of specific urban development and design tools and techniques, realizing the efficiencies of urbanization and building on case studies. Urban sustainability has a different significance for urban developers, city managers, social justice advocates, and urban dwellers. This entry discusses the diverse agendas and practices of urban sustainability, as well as research perspectives on the topic.

The Urban Sustainability Agenda

The emergence of urban sustainability as an important concept in international development corresponds with the tipping of the balance of the world’s population toward a majority of urban, rather than rural, dwellers. This balance was tipped sometime in the first decade of the 21st century, depending on which population estimate is used. Correspondingly, UN-HABITAT, the United Nations agency responsible for local settlements, has taken on urban sustainability as a key challenge. Thinking about urban sustainability in the context of the less developed world brings the human dimensions of sustainable development into focus—that is, the part of the original Brundtland definition that emphasizes poverty alleviation and meeting the needs of the current generation. In the developed world, where the means exist to provide for these needs, the other component of the definition, its focus on intergenerational and environmental equity, is more aptly tackled. Coordinated action by developed and developing nations alike would, of course, be ideal. Some point to significant opportunities for “leapfrog” development, by which the developing world might draw on the experience and expertise of the developed world to bypass the most unsustainable stages of development and create green, sustainable cities before many developed world cities are able to make this transition. This ideal is complicated in practice by the higher up-front costs of green development, the fact that many new technologies are unproven, and the sentiment throughout the developing world that those primarily responsible for the unsustainable state of our cities should be the ones to incur the costs of the sustainability transition.
A common framework for urban development is needed that incorporates the impacts of decisions well into the future as well as around the world. However, initiatives in governing cities with an eye further into the past and the future—such as Portland’s attempts to meet the Kyoto Protocol carbon emissions reduction target or the goal of Masdar City, Abu Dhabi, to generate zero carbon and zero waste by 2016—paradoxically can decrease accountability and action. The politicians and professionals of today will rarely be affected personally by the failure of their projects and goals beyond the horizon of the immediate future, and comparisons with past conditions can be manipulated in any number of ways. The public attention that flows to cities that make grand plans and targets is rarely, if ever, sustained long enough to track their progress, as the standard metrics for evaluating concepts such as carbon neutrality and zero waste do not exist and public and political preferences and pressures are certain to change significantly over time.

Initial studies in urban sustainability were concerned with the impact of cities on sustainable development globally. Coming from an ecological perspective, many sustainability advocates were ambivalent toward or openly derided cities, with scholars such as William Rees going so far as to label cities as ecological black holes. This characterization is justified by the fact that cities develop via the destruction of their local ecologies and their replacement with paved surfaces, biologically unproductive land uses, and the consumption of natural resources far beyond their actual footprint on the landscape (what Mathis Wackernagel and William Rees call the ecological footprint). To most ecologists, cities represent artificial landscapes, in contrast to those composed of mostly nonhuman elements. Furthermore, cities are centers of finance and politics, where many of the most environmentally destructive decisions are made; centers of education, where people are taught the lessons and skills that lead to widespread discounting of natural wealth and productivity; and centers of culture, where these decisions, lessons, and skills are normalized and reproduced. According to this thinking, the surest path to sustainability would be large-scale deurbanization and a return to small, “human-scale” settlements; reliance on “appropriate” rather than high technology; and primarily local rather than global trade patterns. There are some cases in which this theory can be considered to hold: A number of Rust Belt cities in North America, for instance, are more sustainable settlements following their decline than when they were prosperous, and experimental sustainable communities such as Findhorn, Scotland, and Arcosanti, Arizona, have been established quite consciously apart from the city. Still, the implications of this strain of thinking about sustainability, when applied globally, are troubling in that cities are home to an increasing majority of the world’s people and high rates of urbanization are associated with greater levels of freedom and human rights around the world.

The embodiment of sustainability in the urban realm was raised as an issue by scholars who noticed what Andrew Light called the “urban blindspot” in sustainability and related fields. They noted that, despite the currently destructive state of urbanism, the potential for cities to be beacons of sustainability is great. Efficiencies exist in nearly every realm of urban development: energy efficiencies through shared walls in apartment buildings compared with single-family homes; economic efficiencies through multisectoral industrial clustering, as in the case of ecoindustrial networking; and efficiencies in social marketing and rapid changes to social norms toward more sustainable values through, for example, large-scale public demonstrations for climate action; international gatherings such as Earth Summits; and personal lifestyle change efforts such as Earth Day pledges and reusable shopping bag campaigns. Here, the primary notion is to work with the urban advantage that stems from high population density in contrast to the unsustainable resource use and lifestyle patterns found in the suburbs. Positive action in this realm has been pursued primarily by those who study and practice urban design. The designer’s sustainability toolbox consists of ideas such as smart growth, cradle-to-cradle design, zero waste, carbon neutrality, one-planet living, new urbanism, green building, transit-oriented development, and life cycle analysis. Working examples of sustainable design exist as neighborhoods within cities, such as Freiberg, Germany, and Fremantle, Australia.
On July 22, 2009, the U.S. Postal Service dedicated its first “green” roof, the largest in New York City and one of the largest in the country. This photo shows detail and a cross section of the roof, which is on the Morgan mail facility in midtown Manhattan. Built in 1933, the 2.2-million-ft.² facility became a historic landmark in 1986. Its roof was constructed originally to serve as an additional mail processing location, supporting 200 lb./ft.². When the roof was scheduled for replacement in 2007, it was deemed strong enough to support the weight of the soil, vegetation, and other requirements of a green roof. The roof will last up to 50 years, twice as long as the roof it replaced. It will also reduce the amount of contaminants in storm water runoff flowing into New York’s municipal water system. The agency projects the reduction of polluted runoff to be as much as 75% in summer and up to 35% during winter.

Source: © James Leynse/Corbis.

Urban Sustainability in Practice

In professional practice, urban sustainability presents new challenges for the processes of developing, redeveloping, and managing cities. In theory and to some leading-edge cities, urban sustainability represents a new holistic management framework more than any particular process or policy. In this way, urban sustainability is being applied within a small but growing number of city halls to issues of immigration and integration, poverty alleviation and slum upgrading, improving environmental management and environmental impacts, urban design, regional planning and combating sprawl, downtown revitalization, housing, transportation, and risk management—the full gamut. Often, these considerations are grouped in terms of the “brown agenda” of urban sanitation and infrastructure; the “green agenda” of environmental services and resource and energy conservation; and the social agenda of developing just and fair institutions and opportunities in the arenas of economics, education, health, governance and so on. As the social agenda remains the least well understood and least well addressed of the urban sustainability domains and given that its scope is so broad, this domain is often broken down into subgroups such as culture, governance, and education.
Research Perspectives on Urban Sustainability

In the early 21st century, while increasing numbers of cities are establishing sustainability branches and functions, the majority of cities with sustainability policies do not clearly differentiate these from environmental policies, offices, and functions. What specifically makes an urban policy oriented toward sustainability as well as what makes a sustainability policy specifically urban are both questions under examination and experimentation. In line with the sustainable development mantra to “think globally, act locally,” different local conditions make different policy approaches suitable. Developing world cities may adopt a sustainability approach to find better, long-term solutions to the state of slums and life conditions of slum dwellers, while a developed world city in decline might pursue a shift to a new economic base, and a thriving developed world city might leverage a building boom or mega event toward sustainability principles.

From an ethical perspective, inquiry into urban sustainability needs to ask, “What is it we are interested in sustaining?” The answer depends on one’s perspective. For city managers, planners, and elected officials, their particular cities need to be sustained over the long term, and a comprehensive approach to maintaining or enhancing its economic, social, and environmental conditions is the preferred strategy. In this context, we need to ask whether a sustainability agenda can be reconciled with pressures for global economic competitiveness, in which most if not all cities are engaged. It is also important to investigate where the responsibility for achieving urban sustainability lies and the opportunities and limitations for action at the scale of particular cities, by urban governments and their citizens, compared with those of higher orders of government, international bodies, and global civil society.

For social justice advocates, it is the lives of urban dwellers worldwide that need to be made sustainable. With an estimated 30% of the world’s poor living in cities, Sudhir Anand and Amartya Sen ask how sustainable development can be a meaningful concept when the living conditions of so many are too deplorable to be worth sustaining. In this context, urban sustainability demands a narrowing of social and economic disparities, which are often exaggerated in cities. This means correcting long-standing imbalances and relieving poverty and other inequities through social policies and redistributive economic programs that are informed by a holistic approach. The alignment of urban sustainability and democratic agendas becomes apparent here, bringing into focus research questions relating to the relative role of the public and of experts, of social capital and urban citizenship, and of various forms of public participation in urban sustainability.

For urbanists, it is the city, as the dominant kind of human settlement, and the global urban system that need to be brought into balance with the nonurban world. On this point, some researchers point to the value of increasing the resilience of cities for a future sure to be filled with intense shocks and threats, from climate change and economic and social upheavals. Others, such as David Satterthwaite, are primarily concerned with the role that moving cities toward sustainability can play in achieving sustainable development at the global scale. This would mean planning for resilient cities, not just in terms of their own long-term needs and contributions but also in terms of building and maintaining equitable long-term relationships with all other cities in the global network, and thinking about flows of immigration, trade, tourism, ideas, and environmental goods and services around the world. Satterthwaite poses this distinction between inward- and outward-looking sustainable cities in terms of the following question: Sustainable cities or cities that contribute to sustainable development? It is at best disingenuous to talk about sustainability at a local scale if it is achieved by transferring costs, inequities, or waste products elsewhere; at worst, it is the active perpetuation of environmental injustice. The pursuit and study of urban sustainability entail a perspective that moves from the local scale of a single city, down to the individual neighborhoods, businesses, parks, and natural areas within it, and up to the global scale of the world system of cities. The quest is for more effective integration of the diversity of needs and interests operating within and among cities. It is a challenge to consider the impacts and implications of actions for the very long term, respecting the vast diversity of
The term urban underclass has been extremely controversial in the social sciences since its ascen-
dancy in the early 1980s. The term, coined by Gunner Myrdal in 1962 to describe a stratum of the
long-term unemployed population in American

cities, tenaciously persists in academic and policy circles. At the core of all dominant defini-
tions, the term references an urban population that is persistently low income and has difficulty
obtaining suitable waged work to ensure a decent quality of life. Most also agree that there is a
strong racial and class association that corre-
sponds to this population—that is, they are dis-
proportionately African American, Latino, and
workers at the lowest end of the new postindus-
trial service economy. At the same time, this
population is recognized as having relatively
poor access to key goods and services, such as
decent jobs and housing, well-funded schools,
and suitable parks and open space.

But much disagreement persists about the
urban underclass concept. First, scholars clash
over the reasons behind the deployment and reso-
nance of the notion. On the one hand, it is sug-
gested that the term urban underclass is a simple,
objective, and neutral descriptor for a stratum of
the impoverished urban population. It suppos-
edly helps clarify the specifics of a particular
needy, service-dependent population. Analysts
here dispassionately put truth and reality into an
accurate, descriptive term. On the other hand,
others explain the term’s origin and longevity in
its ability to target and stigmatize a population.
Analysts here are said to contribute to a complex
societal process whereby the poor (and particu-
larly impoverished ethnic minorities) become
singled out and differentiated as culturally prob-
lematic beings in need of social rehabilitation.
Analysts, in the process, wittingly and unwittingly
validate a pejorative “classing” and “racing” of
society that pervades public thought. In the debate
over the use and resonance of the urban under-
class concept, these two contrasting positions
dominate.

Scholars also differ on the causes for the rise
and persistence of this population. Staking out a
widely accepted notion, William Julius Wilson
explains this phenomenon by reference to a
changed city, national, and international econ-
omy. Wilson and adherents identify the rise of a
service-based economy (supplanting a manufac-
turing economy) that has afflicated the poor,
particularly impoverished minorities. This rise
of service jobs, concentrating in two areas—
low-wage, “McDonald’s-type” jobs and high-wage,
education-intensive jobs—fails to provide meaningful employment opportunities for this population. Concomitant with the loss of decent-paying manufacturing jobs, the working-class and poor populations get devastated. Unlike Wilson and his adherents, a group of Marxist scholars have sought to explain the reasons for this economic transformation. David Harvey traces this economic transformation to the rise of two forces, neoliberalization and globalization. First, new labor-punishing rules and regulations and corporate labor-cutting practices across America have allowed unskilled, low-wage, dead-end jobs to proliferate. Second, a new global reality has dramatically shrunk the globe. In the process, a hypermobility allows production units to close or move an accelerated number of manufacturing plants out of America to lower-wage world regions.

This position contrasts with the still entrenched notion of the culture of poverty. This alternative, coalescing around the ideas of Ken Auletta, George Gilder, and Charles Murray attributes the origin of the urban underclass to the emergence of an antisocietal culture in inner cities. The rise of counternormative values, manifest in “underclass behavior,” purportedly send inner-city mothers, fathers, and children down paths of social dysfunction, with an inability to integrate into mainstream America. One structural factor is seen by many in this camp to shape this population: the individually damaging effects of a dysfunctional welfare state apparatus that ran roughshod over this population, beginning in the 1960s. Government programs inadvertently killed individual initiative to work and sacrifice, creating a service-dependent population now enslaved to government largesse.

Scholars also disagree on the duration of existence of this population. To some, a distinctive, new urban underclass is less than 30 years old. Its roots are in the post-1980 ascendancy of the postindustrial economy, which has dramatically polarized the rich and poor in urban America. This position notes a long history of poverty, underemployment, and unemployment in U.S. cities. However, they point to a relatively new reality of long-term poverty populations having grown more hopeless, despairing, and socially removed from society’s mainstream. In contrast, others see the contemporary urban underclass population as simply the most recent manifestation of a long-term urban poverty population. There roots have been variously traced to the supposed afflicting effects of the Great Society in the 1960s, the Keynesian economic stimulus apparatus beginning in the 1930s, and the “reality” that the poor have always been with us and will always be with us as long as people have different wills and initiatives to succeed.

Finally, scholars disagree on the level and intensity of the constraints that impinge on the daily lives of this population. Two dominant positions have arisen. The first contends that the black urban underclass reflects a legacy of historical discrimination that pervasively persists today. Some writers fervently argue that African Americans have faced discrimination in housing markets, labor markets, and common social life that superseded that of other previous ethnic populations in cities. In this context, they suggest that blacks today continue to be held back in labor hiring practices, job promotion opportunities, obtaining better housing, and securing government services. Paraphrasing Cornel West, hiring, firing, and everyday life in cities today is still profoundly colored. But other voices proclaim such discrimination as essentially dead. Racism is said to persist in withered, subtle ways, but the reality of an urban underclass now must be explained by other factors, namely, human choices embedded in a ghetto cultural formation. Poverty and isolation are supposedly now normative, the end products of human decision flowing out of the structure of poor black communities. Poor blacks have absorbed and re-created an oppositional culture—that is, a set of behaviors, attitudes, and expectations that fundamentally conflict with those of the broader society.

The urban underclass concept today takes on more salience as poverty has deepened and really expanded across American cities. Yet scholars are no closer to resolving their differences of opinion about this notion’s raison d’être, the rise and causes of this referenced population, and the duration of its existence. After years of national silence regarding urban poverty, the controversy over the notion of urban underclass is likely to intensify.

David Wilson
Water and cities have a complex relationship influenced by natural conditions and by the abilities of human societies to adapt and reshape them to meet their needs and desires. The challenge of providing water of sufficient quantity and quality to urban populations is significant. Demand for water is driven by population growth and changes in the ways in which societies demand water for domestic, industrial, and commercial uses. Providing water to urban settlements has involved technological and engineering innovation. Deeper, and often controversial, struggles over access to and control of water are also important. These institutional and political questions are rarely resolved in a consistent manner and reveal deep contradictions. Many of these involve conditions of scarcity. This scarcity, even though it may have origins in physical conditions, is often not natural. Instead, scarcity is the result of power relations that have evolved in particular places and times. Rapid urbanization, whatever the timing or cause, lays bare the complexities of urban water supply. Opening with a brief examination of the technical aspects of supplying water to urban areas, this entry provides a consideration of systematic inequities in access to water in both historical and contemporary contexts.

**Technology, Engineering, and Urbanization**

Ancient engineering techniques for moving water for domestic purposes displayed keen engineering skill in using gravity. Innovations included the use of natural and manufactured pipes, containers, and taps and the use of various simple machines. The Roman aqueducts, for example, moved large quantities of water over long distances and efficiently and elegantly stored and distributed water within cities. Other ancient and medieval societies similarly mastered the use of gravity-based techniques. The Roman aqueducts, for example, moved large quantities of water over long distances and efficiently and elegantly stored and distributed water within cities. Other ancient and medieval societies similarly mastered the use of gravity, with varying degrees of precision.

Bringing water to a city allowed both private and public uses. In addition to meeting practical needs, many of these uses were symbolic and served to reinforce or legitimate sets of power relations. Even in medieval Europe, regarded as a period of technological reversal and stagnation, the exploitation of water sources outside cities and the construction of water conduits continued. In this case, it was often through the exercise of the ecclesiastical power of the Church rather than the secular power of government. Expertise in gravity-based techniques diffused from city to city or from monastery to monastery. Adoption,
However, was uneven, and even with adoption, place-based particularities influenced access to water and the types of uses made of it—for example, open fountains in Italy or spigots in England.

Cities and towns with ample local water supplies or proven long-distance access to them sometimes enjoyed a comparative advantage as manufacturing and later industrialization took hold. In cities that experienced rapid population growth in the manufacturing era, adequate potable water supplies became a necessity. Demands for potable water supplies in the largest cities were driven by concerns over public health, as human and industrial waste had compromised available local supplies. It had become clear that piecemeal provision of water was insufficient to protect the rich and powerful against the threats of waterborne diseases. Responding to both elite demands and the pressure of broader political movements, collective and most often public ownership and operation of urban water emerged. Success in the development of water and sewerage services dramatically reduced the impact of waterborne diseases. Rapid growth required significant additions to the water resources of cities, particularly if the available local resources were limited or too polluted for use.

In the North American context, New York City extended its influence (using state authority) into a widening hydrological hinterland. As in ancient times, the city and the countryside became linked through this hydrological connection—faster growth and greater water demands led to the expansion of what some have called the “water frontier.” For modern-day New York, this means a network of reservoirs outside the city, with city influence on land use and environmental change. More than 1 billion gallons of water is delivered daily.

Similar stories can be told about most major cities in the core of the world economy as they added publicly provided water supplies. In areas of extreme water scarcity, limits on water supply could constrain population and economic growth and required more aggressive and long-distance appropriation. These, in turn, have prompted conflict as rural demands for water, especially for agriculture, have been displaced by thirsty cities and the perceived inevitability of urban and suburban growth.

Water treatment to achieve an aesthetically acceptable or healthier product has similarly evolved. Techniques have grown from rudimentary settling chambers and sand filters designed to improve the smell and appearance of water to the addition of chemicals and more advanced purification techniques targeted at bacteria, viruses, and parasites. Cities increasingly have come to rely on a complex combination of engineering and chemistry to meet everyday water needs. A failure of these technologies can quickly lead to public health threats.

Geographical and technological fixes for urban water problems require tremendous commitments of resources. In the modern setting, water infrastructure requires significant initial financial investment as well as a commitment to maintenance over the longer term. In the United States, water borrowing by cities to provide for water and sanitation needs grew exponentially in the late 19th century. Urban areas outside the core of the world economy, particularly capital cities and those with an industrial base, also added public water systems. Sometimes, improvements were seen to have significant symbolic value, providing the appearance of modernity as well as health benefits—even if only for a fraction of the city and its population.

Organizing Water Delivery

The construction and operation of urban water systems does not mean that all residents of a city receive water of consistent quality and quantity. Indeed, inequities in water delivery and pricing were and are commonplace and remain a structural feature of many urban landscapes. This is partly because of the reactive nature of water supply provision (supply capacity lags behind demand), but systemic inequity is also an outcome of place-based power relations and, therefore, is of special interest to geographers. These inequities were present in ancient societies and remain visible today. The formal architecture of political power in a state plays a significant role in the development of urban water supplies by influencing the geographical scale for responsibility. Countries with strong central governments have different planning and implementation processes than those where power may be devolved.
to the regional or local scale. Rigorously enforced national environmental or drinking water standards with strong fiscal support will bring results that are vastly different from those where local decision making is coupled with limited access to capital.

In many cities, increases in population outstrip existing or planned capacity. This is true whether population increases are caused by 19th-century industrialization and urbanization or 21st-century migration from the countryside into shantytowns or informal neighborhoods in countries in the periphery of the world economy. Individual areas within a city may have water service as a consequence of local political movements or simply because of political patronage. On the other hand, they may not be served because of lack of political power, to prevent temporary settlements becoming permanent, or to avoid unacceptable compromises of service to other, “more deserving” areas. Residents of areas that lack a reliable supply of good-quality piped water, even at the scale of shared public standpipes, are forced to rely on their own wells or surface water or other methods of provision. Lack of sanitation and the presence of industrial pollution may make wells or surface water unhealthy, leading to higher child and infant mortality rates and shortened life expectancies. Those with no other choices may also be subject to the market relations of vendors, who may get water from a public system only to sell the water under exploitive and monopolistic conditions. This situation, sometimes facilitated and supported by urban politics, can lead to egregious exploitation through the regressive pricing of urban water. Poor and marginalized populations often get less water at lower quality and yet pay significantly more for it. Water provided by public systems may be influenced by collective ideals, public subsidies, and the regulation of a “natural monopoly.” Those excluded from the public supply experience no such protection.

The keystone status of clean water in public health and economic development has drawn consistent attention in international development policy. The 1980s, for example, was declared the International Drinking Water Supply and Sanitation Decade by the United Nations (UN). Water and sanitation feature prominently in Earth Summit (United Nations Conference on Environment and Development, 1992, Rio de Janeiro) documents such as Agenda 21 and in the UN Millennium Development Goals. The 2006 report of the United Nations Development Programme specifically focused on water and sanitation, providing further compelling analysis of water problems.

The practicalities of meeting the water needs of millions of people have involved shifting institutional and organizational arrangements. While there may be limited room for optimism, the situation is complex and laden with contradiction.

Recent conflicts have stemmed from the impact of globalization. Here, a neoliberal agenda of commodification and privatization runs head-on into visions of water as a collective human right. In the context of globalization, policy-based lending from the World Bank and International Monetary Fund has brought the realities of global capitalism and corporate control into the arena of urban water supply. Defining water as an economic good (as well as a necessity) became fused with a vision of private expertise as the best solution for urban water supply woes in the developing world. This expertise was to be provided by global corporations—with attractive, and often guaranteed, returns on their investments—themselves funded with loans from the World Bank or other multilateral lenders. The privatization message took on an almost magical allure and was backed by the financial power and dominance of global institutions and corporate interests. This showed itself in different ways in different settings, with impacts in all world regions. In England and Wales, for example, privatization was a response to a domestic policy agenda (deregulation and privatization of government enterprises) and the financial pressures of compliance with European Union environmental directives. In France, private companies, which have played a significant role in water services for decades, became global-scale operators through mergers and acquisitions. In the United States, where municipalities with aging infrastructure and underinvestment faced massive financial commitments, international corporations offered the promise of better service for lower costs as well as a reduction and “disciplining” of the...
USABILITY OF GEOSPATIAL INFORMATION

A number of possible definitions of usability are available in the literature of geospatial information, and the needs of spatial data usability have been compared and contrasted with the broader data-related activities of providers and users of

public sector workforce. In the cities of the developing world, policy-based loans, often as part of national-scale structural adjustment packages, have transformed the provision of urban water by requiring privatization. Global-scale water corporations have received lucrative concessions and contracts with promises not only to meet ambitious collective water supply goals but also to fully recover their costs (and profits). Global privatization has been paralleled by the development of global-scale governance. This has occurred not only through existing international institutions but also through the creation of new organizational forms, which are not state based but part of the development of a new international regime for water.

While privatization and commodification have been part of this international regime, there has also been resistance to privatization from international nongovernmental advocacy organizations, localized and global social movements, and public sector labor unions—a broader and globalized civil society. While outcomes have varied, there is one clear finding: Privatization and commodification have not been panaceas and have, in fact, moved the inequities of urban water provision into the public limelight. Urban water is no longer the domain of engineers and bureaucrats. It has become the focus of the mainline international environmental organizations, global corporations, global capital investment funds, national and international economic and social development organizations, investigative media, and an array of vocal advocates and activists for democracy and transparency. Place-based stories of protest and resistance, in print and on video, are not confined to the streets of cities in the developing world; they also feature in the city council chambers of North America. The details of each story may be different, but underlying each is a deep and enduring concern over access to and control of water.

As the 21st century unfolds, urban water provision promises to be at the cutting edge of local and global conflict. Conflict over the broader availability of water will be supplemented by struggles over the ways in which the provision of water is organized. Concerns over efficiency of urban water consumption as well as the risks of terrorist threats to the integrity of urban water supplies have joined the list of controversies. Against a backdrop of climate change and evolving forms of global capitalism and civil society, urban water supply will continue to be a focus of examination.

Richard Kujawa

See also Civil Society; Environmental Rights; GIS in Water Management; Public Water Services; Wastewater Management; Water Management and Treatment; Water Needs; Watershed Yield; Water Supply Siting and Management

Further Readings

USABILITY OF GEOSPATIAL INFORMATION

It is hard to isolate a core set of fundamental techniques that clearly distinguish data usability from any single-component discipline; in some ways, it is a uniquely powerful combination of individual techniques that characterizes the field. In summary, data usability might be identified as an umbrella term consisting of several elements aggregated into several groups:

- **Marketing**: added value, benefits, costs, novelty, services provided, and satisfaction
- **Quality**: authoritativeness, guarantee against error, integrity, metadata, reliability, validity, and utility
- **Software and tools**: human computer interaction, standardization, integration, searchable, and interface
- **Human perception/cognition**: authoritativeness, decision type, interestingness, novelty, popularity, satisfaction, trust, user skill levels, familiarity, interpretation, and visualization
- **Applications**: aggregation levels, type, exclusiveness, visualization, integration, decision type, use with models and algorithms, availability, and accessibility

Each individual category can be discussed in light of specific user groups and/or applications. For example, in the marketing category, cost is a very common and often a very important element and plays a large part in usability. In the applications group, availability and accessibility also determine the use of data. Moreover, it is important to realize that elements such as accessibility and cost of spatial data can vary among different countries and cultures. Another example is the update frequency. To decide on the desired update frequency, users should be asked to define the tolerable difference between decisions made and the time frame for future decisions.

There is also a dynamic component in the definition of usability. As time goes by, some data sets will be more useful than others. This is a consequence of the nature of the elements being depicted and the temporal and spatial scale of the representations. Accordingly, consideration will have to be given to the best way of improving the use of the database. Again, a usability framework should provide milestones for the application of objective methods aiming to extend the lifespan of usability.

...
of a database within reasonable limits. This methodology will affect the way data sets are produced, maintained, and used. There is also considerable scope for the implementation of data-modeling techniques such as rule-based classifications and data mining.

Finally, there is an important element linked to the way users perceive and use existing data sets. The same data presented in an unfamiliar way to the user become ineffective. The human interface is an important area for constant improvement. Visualizations such as three-dimensional representations, virtual reality, and animations seem to bridge the gap between data producers and data consumers. Therefore, these techniques improve the likelihood of data being fully understood and used.

Monica Wachowicz

See also Legal Aspects of Geospatial Information; Privacy and Security of Geospatial Information

Further Readings
International standards for HCI and usability:
www.usabilitynet.org/tools/r_international.htm
Journal of Usability Studies: www.upassoc.org/
upa_publications/jus
VAGUENESS IN SPATIAL DATA

This entry examines aspects of vagueness in spatial data from the perspective of a spatial database used to support a geographic information system (GIS). A spatial database is a collection of data concerning objects located in some reference space that attempts to model some enterprise in the real world. The real world abounds in uncertainty, and any attempt to model aspects of the world should include some mechanism for incorporating uncertainty. There may be uncertainty in the understanding of the enterprise or in the quality or meaning of the data. There may be uncertainty in the model, which leads to uncertainty in entities or the attributes describing them. And at a higher level, there may be uncertainty about the level of uncertainty prevalent in the various aspects of a database.

Many operations are applied to spatial data under the assumption that features, attributes, and their relationships have been specified a priori in a precise and exact manner. However, inexactness often exists in the positions of features and the assignment of attribute values and may be introduced at various stages of data compilation and database development. Models of uncertainty have been proposed for spatial information that incorporate ideas from natural-language processing, the value-of-information concept, non-monotonic logic and fuzzy set, and evidential and probability theory. Thus, in the modern GIS, there is a need to more precisely model and represent the underlying uncertain spatial data. The major aspects of spatial data description to focus on for uncertainty considerations include spatial region descriptions, spatially related attributes, and spatial relationships.

Spatial Region Descriptions: Fuzzy Sets

In contrast to an ordinary set for which a set element is either in or out of the set (set membership of only 0 or 1), a fuzzy set is one in which the membership of an element may have a value between 0 and 1, representing the degree to which the element belongs to the fuzzy set. Within a fuzzy set, we may have objects comprising the core (full membership of 1.0 in the set in question), and we may have a boundary (the area beyond which they have no or negligible membership in the set). A classic spatial example of the core and boundary problem is determining where a forest begins. Is it determined based on a hard threshold of trees per hectare? This may be the boundary set by management policy, but it is likely not the natural definition. There are several ways to manage these uncertain boundaries. If a spatial database can represent the outlying trees as being partial members of the forest, then a decision maker will see these features as being partial members if the database is queried.
Spatially Related Properties

Next, consider spatially related properties such as soil types, which might be described in linguistic terms such as

\{sandy, loamy, \ldots\}.

Such linguistic terms are commonly modeled as fuzzy sets. So soil classification might be assessed as belonging to the fuzzy set “sandy” with a membership value of 0.8. It is also possible to allow numeric as well as scalar values. For example, a fuzzy number such as “about 3 cm” of rainfall at a location could be used.

To use minimum bounding rectangles in a spatial database for vague regions, a fuzzy minimum bounding rectangle (FMBR) can be defined as consisting of nested rectangles. The innermost rectangle is the MBR over the core of the vague region (certain region or membership \(= 1\)). The outer rectangle is an MBR over the outer boundary of the vague region. This approach allows the consideration of common indexing approaches such as grid files or R-trees.

Spatial Relationships

The major types of spatial relationships that can be considered are geometrical orientation and topological relationships. An approach to uncertainty in such spatial relations can be based on determining configuration similarity for spatial constraints involving topology, direction, and distance. This approach uses extended objects for direction and topology, and centroids for distance; it handles uncertainty in fuzzy relations, for example, an object that satisfies more than one directional constraint, as well as fuzziness related to linguistic relationship terms. Another approach is based on MBR and spatial extensions of Allen’s temporal relationships. The basic relationship definitions, and their use in defining relevant directional and qualitative topological relationships, provide a framework for the abstract spatial graph, a spatial data structure specifically designed to retain orientation and topological information with respect to two-dimensional objects and to provide information to support fuzzy querying capabilities on these relationships. The weights computed from the abstract spatial graphs directly support fuzzy queries regarding qualitative topological and directional information. These techniques permit queries such as “Does ‘some of Object A overlap most of Object B’?” or to determine that while Object A is slightly southwest of Object B, it is at the same time mostly west of Object B.

Another approach to representing uncertainty that can be used is the theory of rough sets. Rough sets involve a universe, \(U\), and the indiscernibility relation, \(R\) upon \(U\). Then, a rough set \(X\) is defined by

\[
\text{Lower approximation of } X: RX = \{x \in U \mid [x]_R \subseteq X\},
\]

\[
\text{Upper approximation of } X: R\bar{X} = \{x \in U \mid [x]_R \cap X \neq \emptyset\},
\]

where \([x]_R\) denotes the equivalence class of \(R\) containing \(X\).

Consider the spatial concepts, \(U = \{\text{tower, stream, creek, river, forest, woodland, pasture, meadow}\}\), and let \(R\) be as follows:

\[
R^* = \{[\text{tower}], [\text{stream, creek, river}], [\text{forest, woodland}], [\text{pasture, meadow}]\}.
\]

Given some set \(X = \{\text{medium, small, little, tiny, big, huge}\}\), we would like to define it in terms of its lower and upper approximations:

\[
RX = \{\text{tower, stream, creek, river}\}
\]

and

\[
\bar{R}X = \{\text{tower, stream, creek, river, forest, woodland, pasture, meadow}\}.
\]

A rough set in \(A\) is the group of subsets of \(U\) with the same upper and lower approximations. In the example given, the rough set consists of the following subsets:

\[
\{\text{tower, stream, creek, river, forest, pasture}\}
\]

\[
\{\text{tower, stream, creek, river, forest, meadow}\}
\]

\[
\{\text{tower, stream, creek, river, woodland, pasture}\}
\]

\[
\{\text{tower, stream, creek, river, woodland, meadow}\}\]
The major rough set concepts of interest are the use of an indiscernibility relation to partition domains into equivalence classes and the concept of lower- and upper-approximation regions to allow the distinction between certain and possible, or partial, inclusion in a rough set.

The indiscernibility relation allows us to group items based on some definition of “equivalence” as it relates to the application domain. We may use this partitioning to increase or decrease the granularity of a domain, to group items together that are considered indiscernible for a given purpose, or to “bin” ordered domains into range groups. To allow possible results, in addition to the obvious, certain results encountered in querying an ordinary spatial database system, we may employ the use of the boundary region information in addition to that of the lower-approximation region. The results in the lower-approximation region are certain. These correspond to exact matches. The boundary region of the upper approximation contains those results that are possible, but not certain.

Frederick E. Petry

See also Analytical Operations in GIS; GIS Design; Ontological Foundations of Geographical Data; Topological Relationships; Usability of Geospatial Information

Further Readings


James E. Vance Jr. is known for his scholarship on urban, historical, and transportation geography. These interests became apparent in his doctoral dissertation on The Growth of Suburbanism West of Boston, supervised by Raymond Murphy and completed at Clark University in 1952. After holding appointments at the Universities of Arkansas, Wyoming, and Nebraska, he taught from 1958 to 1991 at the University of California, Berkeley, where he directed 28 successful doctoral dissertations. His work emphasized the evolution and structure of cities; the roles of transportation and trade in shaping regional settlement; and the social processes that internally differentiate urban areas. Vance (1990) focused especially on “urban morphogenesis—the creation and subsequent transformation of city form” (p. 38).

The popularity of Vance’s courses on urban geography and transportation geography led him to write monumental textbooks on these subjects. This Scene of Man (1977) surveyed the evolving role and structure of the city in Western history. A revised edition, The Continuing City (1990), added two chapters on the modern metropolis and transportation innovations since 1850. In Capturing the Horizon (1986), Vance traced the emergence of modern transportation systems: canals, railroads, urban transport, maritime navigation, and aviation. His final book, The North American Railroad (1995), interpreted development of the railway networks of the United States and Canada, where, he argued, geographical factors dictated significant variations from British antecedents.

Vance made several influential contributions to geographic theory. First, in his work on the functional organization of the North American downtown, he argued that abstract economic forces such as land rent were insufficient to understand the structure of the central business district (CBD); instead, he stressed historic origins, functional requirements, and social factors. Vance summed up the historical-geographical processes of CBD evolution as “the seven lives of downtown: inception, exclusion, segregation, extension, replication and readjustment, redevelopment, and the city of realms.”
A second geographical contribution was the “mercantile model,” which highlighted the role of long-distance trading ties in locating early settlements around the port, transportation facilities, warehouses, markets, and so on. Intended as a critique of and alternative to Walter Christaller’s central place theory, Vance’s (1970, 1990) mercantile model argued that wholesale trade resulted in the formation of new settlements or “points of attachment,” which if successful became regional centers with their own hinterlands. This emphasis on commercial forces external to the local urban system, confirmed by empirical studies in North America, provided a missing link in central place theory.

A third contribution was the concept of “the city of realms,” an influential spatial model for the contemporary North American metropolis. Vance’s view of the urban-realm model recognized a decentralized metropolis split into a series of daily activity areas no longer dependent for their existence on the traditional CBD. The criteria of urban realms included topography and physical geography, the overall size of the metropolis, economic functions of the realms, and the regional geography of transportation. Vance’s (1977, 1990) “city of realms” predicted the contemporary dispersed metropolis a quarter century before notions of “edge cities” came into vogue.

Brian J. Godfrey

See also Berkeley School; Railroads and Geography; Transportation Geography; Urban Geography; Urban Spatial Structure

Further Readings


Bernhard Varen (latinized to Varenius) was born near Lünenburg, Germany, in 1622. Through studies at the gymnasium of Hamburg and the University of Königsberg, he excelled in mathematics, natural science, and philosophy, leading to the completion of a degree in medicine at the University of Leiden in 1649. There is no evidence of his having practiced medicine. Rather, he settled in Amsterdam, working as a tutor and taking interest in the discoveries of contemporary Dutch navigators, the work of geographers, and the achievements of Willem Blaeu and other cartographers. Varenius contributed to regional understanding with Descriptio Regni Japoniae in 1649 and to studies of religion. However, he is best known for Geographia Generalis, published in the 28th and final year of his life by Elsevier Press in 1650.

Geographia Generalis is a milestone in the history of science, staking a position for a formal discipline of geography, aligning it with the rationalist perspective of the early Enlightenment (represented in the philosophies of René Descartes and Francis Bacon) and with the commitment to empirical documentation. Residing in Amsterdam, Varenius had access to the wealth of new information made available through seafaring voyages of discovery and trade. Documenting and systematizing that knowledge was one of his central objectives. He recorded quantitative information about the shape, size, and motions of Earth, documented findings about the distributions of land and water, and systematized notes on the characteristics of mountains, woods, deserts, and the atmosphere in different locations, seeking where possible to identify trends and general spatial patterns.

Geographia Generalis identifies two branches of geography—special and general. Whereas
special geography is focused on the description of countries and regions (referred to today as regional geography), general geography was seen by Varenius as a systematic science, focused on understanding the features at the surface of Earth and on relationships between Earth and other celestial bodies. He saw value in basing regional description on a foundation of general understanding and proceeded to outline three different aspects of general geography. These included absolute geography, to measure the size, shape, and motions of Earth; relative geography, to draw associations to climatic patterns and the measurement of time; and comparative geography, to describe geographical variations in the characteristics of different parts of Earth and to identify appropriate principles of mapping and navigation.

Historians of geography characterize the successive translations and revisions of Geographia Generalis (by Isaac Newton in 1672 and 1681 and by others well into the mid 1700s) as helping establish a foothold for teaching systematic geography in many of the leading academic institutions of Britain, America, and Europe. It provided a foundation for thinking about the practices of geography and its role in science. The work of Varenius was invoked in 17th- and 18th-century debates over the merits of Cartesian and the Newtonian scientific systems, lauded by Alexander von Humboldt in his Cosmos, and although it no longer garners such central attention, it is seen as a foundation for good scientific practice by 21st-century scholars who seek to advance the science of geographic information.

Donald G. Janelle

See also Chorology; Human Geography, History of

**Further Readings**


used together with other geospatial data sets and layers in a GIS to perform spatial analysis.

John A. Olson

See also Data Format Conversion; Digitizing

Further Readings


VERNACULAR LANDSCAPES AS EXPRESSIONS OF ENVIRONMENTAL IDEAS

Vernacular landscapes, sometimes termed ordinary landscapes, are the surfaces of everyday life that we see all around us and that are created and re-created daily. Cultural geographers study vernacular landscapes to understand the lives of ordinary people who live in those landscapes. Ordinary landscapes take the form of everyday places such as parking lots, tree-shaded suburbs, trailer parks, or a patchwork of fields in Midwestern U.S. farmlands. They are lived in and are continuously changing.

Geographers agree that there are many layers of meanings embedded in any landscape and that multiple cultural landscapes exist in the same place. These vernacular landscapes can be studied to illuminate ideas about the human environment. However, the term landscape is somewhat ambiguous. Its meanings can be understood and even expressed differently by different social groups and at different times. It is used by many professionals, among them architects, artists, Earth scientists, geographers, and historians, with myriad meanings. Differences in meaning between disciplines and even within a discipline present challenges in understanding and translating the term. The landscape is all around us; it is related to nature but is not identical with nature. Landscape is also related to the environment. It is less organic than the everyday environment that sustains and surrounds people, and also less inclusive. There is scenery in every landscape, but landscape is not identical with scenery. Geographers have described landscape as the intermingling of physical, biological, and cultural features.

Cultural geographers observe landscapes with their eyes but interpret them with their minds. Peirce Lewis has argued that landscapes are the products of impressions of our senses rather than the logic of sciences. Landscapes are expressions of cultural values, social behaviors, and individual actions worked into a particular locale over a span of time. Lewis has further maintained that the human landscape reflects human values and aspirations, tastes, and fears, combining them into a tangible, visible form. The landscape holds a fairly accurate cultural record, one that many cultural geographers agree is an unintended autobiography where glories are embedded and cultural warts and blemishes are also included. Grady Clay has said that there are no secrets in the landscape. The ordinary day-to-day qualities of people are exhibited for anyone who wants to find them and knows how to look for them.

Contemporary cultural geographers have created different categories of landscape types. The differences in the categories have to do with the elements contained in those landscapes. In addition to vernacular landscapes, there are symbolic landscapes, which are representations of specific virtues, values, ideas, or memories. For instance, a builder, artist, politician, and/or a financier can aspire to impart a particular idea to the larger public. The Lincoln Memorial and other public buildings and monuments around the Mall in Washington, D.C., were built in the neoclassical architectural style and were deliberately designed to communicate the grandeur and a sense of power. The Lincoln Memorial itself imitates the style of the Greek city-state and communicates the authority and power of democratic principles.

Ordinary landscapes influence and change the perceptions, values, and behaviors of the people who live and work in them. Since they are continuously changing and geographers cannot study everything, they study selected items in the ordinary, everyday landscapes; however, scholars
must put them in context, where they are a part of a larger thing that is undergoing continuous modification and change as a result of both conscious as well as unconscious processes.

**Two Examples of Vernacular Landscapes**

Two examples illustrate vernacular landscapes. The first is the historic beginning of vernacular landscapes as described by John Brinckerhoff Jackson. The second example uses elements in the vernacular landscape of a community in southwest Uganda.

The term *vernacular* suggests something traditional, homemade, or countrified; historically, the term was associated with buildings. Identifying dwellings as vernacular alluded to the work of a craftsman who used local materials and techniques, but the buildings also reflected local environmental and economic conditions. Jackson was one of the early geographers who traced the historical development of vernacular dwellings from their beginnings in European architecture of the 16th, 17th, and early 18th centuries. According to Jackson, the term *vernacular dwellings* was mostly used by architects and architectural historians to emphasize form and building techniques. Vernacular dwellings were seen as loyal to local forms and rarely incorporated external innovations; they were even considered timeless. A shift occurred in the mid 19th century as signaled by the exploration of rural life by antiquarians and others who sought a life beyond the urban, industrial one.
Later studies of the vernacular landscape involved archaeologists, geographers, and social historians, who brought to light the fact that the vernacular building was not timeless but had a history of its own, different from formal architecture yet shaped by ancient archetypes. The vernacular building, they argued, had undergone a long and complex evolution. During colonial times, the American vernacular dwelling, in both rural and urban locations, was movable or even temporary and focused on the child-centered family. This vernacular dwelling has evolved over time to include utilities and other conveniences and an increased number of rooms. Jackson suggested that the American vernacular dwelling, although designed as a micro-environment, greatly depends on the community. The vernacular dwelling is a source of services rather than a political entity. It has evolved in the suburbs, company or college towns, trailer parks, resort areas, and condominium complexes.

This second example describes two elements of the vernacular landscape of the Chiga community of southwest Uganda. The Chiga are mostly subsistence farmers who are increasingly focusing their energies on producing food for sale in produce markets surrounding their locale.

The Chiga landscape is characterized by rugged hills and steep-sided valleys cut deep by occasional streams and swamps. During the rainy season, the swamps flood and cut off entire areas from access to produce markets for extended periods of time. Individual villages build bridges, which provide access across the swamp at its shallowest points. The bridges are unlike conventional bridges as commonly understood. Instead, they appear like an unsurfaced or dirt road with concrete pillars on either side. The pillars are about 3 ft. (feet) wide, erected upright to about waist height and about 12 to 15 ft. apart. Beyond the concrete pillars are deep trenches designed to drain the water away from the bridge surface. At one end of the bridge is a barricade designed to stop vehicular traffic while allowing foot traffic across. The community collects a small bridge toll to help with maintenance costs. A sign just before the bridge proudly declares the “floating bridge” open to traffic and includes the name of the community that built it and sometimes the date the bridge was opened for use. The concept of the floating bridge reflects the fact that during the wet season, the swamp swells and covers the surface of the bridge, although one is always able to see the concrete pillars. Their portions above water appear to be floating and mark the limits of the hard surface of the bridge.

The hilly terrain with the steep-sided valleys makes it impossible to use mechanized farming techniques. Much of the land is cultivated by hand. The Chiga community is densely populated, and land parcels come in relatively small sizes. At a glance, the terrain has a terraced appearance, although terracing is not a technique that the Chiga employ. Instead, the land parcels are divided into horizontal layers as one travels downhill. The land has a patchwork appearance that comes from the various landowners making different land use decisions. Some fields lie fallow; some have crops that are browning as they near harvest season; and some have newly planted rows of sweet potato vines. Still other parcels appear forested as a result of having lost the fertile top soil to persistent soil erosion.

These two examples illustrate the ordinary nature of vernacular landscapes. They are lived in and created through a combination of conscious and unconscious processes. Vernacular landscapes are all around us and are undergoing transformation continuously. Studying them enables us to say something about the values, aspirations, tastes, fears, glories, and blemishes of the people who lived and continue to live in these vernacular landscapes.

Christine W. Mathenge

See also Architecture and Geography; Berkeley School; Cultural Geography; Cultural Landscape; Everyday Life, Geography and; Folk Culture and Geography; Jackson, John Brinckerhoff; Landscape Architecture; Landscape Interpretation; Meinig, Donald; Sauer, Carl

Further Readings

La Via Campesina has evolved as an international movement of poor peasants and small farmers from the global South and North. Initiated by Central, South, and North American peasant and farmers’ movements and European farmer’s groups, Via Campesina was formally launched in 1993 in Mons, Belgium. Existing transnational networks of activists located in peasant movements and nongovernmental funding agencies in the North facilitated the earlier contacts between key national peasant movements, most of which had emerged already in the 1980s. By 2008, Via Campesina represents more than 150 (sub)national rural social movement organizations from 56 countries in Latin America and the Caribbean, North America, (Western) Europe, Asia, and Africa. Since its birth, Via Campesina’s main agenda has been to defeat the forces of neoliberalism.

Transnational regional coalitions of agrarian movements have played a critical role in linking (sub)national movements together. The most organizationally robust and politically coherent regional alliances are those in Latin America and Europe. The most uneven, thin, and organizationally and politically fragile regional alliance is the one in Africa. There are no regional networks of Via Campesina in the Middle East and North African region, Central Asia, the USSR, or China. One of the earliest regional pillars of Via Campesina was the Central American peasant alliance ASOCODE (Asociación de Organizaciones Campesinas Centro Americanas para la Cooperación y el Desarrollo), which was at its peak in the 1990s.

The entry of Via Campesina into the global governance scene has altered the international civil society terrain in many significant ways. For one, it has ended the monopoly of the International Federation of Agricultural Producers (IFAP) in terms of representing the farming sector in international governance processes. Founded in 1946, IFAP is an international farmer’s federation of generally medium to rich farmers. Via Campesina’s entry provided a distinct representation for poor peasants and small farmers. Moreover, Via Campesina’s entry into the global scene ended the monopoly of nongovernmental organizations (NGOs) in representing “civil society” in various state and nonstate fora. Via Campesina is distinct in the sense that it is a movement that directly represents (sub)national organizations of poor peasants and small farmers in contrast to the intermediary role of NGOs.

Many of the national movements that are leading members of Via Campesina have engaged in dramatic anticorporate actions, such as bulldozing a McDonald’s fast-food shop in France, burning a Kentucky Fried Chicken outlet in Bengaluru, India, and uprooting a genetically modified (GM) soya farm and a eucalyptus nursery in Brazil, among others. The protest suicide of Lee Kyang Hae, a South Korean farmer, during the Cancún World Trade Organization (WTO) negotiations was another form of dramatic action.

Via Campesina’s political work focuses on seven issues:

1. Agrarian reform
2. Biodiversity and genetic resources
3. Food sovereignty and trade
4. Women
5. Human rights
6. Migrations and rural workers
7. Sustainable peasant agriculture

However, actual global campaigns have been highly uneven between these issues.

The campaigns against GM crops and the WTO are perhaps the most high profile among all Via Campesina’s campaigns. Their campaign against GM crops is anchored by several high-profile national initiatives, especially in France (by the Confederation of French Farmers, led by José Bové), India (by the Karnataka State Farmers’ Association, led by M. S. Nanjundaswamy, who died in early 2004), and Brazil (by the Movimento dos Trabalhadores Rurais sem Terra or MST, led by João Stedile). This campaign is framed within anticorporate monopoly and antimonocropping practice perspectives. Meanwhile,
the anti-WTO campaign put Via Campesina in the global media spotlight from Seattle to Cancún to Hong Kong. Via Campesina was perhaps the most consistent and organized transnational agrarian movement that opposed the WTO.

The global campaign on agrarian reform by Via Campesina perhaps comes far behind in terms of global projection and impact. This campaign was launched in 1999, together with two other transnational civil society networks—Foodfirst Information and Action Network and the Land Research and Action Network. It was primarily a campaign against the neoliberal land reform framed and promoted by the World Bank. This policy promotes a land reform that is voluntary and based on the willing seller/willing buyer principle. It has been carried out in various countries, including Colombia, Brazil, South Africa, and the Philippines. While Via Campesina has been able to push the World Bank to a defensive political position on this issue, the general impact of the campaign at the national level has been marginal; the same policy was expanded in Brazil, and it remains the main national legal framework for South African land reform.

Meanwhile, campaigns on human rights have been intermittent. It has been limited to occasional global “action alert” calls for specific human rights violations in different countries. However, the Via Campesina campaign for a universal “Peasants’ Charter” can also be located within human rights, especially since this issue is being addressed before the United Nations Commission on Human Rights. There are no significant initiatives in the other areas listed earlier. Finally, since the Bali conference on climate change in December 2007, Via Campesina has identified climate change as a key transnational campaign issue. The group has attempted to address agrofuels and the food price crisis that erupted in 2008 as part of its broader campaign. Whether or not Via Campesina will be able to develop the climate change issue as a master frame in its transnational political campaign remains to be seen.

Moreover, Via Campesina is a transnational movement that goes beyond engagement in “expose and oppose,” agitation-propaganda types of campaigns alone. Via Campesina is seriously engaged in developing concrete alternatives and proposals. The main framework for its “catch-all” alternative is the notion of food sovereignty—the right to produce, trade, and consume food within and near one’s territory. This alternative framework brings in several new key development issues that are related to geography, including the question of place or territory as well as scale. But it has also brought in old development questions, including rural-versus-urban, as well as industrial-versus-agricultural paradigms.

Saturnino M. Borras Jr.

See also Agricultural Biotechnology; International Environmental Movements; Movimento Sem Terra; Neoliberalism; Nongovernmental Organizations (NGOs); Peasants and Peasantry; World Trade Organization (WTO)

Further Readings


VIDAL DE LA BLACHE, PAUL (1845–1918)

Paul Vidal de la Blache is an important figure in the history of geography. Born in the village of Pezenas in the south of France in 1845, educated at the Lycée Charlemagne and the prestigious École Normale Supérieure in Paris, Vidal took the lead in establishing a French school of geography at the turn of the 20th century that became world renowned for its holistic study of landscape. Vidal held positions at the University of Nancy (1872–1877) and the École Normale
Supérieure (1877–1898), and was chair of geography at the Université de Paris, Sorbonne, from 1898 until his retirement in 1909.

Throughout his career, Vidal sought to establish geography as an explanatory science instead of the descriptive, almanac-style fact-finding exercise that most geographers of his time practiced. Having been thoroughly schooled in history, he also emphasized the human aspects of geographical study at a time when geographers usually paid singular attention to the physical environment. Vidal emphasized that existing geographical landscapes are the result of a combination of human and natural processes. As he put it, landscapes should be considered like “medallions,” forged with the image of the social ways of life they include. Nature does not determine social behavior, and social behavior does not fully dominate nature. Rather, social behavior adapts to nature’s constraints and opportunities in the production of what some now call social-nature. In geography, this became known as possibilism.

The scientific task of geography is thus to explain how the various landscapes that geographers observe actually evolved as a result of the different ways in which humans adapted to nature in different times and places. To study these various modes of life (genres de vie) in turn necessitates a holistic approach, including both social and natural science. To Vidal, this was precisely the synthesis that geography as a discipline should achieve, thereby distinguishing it from the more analytic disciplines of either society or nature.

To establish this new scientific geography, Vidal helped found a new research journal, Annales de Géographie, in 1891. This journal promoted holistic, interdisciplinary research on geographical landscapes and was dominated by the Vidalian approach, as was French geography until World War I. While critics questioned whether the notion of genres de vie could be used in the study of more urban, industrialized landscapes, Vidal’s approach was instrumental in the formation of the now famous French Annales School of History, influential for its equally holistic emphasis on the longue durée of human-environmental adaptation in the course of history. Indeed, because most French geographers refused to engage in the disciplinary turf battles at the turn of the 20th century, la tradition vidalienne was largely relinquished to historians (as well as Durkheimian sociologists). As a result, soon after Vidal, French geography largely lost its focus and prominence both in France and elsewhere, and his role in the formation of these more successful disciplines is largely ignored.

Kevin Archer

See also Annales School; Cultural Geography; Febvre, Lucien

Further Readings

Video games have only recently attracted attention from human geographers. Unlike other forms of popular media such as cinema, literature, or television, video games offer a highly interactive and experiential virtual world. It is this “worldhood” or “spatiality” that is an attractive and fertile research ground for geographers. Embedded within each video game is a particular world that the player is able to manipulate and explore. These worlds can be realistic or a complete fantasy, as in many role-playing games. A virtual world or space is often necessary to limit and frame the activities possible within a game. For example, it would be difficult to program or code for a game in which absolutely anything were possible. In this sense, video games are particular milieus of activity, often highly repetitive. A productive engagement with video games would elicit not only important textual, social, and political themes but also how the virtual worlds within video games are constructed, including the types of freedoms and choices they offer to the player, as well as the “perspective” used (such as third person of first person).
The history of video games goes back to the flight simulators widely used during World War II. In 1962, the very first video game, “Spacewar,” appeared. When Atari released the classic coin-operated Pong in 1972, video games started to become enormously popular. The introduction of the personal computer in the 1980s greatly enlarged the market for games played on machines such as the Atari 400 and the Commodore 64 and, later, Nintendo and Sega. Sony’s PlayStation took this industry to a new level. By the late 1990s, Web-based games allowed for the creation of massively multiplayer online role-playing games, such as “World of Warcraft,” connecting millions of players worldwide via the Internet.

The video games industry is lucrative and expanding at an unprecedented rate. Two thirds of U.S. households play them regularly. In terms of annual sales, it now rivals the Hollywood film industry. Indeed, in recent years the mainstream status of video games has been confirmed with huge releases such as the highly anticipated and critically acclaimed “Grand Theft Auto IV.” During the first week of its April 2008 launch, the game grossed more than $500 million, smashing all previous video game and Hollywood records. Competitive video game events, once limited to a few networked computers in a basement, are now international events, such as the World Cyber Games. More surprising is that the average age of a video game player is currently 35 years, and she or he has been playing for more than 12 years according to the Entertainment Software Association.

The geography of the video game industry is an interesting and hybrid one, with the main centers of design and programming situated in North America, Japan, and Western Europe. This triregional structuring of the industry often leads to hegemonic representations but can also lead to blurred cultural and national identities. In the case of the former, video games that depict “wars” often do so from a narrow and single perspective. Games such as the hugely popular “Call of Duty” can be criticized for depicting simplified and racist enemies and allies. The hypersexual and hyperviolent content of video games is also a perennial source of controversy, although there is no clear consensus in the psychology literature on the impact that video games have on players. In this sense, video games are sites of ongoing culture wars. Yet despite these overcoded representations, there is always the possibility of experimentation within video games. Online games such as “World of Warcraft” allow users to “perform” alternate gender identities. In summary then, video games allow players to interact in virtual worlds that “spatialize” the social, political, and sexual dimensions we find in everyday life.

Ian Graham Ronald Shaw

See also Cyberspace; Media and Geography; Virtual and Immersive Environments; Virtual Geographies

Further Readings


Viewshed analysis, a form of visibility analysis that identifies visibility between points in a landscape, emerged as a geographic field several decades ago. Recent advances in software and computing power enabled viewshed analysis to become a common form of geographical analysis, and it is now a standard tool in many geographic
information systems, enabling viewshed analysis to be used in a range of fields. The following entry discusses the techniques used to calculate and analyze viewsheds as well as the applications of viewshed analysis.

Viewshed analysis is typically conducted as a raster-based operation in a GIS. It begins with the calculation of a viewshed, a two-dimensional (2D) projection of a view, using one of many algorithms (see DeFloriani & Magillo, 2003). The viewshed procedure identifies landscape areas that are visible from a given location based on elevations from a digital terrain model (e.g., digital elevation model, triangulated irregular network) and accounting for that location’s height and position, the view angle, and, frequently, a viewer height offset or maximum-view radius. Locations that connect to the observation location by a line-of-sight are identified as visible and part of the observation location’s viewshed, while all other locations are not. The resulting viewshed thus approximates the view from a given location (Figure 1).

The structure of calculated viewsheds is analyzed using metrics that quantify viewshed characteristics. Numerous viewshed metrics exist and include measures of size, complexity, and relief as well as the visual prominence of landscape features of interest. Viewsheds for an observation point may be calculated under different land use scenarios and their metrics compared to assess
the impacts of proposed land use changes on scenic quality. Viewsheds may also be visualized and compared in three dimensions using 3D modeling techniques.

A variety of fields use viewshed analysis. In planning, it is often used to identify the potential scenic impact of proposed landscape changes (e.g., van der Horst, 2006). Viewshed analysis is also used to identify the economic values of different view types using economic valuation techniques (e.g., Bastian, Reiners, Blasko, McLeod, & Germino, 2002). Additionally, archaeologists employ viewshed analysis to reconstruct past landscapes or cultural interactions (e.g., Lake & Woodman, 2003).

Heather Sander

See also Digital Terrain Model; GIS in Archaeology; GIS in Urban Planning; Land Use Planning; Terrain Analysis; Three-Dimensional Data Models; Triangulated Irregular Network (TIN) Data Model

Further Readings


Virilio, Paul (1932– )

An important, if little understood, theorist of social and spatial change is Paul Virilio—the so-called high priest of speed, a planner, a historian of technology, a photographer, and a philosopher of architecture and cinema. Other than military service, his formal education included the study of art at the École des Métiers d’Art as well as phenomenology at the Sorbonne.

Impressed by the events of World War II, Virilio’s work is grounded in the practices of the military, and he regards the culture of speed as driven primarily by its needs, whose conquest of the tyranny of distance extends repeatedly into civilian life. Virilio takes as his point of departure the intersections of military technology and the experience of speed, underscoring the machinic qualities of time and space as they are produced and conceptualized through his central concern, war. Thus, the state is essentially a machine to wage war, exhibiting a logic quite different from the Marxist emphasis on capital accumulation; in Virilio’s reading, the state is a “means of destruction,” not a means of production. For him, geography is a product of warfare because the preparation for and engagement in military conflict, including things such as logistics, intelligence, and the speeds of military machinery and rockets, are the fundamental bases of territorial organization. Space here is reduced to little more than a theater of war, and the state is simply a machine for waging it. Steady improvements in the ability to wage war are thus instrumental in developing the ability to bind together ever-larger units of space and time. Not capital accumulation but the dynamics of military conquest are the driving force behind the historical rounds of time-space compression. Space and time are the products of speed as it emanates from the prerequisites of warfare. Thus, Virilio asserts that

War and the preparation for it produce the space-time of human experience as a function of projectile speeds, logistical rates of transport, or intelligence insight gathering. The territorial organization of space into human settlements and political units of authority, from the earliest human village settlements to medieval city-states, modern nation-states and world-wide empires, reveals a constant tendency: they express different orders of military power, knowledge and technological organization. (1995, p. 365)

Telecommunications also figure centrally in Virilio’s worldview, in which digital technologies
produced a world in which information is speed and duration is nonexistent. Virilio maintains,

Speed enables you to see. It does not simply allow you to arrive at your destination more quickly, rather it enables you to see and foresee. . . . Speed changes the world vision. In the nineteenth century, with photography and cinema, world vision became “objective.” . . . It can be said that today, vision is becoming “teleobjective.” That is to say that television and multimedia are collapsing the close shots of time and space as a photograph collapses the horizon in the telephotographic lens. (qtd. in Redhead, 2004, p. 45)

The tyranny of constant speed leads to alienated, stressed-out, exhausted citizens who populate the virtual geographies of the space of flows; distorts human perception; sterilizes communications; forces a colonialism of daily life by machines; and generates a mindless automation that robs people of their humanity in a hypermotorized, digitized world. Virilio asserts that time-space compression has become sufficiently complete so that the struggle for space—geopolitics—has been displaced by chronopolitics, the struggle for time. In Virilio’s view, postmodern capitalism has created such enormous time-space compression that “distinctions of here and there no longer mean anything” (1991, p. 13) Despite the hyperbole, Virilio’s insights are useful in understanding that speed and velocity are not simply technical issues but profoundly cultural and political ones as well.

Barney Warf

See also Telecommunications and Geography; Time-Space Compression

Further Readings


VIRTUAL AND IMMERSIVE ENVIRONMENTS

A virtual environment is a setting that is not real but includes real traits with which people can identify. The contents may reflect pure imagination or may model the real world. The environment becomes immersive when users are no longer observers but participants in the setting that is depicted, in some cases becoming actors in a larger drama. This entry describes the nature of some of the most popular virtual environments, such as *Second Life*, and explores their significance for geography.

Virtual settings or environments have long been a part of the human experience, as exemplified by prehistoric cave paintings, the utopic “Garden of Eden” and “New Jerusalem,” Homer’s *Odyssey*, and the Greek and Roman “Golden Age” myths. Today, people lose themselves in the elaborate landscapes of movies, plays, and novels. And of course, there is the ever-present video game—the ultimate “out-of-body” experience for devotees. Geographers create their own virtual settings in the forms of maps, geographic information systems, and three-dimensional (3D) flythroughs.

Perhaps the most elaborate virtual environment is the virtual world, which emphasizes participant immersion and community engagement. While that books, movies, and plays invite the reader or viewer to step into imagined worlds, as do 3D renderings of landscapes, these types of immersion lack the “authenticity” of the virtual worlds that began to appear in the mid 1990s. Thanks to improving computer technologies (particularly in
gaming), and to the development of social networking and 3D Internet technologies, 21st-century virtual worlds are fully contained immersive environments in which participants not only imagine their involvement but are actually involved. Modern virtual worlds contain communities of people who interact in settings that are networked, persistent, synchronous, immersive, and, above all, 3D. Participants enter these worlds as extensions of, or alternatives to, the real worlds that they inhabit and the real lives that they lead.

The new virtual worlds are here to stay. The Gartner research group predicted in 2007 that by the end of 2011, 80% of active Internet users (and Fortune 500 companies) will have some sort of 3D presence. Other observers have commented that virtual worlds will soon be pervasive interfaces for the Internet, using multiple entry and exit points, and that “metaverse browsers” will connect participants to multiple worlds. According to Wade Roush, the user may encounter an “interverse” connecting various “intra-verses.” In brief, virtual worlds offer the potential of redefining the communications landscape very much like the World Wide Web did in the mid 1990s.

The Nature of Virtual Worlds

The casual observer can be forgiven for his or her confusion over the multiplicity of terms associated with virtual worlds—for example, “synthetic” worlds, MMORPGs (massively multiplayer online role-playing game), MUGs (multi-user game), and, direct from Neal Stephenson’s 1992 Cyberpunk classic *Snow Crash*, the “Metaverse.” To some degree, they all refer to the same phenomenon. The commercial manifestations of these worlds include *There.com*, *Entropia*, *Active Worlds*, *Sims Online*, *Kaneva*, *Google Lively*, *Wonderland*, *Croquet*, and the increasingly popular (and occasionally infamous) *Second Life*. These platforms are not intended as games. There are no contest rules and no winners or losers. Instead, participants enter these worlds in search of friendships, to interact with professional colleagues, to establish businesses, to create organizations, and, in some rare cases, to earn large amounts of real money.

*Second Life* has monopolized recent press coverage and is the industry leader in terms of money generated, number of “residents” (more than 14.6 million as of this writing), and graphics sophistication. At the heart of *Second Life* is the resident or character, called an *avatar*. Avatars can be modified in an almost infinite number of ways, including by race, gender, age, hairstyle, body mass, and even fashion sense. Some participants create avatars that are extensions of themselves—that is, to augment their true lives—while others construct new and (sometimes radically) different identities. Many participants generate multiple avatars to adopt different identity profiles for different occasions. In some cases, avatar creation is an attempt at therapy, as with the person confined to a wheelchair in real life who creates a walking character. Once in *Second Life*, residents may convert dollars into lindens, the *Second Life* currency, to buy clothing, new skins and shapes for their avatars, real estate, furnishings, and entertainment. Participants inside this virtual world interact with each other very much like they do in the real world, except that knowing who is really behind the wheel may be a mystery.

The geography of *Second Life* is complex and at times chaotic. The basic unit is the island or “sim” (as in “simulation”), which is a 256-m (meter) by 256-m grid embracing about 16 acres. Some of these units have been clustered to create corporate-controlled continents, of which there are perhaps half a dozen. The 21,973 islands (as of July 2008) are normally privately controlled. Islands and continents are placed to accommodate computer server needs, rather than natural processes, and are spaced in a very predictable gridlike sequence. This lack of regard for natural landform creation processes will cause consternation among geographers and geologists who look at the systemwide map. At the local level, however, terrain can be shaped to create mountains, shorelines, water courses, and so on, which, if done correctly, creates greater authenticity. Residents buy or rent real estate on these lands. Since there are no meaningful land use controls on the continents, they tend to be cluttered with garish builds that give the landscape a cartoonish quality. Private island covenants, on the other hand, prevent some of these excesses.

Three-dimensional social worlds such as *Second Life* are not without problems. Some users lament the complexity involved in learning how to
engage a virtual world, and almost everybody complains about platform stability. Avatars, as of this writing, do not show meaningful human expressions unless complex scripting is used. The social side of *Second Life* can be X-rated and off-putting to residents who stumble into the wrong location. *Second Life* is a user-created world with few rules.

Virtual worlds, and particularly *Second Life*, are increasingly being used by universities as meeting places and as a way of extending the university’s global reach. In addition, some of the most beautifully constructed settings in *Second Life* are campuses, as illustrated by the University of Ohio and Vassar College sites. At Vassar, part of the Sistine Chapel has been meticulously re-created.

**The Meaning of Geography**

Virtual environments have long been the subjects of geographical inquiry, although relatively little work has been done on modern virtual worlds. It has been understood for some time, however, that once the technology matures, virtual worlds will become very much a part of the geographer’s milieu (see the special edition on cyberspace of *The Geographical Review*, 1997).

Virtual worlds will not lead to the “collapse” of geography, as observers such as Cory Ondrejka have argued. They may, however, lead to the collapse of distance. In most virtual worlds, people can teleport from one location to another; in *Second Life*, residents can fly as well as teleport. Traditional distance-related location factors may no longer pertain, except at the local level, as people no longer need to accommodate the friction of distance in a world of instant transport.

Place, on the other hand, still exists. Indeed, the central purpose of the virtual world is to construct a place in which participants can create a shared sense of presence (albeit in avatar form). Participants may be scattered across the world, but they can be within speaking distance of each other to join in a meeting, to engage in friendly chatter, or to have a night out on the town. Furthermore, as in the real world, places may be distinguishable by culture group, nationality, lifestyle choice, and personal interests—note, for example, the Amsterdam, Copenhagen, and Zurich locations. Other places provide nonthreatening and anonymous spaces for groups that may have relatively few such options in the real world; this advantage has been noted by some members of the gay community. Finally, a virtual world offers nearly unlimited opportunities for geographers (and others) who want to provide 3D physical and social modeling of places.

*Merrill Johnson*

**See also** Cyberspace; Video Games, Geography and; Virtual Geographies

**Further Readings**

Virtual geographies are a broad area of research within geography and geographic information science that seeks to understand how new digital technologies and modes of communication are creating new notions of space and place. Among those areas of interest are the creation and exploration of virtual environments, including virtual worlds, cyberspace, and cybergeographies, and notions of other invisible social spaces. As the Internet, the World Wide Web, and other communication technologies continue to expand their roles in everyday lives, the study of the virtual geographies of evolving digital society will become an even more important component of the discipline. Understanding the virtual geographies they create, whether they be virtual worlds we inhabit through our avatars, the rapidly changing invisible landscape of cyberspace, or the virtual spaces of social interaction, will become an increasingly important aspect of understanding geography itself.

Perhaps the most recognizable of virtual geographies are digital reconstructions of landscapes, whether real or imagined. Recent advances in affordable graphics technologies are now moving far beyond the static two-dimensional paper map and providing researchers with the tools to not only generate nearly photo-realistic three-dimensional virtual landscape environments but also incorporate realistic light and textures as well as replicate physical systems such as cloud and water movement, fog, and weather. Computer and video games now routinely feature extensive virtual worlds with recognizable geography and real-world behaviors, and the ability to achieve a high level of realism is a key element in the commercial success of such games.

Creating a sense of immersion through the generation of such lifelike virtual landscape features, combined with camera perspectives and navigation that mimic human perceptions of movement through space, is a key element in generating the sense of immersion and interaction that allows users to feel as if they are experiencing a virtual landscape. To further enhance the sense of immersion within the virtual world, many researchers are turning their attention to developing tools and mechanisms for conveying other sensory aspects that imbue a location with a sense of place, such as sound and even smell.

Until recently, much of the work in the development of virtual landscape reconstructions was focused on individual virtual-world projects, but the rapid adoption of Internet technology has spurred the development of online virtual worlds such as Linden Lab’s Second Life (http://secondlife.com). These new collaborative virtual worlds are beginning to demonstrate the power of such environments for the generation and shared exploration of digitally re-created spaces and places. These virtual worlds, based on either real-world or fantasy landscapes, provide users a familiar way in which to interact with a digital landscape, as they move and interact with virtual elements through an avatar, a virtual self. In addition, activities in many virtual worlds such as Second Life are centered on building spaces and places within the virtual platform, creating new virtual geographies that do not necessarily have direct analogs within the real physical world. However, the geographic principles that seek to explain how humans shape and interact with space and place are clearly visible within these virtual geographies.

In addition to the virtual geographies represented within virtual worlds, the development of networks to connect computers has also led to the development of virtual geographies that represent the spatial structures of those networks. Often referred to as cyberspace, a term coined by William Gibson to describe the invisible spaces that represent the connectivity among computers, the virtual spaces of the Internet and the World Wide Web have their own spatial relationships and structures. Several geographers interested in attempting to identify and understand how these spaces are formed and evolve began a research initiative in 1996 with an emphasis on mapping and measuring the spatial aspects of cyberspaces, which was dubbed cybergeography. These efforts have focused on attempting to graphically illustrate the invisible structure of the Internet and the World Wide Web, from maps of Internet traffic to data flows and even the paths navigated through individual Web sites. The rapid rise in popularity of Web-mapping applications such as Google Maps, which allow users to map their
own data onto free base geographic data layers, has also spurred the development of new spatially oriented virtual communities and social networking sites that are creating their own virtual geographies. As these technologies migrate to mobile platforms, they are changing the ways in which people inhabit physical and virtual spaces and redefining how they form a sense of place.

The increasing focus on the exploration of virtual spaces created by these new technologies has also broadened to include other notions of invisible spaces, such as the virtual geographies of human social behavior and how they are being shaped by new communication technologies. For example, recent work has looked at wide-ranging topics such as the virtual geographies of Internet commerce (e-commerce) and virtual geographies of the body and self.

Susan Bergeron

See also Cyberspace; Neogeography; Video Games, Geography and; Virtual and Immersive Environments

Further Readings


VIRTUAL GLOBES

A virtual globe is a computer software that allows interaction with a three-dimensional (3D) representation of Earth or another world. Virtual globes belong to a group of applications collectively termed geobrowsers, which include modern Web-based dynamic maps. Geobrowsers are a key component in the development of “neogeography” as they provide a medium through which users can organize, search, and visualize information according to geospatial parameters. Virtual-globe technology has been available for over a decade but entered mainstream consciousness only with the release of Google Earth in 2005. The subsequent popularity of this software has inspired a rapid evolution in the features and capabilities of many virtual globes. This entry provides an overview of their history and popularization, describes the different types of virtual globes, and discusses their evolving capacity to create and display geospatial data.

History and Popularization

The creation of virtual globes is the result of 3D software, virtual reality and hypermedia, and remote-sensing technology developments that have been ongoing since the 1970s. It was Neal Stephenson’s 1992 novel, Snow Crash, that popularized the concept of a computerized globe showing dynamic imagery and inspired the initial real-life development of such programs. In Snow Crash, the primary protagonist accesses a software program called “Earth” that was created by the Central Intelligence Corporation as a user interface to their geospatial information, including weather data and real-time satellite surveillance. This “live” virtual globe presents greater capabilities than current real-world programs; however, virtual-globe technologies are developing increasing abilities to display dynamic data.

Inspired by Snow Crash, Mark Pesce, a co-creator of Virtual Reality Modeling Language (VRML), developed WebEarth, an open-source VRML application that builds a model of the Earth from composite satellite images. The first commercially available virtual globe to display dynamically updated earth data (clouds) was EarthBrowser. It was originally released in 1998 as a Macintosh shareware product called Planet Earth and continues to be developed by its creator, Matt Giger, for both Macintosh and Windows platforms.

An explosion of virtual-globe technologies occurred in 2001 with the development of Keyhole’s Earth Viewer (acquired by Google in 2004 and released in 2005 as Google Earth), Skyline-Globe, SINTEF (Norwegian: Stiftelsen for industriell og teknisk forskning [The Foundation for
Scientific and Industrial Research) (Norkart since 2006) virtual globe, and Geofusion’s GeoPlayer. However, it was the release of the open-source project NASA World Wind (2004), followed by Google Earth (2005), that brought virtual globes to the attention of a wider audience. In 2005, the use of these tools to aid rescue and relief efforts related to Hurricane Katrina received media coverage demonstrating the abilities offered by virtual globes, and their day-to-day use entered the public consciousness. By June 2008, downloads of Google Earth, the most widely used virtual globe, had topped 400 million.

Both NASA World Wind and Google Earth were developed as stand-alone applications. In contrast, Microsoft leveraged existing server and mapping technologies to create its Virtual Earth platform. It powers Live Search Maps inside an Internet browser. Released in 2005 as a 2D mapping product, it evolved into a globe application when 3D viewing capability was added in 2006. Unique to Virtual Earth is the inclusion of high-resolution aerial photography captured from a bird’s-eye perspective view.

Similar to Microsoft, ESRI (Environmental Systems Research Institute) developed globe technologies that complemented existing products. In 2003, they released ArcGlobe, a 3D analyst extension to ArcGIS 9. This was followed in 2006 by ESRI’s stand-alone globe, ArcGIS Explorer. Similar to most virtual globes, this is a free-to-download product, but its capabilities are greatly expanded when used in conjunction with ArcGIS server.

Currently, Google and Microsoft represent the leaders in virtual-globe technology with hundreds of millions of users, with World Wind and ESRI garnering tens of millions of users. Developments in mobile and multitouch technologies are leading to the next developments in virtual globes. New applications (e.g., Earthscape, developed using the iPhone Software Developer Kit), are making virtual globes accessible anywhere cell phone coverage can be found.

### Types of Virtual Globes

There are two primary types of virtual globes. One attempts to create a realistic mirror of the real world, while the other type is based on graphical representations of global information data sets. “Real-world” globes, such as NASA World Wind, Google Earth, ESRI ArcGIS Explorer Microsoft Virtual Earth, and SkylineGlobe, create a representation of Earth by tiling high-resolution satellite imagery and aerial photography over a digital elevation model of the underlying terrain. Both Google and Microsoft invest considerable time and effort into acquiring, processing, and serving high-resolution imagery. World Wind, an open-source community project, uses mostly public domain data sets such as Landsat 7 imagery and Shuttle Radar Topographic Mapping (SRTM) project terrain. Other real globes built on open-source virtual globes, for example, Ping’s 3Map (based on WebEarth), Dapple, and Punt (based on World Wind), also leverage the same data sources. Similarly, small development projects (e.g., EarthBrowser, Norkart Virtual Globe, and Poly9 FreeEarth) rely on public data sets and have a limited coverage of high-resolution imagery.

The second type of virtual globe provides a global representation of data sets with limited or no land cover imagery. These “specialized” globes are representations of social, economic, infrastructure, or environmental data (e.g., Global-i). A common application for these globes is weather visualization (e.g., Software MacKiev’s 3-D Weather Globe & Atlas). The key requirement for these globes is the ability to update data dynamically—a feature that is also used within integrated data layers in “real-world” globes, for example, the Google Earth weather layer.

### Geospatial Content

The ability of virtual globes to display dynamic content makes them more than just a Web-based map or simple satellite image representation of the world. Most virtual globes provide integrated “layers” of content both static (e.g., political borders) and dynamic (e.g., clouds) in nature. They also allow users to add their own geospatial data. The standard that emerged to create content for virtual globes is an object-oriented extensible markup language, Keyhole Markup Language (KML). Originally developed by Keyhole and then Google, after their purchase of Keyhole, Inc., in 2007, KML was submitted to the Open Geospatial Consortium to become an
open standard. It was officially accepted as an international standard on April 14, 2008. Through KML, developers, scientists, educators, and anyone with georeferenced information have the ability to create informative visualizations and display them within a range of virtual globes and other geobrowsers.

John E. Bailey

See also GIS Software; Google Earth; Neogeography; Open Geospatial Consortium (OGC); Three-Dimensional Data Models; Virtual and Immersive Environments

Further Readings


VISION AND GEOGRAPHY

Vision has been a topic of much interest not only for geographers but also for philosophers, painters, photographers, filmmakers, art historians, and cultural theorists. Since vision is studied and understood differently by a variety of people, it should not be expected that its theoretical and material impacts could be experienced in a similar vein. Vision has long been a concern for ontology (the study of existence), epistemology (the theory of knowledge and its production), and methodology.

Modern Western society has held vision as the paramount sense called on to produce knowledge, suggesting that seeing means knowing. Geography has a long-standing relationship with visual culture and has often been called a visual discipline. The link between vision and order, classification, and description has heavily influenced geographic thought. Throughout the late 19th and part of the 20th centuries, geographers were expected to describe, understand, and represent the world through maps or words completely and objectively. Geographers relied heavily on their senses, predominantly vision, to draw empirical or experience-based conclusions. Today, vision continues to dominate contemporary geographic research. However, in the past few decades, much work has been done by geographers and others concerned with the visual to recognize that vision cannot be taken as given. Ways of seeing, imagining, and representing what is seen are now understood to be the effect of specific social and technological circumstances.

Geographers approach the spatiality of vision in exciting and innovative ways. Contemporary human geographers have explored social practices that construct visuality, examined images that give shape to geographical imaginations, and engaged with various technologies of vision that design ways of seeing. They examine and produce meaning through map making and geographic information systems imagery by reading landscapes as visual texts and by investigating representations of space in a variety of media, such as painting, photography, and film. In the past 30 years, geographers have become increasingly concerned with representations of space within the visual field. Denis Cosgrove greatly influenced the way geography approaches the visual. He engaged with cultural landscapes not as passive objects but as sites where power relations, gender roles, national identity, political ideologies, and other social processes are actively produced. His scholarship pursued a new line of inquiry and methodology within human geography. Stephen Daniels and Denis Cosgrove, among others, began to apply iconography (a critical reading of imagery to explore cultural values) to interpret images as socially, historically, and spatially contingent texts. Images are now understood not simply as mimetic evidence of objective, stable, and complete realities.
but as powerful tools that actively construct the geographic imagination.

Technology plays a critical role in producing new ways of seeing. Technological advances in image capture, such as photography and film, engineer space and reality in meaningful ways. For example, with the advancement of aerospace engineering, images of Earth were taken that captured our planet in its entirety, representing Earth as being within the control of humans and our technologies and thus playing a powerful role in furthering political imaginations and geocultural agendas.

To address questions related to the ontologically stable world images present, many geographers have drawn on poststructuralist thought. Poststructuralist theory advocates that what is understood as material reality is a pieced-together fiction that is fragmented, partial, and multiple. Theorists such as Michel Foucault and Jacques Lacan have been instrumental in conceptualizing vision, visuality, and the function of the gaze for the modern subject. Vision is understood as what the human eye is capable of seeing within the visible portion of the electromagnetic spectrum. Visuality is broadly understood as socially produced and perspectival. Visuality is a process that is historically, spatially, and technologically contingent. The concept of the gaze is integrally connected to vision and visuality. Michel Foucault’s understanding of the relationship between the gaze and subjectivity has been highly influential in geography and the social sciences more broadly. Foucault argues that the modern subject internalizes the panoptic gaze and is under perpetual surveillance both by himself or herself and by others. This understanding of the gaze renders the modern subject as fully visible, trackable, and governable. The psychoanalytic theorist Jacques Lacan’s notion of the gaze is distinct from the act of looking—the eye and the gaze are split from one another. The gaze itself is the object of looking and does not belong to the subject but rather to the object, such as a painting or a film. Lacan’s theorizations of the gaze were taken up by psychoanalytic film criticism in the 1970s. The so-called Lacanian film theory is the site of much theoretical confusion and is being rearticulated by many scholars advancing a more rigorous understanding of the Lacanian gaze.

Geographers are engaged with the visual in a variety of contexts. Gillian Rose dedicated much attention to the relationship between geography and the visual. She examined how geographical knowledge within academia is constructed, packaged, and presented through visual tools such as PowerPoint slides, questioning a neat presentation of images on a slide that portrays knowledge as being spatially captured, stable, and whole. Marcus Doel and David Clarke have written on the ways by which the visual is constructed in film by film and in particular how montage, the assemblage of parts, is central to the relationship of human geographers to the visual. Increased research has been initiated on how to produce new ways of seeing through geographic information systems (GIS) and what representational practices are embedded in this powerful visual technology. Chris Lukinbeal is advancing research on analyzing the visual products generated by GIS. He explores how these technologies are put to work in the academy and in broader social contexts. Also, through critical map reading, geographers have produced insightful scholarship on how maps play a role in the construction of tourist spaces and consumer identities. Many geographers are moving toward a geography that does not rely so heavily on the visual and accesses other senses for knowledge production. However, because of geography’s deep roots within the visual field, it is still robust terrain for geographical inquiry.

Nazanin Naraghi

See also Cosgrove, Denis; Media and Geography; Photography, Geography and; Rose, Gillian; Television and Geography

Further Readings


**Volcanic Eruptions as Risk and Hazard**

Volcanoes are a principal agent of degassing of the interior of the Earth and other planets. They are thought to be the main source of the Earth’s atmosphere and hydrosphere, and thus they are a vital part of the sustainable Earth system. Volcanic activity has provided the air we breathe and the water that makes up most of our body mass. Volcanism also provides vital enrichment to the Earth’s soils, particularly in tropical areas. In spite of the long-term benefits, the effects of eruptions can be seriously negative in the short run, so volcanoes can be considered a type of natural hazard that threatens life and property.

Among natural hazards, volcanoes have caused far fewer deaths and damage to property historically than have floods, coastal hazards, and earthquakes and so are considered hazards of local or minor rank by some people. The historic record may be misleading because it is brief compared with geologic time and because large eruptions occur too rarely to have been accurately assessed and understood. There are at least 1,500 volcanoes that are considered active in the world, and about 400 have erupted in the past century. Eruptions span at least eight orders of magnitude, ranging from erupted magma volumes of less than 10,000 m$^3$ (cubic meters) to more than 1,000 km$^3$ (cubic kilometers). But most eruptions are quite small in scale, and their hazards are generally quite localized to areas near the volcano. Larger eruptions are known to have global impact, but because of their statistical rarity, the scientific understanding of these events is very limited. Understanding of the largest eruptions (super-eruptions) is the most limited, but these possibly include worldwide loss of multiple growing seasons and huge global loss of life (volcanic winter).

The assessment of volcanic hazards begins with geologic maps, which record the distribution of past volcanic deposits that reflect past activity and the locations where hazardous events occurred, leading to hazard maps that cover the volcano environs, especially in areas downslope from active vents. Volcanic deposits are dated to assess the frequency and probability of hazards, and vulnerability is assessed through geographic information system population density maps and social science surveys. The topography of areas near volcanoes provides an important key to hazard zonations, because many types of volcanic hazards are governed by gravity and the damaging volcanic agents (lava flows, pyroclastic flows, mudflows, avalanches, debris flows) descend from high to low elevation following valleys. A useful tool in hazard work has been the development of numerical models of hazards, which can be applied to the individual topography to derive “objective” hazard maps. Completed hazard maps exist for only a small fraction of Earth’s active volcanoes. To accompany hazard maps, hazard reports are written in plain language for the public to explain the nature of hazards that occur during eruptions. These reports are used in local communities and especially schools. Where risk is high, additional measures for public education and outreach are undertaken, and zoning measures may be implemented.

Atmospheric hazards that result from eruptions are of special interest, because they typically extend farther from the volcano and may thus affect a broader area. Explosive eruptions create finely divided magma that transfers its heat rapidly to the air and rises to stratospheric height. Since many particles are so fine that they do not fall, they can be carried hundreds to thousands of kilometers before fallout. Ice nucleates on this fine ash and helps it grow and fall out. Stratospheric ash is a severe aircraft hazard, while fine ash fallout can occur on a continental scale in super-eruptions and is a deadly hazard to lungs. Ash fallout masses and particle sizes decrease
with distance for the first 100 kilometers or more, but distal fallout is governed by meteorological processes and may result in heavy fallout far from the volcano. Sulfur dioxide is a second hazardous material contributed by eruptions to the stratosphere. It reacts with the atmosphere and forms sulfuric acid, which exists as a liquid aerosol particle that stays in the stratosphere much longer (a few years) than ash (a few days) and can create stratospheric warming and surface cooling.

Although monitoring of volcanoes is likely to lead to successful forecasting of most eruptions, many volcanoes remain completely unmonitored because of insufficient funds. Many more have only very limited monitoring. New holistic assessments of volcanic threat that measure population distributions and hazards beyond the immediate vicinity of the volcano (especially those to aircraft) are now being employed to guide decisions about which volcanoes should have priority for monitoring in the public interest. Remote satellites are used to measure thermal anomalies, surface deformation, gas emission rates, and vegetation changes at volcanoes around the world to provide direct field information at unmonitored volcanoes. A worldwide alert system exists to integrate ground monitoring data and satellite observations in order to provide volcanic cloud hazard warnings to aircraft, which are especially vulnerable at night.

Many volcanoes are far from human population centers, but there are especially important volcanic hazard sites where active volcanoes occur near large cities (e.g., San Salvador, El Salvador; Guatemala City, Guatemala; Mexico City, Mexico; Quito, Ecuador; Naples, Italy; Auckland, New Zealand; San José, Costa Rica; Shimabara, Japan). The realization of the vulnerability of these cities to volcanic hazards has led to multidisciplinary hazard studies aimed at mitigation, which employ monitoring, public communication, and outreach.

William I. Rose
The spatial and temporal distribution of volcanism on Earth’s surface is associated with geodynamics. Volcanic morphology is related to physical properties and chemical composition of the magma governed by the tectonic setting as well as exogenous processes over geological time. Eruptive activity comprises phenomena that are potentially dangerous to humans and infrastructure. The negative effects of those phenomena, however, can be minimized with hazard evaluation studies and volcanic monitoring. In contrast, eruptive activity has generated some of the most fertile soils of our planet, geothermal energy is produced from the internal heat of volcanic systems, volcanic materials have constructive and industrial uses, and volcanic landscapes are tourist sites.

**Types of Eruptions**

Eruptions occur when the magma reaches the surface through a vent or crater. However, magma
also erupts through fissures on the flanks of a volcano or in flat areas. An initial classification of eruptions differentiates between effusive and explosive eruptions.

Effusive eruptions are characterized by emissions of lava. Eruptions of low-viscosity and high-temperature lavas produce pahoehoe morphological features. In contrast, aa lavas present a fragmented and rough morphology due to a relatively higher viscosity. With the increase in viscosity of lavas and decrease of temperature, domes may form. The accumulation of lavas over geological time generated shields, composite, and stratovolcanoes. The eruptions of Hawaiian volcanoes are typically effusive.

Explosive eruptions are produced by the sudden separation of volatiles from magma, fragmenting it and the surrounding rocks inside volcanic edifices. Volcanic explosions eject fragmented material known as tephra into the atmosphere by eruptive columns or produce pyroclastic flows sweeping the volcanoes’ flanks. Tephra includes various sizes of particles: block (>64 mm [millimeters]), lapilli (2–64 mm), and ash (<2 mm). Due to temperature contrasts with the atmosphere, it rises until it loses buoyancy and then travels under the influence of the wind and falls, mantling the landscape with a thickness from millimeters to meters. These deposits are called fall deposits. Based on the analysis of distribution, thickness, and chronostratigraphic studies of fall deposits, volcanologists infer the magnitude and development of an eruption. When an eruptive column collapses due to its high density, dense clouds of tephra flow down over the volcanoes slopes, forming pyroclastic flows. A pyroclastic flow consists of a hot mixture of fine and coarse fragments of rock, pumice, and gas, and its flow is controlled by the topography, moving fast along canyons or ravines until it stops and the material is deposited. According to the components, ash flows, pumice or scoria flows, and block and ash flows can be distinguished.

In some volcanoes, magma intrusion may produce partial collapse and a blast. Magma intrusions increase the pressure on the volcano’s flanks, provoking the partial collapse of the edifice and a sudden release of the lithostatic pressure over the magma body, producing a lateral blast. The sector collapse generates a debris avalanche whose distribution is not governed by the topography, covering large areas and traveling considerable distances. Its morphological features are characterized by conic mounds called hummocks.

The Volcanic Explosivity Index (VEI) describes the magnitude of explosive eruptions. VEI ranges from 0 to 8; each increase represents a factor of 10 in the volume of erupted material. Determination of an eruption’s VEI depends on the volume of erupted material, height of the column, and duration. The AD 79 eruption of Vesuvius (Italy), which destroyed Pompeii and Herculaneum, had a VEI of 5.

**Volcanic Morphology**

Volcanoes are endogenous features. Their shape and dimensions depend on geodynamic settings, magma production, and emission rates. According to morphology, they can be scoria (cinder) cones, domes, shield volcanoes, composite volcanoes, calderas, maar, tuff rings, and tuff cones.

Cinder cones are made of tephra falls that accumulate around the vent. They may grow on the flanks of shield volcanoes, composite volcanoes, and calderas. Cinder cones are born to constitute volcanic fields with eruptions lasting from days to years. An example is the birth of Paricutín volcano in Western Mexico in 1943; its eruption lasted 9 years, with social, economic, and ecological effects on the region.

The morphology of lava domes varies from dome shapes to pinnacles or spines. The domes may grow on the slopes or within the crater of composite volcanoes. As a dome grows, its surface cools, and partial collapses of it can generate pyroclastic flows. Domes can seal the conduit system, provoking the pressurization of the volcanic system and triggering explosive eruptions. The eruption of Mt. Pelee (Martinica Island) in 1902 resulted from dome growth.

Shield volcanoes owe their name to their similarity in shape with the old European warrior shields. They are built by the piling of successive lava flows erupted from a central vent or fissures on volcano’s flanks and are slightly convex, with gentle slopes and sometimes with a caldera or cinder cones on top. Mauna Loa (Hawaii) is
considered the largest and one of the most active volcanoes of Earth; its height from the ocean floor is approximately 10 km (kilometers). According to their basal diameter and height, shield volcanoes are classified as Hawaiian (Mauna Loa, Mauna Kea), Galapagos (Alcedo and Cerro Azul), Icelandic (Skjaldebreidiur and Skalarfell), or Mexican (Cerro Grande and Santa Clara).

Lavas and pyroclastic material make up composite or stratovolcanoes during their complex and large evolution. Symmetrical cones, steep slopes, and a crater at the summit are their morphological features. The magma rises from magmatic reservoirs through conduit systems to reach Earth’s surface. Eruptions at composite volcanoes generate lava domes, eruptive columns, and pyroclastic flows or undergo partial collapses. Mt. Fuji (Japan), Mt. Rainier (United States), Popocatépetl (Mexico), and Arenal (Costa Rica) are examples of active composite volcanoes. High-altitude or high-latitude volcanoes host glaciers at their summits. Interaction between volcanic activity and the presence of ice bodies may produce the debris flows or lahars that sweep the volcanoes slopes. Also, rainfall may remobilize loose tephra to form lahars.

A caldera is a negative morphological element with a circular to elongated concave shape of several kilometers. The origin of calderas is associated with major eruptions. Magma is erupted through vents and as the magmatic chamber is emptied, subsidence occurs and a depression is formed and lavas and pyroclastic flows are distributed over a considerable area. Voluminous pyroclastic flow deposits with a variable degree of consolidation are generated. Crater Lake (United States) with a diameter of 9 km was produced by
VOLCANOES

Mt. Mazama’s eruption in 6800 BC. Other calderas are Taupo (New Zealand), Santorini (Greece), and La Primavera (Mexico).

When magma encounters water bodies such as the sea, lakes, rivers, or aquifers during its ascent to the surface, explosive eruptions are generated. The temperature differences between magma and water suddenly produce steam. The resulting increase in volume fragments the magma and the surrounding rocks. Ejected material deposited in the proximity of the vent builds up tuff cones. A greater dispersion of ejected material forms tuff rings. A maar is a low-relief form, like a crater produced when explosions fragment the surrounding rock, leaving no deposits around. Maars are often filled with water and form small lakes.

Volcanic Hazards

Volcanic phenomena such as lava flows, tephra falls, pyroclastic flows, debris avalanches, lahars, gas emissions, earthquakes, and tsunamis are potentially dangerous to humans and the environment. Hazard evaluation and monitoring of active volcanoes or volcanic fields can reduce volcanic risk. Hazard evaluation includes the study of historical eruptions, characterization of eruptive activity through time, and analysis of volcanic deposits using stratigraphic, geochemical, geochronological, and geophysical criteria, allowing determination, with an acceptable degree of uncertainty, of the type, extent, and spatial distribution of volcanic products.

Monitoring networks for follow-up of volcanic seismicity, deformation, gas emission, and geochemical and hydrological changes, among others, provide valuable data for the forecast of eruptive processes and associated hazards over the course of an eruption.

Hazard evaluations and monitoring data are of great importance to decision makers for land use planning and protection of people who live under the threat of volcanic hazards.

Volcanic Areas as a Source of Natural Resources

Volcanic soils cover extensive areas around the Pacific, East African Rift Valley, the Canary Islands, and Azores and are considered among the world’s most fertile soils. Most areas covered by volcanic soils are at the same time exposed to volcanic hazards; however, hazards evaluation studies can reduce the potential risks to population and infrastructure. Ore deposits are associated with magmatic processes. Crushed lava, pumice, and scoria are the source for construction and industrial raw materials.

At some places, close-to-the-surface stagnant magma bodies heat groundwater, generating geothermal systems, which are used as hot mineral springs for bathing, cooking, or heating. Geothermal energy provides heat for 90% of the housing in Reykjavik (Iceland), and geothermal power plants generate electricity. The United States is the world’s largest producer of electricity from geothermal energy.

Volcanoes are among the most scenic landscapes around the world; these include Thinveling (Iceland), Teide Volcano (Canary Islands), Mt. Fuji, Unzen Volcano (Japan), Arenal Volcano (Costa Rica), Pacaya Volcano (Guatemala), Vesuvius Volcano and Pompeii (Italy), Villarica Volcano (Chile), Hawaii (United States), and so on. These tourist sites attract millions of visitors each year. The United Nations Educational, Scientific and Cultural Organization considers some volcanic areas as “geoheritage” sites. In addition, other geological or geomorphologic elements of nature are often worthy of being preserved, and they form part of geoparks, which are sites with geological, archaeological, ecological, and cultural significance. Geotourism, education, and sustainable development are the main components of the geoparks. Kawaninka Geopark in southwest Australia comprises volcanic cave systems, offshore volcanic island, dormant volcanoes, craters, lakes, and wetlands. Magma Geopark in southwest Norway consists of intrusive igneous rocks that crystallized 930 million years ago. Cultural history related to mineral exploitation and the rounded outcrops characterizes the landscape.

Patricia Julio-Miranda

See also Geothermal Energy; Geothermal Features; Plate Tectonics; Volcanic Eruptions as Risk and Hazard
**VORONOI DIAGRAMS**

The Voronoi diagram (also called a Dirichlet tessellation or a set of Thiessen polygons) is a partition of a metric space such that we associate all locations in that space with the closest object in that space, based on the specified metric. Thus, each object is the generator of a cell or tile, and the set of tiles covers the space or map.

In the simplest case, we are given a set of points $S$ in the Euclidean plane, which are the Voronoi generators. Each generator, $s$, has a Voronoi cell, $V(s)$, consisting of all points closer to $s$ than to any other generator. The cell boundaries of the Voronoi diagram are all the points in the plane that are equidistant to two generators, and the Voronoi nodes are the points equidistant to three (or more) generators. Voronoi cells can be defined for metrics other than Euclidean, such as the Manhattan distance, and for other surfaces than the plane, such as the sphere. Voronoi cells can also be defined by measuring distances to objects that are not points. The dual graph of the Voronoi diagram of $S$ corresponds to the Delaunay triangulation (DT) of $S$ (Figure 1). Here, all Voronoi edges have perpendicular Delaunay edges, and all Voronoi vertices are the centers of the circumcircles of the DT.

The idea of the Voronoi diagram is relevant in many spatial sciences, giving descriptions of proximity, adjacency, clustering, territoriality, and others. The DT is widely used as a stable and well-defined triangulation for terrain modeling. Informal use of Voronoi diagrams can be traced back to Descartes in 1644. The Voronoi diagram was used in 1854 by the British physician John Snow to show that the majority of people who died during the cholera epidemic in the Soho district of London lived closer to the contaminated pump at Broad Street than to any other source of water.

**Properties**

Given a set of service locations (e.g., post offices), the Voronoi diagram identifies the closest service to any particular location. The location furthest...
from any point in $S$ is one of the vertices of the Voronoi diagram of $S$. This has the largest possible empty circle within the map. This is equivalent to the triangle in the DT of $S$ with the largest circumcircle. Every triangle in the DT has an empty circumcircle. Equivalently, every edge in a DT has an empty circle touching the two ends. Given a set of $n$ points in $S$, the closest pair of points will be on an edge of the DT of $S$. Similarly, the nearest neighbor to each of a set of points will be defined by an edge of the DT of $S$. The Euclidean minimum spanning tree of a set of points $S$ is a graph without any cycles that connects all points in $S$ with a minimum total edge length. It is a subset of the edges of the DT of $S$. The DT is a planar graph. By Euler’s formula, it has at most $3n - 6$ edges and at most $2n - 5$ triangles. The convex hull of $S$ is a subset of the edges of the DT. The DT maximizes the minimum angle of each triangle by comparing it with its neighbors. This approach gives the fattest triangles possible for the set $S$ (Figure 2).

Voronoi diagram construction is “local”: Inserting a generator adds a new cell that was “stolen” from its neighbors. Thus, the Voronoi diagram and the resulting DT may be updated locally. If the set of points $S$ are on the boundary of a closed shape, then the medial axis transform (MAT), or skeleton, is a subset of the Voronoi edges (the Voronoi vertices have empty circumcircles). In three dimensions, many of the properties described above for two dimensions still apply.

**Applications**

Apart from geography, many disciplines use Voronoi diagrams, including: cosmology (e.g., galaxy clustering); biology, ecology, forestry, and zoology (e.g., plant and animal competition, tree crown areas); geology (e.g., ore reserves and simple mapping based on a Voronoi cell around each drill hole or outcrop, surface and
volume interpolation, fluid flow); meteorology (e.g., rainfall based on a Voronoi cell around each rain gauge); robotics (e.g., path planning from the medial axis); and pattern recognition (e.g., crust/boundary and skeleton/MAT for points representing an object boundary).

In geography, the Voronoi diagram is used for cluster analysis, point pattern analysis, location optimization, surface and volume interpolation, surface modeling from contour maps, growth models, adjacency analysis, buffer zone calculation, collision detection in dynamic systems, fluid flow simulation rapid digitizing of polygon maps, reconstruction of scanned maps, merging of field and object data in a geographic information system, runoff modeling, watershed estimation, catchment analysis, and region detection in remote sensing, to name a few (Figures 3 and 4).

The primary value of the Voronoi diagram is that it provides a mathematically defined and consistent allocation of space to the nearest generator. This property leads directly to the idea that the Voronoi boundaries are equidistant between generators and hence may be used for path planning and medial axis generation. Similarly, as all spatial locations are assigned, the resulting tessellation provides a functional definition of adjacency between discrete objects, based on geometry alone, which provides useful techniques for cluster analysis, interpolation based on the immediate neighbors to the unknown point, and collision detection for moving vehicles or interactive map construction. The dual DT, based on the Voronoi diagram, is valuable both because it minimizes splinter triangles and because individual updates only change local portions of the map.

Christopher Malcolm Gold

See also Geometric Measures; Geostatistics; GIScience; Spatial Statistics; Triangulated Irregular Network (TIN) Data Model

Further Readings

VULNERABILITY, RISKS, AND HAZARDS

Study of hazards involves the concepts of vulnerability, risks, and hazards, with hazards research evolving to include considerations of social vulnerability and resilience. Although public use of the words vulnerability, risk, hazard, and threat has sometimes been interchangeable, each word has its own distinct definition within the field of hazards geography.

Hazards

Hazards represent threats of potential damage or destruction to individuals and society. The actual hazard event, such as a flood, earthquake, wildfire, blizzard, or nuclear reactor accident, may result in a disaster if the incident results in substantial human disruption, whether measured by property damage, injury, or loss of life. An event must have the potential to be sufficiently disruptive of human activities to be considered a hazard, thus the physical magnitude of the event that is considered a hazard varies geographically and temporally. For example, several centimeters of winter snow would be considered routine in the northern Midwest, while it would pose a significant hazard in Southern Florida. Likewise, routine moderate precipitation is not considered a hazard but a valuable resource. However, too little or too much rain results in drought and flood hazards, respectively. Indeed, hazards are sometimes termed negative resources.

Geographic study of natural hazards grew out of the pioneering work of Gilbert White, nearly three quarters of a century ago, dealing with river flooding. Because flood losses were increasing even though substantial investments had been made in the construction of dams and levees, White saw the need to fully explore how human activity was related to flooding. To appropriately understand flood hazards, the complex interrelationships between the natural environmental systems that led to flooding and the web of human activity that resulted in lives and property being placed at risk needed to be thoroughly understood.

Natural and Technological Hazards

Building on these studies of flood hazards, the hazards field expanded to include not only a wide variety of geological, hydrological, and meteorological events but also many technological hazards, including those related to industrial and transportation accidents, releases of toxic chemicals and radiation, and pollution. At the same time, the study of hazards spread from American or European settings to less industrialized non-Western societies—although such studies remain in the minority. Hazards related to global warming are increasingly being considered, and studies have considered the consequences of such warming on drought, wildfire, and hurricane hazards, among other hazard threats. Furthermore, growing world populations have led to both overgrazing and deforestation, both events that may increase the likelihood of flood, drought, and landslide hazards. Thus, hazards may have either natural or human causes.

Recent research has included Natech hazards, those in which natural hazard events trigger technological disasters. Natech hazards include events such as flooding or seismic activity that spills toxic chemicals. The definition has expanded to include disruption of critical infrastructure, such as water supply lines, electrical transmission systems, or transportation networks, resulting from natural hazards.

Geographers have also studied the risk and distribution of various diseases from a hazards perspective, yet diseases and pollution have often been studied from other perspectives. Furthermore, geographic study and teaching about hazards often excludes disease and pollution hazards. While Ken Hewitt has proposed the geographic study of hazards of war, and others have studied terrorism hazards, these topics are ignored by the majority of hazards geographers. Nevertheless, urban violence, poverty, and street crime can all be studied from a hazards perspective.

Geographic study has tended to concentrate on the hazard itself, or the spatial patterns of disaster, while societal response and disruptions resulting from disasters are typically studied by sociologists. In studying hazards, geographers consider both the physical event and the human response or adjustment to it, as it is the complex
interactions of the physical and human systems that create and determine the intensity of the hazard. Changes in technology, human occupancy, and timing provide the context that can either accentuate or ameliorate hazards. While some geographers have emphasized hazards resulting from specific physical threats, others have focused on human responses, including perception, hazard mapping, land use planning, evacuation, and reconstruction, among other mitigation topics.

Human perceptions of hazards were viewed by Robert Kates as the first step in his Adjustment Process Control Model. Once the awareness of and concern about a hazard reached a critical threshold, an individual or group initiated a search for ways to reduce or mitigate that hazard threat. This search for adjustments was constrained not only by the searcher’s knowledge of possibilities but also by economic, environmental, social, political, and technological factors. While the connections between hazard perception and adjustment behavior are often considered in hazard studies, the linkages are far from being direct. Many cultural and contextual issues influence and constrain perceptions of both hazards and potential adjustments, and much remains to be done to develop better models that explain human response to hazards.

**Risks**

Risks have been loosely described as *environmental threats*, but risk can be viewed as a function of hazard and vulnerability. Risk is often defined as a measurement of the probability of experiencing an extreme event or an event of a particular magnitude. Although the public often misconstrues probability information, much geographic study of and societal response to floods has dealt with the concept of the 100-year flood, or a flood with a 1% probability of occurrence in any given year.
Vulnerability
to hazards varies depending on both the physical and the social setting of a community. Because vulnerability can be defined as the potential for and consequences of casualty or economic losses, it is not necessarily directly related to hazard risk or probability. For example, a playing field occupying a floodplain that is inundated every year or two is less likely to sustain property damage significantly disrupting human activities than a residential area located nearer the fringe of the floodplain that may be flooded every other decade. Thus, vulnerability is related to the physical probability that an area will be flooded and to the type of human usage of the site. While physical conditions determine the nature and frequency of the hazard event, social conditions control the land use and occupancy decisions regarding hazardous sites.

Social Vulnerability

Social vulnerability is strongly influenced by the income, racial or ethnic status, age, education, and political standing of a population. The poor are disproportionately more likely to occupy lands that are subject to frequent flooding or landslides and sites that are in close proximity to toxic waste dumps and industrial polluters. Wealthier individuals have the economic resources to avoid physically vulnerable sites and often have control of political institutions that may influence siting of such developments. Furthermore, the poor are most likely to occupy dwellings that provide minimal resistance to seismic shaking or offer little protection against high winds or floodwaters. Regardless of their residence, individuals who are elderly or disabled are more vulnerable to hazard occurrences and present challenges during both the evacuation and the disaster recovery periods. Polarization and spatial segregation of different socioeconomic groups result in their different vulnerabilities to hazards.

A “progression of vulnerability” has been identified by Ben Wisner and Piers Blaikie in their Disaster Pressure and Release Model to demonstrate how unsafe conditions interact with hazards to produce disasters. Root causes that are related to poverty and social marginalization lead to dynamic pressures that result in unsafe conditions. These are manifested by populations living in dangerous locations, with inadequate incomes, and lacking public institutions that might mitigate or warn about the hazard threat. Economic vulnerability is enhanced when meager incomes are threatened by disaster-induced job losses. Certain types of employment are far more vulnerable to specific hazards than others. For example, peasant farmers are far more vulnerable to drought than urban workers.

Resilience

Resilience to hazard losses refers to individual and community attributes that enhance both loss avoidance and disaster recovery. Resilience can also be viewed as the ability to absorb or tolerate hazard consequences, both physically and socially. Resilient communities have greater abilities to recover from a disaster. Financial resources are key, inasmuch as wealthy groups can draw on existing resources to rebuild and restore homes, businesses, and damaged infrastructure. Likewise, wealthier individuals and groups are more likely to have incorporated hazard mitigation into the design and construction of their houses and businesses, thus reducing their vulnerability to hazard losses and increasing the likelihood that a hazard event will not result in an interruption of business activities. Resilient communities are less likely to suffer long-term losses of employment or public services, inasmuch as pre-event planning provides mechanisms to both avoid or minimize losses and to appropriately respond to changing conditions.

Hazards and Vulnerabilities of Megacities

The unique hazardousness of megacities has been described by geographers, most notably J. Kenneth Mitchell. Given their huge populations, which may be defined as exceeding 10 million residents, a disaster could potentially involve so many casualties and so much destruction of property and infrastructure that it would cause social and economic disruptions of entire nations. Megacities, which are disproportionately located in less developed countries, are also frequently located in low-lying coastal settings that are vulnerable to both coastal storms and sea level rise, both of which could be exacerbated by global warming. Yet for many
hazard threats, such as tornadoes, landslides, and even some river flooding, only a portion of the megacity would be physically vulnerable to destruction from a particular event. In contrast, because of their much smaller geographic area, the entirety of a rural village or small town might suffer the consequences of such events. While the nature of the physical vulnerabilities of megacities and small communities varies for many threats, certain events, such as earthquakes or tropical cyclones can result in widespread destruction in megacities.

Megacities have greater resilience to hazards than smaller rural communities. Not only is the national wealth and political power typically concentrated within megacities, but also these cities have a disproportionate share of their nation’s emergency response capabilities, including physicians and hospitals, firefighting equipment and personnel, and transportation links with the outside world. Nevertheless, the truly megadisaster does have the potential to overwhelm this response capacity, justifying the attention given to the hazard vulnerability of megacities.

**Hazards and Vulnerability of Place**

Geographic information science (GIScience) provides a powerful tool to analyze spatial variations in hazard vulnerability. While Ken Hewitt and Ian Burton promoted the concept of “hazardousness of a place” three decades ago by discussing all physical and technological hazards within a Canadian city, recent development of the “hazardousness of a specific place” concept by Susan Cutter involves spatial analysis tools that integrate physical vulnerability data and land use information with multiple measures of social and economic vulnerability. This work enables geographers and emergency planners not only to identify the specific locales within a community that have the greatest physical vulnerability to a particular hazard or group of hazards but also to input the character of the built environment (density and quality of construction, type of land use), the social characteristics of the population, and the location of highways and other key infrastructure, to evaluate both the need for evacuation and the efficacy of particular evacuation routes. By combining risk and vulnerability data, GIScience permits the pre-event determination of those locales most and least likely to suffer destruction from multiple scenarios of different hazard events, enabling the better staging of disaster recovery resources. High levels of physical vulnerability—such as along coastal beaches—often do not correspond with high levels of socioeconomic vulnerability, thus detailed GIScience analysis may determine that residents occupying areas of medium physical vulnerability to one or more hazards may actually be the most vulnerable to disaster losses given their social vulnerabilities and lower levels of resiliency.

*John A. Cross*

**Further Readings**


In 1507, on two maps of the world developed to accompany his *Cosmographiae Introductio*, Martin Waldseemüller included the name “America.” These maps were the first to use the name “America” for the southern part of the newly discovered Western Hemisphere, located in the middle of a land mass that would metamorphose during the 16th century into what we recognize today as South America.

The complete title of the first map, “Universalis cosmographia secundum Ptolemaei traditionem et Americi Vespucii aliorvmque lustrations,” recognizes the work of the ancient Greek cartographer Claudius Ptolemy, as well as the reports of “discoveries” from 1497 to 1504 by the Italian navigator Amerigo Vespucci. It is not clear how much of the South American continent Vespucci actually visited, but his name was clearly placed in the center of the land area. Most significant in this recognition of Vespucci’s discoveries is the fact that he concluded that the land was not a part of Asia. Unlike Columbus, who was certain that he had reached Asia, Vespucci was convinced that this land was something else. Vespucci transmitted this view in a series of letters, and Waldseemüller mapped this perspective on the new maps. Within the context of the *Cosmographiae Introductio*, this was a dramatic shift in the European worldview.

Waldseemüller’s partner in this work was Matthias Ringmann, who edited and amended the text of Claudius Ptolemy’s *Geographia* (the core of the *Cosmographiae Introductio*), a compilation of what was known about the geography of the world in about AD 150. Using the versions of *Geographia* published in Rome in 1478 and Ulm in 1482, as well as a Greek manuscript, Ringmann and Waldseemüller followed the modified text and original Ptolemaic maps with 20 new maps describing areas of the world not known 13 centuries earlier.

The first map was a modification of one of Ptolemy’s conic projections, extending the coverage of the Eastern Hemisphere to include all of Earth’s surface, except for the area in the Southern Hemisphere from 40° S latitude to the pole; however, the southern tip of Africa is carefully defined. As the knowledge base grew, maps created throughout the 16th century changed, with additions and modifications intended to make each one the most accurate and up-to-date representation. As new data emerged from the exploratory ventures to the New World (as well as eastward from the southern tip of Africa across the Indian Ocean), the maps of the world changed drastically (e.g., Mercator’s maps of 1538 and 1569).

The title of the map, “World Description According to Ptolemy and the Travels of Americus...”

---

**Waldseemüller, Martin**

*(ca. 1470–ca. 1522)*

---

"W" on page 3041
Figure 1: The world according to Ptolemy and the travels of Americus Vespucius and others.

Vespucius and Others,” makes clear the cartographer’s intention: to create a new world map from the most up-to-date resources (see Figure 1). Waldseemüller’s second world map, composed of 12 globe gores, also includes “America.”

In subsequent maps, Waldseemüller replaced the name “America” with “Terra Nova.” Relying on the latest and most substantive information available, he did not employ the name “America” in his revised edition of the map in 1513. This revision provides little explanation about the resources that were used. In the *Carta Marina* of 1516, however, there are extensive explanations of the map content. It is important to note that the *Carta Marina* employed a cylindrical projection with a format like that of the portolan style navigation charts employed during this period.

While Waldseemüller did not use the name “America” on his later maps, and others acted similarly, enough world maps from the period continued to use it (e.g., Peter Apian’s map of 1520, which looks very much like Waldseemüller’s map of 1507). German and Dutch cartographers were instrumental in firmly establishing the use of the term. Waldseemüller produced other maps, all developed on the principle of obtaining and organizing the most reliable and up-to-date information.

As for the “Universalis cosmographia secundum Ptolomaei traditionem et Americi Vespucii aliorumque illustrations,” of the 1,000 copies that were printed, only one remains. It is on permanent exhibit at the Library of Congress in Washington, D.C.

*George F. McCleary Jr. and Karen S. Cook*

**See also** Cartography, History of; Mercator, Gerardus; Portolan Charts; Ptolemy

---


A longtime professor of geography at the University of California, Berkeley, Richard Walker has played a significant role in Marxist theorizations of economic geography, agriculture, water and the social construction of the environment, and urban change. A student of David Harvey, Walker completed his PhD at Johns Hopkins University in 1977. With more than 80 refereed articles and four books, his work has been influential in several domains of human geography. He has long insisted eloquently on the centrality of the production process, the division of labor, and the politics of the state as driving forces behind numerous social and spatial phenomena under capitalism. He has also written on geographic pedagogy, particularly the challenges of teaching political economy. He has been actively involved with the journal *Antipode*, serving as its editor from 1991 to 1999. In addition to his research, Walker has mentored a number of successful PhD students, including Michael Storper.

Walker’s early works centered on the dynamics of American suburbanization, which he recast in light of the changing urban division of labor in the late 19th century rather than as an accumulation of individual residential location decisions. A series of papers and book chapters embellished this theme so often framed in empiricist and idealist terms. Thus, he maintained that suburbanization was not a “crabgrass frontier” but, rather, the reflection of long-standing industrial decentralization, real estate speculation, and the active promotion of business and government elites.

His other works in economic geography include powerful critiques of technological determinism; analyses of the relations between class, space, value, price, and profit; theorizations of uneven spatial development; assaults on behavioral perspectives of the firm; and an analysis of services as part of the broader logic of commodity production rather than a postindustrial utopia with their own, independent dynamics. *The Capitalist Imperative*, coauthored with Michael Storper in 1989, is widely heralded as one of the discipline’s most concise explications of the national division of labor and its consequences. Similarly, Walker and Sayer’s *The New Social Economy* in 1992...
aptly summarized structuralist accounts of changing job patterns, technological change, and state policy.

He has also spent decades studying the historical development of California. Specific lines of thought within this topic include the geopolitics of water in the state, particularly the powerful role played by agribusiness. Walker also wrote extensively about the development of the greater San Francisco Bay area, its historical transformations, its changing social and spatial features, its struggles over green spaces, and its ongoing globalization.

Barney Warf

See also Harvey, David; Marxism, Geography and; Smith, Neil; Storper, Michael; Suburbs and Suburbanization

Further Readings


WAR, GEOGRAPHY OF

History and contemporary events have demonstrated that there is a ubiquitous and fundamental link between geography and military operations of all types (i.e., peacekeeping through war). The relationship between warfare and factors of geography such as terrain, weather, climate, and elements of the human landscape has always been evident. Likewise, the essential geographic concepts of location, time, space, and distance have a profound influence on military operations. Thus, military geography is defined as the application of the geographic discipline—its information, principles, tools, methodologies, and technologies—to the organization and implementation of the full spectrum of military operations.

Analytical Framework

Its publications, theory, and practice of war suggest that, at its core, military geography examines the characteristics of the environment within which military operations take place and that operations are influenced by the uniqueness of the natural and human landscape within diverse regions. The sum total of the geographic characteristics of a place is called a military operating environment. This is important because the development of a military strategy involves the selection of objectives, the deployment of forces, a method and sequence of employment, and the movement of military power to an area. Consequently, every phase of a military operation is subject to the effects of terrain and the elements of the natural landscape, the pervasive influence of weather and climate, and the elements of the human landscape. Hence, specific characteristics of places can be linked systematically with their effects on military activities, and the characteristics and effects can be correlated to regions. These effects are to some extent predictable, manageable, and can be useful in planning military operations.

Military Operating Environments

The study of geography demonstrates powerfully that places matter and that each place has unique characteristics. Military geographers think of places as operating environments, each exclusively influenced by the interrelationship of a discrete set of geographic variables. Karl von Clausewitz called the operating environment “terrain” in his famous 1832 treatise On War. In von Clausewitz’s view, the environment is composed of the sum of the land and its inhabitants. Like von
Clausewitz, other strategists indicate that the operational significance of the environment varies with the mission, technology, and current circumstances. So too, then, must a geographic assessment of a military operating environment. Consequently, military geographers link geography and military operations by asking three fundamental questions: (1) What is the environment like? (2) Why is it like this here? (3) How will it shape the operation?

Thus, the *military operating environment* is the aggregate of all factors of the landscape that shape and control the ebb and flow of military operations, and in the final analysis, an examination of the operating environment typically results in an assessment of the following:

- Key terrain: strategic areas and selected critical objectives
- Surface structure: movement corridors and terrain compartments
- Weather and climate: effects on humans, machines, and operations
- Transportation networks and nodes
- Resources
- Logistical requirements
- Human landscapes: population, ethnic groups, urban zones, and cultural considerations

### The Environmental Matrix

Military plans must be considered based on the advantages and limitations afforded by the geographic characteristics of the operating environment. In a wartime context, the purpose of any strategy is to weaken or destroy the enemy’s ability to resist and to enable the fulfillment of stated objectives. To this end, distinctly different strategies have been pursued throughout history. The fundamental military strategy is the employment of military force to cause an enemy to capitulate completely. At the other end of the spectrum, people may employ a more limited approach, in which destruction of the enemy is thought to be impossible because political aims are restricted or because military power is inadequate. Insurgent forces use this form of strategy to prosecute their objectives: They employ military force at selected times and places with the objective of wearing down their opponent. Nonetheless, regardless of the strategy, the success of a military operation depends on a reliable plan that takes into account a cogent analysis of extant geographic factors in a military operating environment.

Hence, the foundation of a geographic analysis of the operational significance of a region and its characteristics is called the *environmental matrix*. The environmental matrix is defined as the sum of all factors that operate at a place and that can have an effect on the successful implementation of any operation. The environmental matrix includes both natural and human components and assumes that the operating environment is the manifestation of their combined effects. The matrix, however, is only a methodology for analysis and is not predictive. Furthermore, because the landscape is not static and the context and objectives of military operations vary over time, care must be taken to reevaluate significant elements of the matrix continuously. An example of an environmental matrix is given in Figure 1.

### Scales of Analysis

Variations in the size and scope of military problems demonstrate the need for military geographic analyses to be conducted at different spatial scales. In a military sense, scale is translated into military operations at the strategic, operational, and tactical levels—or for simplicity, macro- and microgeographic scales.

At the macro scale, military strategy is the method of employing military power to secure a national objective: Consequently, strategic military geography narrows down to the collection, compilation, analysis, and interpretation of geographic data for use in the preparation of war plans or plans to support national-level military operations other than war. Within this context, the principal concerns of strategic military geography include strategic mobility, accessibility, networks, resources, and vulnerability.

At the microgeographic scale, tactical military geography is the translation of geographic information as it relates to the employment and movement of military units during battle. Therefore, military geography at this scale is highly detailed and is typically directed toward the study of military characteristics of discrete types of terrain and geographic conditions and the development
of plans to exploit those conditions. Tactical military geography includes the structure of terrain, elements of the natural landscape, conditions in the atmosphere, and the direct influence of the human landscape on operations. The manifestations of the military operating environment at the micro scale can generally be expressed as (a) observation, (b) cover and concealment, (c) mobility, (d) communications, (e) navigation, and (f) human imprints on the battlefield and rules of engagement.

Approaches to Military Geographic Analyses

The existence of interactions between military environments and operations clearly requires methodologies and approaches that enable cogent
analyses of their potential influence on success or failure. Hence, military geography analyses can be grouped into three formal categories: systematic, topical, and regional.

In a military context, systematic geography engenders the application of systematic sciences such as geomorphology, climatology, and meteorology to the accomplishment of military operations or solving military problems. The full scope of systematic sciences that support military geography ranges between social and physical sciences, with widely divergent geographic subjects such as oceanography, meteorology, demography, biogeography, medical geography, and pedology, to name a few. Topical military geography serves to link systematic sciences to military science and focuses on the application of scientific knowledge to solve basic military problems. For example, data developed by geomorphologists, climatologists, biogeographers, and pedologists can be examined in the context of cross-country mobility to demonstrate the effects of slope, vegetation, and soil conditions on the ability of various military vehicles to cross a given landscape. Thus, topical military geography accounts for the differences imposed by diverse environmental conditions (e.g., deserts, forests, weather) on various types of military operations.

Similar to its role in academic geography, regional military geography assimilates the various characteristics of discrete formal or functional regions into an integrated study. Thus, the examination of military geography from a regional perspective should provide an integrated assessment of a formal region, such as a theater of operations, or a functional region, such as a terrorist network. Military geographers have developed regional study into a highly specialized and detailed methodology called area analysis. Area analyses stand out as mission-oriented studies in that they form the basis for a systematic interpretation of geographic conditions on a proposed course of action.

The Evolution of Military Geography

Linkages between geography and war and the exploitation of geographic information to support military affairs have likely existed for many millennia. Accordingly, military geography has evolved since its formal beginnings in the 19th century, with developments in theory and methods of warfare, technological innovations, changes in the global strategic situation, and extension of areas of military interest. Early military geographies (e.g., Théophile Lavallée, Géographie Physique, Historique et Militaire, 1836, and Albrecht von Roon, Militarische Landesbeschreibung von Europa, 1837) were highly descriptive regional catalogs of data and chorographic descriptions of terrain, but they typically lacked incisive analyses. As an academic discipline, military geography essentially reached a contemporary zenith during World War II and the Cold War as a great deal of research was focused on supporting a global war and the important geostrategic conditions of the postwar world. During this era, military geographers not only included traditional assessments of military environments and regions but also saw the introduction of sophisticated analyses of the technologic requirements to support military operations and the geopolitics of global conflict. The Vietnam War and the period immediately following that conflict represent the nadir of academic military geography in the United States. This demise was caused largely by the social and political upheaval that occurred in its aftermath, which found its way onto American campuses.

Military geography, however, has experienced a renaissance and has perhaps achieved a new acme during the period following the Cold War, especially among academic geographers. The de facto strategic partitioning of the world by the two major superpowers effectively ensured that conflicts between client states were limited and that the bipolar strategic scenario was essentially stagnant for many years, thus restricting the nature of military geography. The new global situation has triggered a series of widespread developments in military affairs, and this expansion of areas of military interest has revitalized military geography. An examination of recent publications indicates that the discipline has expanded its scope well beyond traditional analyses of the terrain, weather, climate, and elements of human landscape as they pertain to warfare and violent conflict. Indeed, as the scope of military operations has expanded because of formerly nontraditional uses of military forces, such as humanitarian support operations, so too has the scope of military
Contemporary events such as ethnic warfare, environmental change, and global terrorism have forced an expansion of military geography as well. Today, research efforts have been extended to areas such as environmental security, security landscapes, the geography of ungoverned space, strategic chokepoints and piracy, energy and water resources, disaster relief, global-warming scenarios, and more effective analyses of latent ethnic divisions that have erupted into violent conflict following the end of the Cold War.

Francis A. Galgano

See also Cold War, Geography of; Environmental Security; Fear, Geographies of; Geopolitics; Military Geography; Political Geography; State; Terrorism, Geography of; World-Systems Theory

Further Readings


Waste incineration is a waste disposal method that can be used to combust a range of materials classified as municipal solid wastes and hazardous wastes. Incinerators, sometimes referred to as thermal treatment plants, convert wastes into steam, gas, heat, or ash (those that produce a source of energy are often known as waste-to-energy plants). Waste incineration is a contentious and emotional issue. Geographers and other social scientists have explored many conflicts associated with waste incineration. Following a brief review of the history of waste incineration, some of the key conflicting issues are highlighted in this entry.

Waste incineration, or the systematic burning of waste, has been taking place for a little over a century. It is recorded that the first incinerator was established in the United Kingdom in 1874 and the first waste-to-energy plant was developed in the mid 1890s. The United States had more than 600 municipal waste incinerators in operation during the 1930s. Incinerators at that time employed low-level technology, and they functioned with limited control over the waste mix that entered the facility or the emissions that were produced by the combustion process. Mounting scientific evidence about the issue of human health hazards and environmental contamination led to growing public concern about the practice in Europe and North America from the 1950s onward.

Since the 1970s, tough national and transnational levels of emission controls have encouraged improvements in incinerator technology. Indeed, the 1980s and 1990s have seen a resurgence of interest in incineration as a waste management option because of enhanced levels of profitability, improved design, and a growing consensus for the need for energy supplied from non-fossil-fuel sources.

Some of the key arguments proffered by the proponents of incineration include the following:

- Incineration emissions are insignificant relative to total air pollution in developed economies, and any emission problems can be solved technologically.
- The generation of energy from incineration preserves nonrenewable fuels and therefore contributes to a net reduction in greenhouse gas emissions.
- Energy recovered from incinerators can serve as a revenue source.
- The volume of waste is reduced by as much as 90% and may extend the available landfill space.
- Incinerators offer geographical concentration of waste in comparison with other, more dispersed options such as landfills.
- No significant alterations to waste collection practices are required, and the construction, management, and operation of incineration plants can be carried out by the private sector, reducing potential tax burdens.
However, incinerator facilities and proposals for such plants have faced opposition from local communities in most countries in Europe and in the United States for at least the past 25 years. Some of the main arguments put forward by the anti-incinerator lobby include the following:

- The incineration process releases dioxins and furans into the air, resulting in possible risks to human health as well as to the environment.
- Incineration simply transfers contaminants from one medium to another (from the ground to the atmosphere).
- The release of contaminants into the atmosphere cannot be controlled in comparison with containment in a landfill.
- Incinerator plants are costly to construct relative to other waste management options.
- Ash produced from the incineration process still needs to be disposed of.
- The incineration process requires paper and other combustibles, competing with and detracting from recycling and waste minimization programs.

Geographers and a range of social scientists have produced a large body of research exploring contentious issues such as community responses to waste incinerator facilities, risk communication for incinerator siting, the technical processes of risk analysis and public perception of risk associated with incinerators, and the impact of waste disposal facilities on housing prices. One of the most important areas of research to emerge in relation to incineration conflicts has been the social and environmental justice movement. The uneven spatial location of waste infrastructure has been well documented. Often waste facilities tend to be located in areas that are characterized by remoteness, areas with peripheral communities, areas with economic marginality, areas with political powerlessness whose people have a culture of acceptance, and areas of existing environmental degradation. Community opposition to waste management infrastructure, such as incinerators, has given rise to many phrases, including “not in my backyard” (NIMBY) and “locally unwanted land uses” (LULUs). A key extension of this opposition has moved from NIMBY to NIABY (“not in anyone’s backyard”) as the objection is often based not only on self-interest but also on wider social and political issues. These include general environmental concern, dissatisfaction with the consultation process, and distrust of decision makers.

It has been argued that while older incinerators were responsible for air pollution, more modern waste-to-energy plants claim to have rectified this problem by incorporating better pollution control technology and improved combustion processes. The common goal of all modern waste-to-energy plants is the production of an essential product—energy.

Many people consider incinerators a better waste disposal method than the traditional dumping of wastes in sanitary landfills, and they are commonly used in countries such as Japan, where land available for landfills is scarce. Despite the controversial image of incinerators, current research generally concludes that there is a place for incineration provided that it is part of an integrated waste management plan and that it incorporates strong waste prevention, waste minimization, and recycling programs.

Frances Fahy

See also Environmental Justice; Landfills; Locally Unwanted Land Uses (LULUs); Not in My Backyard (NIMBY); Recycling of Municipal Solid Waste; Urban Solid Waste Management

Further Readings


WASTEWATER MANAGEMENT

Any water whose quality has been affected after being used by human-related activities is considered to be wastewater. Therefore, wastewater management is intrinsically related to water quality
management. Its definition can be broadly summarized as the activities that a person or a group of individuals or entities carries out to protect public and environmental health from the adverse effects of contaminants found in wastewater. Managing wastewater encompasses several important areas that can be summarized as follows:

- The collection and transportation of the wastewater away from highly populated or environmentally sensitive areas via sewerage networks (sewerage is the infrastructure used to collect and transport wastewater, including pipes, pumps, screens, channels, and combined sewer overflows, used to move sewage from its origin to the point of eventual treatment or disposal)
- Treatment prior to discharge
- Releasing wastewater again into the environment (land, rivers, lakes, and oceans) or reusing the treated wastewater for beneficial purposes (e.g., cooling of power-generating facilities, groundwater recharge augmentation)
- Ensuring that the concentrations of contaminants found in the receiving water bodies or land do not harm people and the environment

**Sources of Wastewater**

Wastewater is collected in sewerage networks (if available) or in small decentralized systems such as privy houses, pit latrines, septic tanks, and so on. Most cities throughout the world have sewerage systems that allow for the collection of both wastewater and runoff resulting from rain. Runoff carries a mixture of water, sediments, oil, and grease from streets that is combined with wastewater from human-related activities that produce liquid wastes. Sources of wastewater from human-related activities are classified as point source or direct, and nonpoint source or diffuse. Examples of direct sources are the discharges from domestic residences, public properties such as governmental buildings, private commercial properties, industrial and mining facilities, and livestock farms. Examples of diffuse sources are agricultural areas. Each of these sources can add different types and concentrations of contaminants to water.

**Wastewater Constituents**

Wastewater is composed primarily of water. Alongside water, there are high concentrations of chemicals, toxic compounds, and organic and inorganic matter. When wastewater is accumulated and is left untreated, the decomposition of the organic matter that it contains leads to nuisance conditions, including the production of malodorous gases. Untreated wastewater contains a large number of pathogenic organisms (bacteria, viruses, parasitic worms, etc.) that come from human and animal intestinal tracts. These organisms are the leading causes of epidemics such as typhoid, cholera, hepatitis A, dengue fever, among others and bacteriological and viral diseases. Wastewater also contains nutrients, such as nitrogen and phosphorus, that exist naturally in the environment. However, the high concentrations of these nutrients in wastewater can stimulate unwanted growth of algae and other aquatic invasive species. Wastewater may also contain heavy metals and different types of toxic compounds that are known carcinogens. Because of these reasons, the highest priority of wastewater management has been to adequately remove potential nuisance conditions that can severely affect public and environmental health.

**Brief History**

Wastewater problems are very old. But it was not until the mid to late 18th century that management of water quality and wastewater began. Events such as the Broad Street cholera epidemic in London led to the enactment of the first regulations to protect public health and drinking water from wastewater discharges. The “sanitary idea” of Edwin Chadwick in London proposed that wastewater must be collected via sewerage networks away from the highly populated centers and the community water supply sources. The collected untreated wastewater was then discharged untreated into water bodies further downstream of communities. Engineers during these times favored the construction of drinking water treatment plants instead of having to
spend money in treating wastewater prior to its being discharged.

Concern for the pollution of rivers resulted in the creation of the first type of surface water quality standards, the “dilution standards,” which are still used today in combination with what are known as “end of pipe” effluent standards (for wastewater treatment plants, or WWTPs), and ambient water quality standards for the protection of river basins.

Broad irrigation and intermittent filtration of wastewater on land were the first known types of treatment other than discharging untreated wastewater into water bodies. Intermittent filtration was the first step in the development of sewage treatment techniques that involved the biochemical oxidation of the organic matter. In the late 19th century, several methods of sewage treatment were developed and tested. Examples of the new technologies developed in that period were the contact and trickling filters developed by Joseph Dibdin and the septic tank developed by Donald Cameron. Modifications to the Cameron septic tank later followed (Travis tank, Imhoff tank, etc.). Modern technologies evolved from these simple but effective wastewater treatment systems.

### Modern Approaches

Countries throughout the world have followed similar approaches in establishing policies and regulations for the management of wastewater, each with different levels of success. For example, the United States and Mexico have almost identical regulations for managing wastewater, but due to heavy financial burdens for operation and maintenance costs, as well as costs of monitoring and control of wastewater discharges, Mexico’s wastewater treatment coverage is much less than in the United States. Other countries in Latin America such as Brazil and Argentina have wastewater management programs similar to those of the United States and European countries such as Germany, the United Kingdom, and France.

Many of these less developed countries have enacted regulations that emulate those of the more industrialized and developed nations. Examples of some of the wastewater management regulations include the application of point source standards or end-of-pipe regulations, requiring discharge permits, wastewater quotas, incentive programs to reduce nonpoint sources of pollution, and also the application of ambient water quality standards. Figure 1 summarizes the wastewater management process. Within each section, there are major issues to be addressed. For instance, the collection and transportation of sewerage is an important topic of hydraulics in the field of civil engineering.
WATER DEGRADATION

Wastewater Treatment

Wastewater collected in sewerage systems is commonly treated at large-scale WWTPs. However, for many communities, this practice is not cost-effective or practical. These latter communities rely on what are known as onsite wastewater treatment systems (OWWTS). All treatment methods have been classified into two categories. Methods in which the applications of physical forces are used to remove pollutants are known as “unit operations.” Methods of treatment in which chemicals or biological reactions are applied are known as “unit processes.” These two groups of methods are often applied simultaneously. Several levels of treatment can be attained, depending on the target goals desired. The levels of treatment are preliminary, primary, secondary, and tertiary (or advanced).

The most common treatment is an aerobic system called the activated sludge process. This wastewater treatment process is based on the recirculation of a biomass composed of microorganisms that are able to absorb and adsorb the organic matter carried in the wastewater. Other types of treatment may include ecological approaches using reed bed systems such as constructed wetlands. Modern systems include tertiary treatment by microfiltration or synthetic membranes. These advanced treatment systems, however, are very expensive, and their use has been limited. As the membranes required for advanced treatment become less expensive, these methods will become more popular.

Agustin Robles-Morua

See also Cholera, Geography of; Nonpoint Sources of Pollution; Point Sources of Pollution; Water Degradation; Water Management and Treatment; Water Pollution

Sources, Distribution, and Uses of Freshwater

Water is a “renewable” resource that provides essential services, is constantly restored by the hydrologic cycle, and can be degraded when used or altered faster than it can be replenished. Freshwater degradation occurs when the physical, chemical, or biological characteristics of water become harmful to the environment or organisms, including humans, by which the usefulness of the water resource is in some way reduced. The quality of water as a resource, and therefore the acceptable level of degradation, depends on the intended use of the water and consequently also depends on the desires of multiple, often conflicting stakeholders. The globally variable distribution of water resources, the burgeoning human population with increasing consumptive uses, and increasing waste production and pollution make water degradation an important societal and ecological concern. This entry discusses the sources, distribution, and use of freshwater; water stresses, causes, and drivers; indicators and assessment of water degradation; and water degradation prevention measures.

Further Readings

110,000 km³ (cubic kilometers), which is variably distributed by ecological region.

Although we have enough water at a global scale, the distribution of freshwater has been a problem. P. Gleick indicated in 1993 that two thirds of the world’s population lives in areas receiving only one quarter of the world’s annual rainfall. The global freshwater demand per capita is rising substantially as a result of economic development and population growth. Agriculture represents 70% of the global annual freshwater use (FAO-AQUASTAT). Meeting the rising water demands and the increasing reliance on irrigation to produce food will be a challenge for the growing population and for economic activity in the face of the decline in the finite freshwater resources and increases in pollution.

Water use can be classified as consumptive when water is physically removed for a specific purpose, such as public potable water supply, irrigation, livestock, mining, and others. Non-consumptive uses include hydroelectric power generation, fisheries, navigation, environmental flow, and others that require a certain amount of water at a given point and time but that do not necessarily remove water from its source.

Water Stresses, Causes, and Drivers

The degrading factors that influence water quality can be chemical, biological, or physical, often with compounding interactions among these three causes.

Chemical Water Pollution

Chemical water pollution is the reduction of the usefulness of water by contamination with one or more degrading substances, such as sediments, organic wastes, nutrients, metals, salts, and many
other natural and synthetic chemicals that can be caused by both anthropogenic (human caused) and natural processes. Humans have a great impact on water quality through their consumptive uses and also in the generation of pollution. Several components of the hydrologic cycle can also affect the quality of water; for example, evaporation from surface pools can concentrate salts and other chemicals by reducing the overall water volume, and runoff and infiltration can leach harmful levels of metals into groundwater. Degradation of water quality due to processes in the hydrologic cycle is referred to as background pollution or natural contamination to distinguish it from degradation from anthropogenic causes.

Sources of pollutants can be classified as either point or nonpoint sources. Point sources are generally categorized as contamination coming from a discrete source, such as a discharge pipe. Point sources are generally easy to identify, have quantifiable discharges, and have readily evident environmental impacts; examples include industrial effluents, wastewater treatment plants, landfills, and abandoned mines. Nonpoint sources are generated from broad and diffuse sources that can be difficult to identify and quantify. Examples include agricultural and urban runoff. The pollutants from nonpoint sources enter water bodies by surface and groundwater movement and from the atmosphere in the form of precipitation (e.g., acid rain). Nonpoint source pollution accounts for the major sources and causes of water degradation globally.

**Biological Pollution**

Biological pollution of water resources has mostly been identified with waterborne diseases that include infectious hepatitis, cholera, bacterial dysentery, and microscopic parasites such as *Giardia* and *Cryptosporidium*. Many of these diseases are associated with the presence of raw or improperly treated sewage or animal wastes that get into a drinking water resource. Improvements in wastewater treatment have reduced or eliminated most cases of waterborne infectious diseases in developed countries, but these diseases continue to be widespread in undeveloped nations. Discharges of organic matter, such as sewage, pulp mill effluents, and animal processing wastes, can affect water quality by creating an oxygen demand. Aerobic (oxygen using) waterborne bacteria consume the available dissolved oxygen (DO) during the decomposition of organic matter, reducing DO to a level insufficient to support other oxygen-breathing aquatic organisms (e.g., fish) and making the water unfit for human consumption. The measurement of the oxygen demand needed to satisfy the decomposition of organic matter is called the biological oxygen demand (BOD).

**Eutrophication**

Eutrophication is a widespread problem and exemplifies the interactions between chemical pollutants and biological processes to degrade water quality. Eutrophication is the process whereby a water body accumulates nutrients (mostly nitrates and phosphates) that are essential for, and often limit, the growth and proliferation of algae and other aquatic plants. Eutrophication is a natural process (natural eutrophication) that occurs when nutrients leach from soils or erode from rocks. However, anthropogenic activities, mostly associated with the use of agricultural fertilizers, have greatly increased the rate at which water bodies are becoming eutrophied (cultural eutrophication). Algae proliferate (bloom) and use the excess nutrients, fixing atmospheric carbon dioxide (CO₂) into organic matter in the form of new algal cells. As these cells die and decompose, they create a BOD that leaves little DO to support other aerobic aquatic organisms (e.g., fish).

**Physical Factors**

Water control and supply projects have been in use since ancient times and have led to numerous human-benefitting results, including economic growth and food production. Structures such as dams, reservoirs, and distribution systems can support urban and agricultural development but often have severe ecological consequences. Dams and reservoirs can degrade the ecological usefulness of the water by reducing stream flows, halting nutrient and sediment delivery, blocking fish migrations, and destroying habitats.

**Water Stress**

Water stress is mainly caused by overtapping of available water resources without considering
sustainability or following few or no water and soil conservation practices to augment groundwater recharge and reduce runoff. Overpumping of groundwater is often associated with salinization of groundwater in coastal areas. Salinization is the increase in soluble salts in the water due to various factors. The increased use of chloride salts in roads during winter and overpumping of groundwater in coastal areas, which leads to the lowering of the piezometric surface (saltwater intrusion), are the major sources of salinization. Some surface irrigation practices in arid regions can also increase salt accumulation on the surface of irrigation fields and hence increase the salinity of the receiving water bodies during runoff.

**Thermal Pollution**

Thermal pollution is water degradation due to the alteration of the temperature of the water and is also a common problem, especially for aquatic organisms. Currently, the main source of thermal pollution is using water as a coolant in electrical power generation and other industrial manufacturing plants. These processes increase the temperature of the receiving water bodies, reducing the available dissolved oxygen, and stressing aquatic organisms. In some instances, such as the release of deep cold water from a dam, the temperature of water bodies decreases, which can also stress warm-water organisms.

<table>
<thead>
<tr>
<th>Water Degradation Prevention Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The hydrologic cycle and the environment through which water travels contain many chemical, physical, and biological processes that assist in decreasing the mass and concentration of harmful materials. Examples include the biodegradation of organic and synthetic wastes and the sedimentation of metals. This natural attenuation capacity depends on the form and residence time of the water; that is, flowing water generally has a greater ability to self-cleanse than does groundwater. However, water quality suffers when the rate of degradation exceeds this attenuation capacity. The most effective methods of reducing water degradation are to identify and lessen or eliminate the causes if possible. This often involves land management procedures termed <strong>best management practices</strong> (BMPs). BMPs include practices such as replacing water-demanding crops with dry-land (xeriphytic) crops to reduce water consumption and decreasing excess nutrient run-off from agriculture by using less fertilizer and more conservative cropping systems.</td>
</tr>
</tbody>
</table>

**Assefa M. Melesse and Leonard J. Scinto**

*See also* Agrochemical Pollution; Climate Change; Groundwater; Nonpoint Sources of Pollution; Pesticides; Point Sources of Pollution; Wastewater Management; Water Management and Treatment; Water Pollution
Water Management and Treatment

Scientific water management is a relatively new branch of science. Yet proper use of water resources and their management and treatment (widely understood as preparing the water for various purposes) are inherently connected to development and civilizing societies on Earth. This field has recently come into prominence because of the increased water demand related to global population growth and more intense use among almost all social and industrial sectors. Compounding this, global warming and climate change scenarios on Earth forecast that water resources will diminish in many places, while intensified extreme phenomena (e.g., floods or droughts) will render the proper distribution of water resources more difficult. The diminishing quantity and quality of available water resources generate the need for their better treatment. This requires new investigation of alternate treatments such as new methods for collection precipitation or improved methods for the desalinization of seawater.

Water Management

Water management is usually supervised by governments through designated governmental agencies. Their main task is to ensure an adequate quantity and quality of water for the use of people, society, and the economy. In many countries, the institutions that are set up to supervise water management also deal with the protection of water against pollution and the protection of a country’s territory against floods. Because the issues of water management are of vital global importance, many have broader implications and must be dealt with at the international level. For example, European Union member states act collectively under the “Water Framework Directive” or the “Flood Directive.” International cooperation in this field is also carried out by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Specialized nongovernmental organizations have also been playing a vital role recently in influencing the decisions taken in the field of water management.

Water Resources

Water belongs to the category of “depletable natural resources”; at the same time, it is also considered one of the “renewable resources.” There are three basic groups of resources for meeting water needs (Table 1):

1. Atmospheric precipitation and deposits
2. Underground waters at deep water-bearing layers (with no direct recharge of surface waters)
3. Surface waters (river runoff comprising surface and shallow ground runoff)

Water Needs

Water needs are determined by the quantity of water necessary for the human population and for the functioning of those sectors of the economy that are active in a given area (region, country, continent): agriculture and forestry, industry, electrical power generation (especially hydroelectric power generation), municipal economy, and inland ship and cargo transport.
<table>
<thead>
<tr>
<th>Continent</th>
<th>Area (million km²)</th>
<th>Population (millions)</th>
<th>Water Resources (km³/yr.)</th>
<th>Potential Water Availability (1,000 m³/yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2007</td>
<td>2050</td>
<td>Per 1 km²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Africa</td>
<td>30.1</td>
<td>944</td>
<td>1,953</td>
<td>4,050</td>
</tr>
<tr>
<td>Asia</td>
<td>43.5</td>
<td>4,010</td>
<td>5,378</td>
<td>13,510</td>
</tr>
<tr>
<td>Australia and Oceania</td>
<td>8.95</td>
<td>35</td>
<td>49</td>
<td>2,404</td>
</tr>
<tr>
<td>Europe</td>
<td>10.46</td>
<td>733</td>
<td>669</td>
<td>2,900</td>
</tr>
<tr>
<td>North America</td>
<td>24.3</td>
<td>523</td>
<td>718</td>
<td>7,890</td>
</tr>
<tr>
<td>South America</td>
<td>17.9</td>
<td>381</td>
<td>528</td>
<td>12,030</td>
</tr>
<tr>
<td>The World</td>
<td>135</td>
<td>6,625</td>
<td>9,294</td>
<td>42,785</td>
</tr>
</tbody>
</table>

**Table 1** Renewable water resources and water availability by continents

It is estimated that the minimum quantity of water required for a person to drink, to use for sanitary (hygienic) purposes, and to support agricultural cultivation is 1,000 cubic meters (m³) per year (Figure 1). Existing world water resources are estimated to be sufficient to cover the minimum needs of 42.8 billion people, a figure more than six times the world population in 2007. The world’s population is estimated to grow to 9.3 billion people in 2050, at which time there will still be 4,600 m³ of water available for each inhabitant of Earth (Figure 2). However, it has to be borne in mind that these figures only deal with quantity and that at present a considerable fraction of available water resources requires costly treatment.

In the future, water quality may be expected to deteriorate significantly (especially in many densely populated areas of our planet), so the actual availability of pure water may become limited. Moreover, water resources are very unevenly distributed across Earth. There are large differences in supply and demand even within a given country or continent.

Water can be used by water consumers (who use it up, e.g., for agriculture and forestry, industry and heat engineering, or the general municipal economy) and also by water users (who take advantage of water resources without using them up, e.g., for hydroelectric power generation, inland ship transport, and water tourism and recreation). According to different estimates, around 67% of world water is used by agriculture, 20% to 25% by industry, and the rest by the municipal economy. Of course, the distribution in a particular country depends on the environmental conditions and the degree of economic and social development in that country.

**Water Treatment**

Chemically pure water is never found in nature. Being one of the best solvents, water contains
not only hydrogen and nitrogen but also a large variety of contaminants, both chemical and bacteriological. These substances may be dissolved in water or form suspensions. Because water is a perfect habitat, it can also contain microorganisms. The products of human activities, such as agricultural and industrial waste and sewer water discharge, cause a number of pollutants to enter the water. Some contaminants can be determined organoleptically by evaluating the color, turbidity, and density of particulate matter. The most widespread chemical contaminants are metals, including manganese, aluminum, lead, zinc, and copper. The nonmetals, such as nitrate, fluoride, and phenols, appear less frequently. However, agricultural and municipal economic reasons are the cause of increasing contamination of water resources by nitrates, pesticides, herbicides, and polychlorinated biphenyls. Microorganisms can be primarily found in water in the form of bacteria and viruses.

All these reasons explain why it is necessary to purify water. Water treatment is the process of bringing water to the state required for a specific purpose. Different processes are used depending on the end use; some processes adjust underground or surface water to make it suitable for drinking purposes, while other processes are used to adjust contaminated water (e.g., from underground mine workings) to satisfy cooling needs in conventional power plants.

Some water purification processes employ physical methods, such as sedimentation or adsorption, while others use chemical and biological methods. In addition, potable water is disinfected by chlorination, ozonation, or UV radiation (Figure 3). Potable water has to meet...
the requirements stipulated by state law. The World Heath Organization, the U.S. Environmental Protection Agency, and the European Union provide guidelines stipulating the recommended (maximum and minimum) values of the various substances that drinking water should contain.

**Water Management Problems**

The principal challenges that water management agencies will have to face in the coming years include the following:

- Shortage of good-quality water (the lack of potable water and sanitary facilities is already an acute problem)
- Changes in the distribution of water resources connected with global climate change
- Natural disasters directly connected to water (floods) or causing damage to the existing natural or human-made water management infrastructure
- Conflicts caused by unequal access to water resources
- Deteriorating quality of water resources leading to higher treatment costs

**Timeline of International Water Management Efforts**

Today, water is considered one of the most important factors for sustainable development. The most important timeline of events that led to treating water as such is presented as follows. The majority of the documents supporting the timeline events are available through the United Nations Organization agencies.

1965–1974. The world’s attention was first drawn to water issues during the International Hydrological Decade (1965–1974), initiated by the UNESCO. This program led to an unprecedented advance in the field of water science knowledge and cooperation.

1972. In this period, another important event took place—the United Nations Conference on the Human Environment—which produced an important declaration stating, “A point has been reached in history when we must shape our actions throughout the world with a more prudent care for their environmental consequences” (Declaration of the UN Conference on the Human Environment). The declaration made environmental issues a priority and set the stage for further investigation into water resources.

1977. The first intergovernmental conference focusing on water issues was held in Mar del Plata, Argentina. This “UN Conference on Water” resulted in the “Mar del Plata Action Plan” with recommendations covering all the essential components of water management.
Twelve resolutions covering a wide range of specific subject areas were also adopted, making it one of the most effective and productive meetings thus far assembled concerning the subject of water resources.

1987. Ten years later, the World Commission on Environment and Development (also known as the Brundtland Commission) published a report titled *Our Common Future*. This report shaped the guiding principles for sustainable development. Although the report does not expressly address water, it contains the most commonly quoted definition of sustainable development, which is also applied to water resources: “Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.”

1992. Another advance on the sustainability path was the “Dublin Statement,” adopted by the International Conference on Water and the Environment. Its four principles are often quoted as the guiding principles of water resource management.

1992. The most comprehensive plan for global, national, and local actions in every area of human impact on the environment is Agenda 21, adopted by the UN Conference on Environment and Development meeting held in Rio de Janeiro, Brazil. Chapter 18 of the document is devoted to freshwater resources.

1996. On the initiative of water specialists and international organizations and in response to increasing concerns about world water issues among the global community, the World Water Council was established. Every third year, it organizes the World Water Forum, which is the largest periodic international event in the field of water.

2000. The UN General Assembly in New York created the Millennium Development Goals, aimed at ensuring environmental sustainability. The specific goals were to integrate the principles of sustainable development into country policies and programs, to reverse the loss of environmental resources, and to reduce by half the proportion of people without sustainable access to safe drinking water by the year 2015.

2001. The Freshwater Consultation held in Berlin, Germany, produced two important documents: (1) the “Bonn Recommendations for Action,” focused on sustainable management of water resources, and (2) the “Bonn Charter for Safe Drinking Water.”

2002. The goal of the World Summit on Sustainable Development held in Johannesburg, South Africa, was to reinforce and fully adopt the Millennium Development Goals set out 2 yrs. (years) before. The “Plan of Implementation” of this summit includes actions related to water sustainability for the eradication of poverty and protection and management of natural resources for economic and social development. The conference also called for governments to develop integrated water resource management and water efficiency plans by 2005.

2003. In an effort to increase awareness of the importance of sustainable freshwater use, protection, and management, 2003 was designated the International Year of Freshwater. This coincided with the publication of the second *UN World Water Report*—a comprehensive review giving an overall picture of the state of the world’s freshwater resources and aiming to provide decision makers with the tools to implement sustainable use of water. This report is published every 3 yrs. and brings together the efforts of 24 UN agencies.

2005–2015. Today, we are in what has been proclaimed the Decade of Water for Life (2005–2015) by the United Nations. The primary goal of the decade is to promote efforts to fulfill international commitments on water-related issues, such as the Millennium Development Goals.

*Damian Absalon*

---

*See also* GIS in Water Management; International Watershed Management; Public Water Services; Urban Storm Water Management; Urban Water Supply; Wastewater Management; Water Degradation; Water Needs; Water Pollution; Water Supply Siting and Management
Water needs are defined for the purposes of this entry as the requirements of Earth systems for water, and the entry specifically explores the interactions between humans and the environment in the use of water and the impacts of those uses on the functioning of Earth’s ecosystems. The needs of Earth’s ecosystems (including humans as a part of these ecosystems) for water are relevant both because water is an important aspect of human-environment interactions and also because water features, water availability, and water use are defining elements of place. Geography has a rich tradition of research on water and wetland ecosystems and human use of water resources. This entry addresses several aspects of water needs: the need of Earth’s ecosystems for water, human uses of water, the impact of various human uses on water quantity and water quality, and the linkages between water and energy. In addition, it discusses the need for information and tools to better manage the world’s water resources and the need for development of informed, effective water governance institutions to help alleviate potential conflicts over this precious and increasingly scarce resource.

Water Needs of Earth’s Ecosystems

The primary and most critical water need is the need for sufficient water at the appropriate time and in the required amount to sustain Earth’s ecosystems, of which humans are a part and on which all life depends. As water moves through the hydrologic cycle, not only is water itself transported but also energy and materials are moved through their own biogeochemical cycles, habitat is provided for aquatic organisms, and terrestrial systems are sustained. Water and freshwater ecosystems provide numerous ecosystem services to people worldwide. Ecosystem services are the wide range of benefits provided to people through the functioning of Earth’s ecosystems. This includes many types of services such as provisioning services that provide food, water, and fiber; supporting services such as transportation and cycling of materials; preservation services such as preserving plant and animal species; and cultural and aesthetic services that include social, economic, spiritual, and recreational benefits.

The allocation and management of water resources, especially in international river basins, are becoming more difficult. Increasing demands are being placed on human and environmental systems by competing water uses that include hydropower generation; flood control; agricultural, industrial, municipal, and industrial water use; flows for water quality; fish habitat and fish passage; and recreational and cultural uses. Competing interests for water are taxing the limited water supplies. The water needs of agriculture, industry, and urban areas compete with environmental claims for in-stream water or the water rights of indigenous people. Traditional water governance structures are not well suited to address the complex issues and needs of competing agents to resolve the emerging problems over water quantity and quality, nor are they flexible enough to address the projected rapid changes in the timing and delivery of water as the world’s climate changes.

As part of the Pilot Analysis of Global Ecosystems, the World Resources Institute (WRI) assessed the condition, status, and trends in the world’s freshwater ecosystems. WRI selected and
analyzed both quantitative and qualitative information and developed five indicators of the condition of the world's freshwater systems:

1. Human modifications of water bodies and watersheds
2. Water quantity
3. Water quality
4. Food (fish in particular)
5. Aquatic biodiversity

A major finding of this project was that the world's freshwater systems are so degraded that their ability to support human, plant, and animal life is greatly in peril.

Freshwater systems in general and wetland ecosystems in particular have been subject to serious degradation worldwide. Among the key findings of the Millennium Ecosystem Assessment (MEA) conducted by the WRI, United Nations Environment Programme, World Bank, and others were that wetland and freshwater systems have suffered greater and more rapid loss and degradation than other ecosystems worldwide and the condition of both freshwater and coastal wetland species is deteriorating faster than in other ecosystems. The authors of the MEA, which was released in 2005, identified population growth and increasing economic development as the primary indirect drivers of degradation and loss, and the primary direct drivers as infrastructure development, land conversion, water withdrawal, eutrophication, and pollution, as well as overharvesting and over-exploitation of fisheries and other resources and the introduction of invasive alien species. Further key findings included the expectation for population growth and global climate change to increase the rate and extent of wetland loss, the incidence of waterborne diseases, and nutrient loading to freshwater and coastal systems. These impacts are expected to be severe and may result in the loss of many of the functions that we rely on wetlands and freshwater systems to provide, but they have been largely taken for granted until now.

Protection of these ecosystems and the services they provide is thus a critical element to consider as the world plans for the water needs of the next millennium.

### Water Use

About 4,000 km$^3$ (cubic kilometers) of water each year are withdrawn from freshwater systems for human use, an amount equivalent to about 20% of the base flow of the world’s rivers. Groundwater withdrawals are estimated at approximately 600 to 700 km$^3$/yr. (per year)—or about 20% of global water withdrawals. On a worldwide basis, agriculture withdraws the most water from surface and groundwater systems, with about 70% of water withdrawals worldwide used for irrigation. In the United States, the U.S. Geological Survey (USGS) has estimated that water withdrawals for energy production are responsible for the greatest amount of water used, with the quantities of water used for thermoelectric and thermonuclear power generation slightly higher than those withdrawn for agriculture. Human use of freshwater has altered both the amount of water delivered to rivers, streams, and wetlands and the timing of its delivery. These changes have resulted in the decline and even the extinction of freshwater plant and animal species and may impair the ability of freshwater ecosystems to sustain themselves.

Water scarcity now affects much of the world, according to the United Nations Comprehensive Assessment of the Freshwater Resources of the World. About 40% of the world’s population—roughly 2.3 billion people—live in regions with a per capita water supply of less than 1,700 m$^3$/yr. About 1.7 billion people live in river basins where water supply is less than 1,000 m$^3$/yr., and nearly 10% of the world’s population suffers from serious water shortages.

### Water Quality

Water quality appears to have degraded worldwide with the growth of intensive agriculture and large urban/industrial areas. Water pollution is a major cause of death and disease in the developing world, although surface water quality has improved in North America and Western Europe with respect to some pollutants such as phosphorus and some pesticides. Nonpoint source pollution from agricultural runoff is still a concern, however, even in the richest nations of the developed world. The delivery of nitrogen to coastal
regions worldwide is expected to increase by 10% to 20% in the next two decades.

**Water for Agriculture**

In the late 1990s, irrigated agriculture accounted for 40% of the global food production, even though just 17% of the global cropland is irrigated. This reflects the disparity between the productivity of rain-fed systems versus irrigated systems. Agriculture is society’s major user of water, withdrawing 70% of all water worldwide, according to the World Meteorological Organization.

**Water and Energy**

Water and energy are highly linked throughout the world. Water is both a source of electric power and a resource that requires energy to obtain or distribute to places where it is needed. The production of many forms of energy, not only hydropower but also thermoelectric and thermonuclear power, requires the use of water for cooling. Often, when people remove water from a river or stream for use, the water returns to that stream at a warmer temperature. In the United States, there has been a growing recognition of an “energy-water nexus,” or an interaction between water and energy. Of the total electricity generated in the world, hydropower generated approximately 18% of the electricity used worldwide in 2006 and accounted for about 5% to 6% of overall energy use. There are 19 countries that rely almost entirely (90% or more of electricity generated) on hydropower for generation of electricity, including Brazil, Norway, Burundi, and Laos.

**Water and Wetlands at the Land-Sea Margin**

Nutrient pollution and the resulting algal blooms are more frequently observed in both inland and coastal systems around the world. At least 415 coastal areas have been identified by the WRI as experiencing some degree of nutrient enrichment; more than one third of the areas identified have been affected so severely that the oxygen concentrations in the coastal waters have become low enough (<2 parts per million) to be lethal to marine organisms for a portion of the year. As a result of this nutrient pollution, primarily from agricultural runoff, more and more coastal regions are being affected by the zones of low oxygen concentration, threatening coastal and marine life and the associated fish and shellfish production from nearby fisheries.

The loss of coastal wetlands and the protection they provide to coastal ecosystems has been blamed for both the increased impact of eutrophication and the increase in damage resulting from the unmitigated wave and wind energy of hurricanes and tropical storms.

Restoration of coastal wetlands would protect valuable coastal regions that are presently vulnerable to damage from hurricanes, tropical storms, and tsunamis. Restoration of riverine wetlands could help lower the delivery of nutrients to coastal waters, decreasing problems with hypoxia and preventing the loss of economic benefits from the harvest of shellfish and fin fish. In addition, land management practices that reduce nutrient pollution and sediment export from cropland would benefit both the aquatic systems within agricultural watersheds and the coastal environments downstream.

**Water and Society**

The human and cultural dimensions of our relationship with water are perhaps the most difficult to assess, describe, and quantify; yet our cultural, aesthetic, and spiritual relationships with water are among the most powerful forces spurring society to action. Connection to place, and often to places that are characterized by the presence of water, has been recognized as an important aspect of the development of a conservation ethic. Water is an integral part of religious ceremonies in many cultures, and specific water bodies (such as the Ganges River for Hindus) are sites of holy pilgrimage.

**Reliable Information on Water Use**

Current efforts toward global assessments of the condition and trends of freshwater ecosystems worldwide are hampered by the lack of standardized, comprehensive data collection and by the transboundary nature of many of the world’s
watersheds and river basins. Hydrologic stations around the world have been declining over the past three decades, and some important data (such as the location of small dams 15 meters in height or less) have not been collected. In the United States, annual threats to the budget of federal agencies charged with monitoring stream flow and water quality (i.e., the USGS and the U.S. Environmental Protection Agency [EPA]) have affected water-monitoring programs such as EPA’s Index of Watershed Indicators (IWI) program (26% of U.S. watersheds have insufficient data for classification with this index) and the USGS National Water-Quality Assessment (NAWQA) program. In addition, funding for the 50 state Water Resources Research Institutes has been threatened annually throughout the early part of this millennium. Scientists who rely on such programs for critical data on the nation’s water resources must expend substantial energy each year in attempting to reinstate funding for these programs. Consistent underfunding of NAWQA has required the USGS to prioritize watersheds for monitoring, shifting focus from region to region every few years rather than maintaining long-term, continuous monitoring programs in the 60 basins identified as a representative sample of watersheds nationwide.

The collection of comprehensive, basic hydrological and geochemical data worldwide would significantly enhance the ability to monitor the status and condition of the world’s freshwater resources and to anticipate and address threats to freshwater ecosystems. To manage water resources effectively, water scientists need to develop a global database that will allow the monitoring of precipitation, runoff, stream discharge, withdrawals for various uses, and water quality data collected, using the standard methodology. Key water quality variables that need to be measured include sediment and dissolved organic carbon, temperature, nutrients (especially compounds containing nitrogen and phosphorus), bacteria, and the occurrence and abundance of organisms that cause waterborne diseases.

Data concerning groundwater withdrawals are even more difficult to obtain than data on surface water withdrawals, compounding the difficulty in understanding current uses or forecasting the sustainability of the world’s water supplies. The WRI recommends the compilation of a global data set on groundwater resources (including their distribution, capacity, and use) and has encouraged national governments to establish water-quality-monitoring programs that combine chemical and biological measures of water quality for both surface water and groundwater.

Finally, information concerning the value of ecosystem services provided by freshwater ecosystems, including wetlands, lakes, rivers, and streams, should be placed in the hands of decision makers. Decision makers at many levels are often uninformed concerning the value of the many ecosystem services provided by freshwater ecosystems and the benefits these systems provide to people. As a result, their decisions are seldom informed by even semiquantitative estimates of the economic value of both the marketed and the nonmarketed services provided by freshwater ecosystems, leading to an undervaluing of those services in decision making.

Conclusion

Freshwater is one of the world’s most precious as well as most threatened resources. Conservation of existing freshwater resources, protection of surface and groundwater from pollution and overuse, and distribution of clean water for drinking and household use to regions where water is scarce will be among the greatest challenges to the national governments of the world in the next century, as population increases and clean water becomes increasingly scarce. Strengthening and informing the institutions responsible for water governance will also be critically important in ensuring that the water needs of the future are met.

Mary V. Santelmann

See also Agrochemical Pollution; Anthropogenic Climate Change; Coastal Dead Zones; Environmental Services; Groundwater; International Watershed Management; Nonpoint Sources of Pollution; Urban Water Supply; Wastewater Management and Treatment; Water Degradation; Water Management and Treatment; Water Needs; Water Pollution; Water Supply Siting and Management; Watershed Management; Watershed Yield; Wetlands
Further Readings


Water Pollution

Water pollution occurs when harmful materials are introduced into the lakes, rivers, oceans, and groundwater. These harmful materials are referred to as pollutants. There are a variety of pollutants ranging from biological (e.g., bacteria and viruses) to chemical (e.g., metals, solvents, pesticides, and floating detergents and oils) forms, and from nutrients (e.g., phosphorus and nitrogen) to suspended sediment. They cause diverse problems in aquatic ecosystems. Pathogens serving as typical microbiological pollutants cause many illnesses ranging from typhoid and dysentery to minor respiratory and skin diseases. Chemical pollutants are poisonous to aquatic life, birds, animals, and people. Excess inputs of nutrients from agricultural management lead to eutrophication—the excessive growth of algae, periphyton, and weeds, which can deplete dissolved oxygen to the detriment of fish, reduce potability, and preclude recreational uses of water. Suspended sediment threatens aquatic ecosystems directly and indirectly. Reduction of light penetration due to the presence of suspended sediment directly reduces photosynthesis. In addition, sediment smothers bottom-dwelling organisms and clogs fish gills, prevents successful development of fish eggs and larvae, and modifies fish movement and migration. Indirectly, suspended sediment serves as a carrier for the nutrients, metals, and organic biocides that adsorb to the sediment.

Because of the complex interaction between groundwater and surface water, groundwater pollution, sometimes referred to as groundwater contamination, is not included here. Surface water pollution is generally classified by sources into point and nonpoint source pollutions. Point source pollution refers to the process by which harmful substances enter a waterway through a discrete conveyance, such as a pipe or a ditch. Examples of point sources include discharges from a sewage treatment plant or a factory, or a tributary that transports pollutant loads into the main stream. Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. It is often a cumulative effect of small amounts of contaminants gathered from a large area. Nutrient runoff in storm water from “sheet flow” over an agricultural field or metals and hydrocarbons from an area with highly impervious surfaces and vehicular traffic are sometimes cited as examples of nonpoint source pollution. Different types of nonpoint source pollutants derive from different types of sources. Suspended sediment is largely originated from cultivated agricultural lands, deforested areas, urban construction sites, dirt roads, and even eroded channel banks. Phosphorus inputs mainly come from fertilizer applied to agricultural soils and
manure supplied from concentrated livestock operations. Although, part of it (about 30% of the total input in the United States and Europe) can be sequestered by crops, the majority of applied phosphorus remains in the upper 10 centimeters of soils in the agricultural fields or exports to surface waters by erosion or leaching. In the United States and Europe, only 18% of the nitrogen input in fertilizer is removed from farms in produce. The surplus of nitrogen may accumulate in soils, erode, or leach to surface water and groundwater. Some may enter the atmosphere through volatilization of NH₃ (ammonia) and microbial generation of N₂O (nitrous oxide). Much of the nitrogen volatilized to the atmosphere is subsequently redeposited on land or water and eventually returns to aquatic ecosystems.

The degree of water pollution can be quantified by water quality, the physical, chemical, and biological characteristics of water in relationship to a set of standards. The most commonly used criterion for measuring water quality is the total maximum daily load (TMDL), which is a calculation of the maximum amount of a pollutant type that a water body can receive and still safely meet the water quality standards. The TMDL is the sum of the individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, and a margin of safety (MOS)—that is,

\[ \text{TMDL} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}. \]

According to the U.S. Clean Water Act Section 303 implemented in 1972, each state is required to identify and list the impaired water bodies based on its TMDL standards.

Pollutant loads from point sources such as municipal sewage treatment plants tend to be continuous, with little variability over time. Often they can be monitored by measuring water discharge and pollutant concentrations periodically at a single place. Consequently, point sources are relatively simple to measure and regulate and can often be controlled by treatment at the sources. The primary focus of legislation and efforts to curb water pollution for the past several decades was on point sources. However, it is well-known that nonpoint sources are now the dominant inputs of both sediment and nutrient pollutants in most U.S. surface waters. Therefore, greater attention has been placed on the contributions from nonpoint surface waters, especially in rapidly urbanizing or developing areas. Nonpoint source pollutants often derive from extensive areas of land and are transported via overland and underground or through the atmosphere to receiving waters. Therefore, estimation of nonpoint source pollution loads is much more difficult because the diffusive nature of the sources means that the affected area is extensive and hard to identify due to the complicated processes of pollutant movement.

Physical processes relevant to nonpoint source pollution are easier to understand from the perspective of the watershed, which refers to the area of land where all the water that is under it or drains off it goes into the same place, termed the outlet. A watershed is a basic geomorphic unit that can be appropriately divided into two components: hillslope lands and the stream network connected to them. Nonpoint sources of pollution are typically located in hillslope areas, but the associated pollutants can affect a large portion of the downstream area by their movement with surface and subsurface flow. The processes of pollutant transport may be described as solid particulate transport and dissolved substance movement, respectively. The former includes suspended sediment and particulate phosphorus and other compounds that can be absorbed on sediment, whereas the latter mainly contains dissolved phosphorus and nitrogen. Suspended sediment is transported by surface runoff. A large proportion of phosphorus is transported with suspended sediment. Therefore, the concentration of phosphorus in water bodies is normally positively related to that of suspended sediment if management practices for phosphorus are not implemented. Nitrogen is primarily transported in dissolved form through surface runoff and subsurface or groundwater through infiltration and leaching.

The processes of pollutant transport are complex. Soils eroded from nonpoint sources such as agricultural fields and construction sites in hillslope areas of a watershed are transported by surface runoff due to rainfall or snowmelt in the form of rill or interrill flow (collectively termed overland flow) into the connected branches of the stream.
network. Part of the transported suspended sediment may be deposited in the stream bed and resuspended later. Therefore, the processes of suspended sediment transport are controlled by the intensity and duration of rainfall or snowmelt events, hillslope topography, land use and land cover, and in-channel hydraulic dynamics. These processes typically vary with both space and time.

Suspended sediment transport has been extensively studied for decades. Usually, suspended sediment load $Q_s$ is determined by establishing a sediment-rating curve (SRC) (Figure 1), which is a mathematical relationship between $Q_s$ (or sediment concentration $C$) and $Q$:

$$M = aQ^b,$$

where $M$ is either $Q_s$ or $C$, and $a$ and $b$ are rating curve parameters determined by regression analysis using data obtained via in situ sediment

**Figure 1** A sediment-rating curve

Source: Author.
WATER POLLUTION

In addition to temporal variation, pollutant transport also varies in space. The spatial distribution of pollutant loads has been conventionally characterized using various process-based watershed models, which use various mathematical equations to describe the hydrological, sediment, and chemical processes involved and automatically link the solutions of the equations among spatial elements in terms of physical principles such as mass balance and wave propagation. According to their different spatial arrangements, watershed models may be generally categorized as lumped and distributed models. In the former, such as the Dynamic Watershed Simulation Model and the Soil and Water Assessment Tool, a watershed is divided into limited, relatively coarser areas assuming that variations of various physical processes controlling pollutant transport within each area are negligible. In the latter, such as the Annualized Agricultural Nonpoint Source Pollution model and the Better Assessment Science Integrating Point and Nonpoint Sources model, however, a watershed is dissected by a grid with regular sizes, and each cell has values representing its physiographic conditions. The lumped models are relatively simple and easy to use, but they may inappropriately ignore the process variations within the spatial elements used in the models. The distributed models can accurately characterize the processes involved in pollutant transport at very small spatial scales, but often their input files are very complicated, and some of the required input parameters are not known and have to be artificially created. With respect to predicting pollutant load for the entire watershed, both types of models behave similarly.

Peng Gao

See also Agrochemical Pollution; Coastal Zone and Marine Pollution; Nonpoint Sources of Pollution; Point Sources of Pollution; Wastewater Management; Water Degradation; Water Management and Treatment; Water Supply Siting and Management
Water management is a very broad term that pertains to the design and deployment of planning approaches to access and supply water. The term encompasses the planning and provision of water quantity (adequate volume of supply), water quality (safety of source), and also flood protection. Originally the term implied provision of water only for people, but more recently it has begun to

**Further Readings**


**Figure 2** An anticlockwise loop

Source: Author.
incorporate adequate supply and quality for the natural environment—namely, wildlife and its habitat. Water is essential for all life, and an increasing number of locations encounter either water quantity or quality concerns. This entry discusses water quantity, the philosophies of managing water quantity in the United States, water quality, flood protection, and water management through good governance.

While more of Earth’s surface is covered by water (approximately 70%) than land, because of the vast size of the oceans, the majority of the planet’s water is saltwater (97.5%). Of the 2.5% of water that is freshwater, approximately 70% is frozen in the Arctic and the Antarctic or is effectively inaccessible to humans as soil moisture or deep groundwater. Of the world’s total water, only about 0.007% is freshwater available for human use. Freshwater is a globally scarce resource, and it also has a highly variable distribution depending on location and climate. Water management is a core topic of geography as it links both natural systems and human action. A watershed is geographically defined in hydrology as consisting of all areas that drain to a common waterway. While watershed-based management is the logical approach to benefit hydrology, watersheds often transcend political boundaries, making watershed management more challenging.

### Water Quantity

Provision of an adequate volume of freshwater supply, or water quantity, is a primary concern of hydrologists, planners, and other individuals responsible for water management. While freshwater is globally scarce, its distribution is highly variable, which means that different locations encounter distinctive challenges to provide freshwater supply for human and industrial use. For example, arid regions in the southwestern United States have severe water shortages, while water-rich areas along the Great Lakes (the United States and Canada) have plentiful supply.

In general, management of water quantity is best approached at the drainage basin or watershed scale, which is the extent of land (the catchment area) that channels snowmelt and rain drainage into a waterway. However, water, particularly lakes and rivers, has been traditionally used as a convenient geographic feature of the landscape to divide land into different political boundaries. This means that many watersheds cross political boundaries at different scales. Some examples of transboundary rivers include the Colorado River, which forms part of the boundary of Arizona with Nevada and California, and the Ohio River, which forms the southern boundary of Ohio, Indiana, and Illinois and the northern boundary of West Virginia and Kentucky. Some national boundaries are also formed by rivers, such as the Jordan River, which flows along Syria, Israel, Palestine, and Jordan, or by lakes, such as the Caspian Sea, which borders Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan.

Even if water is not the actual boundary, water also flows through different political boundaries, making the management of water politically challenging. Consider, for example, the Tigris and the Euphrates rivers, which have headwaters in Turkey and flow through Syria and then into Iraq. Depending on their position within the watershed, nations often adopt different views as to how water management should be approached. Turkey views the Tigris and Euphrates system, which is sourced in that country, as a resource that it has the right to contain and has built the Ataturk dam and other smaller dams to manage the flow of water from Turkey into Syria. Downstream, Syria and Iraq argue that they have a right to the water that traditionally flowed through the rivers’ water course and contest Turkey’s right to restrict the rivers’ flow north of their borders. In a world with a growing population and an increasing demand for limited water, water management is a real source of conflict, particularly where watersheds cross political boundaries. Indeed, several books have explored the issue of wars over access to water. Even within nations, there can be conflict over how water should be allocated. One recent example in the United States is the dispute between Virginia and Maryland about the right of a growing suburban county in Virginia to access additional water from the Potomac River. That this dispute had to be settled by the U.S. Supreme Court in 2003 demonstrates the intensity of conflict surrounding access to water.
Philosophies of Managing Water Quantity in the United States

Within the United States, water allocation is within the purview of individual states, and there are two philosophies about how water allocation should be managed. The Mississippi River geographically divides the two different philosophies, with the right-to-use riparian doctrine to the east and the prior appropriation doctrine to the west. The demarcation of these is linked to both the biogeography of the regions and the historical uses of the water.

**Right to Use**

The right-to-use doctrine means that property owners along rivers and lakes have a right to reasonable use of the water as it flows past their property. Use is considered reasonable if the quantity and quality of flow are not diminished, preventing other riparian users from making reasonable use of the water. The right-to-use doctrine is used in states with moister climates and more plentiful water sources, though as with the example of Virginia and Maryland above, even locations that traditionally had larger volumes of water are encountering water management conflict with the rising population and increased use of water resources. Increasingly, the right to use depends on governmental regulation to monitor the reasonableness of use. This regulated riparian system is administered by state agencies that apply the principles of reasonable use to issue permits for the use of or discharge into water.

**Prior Appropriation**

Prior appropriation became the method for water allocation in the western states because of their drier climate. Historically in the west, fewer people sought the rights to use water in association with mining claims and, later, for agricultural irrigation. With the higher annual variability in rainfall in the region, there was greater uncertainty about availability of water. Moreover, in the western states, where water is limited, limiting the use of water to only adjacent landowners would also limit the number of settlements because nonriparian lands would have significantly diminished productivity. Hence, unlike the right-to-use doctrine, the prior appropriation doctrine separates water rights from land ownership. The principle of the prior appropriation doctrine is commonly explained as “first in time, first in right,” because it is a system where the earliest water users have rights to water that take precedence over subsequent claims. Through the prior appropriation doctrine, water rights entail the diversion of water from its source for a beneficial use. If appropriated water is no longer put to beneficial use, that right is lost as the right passes to the next user with a claim; this “use it or lose it” attribute of the prior appropriation system is not conducive to water conservation by users with early rights.

The growing population of the western states, high rainfall variability, and increasing demand for water mean that in years of low rainfall some rivers would effectively run dry. For example, the transboundary Colorado River, whose allocation was determined in the years following particularly high rainfall, has been so depleted that only a trickle enters Mexico, and in some years, the river no longer consistently reaches the sea, with devastating effects on wildlife and habitats in former wetlands and coastal areas.

**Minimum Flows and Levels**

The potential for devastation of the environment through overappropriation of water, particularly in low-rainfall years, in the 1990s led to an effort to devise a system to protect the environment, working in concert with the prior appropriation doctrine, in the watersheds of the western states. The western states now have instituted laws that ensure minimum flows and levels within watercourses to provide for the needs of habitat and wildlife. Rising demands for water in the eastern states under the right-to-use doctrine have also led to the formulation of water management regulations to protect minimum flows and levels for wildlife. One example is within the South Florida Water Management District. Here, the water management system has been significantly modified to incorporate
the needs of wildlife and its habitat for water of adequate quantity and quality.

**Water Quality**

While conflicts surrounding water allocation relate to the ability of competing interests to access sufficient quantities of water, water quality issues largely pertain to concerns over the deterioration of water as a result of pollutants entering waterways. Water quality issues tend to manifest more in downstream portions of rivers, which experience accumulation of pollution from upstream. Two types of pollution can occur: (1) from *point sources*, that is, single identifiable sources such as factory pipes discharging effluent into a river, and (2) from *nonpoint sources*, which consist of many diffuse sources, including water runoff moving over or through the ground transporting urban pollutants, fertilizers, contaminated sediments, or biological waste.

Point source pollution is easier to regulate than nonpoint source pollution. One of the key challenges of managing nonpoint source pollution is that while the individual activities may fall within environmental safety guidelines, the cumulative effect in the watershed is the creation of unsafe levels of pollution. While, at an additional expense, water can be treated to improve water quality before distribution for human consumption, poor water quality also has a deleterious effect on the natural environment. For example, in the Florida Everglades, elevated levels of naturally occurring phosphorus have resulted in a shift from natural to invasive vegetation, resulting in a negative effect on wildlife, including endangered species.
Flood Protection

Flood protection is a high-profile aspect of water management. Flood protection largely entails protecting homes, roads, and other aspects of the built environment from inundation during high-water events. In many locations, flooding is part of the natural cycle of a watershed. For example, until the Aswan Dam was constructed, the Nile River annually overflowed its banks, depositing soil sediments and making the area fertile for agriculture. Throughout the world, many dams and levees have been built in an attempt to prevent flooding of property. While these water management structures offer some stabilization of water levels and flood protection, they may be unable to provide protection from extreme high-water events and also may have deleterious effects on the environment.

In addition to protection from flooding of rivers, flood protection encompasses protection of coastal areas from hurricanes, typhoons, and storm surges. Recent events have demonstrated the devastating effects of inadequate coastal defenses, such as the 2004 tsunami and the breaking of the New Orleans levees by Hurricane Katrina in 2005. Beyond surface inundation, flood protection is also important for preventing saltwater intrusion of freshwater aquifers, which once contaminated may take many years to be usable again for human’s freshwater needs.

Managing Water Through Good Governance

Water management concerns in the 19th and 20th centuries were understood as technical issues to be solved by hydrologists and engineers. Since the end of the 20th century, there has been a shift toward understanding water management concerns not only as engineering challenges but also as highly contested, often politicized, issues that require the engagement of wider stakeholders toward designing sustainable and equitable water management strategies. Good governance of watershed-based management requires the inclusion of wider-ranging nongovernmental interests in shaping water management policy for a given watershed, which is important in light of increasing demands for limited water. One example where water management practices were significantly modified through the integration of wider stakeholder groups in a watershed-scale planning process was in South Florida. Through the involvement of competing stakeholders, a common vision emerged for improving water management. This perspective included a shift in focus from primarily water supply and flood protection to provision for the environment toward securing the long-term sustainability of the water supply to meet an anticipated growth in both human demands and environmental needs.

Mary Dengler

See also Everglades Restoration; Hurricane Katrina; Indigenous Water Management; International Watershed Management; Nonpoint Sources of Pollution; Participatory Planning; Point Sources of Pollution; Wastewater Management; Water Management and Treatment; Water Needs; Water Supply Siting and Management; Watershed Yield

Further Readings


WATERSHED YIELD

The ebb and flow of sediment movement in a watershed is spatially and temporally complex and difficult to quantify. However, attempting to quantify and understand sediment dynamics in a watershed is important for the successful management of aquatic and terrestrial ecology and
the associated health of the watershed. Soil erosion is a worldwide problem that has degraded small and large watersheds. Estimating the sediment yield of a watershed helps resource managers understand the amount of soil erosion that exists and how much sediment is stored in the watershed. Within the fluvial hierarchy, watersheds provide a spatial framework by which the physical and environmental metrics influencing sediment movement can be evaluated. A watershed is defined as the contributing area of land that captures and drains precipitation to an outlet point, which does not have to be a stream or lake confluence. Rather, the outlet can be a point on a stream reach, and the contributing area of the watershed would be delineated from the predefined point.

Sediment yield in a watershed is quantified using the amount of sediment passing a point in the watershed per some unit of volume per time (i.e., cubic meters per kilometer per year) or mass per time (kilograms per square meter per year). Sediment yield can be estimated by coring reservoirs and lakes, performing suspended sediment sampling at the outlet, direct site observation and calculation of erosion, and computer modeling. Reservoirs and lakes act as sediment traps and through coring or bathymetric surveys can provide an insight into temporal and spatial changes of sediment routing through the watershed. Suspended sediment is measured at the outlet and plotted against discharge. A rating curve can be established if the duration of sampling spans multiple high- and low-discharge events. The source of suspended sediment (mostly silt and clay) is mainly from surface and subsurface erosion, which includes roads, culverts, tile lines, rills, gullies, overland flow, and stream banks. One of the concerns of only measuring suspended sediment is that bed load transport is not accounted for. However, bed load normally comprises a small amount of the sediment transport in large river systems. Direct site observations are difficult and time-consuming. In turn, soil erosion models have become a popular means of establishing the erosion estimates. These include, but are not limited to, the universal soil loss equation, revised universal soil loss equation, water erosion prediction project (WEPP) model, and geographic information systems (GIS).

Sediment is mobilized and transported in a watershed by physical and chemical weathering and erosion. Only a small portion of the sediment eroded in a watershed is quantified as the sediment yield of the watershed. This is because sediment is deposited and stored throughout the watershed. Temporary and permanent storage exists on the bed of the channel, bars, floodplains, wetlands, impoundments, and hillslopes. Watersheds of contrasting size route sediment differently. Watersheds draining a small area will generally have sediment yields greater than watersheds draining a larger area. Where relief and hillslope gradient are higher, sediment has a greater opportunity to reach the stream. Watersheds draining a larger area have streams that parallel floodplains and terraces, which store flood deposits and hillslope-generated sediments.

Besides watershed size, variables that influence sediment yield include climate and precipitation, vegetation, soils, topography, and land use. Rainfall has the ability to intensify erosion, especially on high-gradient slopes with sparse vegetation. Vegetation captures rainfall, and through the process of stem flow and the interception of falling droplets, infiltration occurs and rain splash erosion is decreased. In addition, roots of the vegetation (on hillslopes and floodplains) hold the soil in place, which increases cohesion and decreases surface erosion. Coarse-textured soils with low infiltration capacity, hydrophobic soils, and soils with low organic matter or weak structure tend to be the most susceptible to erosion. Generally, particle size decreases downstream, and because larger streams are inset into their own deposits, bank cohesion increases while sediment yield decreases. However, it is important to recognize that this oversimplified fining hypothesis is spatially complex. Under the influence of gravity, slopes with higher gradient and longer slope length cause increased soil erosion. Changes in land use affect the sediment yield in a watershed. Anthropogenic changes, including mining, deforestation, urbanization, fire, and agriculture, have altered sediment yield worldwide.

Researchers have attempted to portray sediment yield in a regional context, but high spatial variability has limited the results. When sediment yield is plotted as a function of precipitation, three sediment yield peaks exist at (1) ∼450 mm (millimeters; continental semiarid climate), (2) 1,250
to 1,350 mm (Mediterranean climate), and (3) >2,500 mm (tropical monsoon climate). The peak at ~450 mm corresponds to a transitional zone between desert shrub vegetation and grasslands. Precipitation slightly greater than ~500 mm is associated with grasslands and forests, with a decrease in the erosion potential. Sediment yield peaks at 1,250 to 1,350 mm and >2,500 mm are associated with seasonal precipitation amounts. Concerns about relating sediment yield to precipitation are that (a) seasonal precipitation affects the vegetation, which determines the erosion potential, and (b) anthropogenic alteration to the environment will mask the role of precipitation. Sediment yield should be determined on a watershed-by-watershed basis because of the inherent variability that exists in sediment transport and storage throughout the watershed.

Dale Splinter

See also International Watershed Management; Surface Water; Water Needs; Water Supply Siting and Management; Watershed Management

Further Readings


Water is a critical resource for the health of ecosystems and the reproduction of society. Water siting refers to the process of transformation of this basic component of the biosphere into a resource able to satisfy human needs. Siting includes, therefore, both the places where water is captured for human activities and the technologies and institutional arrangements that make this transformation possible. Water management refers to the institutional, legal, and technological arrangements by which water is allocated temporally and spatially to the different users (agriculture, industry, urban, environmental flows).

Surface water and groundwater are the two main conventional sources of freshwater, and their use entails different technologies of capture and also different institutions to regulate its use. Surface water of rivers and lakes can be directly captured from the source by means of ditches, especially for agricultural use. However, for thousands of years, dams, reservoirs, and channels have been developed to guarantee water availability where and when needed. Interbasin water transfers are justified on the ground that they contribute to redress the balance between “surplus” and “deficit” basins. Dams, reservoirs, and water transfers are important human interventions to mobilize and transform nature and have important consequences on the environment and society. While these interventions allow population and crop growth where water is scarce, they also modify the physical environment and affect the living condition of local populations and environments.

Aquifers are underground geological formations formed by layers of porous and permeable materials containing water. By means of wells or pumps, water can be brought to the surface. In this case, the use and consumption of water tends to be more local. Overextraction of water from aquifers can cause depletion and pollution, often irreversibly damaging the source.

Other nonconventional sources of water supply may be also relevant in some contexts. Desalination technologies involve several methods to
turn seawater or brackish water into freshwater. Currently, the most efficient of such methods is called reverse osmosis. However, large amounts of energy are consumed in the process, with subsequent emissions of carbon dioxide (if the primary energy sources are fossil fuels). In turn, this process is reflected in the economic costs and subsequently limits such technology to urban (including tourist related) and industrial uses in the developed world.

Water harvesting is another technology traditionally practiced in the developing countries. It consists of the capture and storage of rainwater and has the advantage of not requiring a large infrastructure. Its usefulness at the local scale makes it an interesting resource that is being rediscovered in Western societies. Equally, the treatment and reutilization of wastewater (gray water) by means of small-scale or centralized utilities can be a resource for agriculture, industry, and even household outdoor uses. This practice is common in California.

Water management requires the existence of a series of formal and informal institutions, practices, and regulations that determine how water is to be allocated across space and time among different users. Agriculture accounts for most of the water consumption worldwide. However, urban water consumption is dramatically increasing due to the processes of urbanization of rural land in the developing world and the increase of water consumption in Western urban areas because of changes in urban patterns and the widespread use of water-consuming appliances. Tourism also accounts for an important share of urban water consumption in some regions of the world, especially in the coastal temperate areas. Eventually, industry...
could be a heavy and intensive user of water depending on the activity, and it especially affects water quality.

The special characteristics of water differentiate it from other raw materials such as oil, minerals, or food in transportation at the international level. Water sources tend to be acquired locally or regionally. Although water use is geographically bounded to place, international trade of commodities, from garments to vegetables to computers, implies a very significant flow of “virtual water,” that is, the water that has been used locally to produce each item. Increasingly, trade strategies are considered by water-stressed countries to alleviate water scarcity.

During the 20th century, engineering perspectives on water supply have reigned supreme, and policymakers have tended to centralize and increase supply by building new infrastructure to capture water. Although much of this philosophy still persists, there is an ongoing transition from a supply-side approach to water resources toward demand management, which tends to make the most of available resources while downsizing the scale of the infrastructure of supply. Demand-side management includes both economic and noneconomic tools, such as educational campaigns, restrictions, and so on. Price mechanisms are the main instruments for regulating demand and promoting the efficient use of resources. Efficiency in the management and use of water is deemed essential. Institutional changes become materialized in new water legislation that—for example, in Europe—tends to establish the river basin as the unit of policy action and integrated water resources management and for incorporating environmental costs into the price of water for full cost recovery of water supply. Water markets represent an important institutional arrangement to allocate water to the highest economic value (e.g., in Chile, Australia, South Africa, and the Western United States).

To sum up, water siting and management comprise both supply- and demand-side management strategies, encompassing a series of technological and political arrangements. As long as climate variations enhance water stress in some parts of the world, technology, productive activities, and urbanization may either alleviate this situation or contribute further to the social scarcity of water.

Hug March Corbella and David Saurí

See also International Watershed Management; Urban Water Supply; Water Management and Treatment; Water Needs; Watershed Management

Further Readings


WATTS, MICHAEL (1951– )

Michael J. Watts is a Marxist geographer specializing in political ecology and economic geography. Born in England, Watts has published more than 200 scholarly articles, books, and essays that have appeared in leading journals in geography and anthropology. His work focuses on the politics of oil, agrarian political economy, and development. Much of that work is based on field research in Nigeria and West Africa and related work in India, Vietnam, and the United
States. He is the Class of 1963 Professor of Geography at the University of California, Berkeley, where he has taught since 1979. Watts’s scholarly work combines his commitments to social change with his formidable intellect, yielding a wide-ranging body of work whose influence extends far beyond geography.

Watts is widely regarded as a founding figure in the field of political ecology for his initial research on the politics of famine in Nigeria during the 1970s. Drawing from his training in cultural ecology and anthropology at the University of Michigan under Roy Rappaport, Bernard Nietschmann, Eric Wolf, and Michael Taussig, Watts brought Marxist political economy to bear on questions of nature and society. He argued that famines were crises of distribution that laid bare the structural inequalities of capitalist markets as means of distribution, challenging the prevailing neo-Malthusian accounts of famine as instances of scarcity created by the demands placed by a growing population on natural resources. Watts’s arguments also challenged Nobel laureate Amartya Sen’s critical explanation of famine as an outcome of the social curtailment of freedom.

One of the last students to receive a doctorate in geography at the University of Michigan, Watts’s approach contrasted sharply with the lingering influences of Carl Sauer’s “Berkeley School” of geography that he encountered as a new professor. At Berkeley, Watts developed his approach to political ecology through engagement with questions of culture, power, and political economy through participation in critical efforts to rethink Marxist political economy. In particular, Watts drew on the works of Raymond Williams and E. P. Thompson to address the importance of culture to questions of nature, resource struggles, and society, engaging with poststructuralism and the cultural turn in the social sciences. Together with Alan Pred, he developed a critical approach to studying capitalism in terms of its historically and geographically specific patterns of accumulation and forms of resistance. Watts continues to develop these themes through research on the politics of oil in the Niger Delta, bringing Foucaultian-inspired analytics to bear on questions of governance and natural resources.

A geographer unburdened by the disciplinary bounds of the field, Watts has helped influence a range of research as a collaborator, colleague, and advisor. At Berkeley, Watts served as director for the Institute for International Studies from 1994 to 2004, founding a series of seminars and colloquia that shaped a generation of scholarship. In particular, the Berkeley Workshop on Environmental Politics, which he cofounded with Nancy Peluso and Donald Moore, has become a critical locale for debates on environment, cultural politics, and political economy. He has also worked with Gillian Hart to build Berkeley’s programs in development studies and African studies. He has directed more than 60 doctoral dissertations, and many of his students are now prominent scholars in geography. He is also one of the more highly regarded lecturers on the Berkeley campus. Watts has received numerous awards and accolades during his career, including a Guggenheim fellowship in 2003 for his work on oil in Nigeria. He delivered the first talk in the Hettner Lecture series at the University of Heidelberg in 1999.

Joe Bryan

See also Cultural Ecology; Development Theory; Famine, Geography of; Marxism, Geography and; Political Ecology

Further Readings


Wayfinding is the cognitive-conceptual process of finding and planning a route from an origin to a destination through a known, partially known, or
unknown environment. Travel from an origin to a destination is a fundamental human activity that nearly everyone completes on a daily basis. The centrality of wayfinding to humans is made evident by the expanding knowledge domain specific to wayfinding and related concepts as well as the booming, multimillion-dollar industry providing services and support for wayfinding and navigation technologies.

Wayfinding should be distinguished from locomotion (movement) and navigation. Wayfinding is the cognitive-conceptual aspect of route finding and planning, locomotion refers to the actual physical movement of a cognitive agent in an environment, and navigation is a stylized form of wayfinding that typically includes guiding a vehicle such as a ship or an aircraft. Wayfinding’s cognitive-conceptual nature is stressed as it synthesizes complex cognitive processes (e.g., landmark recognition, route retracing, route planning, route selection, path integration) with conceptual primitives of spatial knowledge (location, direction, distance, connectivity, and spatiotemporal sequence).

The basis for wayfinding is knowledge about one’s environment, or if knowledge (internal/mental or external) is not available, the administration of a wayfinding strategy to uncover such knowledge. In addition to the primitives of spatial knowledge mentioned above, successful wayfinding also requires knowledge about landmarks (salient objects located in an environment), knowledge about routes (how landmarks and other salient locations are connected), and survey knowledge (how landmarks and routes are spatially arranged).

Research on landmarks has undergone a renaissance in recent years because of the increased availability of navigation devices and improved analysis functions for identifying landmarks for use in navigation services. Mimicking the extensive human emphasis on landmarks when wayfinding, several technological developments now allow for the automatic identification and selection of landmarks in databases, three-dimensional city models, and the Internet. Across all proposed landmark taxonomies, two orthogonal approaches can be distinguished: (1) reference to the landmarks themselves, identifying three kinds of landmark salience (visual, semantic, and structural), and (2) focus on the geometric conceptualization of the landmark when used in wayfinding and navigation, indentifying three geometric dimensions (pointlike, linear, or area-like).

The first step in every wayfinding activity is to determine one’s location in the environment. This location information, from a cognitive point of view, is not the exact coordinate pair at which a wayfinder is located but an alignment of the wayfinder’s mental representation of the environment and the information the wayfinder is accessing either directly (through perceiving his or her surroundings) or indirectly (e.g., through a map). Figure 1 shows this triangular relationship schematically with relations among the wayfinder, the environment, and an external knowledge source such as a map.

Some wayfinding strategies are employed when one’s current location or possible wayfinding routes are partially or completely unknown. In these cases, the term wayfinding is used in its most literal sense: to find one’s way. Other wayfinding strategies are specific to route choice behavior; that is, from a given set of known alternatives a specific route is chosen. Examples are choosing the shortest or longest route segment first or choosing the route segments with the smallest deviating angle from the destination.

Most wayfinding activities take place along constraining artifacts such as street or public

![Figure 1](Image) The interaction among wayfinder, environment, and representations of the environment

Source: Author.
transportation networks. Even most natural environments offer superimposed artificial structures such as trails. It is of crucial importance to understand the influences that specific environments have on wayfinding and on wayfinding success. This point becomes particularly apparent when the environment, either cultural (e.g., a city layout of streets and buildings) or natural (e.g., mountain ranges), is misaligned from our mental preconceptions. Examples include the northwest to southeast orientation of the mountains located outside Santa Barbara, California, or the southwest to northeast isthmus on which Madison, Wisconsin, is built. The naming of features within these landscapes, based on the traditional gridded city block convention of the United States, often contrasts with the true characteristics of the feature.

Other examples that stress the importance of the environment on wayfinding become apparent when we look at different wayfinding strategies. How is wayfinding in street networks different from wayfinding in deserts? While in relatively unstructured environments, such as open oceans or deserts, information about one’s location and especially direction (i.e., bearing) is of utmost importance, the constraining nature of structured environments deemphasizes these spatial primitives and places a greater emphasis on connectivity. For example, when wayfinders are moving through a road network, choices about where to turn are very limited and the actual turning angle is of secondary importance. The initial physical turn (e.g., at a highway interchange) may even be in a direction opposite the planned direction change.

The importance of understanding and using the knowledge that an environment offers is recognized in several research communities and is gaining particular importance for researchers interested in supporting wayfinding through cognitively ergonomic navigation devices. For example, an understanding of the environment can lead to a tremendous reduction in the amount of information that a wayfinder must remember during the process of wayfinding. If this inherent environmental knowledge can be formally characterized through a cognitively guided analysis of an environment, these principles of understanding and organizing an environment can be used to communicate environmental knowledge and/or help wayfinders better understand their surroundings.

Wayfinding, especially in large cities but also on a geographic scale, often takes place in a multimodal environment that offers various forms of transportation. Pedestrian walks are combined with public transportation, which in itself can be a combination of, for example, buses and subways. Taxicab rides to an airport are combined with indoor wayfinding in airport buildings, flying to another airport, and so forth. The challenges of multimodal wayfinding are manifold and often involve tasks such as temporal sequencing of events, switching between different signage systems (indoor vs. outdoor), and switching from constrained travels (e.g., a cab ride) to semistructured wayfinding in large airport spaces.

In summary, wayfinding is a cognitive process that synthesizes a variety of cognitive subprocesses and combines different kinds of spatial knowledge. Wayfinding and wayfinding strategies are deeply interwoven with the characteristics of an environment in which the wayfinding process takes place. Current developments in technology support wayfinding services by providing tailored, cognitively ergonomic information solutions. Wayfinding, as an everyday process, is central to a modern understanding of spatial cognition.

Alexander Klippel

See also Behavioral Geography; Mental Maps; Spatial Cognition

Further Readings


WEATHER AND CLIMATE CONTROLS

Climate, which consists of observations of meteorological parameters (i.e., weather) over a specified period of time, is shaped by many environmental factors. Although weather conditions at any particular time can be ephemeral and deviate from expectations, over a long period of time, certain characteristics are associated with any given location on Earth. The longer the period of record, the more likely that climate regimes will be identifiable with recognizable temperature and precipitation characteristics. This entry discusses seasonal changes in climate as well as major controls and localized controls on weather and climate.

Seasonal Changes in Climate

The seasons are among the most well-known environmental parameters that affect long-term climate and shorter periods of time associated with weather. Seasonal changes in climate for a given locale are imprinted on the daily lives of the biology in these locales, in everything from the smallest plants to the local human inhabitants. For example, anyone reading this passage may be able to picture the environmental conditions in their own hometown during each of the four astronomical seasons and may also imagine the likely climate conditions present during these seasons. These “memory maps” of climate changes due to the seasons can be found in anyone inhabiting a particular area for a long enough period; in fact, with enough living experience, nearly all biological life forms appear to incorporate temperature and/or moisture into their evolutionary adaptations, associated with particular sites on Earth.

It is important to note that the effect of seasons on weather and climate is solely due to changes in solar insolation (incoming sunlight) during the year, and this is reflected in the latitude of an individual location above or below the equator—all places along a given latitude will receive these changes in incoming solar energy. The general patterns of incoming energy are reflected in the seasonality, as discussed above. Although we have four seasons in the United States, other regions of the world do not have such distinct divisions in yearly climate. For example, areas located within 23.5° of the equator have very minor changes in temperature throughout the year—these latitudes are commonly known as the tropics, as they lie between the maximum latitudinal extents of vertical solar declination. We refer to the annual range in temperatures in the tropics as very minor. In areas far to the north, such as Alaska and above the Arctic Circle, the annual range can be very great—these areas can receive lengthy periods of dim to no sunlight during winter, contrasted with lengthy periods of daylight through summer. Therefore, latitude plays a significant role in seasonal-scale climate trends. However, many other geographic parameters control the actual weather that occurs at any selected location, and these other controls on weather are the focus of this entry.

Major Controls on Weather and Climate

A general discussion of the controls on climate typically begins with the assessment of the thermal properties of land or soil versus those of water, typically referring to the oceans and their enormous heat storage capacity. Land absorbs the solar energy that is received during the day and rapidly heats up due to a low specific heat (a physical property referring to the energy a substance must absorb to raise the temperature of a 1-gram mass of water by 1°C). The reverse is also true: At night, when the sun is no longer providing incoming energy to the surface of Earth, the land cools down rapidly due to the same characteristic of low specific heat. The opposite is true of water, which has a very high specific heat. It takes a long time, therefore, for water to heat up and cool down. This is reflected in the long lag times between peak solar insolation and peak water temperatures. For example, if one were to visit one of the Great Lakes (such as Lake Huron or Superior) in May, one might find the water to be too cold to swim even on a 100°F day. However, visiting in August on a day with a maximum temperature of 85°F, one would likely experience water temperatures 10° to 15° higher. This is because even though the sun reaches its seasonal declination zenith on the summer solstice (June 21), it takes about another 30 days for this peak in incoming energy to translate into a peak in water temperatures. The end result in these differences
in specific heat between land and water is a greater range in temperatures in locations that are far removed from large bodies of water (called continental climates), with a smaller annual range of temperatures at locations located near such bodies of water due to the moderating effects of proximity to these features. Furthermore, these properties are reflected in the differences in climates between locations in the Northern Hemisphere versus those in the Southern Hemisphere. In general, Northern Hemisphere climates are more variable and have a higher annual temperature range than Southern Hemisphere climates. Once these more rapid swings in temperature over large land masses are considered, it is logical that the majority of severe weather events such as tornadoes, mesoscale convective complexes, and derechos occur in the Northern Hemisphere.

When one considers the differential heating between water and land, another factor must be considered—that of oceanic currents. Just because two cities at a given latitude are within a certain distance from an ocean does not imply that the weather at both places will be the same. In fact, ocean currents play a large role in the actual climatic conditions at these coastal locales. Typically, western coasts in the Northern Hemisphere are associated with cool currents, as colder water circulates toward the equator from the polar regions. This is reflected in the cool oceanic water off of the northwest coast of the United States—taking a dip in the waters off Seattle even in August can be quite a chilly experience. Surfers in California often have to wear wetsuits to prevent hypothermia, even as far south as Los Angeles or San Diego. The opposite is true of most east coast locales. For example, the water in Miami may be cool in winter, but it is still much warmer than water at the same latitude along the western coast of the North American continent. This is due to the Gulf Stream, an enormous current of warm water that travels up the eastern coastline of the United States before curving out into the Atlantic and flowing toward Europe. In fact, given the latitude of the United Kingdom and Northern Europe, winters would be much more severe if not for the modifying effects of the warm Gulf Stream flowing just offshore. Thus, in the Northern Hemisphere, cities near western coastal boundaries often experience cool marine climates, whereas cities near eastern coastal boundaries often experience more continental climates, with a warming influence from northerly bound currents. These trends are reversed in the Southern Hemisphere.

A final observation on the differences in climate between two coastal cities located on opposite coasts includes an examination of the wind patterns at western versus eastern continental margins. For example, San Francisco, on the Pacific (western) coastline of the United States, experiences prevailing winds from the westerly direction, which drive the air situated above the cool California current ashore, producing cool sea breezes and late-afternoon advection fog. In contrast, Charleston, South Carolina, located on an eastern coastline, receives westerly prevailing winds also, but these flow from land toward the ocean (hence, a continental climate). Charleston’s weather would be influenced by the warm oceanic current just offshore, resulting in milder wintertime temperatures. Therefore, the environment over which the prevailing wind travels helps control the climate patterns that subsequently occur, even at two coastal locations. These are collectively referred to as continental versus maritime climate controls.

Another major climate control is the altitude of any location. Since Earth’s atmosphere is significantly denser at the surface than at increasing altitude, higher locations experience greater temperature ranges and are generally cooler than locations with lower altitudes. However, it is important to note an important caveat with the assumption that a linear decrease in temperature takes place with increasing elevation: The soil or material composing the majority of the exposed surface plays a large role in the true climatic conditions experienced at locations with high elevations. The concept of greater or lesser energy absorption based on differing reflectance properties of surface material is known as albedo. The end result, however, is that locations that are at similar elevations and similar latitudes may have different temperature ranges based on the underlying material that is exposed to sunlight. Darker rock or heavily built urban environments will be more likely to absorb and slowly release heat energy than environments containing lighter colored material or less built structure, which would tend to reflect more sunlight than the darker
material (higher albedo). This could result in the former possessing generally warmer temperatures and the latter exhibiting colder temperatures.

**Localized Controls on Weather and Climate**

Albedo can be associated with any feature covering Earth’s surface. This includes not only snow, water, rock, vegetation, and human-made objects but also atmospheric features such as clouds. Therefore, excessively cloudy locations are likely to have lower daytime temperatures as much of the incoming sunlight is reflected out to space. One can often see this taking place when looking at large thunderstorms at a distance—the base of the cloud may appear dark, because most of the sunlight has been reflected off the top of the clouds, which may appear bright white. This relates to weather in that incoming sunlight that is not reflected is absorbed by Earth’s surface, which slowly warms. Most of the heat energy in a location actually occurs from the ground up; therefore, the more sunlight absorbed, the higher the temperatures will be in general. Therefore, places with greater cloud cover are likely to have lower daytime high temperatures.

Water vapor in the atmosphere and in clouds actually acts as a greenhouse gas, absorbing heat energy and then reemitting it back toward Earth’s surface. Therefore, water vapor and, in effect, cloud layers act as electric blankets—absorbing the energy released by Earth’s surface at night and releasing it to the atmosphere. The end result is that while cloud cover lowers daytime high temperatures, it actually prevents nighttime temperatures from dropping very much. Very cloudy locations will show little variation in temperatures between night and day, assuming all other weather parameters are unchanged. One of the best examples of this would be the monsoon climate of southeast Asia, caused by a seasonal shift in wind direction. When the monsoon shifts to the rainy season, temperature variations between days and nights are miniscule.

Large-scale weather features, such as the subtropical high-pressure systems situated at about 30° north and south of the equator, the Inter-Tropical Convergence Zone, and climate teleconnections such as the El Niño–Southern Oscillation, can affect weather conditions on climate timescales. As an example, the Bermuda High Pressure System, a strong anticyclone that commonly occurs during the Northern Hemisphere summer over the central Atlantic, can serve to both bring drought conditions to the southeastern United States and, at the same time, act as a steering mechanism for southerly-tracking hurricanes, funneling their tracks across Florida and into the Gulf of Mexico. The effects of El Niño, in particular, are known to vary geographically over relatively regional geographic scales.

Another relatively local control on weather conditions is orography, or the presence of mountain ranges. The orientation of the mountain range to the prevailing winds is essential in determining long-term climate patterns. North-south-oriented mountain ranges such as the Rocky Mountain Cordillera in the Northern Hemisphere or the Andes in the Southern Hemisphere are associated with a distinct climate boundary depending on which side of the mountain range experiences the prevailing winds. The side that experiences these winds will also experience rising air, which cools adiabatically, and a large amount of precipitation and cloudiness—this is known as the windward side of the mountain range. Descending air that has then crossed the mountain range sinks on the leeward side and warms adiabatically, essentially drying out. In these areas, deserts called rain shadows are commonly formed. Much of the arid southwestern United States is associated with this rain shadow phenomenon. Much of the effect of the monsoon in southeast Asia is associated with wind flow toward or away from the Himalayan mountain belt. It should be noted, however, that mountain ranges parallel to the prevailing wind direction have a lesser impact on local climates—the Alps of Western Europe, which are situated in a primarily east-west orientation, have much less of a windward-leeward relationship than the aforementioned North and South American Cordillera.

Other rarer and more localized weather controls include lake effect snows, lake breezes, mountain and valley breezes, and katabatic winds.

*Brian H. Bossak*
WEBER, ALFRED (1868–1958)

The younger brother of the famed German sociologist Max Weber, Alfred Weber developed an enormously influential model of corporate location based on the minimization of transportation costs that powerfully shaped economic geography, particularly location theory, spatial science, and regional science, for decades to come. Weber’s famous model was originally developed for the analysis of manufacturing, although it can be applied to other sectors such as services as well. It was very useful to the exploration of the influence of transportation costs in a rigorous way, and many economic geographers still work in this tradition.

Alfred Weber taught at the University of Heidelberg from 1907 to 1933, when he was dismissed by the Nazis. Although he stayed in the country during World War II, he played a significant role in the resistance movement of the German intelligentsia. Following the Nazi defeat in 1945, he was reinstated at his old university, where he remained until his death.

Weber’s approach emphasizes the role of transportation costs in the location decisions of individual companies. He attempted to determine the patterns that would develop in a world of numerous, competitive, single-plant firms. Weber began by assuming that transportation costs are a linear function of distance, that producers face neither risk nor uncertainty, and that the demand for a product is infinite at a given price—that is, producers could sell as many units as they produced at a fixed price. Firms encountered costs of moving inputs, or backward linkages from suppliers and raw materials, as well as outputs, or forward linkages to clients in the market (Figure 1). The best location for a manufacturing plant is the point at which total transportation costs, that is, costs of transporting inputs plus outputs, are minimized.

The costs of moving supplies and materials vary according to their weight and the degree to which they are used in the production of each good, leading firms to be either resource or market oriented. Thus, firms for which the costs of moving inputs are greatest (weight-losing industries) tend to locate near the site of raw materials, such as mining companies, while those for which the costs of transporting goods to market (weight-gaining industries) are greatest tend to be market oriented, such as bottled-drink manufacturers (Figure 2). Weber modeled this process both mathematically and using physical weights and drew lines of equal

See also Adiabatic Temperature Changes; Air Masses; Atmospheric Circulation; Atmospheric Energy Transfer; Atmospheric Moisture; Atmospheric Pressure; Climatology; Climate Types; El Niño; Land-Water Breeze; La Niña

Further Readings

Figure 1  All firms must confront purchases of inputs (backward linkages) and sales of output (forward linkages), which are mediated over space by transport costs.
Source: Author.
total transport costs called *isodapanes*. The optimal location, he further maintained, would also be influenced by spatial variations in labor costs and by agglomeration economies.

Despite its broad appeal, there are several developments that limit its applicability. First, not all firms need to minimize transport costs; given the rent-transport trade-off that all firms must make, some firms will accept higher transport costs and locate on the urban periphery to minimize rents. Second, the production process is much more complex than it was in the early 20th century, when Weber developed his model. Many plants begin with semifinished items and components rather than with raw materials. Producers’ goods seldom lose large amounts of weight; therefore, there is not much tendency toward material orientation. Weber’s model has also been criticized for its unrealistic view of transportation costs as a linear function of distance. Because of fixed costs, especially terminal costs, long hauls cost less per unit of weight than short hauls do. Plants tend to locate at material or market points rather than at intermediate points, unless there is an enforced change in the transportation mode, such as at a port. However, with the expansion of the modern trucking industry and its flexibility in short hauls, the disadvantages of intermediate locations have been reduced.

Finally, other developments have a bearing on how industrial location choices have changed. Transportation costs have been declining in the long run and now constitute a relatively small share of the final costs of most goods. This decline increases the importance of other locational factors, particularly labor costs and productivity. This trend is most obvious in firms producing high-value products. Yet for firms that distribute consumer goods (e.g., soft drinks) to dispersed markets, transportation costs remain a significant factor. Second, natural resources are no longer as important in the growth of economies as they were historically. Instead, there has occurred a widespread transmaterialization of resources as smaller, lighter products are made from resources to which high technology and brainpower have been added. Finally, real-world patterns are evolutionary, not the result of decisions made by optimizers at one moment in time. Most real-world decisions do not result in the best (the most profitable) locations, and locational decisions, once made, often lead to industrial inertia, the tendency to

---

**Figure 2** Transport cost structure of raw material and market-oriented firms. Firms face the costs of moving raw materials (RM) and final products (FP), which when combined create total transport costs (TTC) that are minimized either at the site of inputs (A) or at the market (B).

*Source:* Author.
continue investing in a nonoptimal site even if more optimal locations exist.

Barney Warf

See also Economic Geography; Factors Affecting Location of Firms; Location Theory; Regional Science; Transportation Geography

Further Readings


WEB GEOPROCESSING WORKFLOWS

The rapid evolution from monolithic desktop geographic information system (GIS) applications with tightly coupled geodata to spatial data infrastructures (SDIs) with independent, interoperable, and distributed Web services has changed the GIS world fundamentally. Nevertheless, the existing SDIs are focused on data retrieval and visualization. To generate information out of data, it becomes necessary to process the data. However, the complexity of spatial data often requires the functionality of several geoprocesses and has led to Web-based geoprocessing workflows. The Web-based geoprocessing workflows can be viewed as a combination of two fundamental concepts: geoprocessing and workflow in a service-oriented and Web-based context.

Geoprocessing

In the absence of a general definition, the term geoprocessing can be seen as a specialization of the term processing in a spatial context. In other words, geoprocessing is the processing of spatially related data. In classical desktop GIS applications such as GRASS or ArcGIS, geoprocessing represents the core GIS analysis functionality and thus is one of the key concepts. In contrast to monolithic desktop GIS, distributed GIS are based on loosely coupled services organized in SDIs. According to the ISO 19119 specification, there are four different types of geoprocessing services:

1. Spatial processing, such as coordinate transformation services, feature manipulation services, or route determination services
2. Thematic processing, such as thematic classification services, geographic information extraction services, or image processing services
3. Temporal processing, such as temporal reference system transformation services, subsetting services, or temporal proximity analysis services
4. Metadata processing, such as statistical calculation services and geographic annotation services

From the work of the Open Geospatial Consortium, the Web Processing Service specification evolved as a standardized but generic service approach to perform geoprocesses in an SDI on distributed data. These processes can be as simple as the sum of two numbers (e.g., population) or as complex as a global climate model. The data required by the service can be delivered across a network or made available on a server. Image data formats or data exchange standards such as geography markup language or KML can be used to encode the data. The Geoprocessing Web Services form the building blocks for Web-based geoprocessing workflows.

Web-Based Workflows

The term *workflow* was defined by ISO 19119 as “the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.”
This concept of a workflow has been extensively researched in the information technology (IT) and business fields for several decades. With the advent of the service-oriented architecture paradigm and the increasing data-processing power of network computing, Web-service-based workflows are currently a prominent workflow type. By integrating several Web services from different partners into a single workflow, it becomes possible to form virtual enterprises. These concepts of Web-based workflows rely heavily on service chains to exchange information between workflow participants. There are three different architectural patterns defined for service chains according to ISO 19119:

1. User transparent chaining
2. Translucent chaining
3. Opaque chaining

Especially the opaque chaining pattern is applied by the “mainstream” IT workflow management systems, which mostly use the idea of Web service orchestration (WSO). This concept is defined as a description of how composed Web services interact on the message level. The description includes the business logic and execution order. Based on the predefined message exchange protocol, the interaction is controlled by a central orchestration engine that enables the Web services to be held loosely coupled. This common central orchestration approach is widely supported by several major IT WSO frameworks. The frameworks allow the visual composition of workflows instead of programming and hence enable flexible and rapid workflow modeling and execution. The Business Process Execution Language is mainly used by these frameworks since it is the de facto standard.

**Web-Based Geoprocessing Workflows**

Web-based geoprocessing workflow brings both terms together. It can be seen as an automation of a spatial process/model, in whole or in part, during which geoinformation is passed from one distributed geoprocessing Web service to another according to a set of procedural rules and standardized interfaces. In other words, Web-based geoprocessing workflows integrate loosely coupled spatial data and services in an interoperable way, where each part of the workflow is responsible for only a specific task, without being aware of the broader purpose of the workflow. Especially in highly specialized environments such as the GI domain, not every processing step can be potentially handled by a single entity, and therefore, geoprocessing workflows have to be formed. Therefore, outsourcing specialized tasks to highly specialized Web services becomes necessary. As a result, workflows become flexible and are able to quickly adapt to changing market conditions thus leading to higher flexibility and scalability of geoprocesses.

The idea that geoprocessing workflows should be flexible and scalable reflects the general transition from a supply-driven economy to an on-demand economy in the geodomain. Therefore, Web-based cross-enterprise geoprocessing workflows as virtual business processes can be formed by integrating several processes from different partners while still being regarded as a single process from an external point of view.

Due to the distributed nature of geographic data, geoprocessing workflows provide a flexible means for the processing of highly distributed and complex data for a wide variety of applications. The aggregation of existing geoprocessing workflows, exposed as Web services or wrapped by Web services, into a single workflow uses the powerful and flexible capabilities of Web-based geoprocessing workflows.

The full potential of Web-based geoprocessing workflows as an integration platform has already been demonstrated by several research communities. However, further progress of this technology and its broader adoption require that advances be made in the areas of semantic geodata interoperability and in the legal aspects of geospatial information.

Bastian Schaeffer

See also Internet GIS; Legal Aspects of Geospatial Information; Semantic Interoperability
WEB SERVICE ARCHITECTURES FOR GIS

There have been many successful developments of geographic information systems (GIS) serving different purposes and different organizations and using different GIS software packages. However, geospatial information sharing and acquisition remains a challenge due to the heterogeneity of existing systems in terms of proprietary system designs, data models, and database storage structures. The emergence and use of Web services and Web-service-oriented architecture (SOA) technologies offer the potential to overcome barriers to interoperability among heterogeneous GIS.

Service-Oriented Architecture

The SOA was developed by IBM, Microsoft, and other leading IT industry organizations to support the development of applications that integrate existing computing technologies into solution-based systems. A pure architectural definition of SOA presents it as a design within which all functions are defined as independent services with well-defined and invokable interfaces. An SOA is essentially a collection of Web services that communicate with each other by passing simple data or coordinating some activities. IBM has created a model for an SOA that describes three roles—(1) service provider, (2) service requestor, and (3) service broker—and three basic operations—(1) publish, (2) find, and (3) bind. Service providers publish services to a service broker. Service requesters find required services using a service broker and bind to them. The binding from the service request to the service provider should loosely couple the service. This means that the service requestor has no knowledge of the technical details of the provider’s implementation, such as the programming language, deployment platform, and so forth. Because Web services in SOA are based on open standards, they are able to work together and understand each other even though they don’t use the same language or share the same application platform. For example, the data service “Wisconsin land use map”—residing on a Microsoft Windows server in Wisconsin—can be invoked by the service “display Wisconsin land use map” written in Java code and residing on a Linux server in Los Angeles.

To implement an SOA, the open-standard specifications—WSDL (Web Service Description Language), SOAP (Simple Object Access Protocol), and UDDI (Universal Description, Discovery and Integration Service)—are developed to support the interaction of Web services. The WSDL is an Extensible Markup Language (XML)–based language used to describe the services that a business offers and to provide a way for individuals and other businesses to access those services electronically. A complete WSDL definition contains all the information necessary to invoke a Web service, such as what a Web service can do, where it resides, and how to invoke it. It provides a way for service providers to describe the basic format of Web service requests over different protocols or encodings and thus helps improve interoperability between applications. The SOAP is a
communication protocol for communication between applications running on different operating systems with different technologies and programming languages. It defines a format for sending messages between communicating applications via the Internet and specifically using Hypertext Transfer Protocol (HTTP). SOAP consists of three parts: (1) an envelope that defines a framework for describing what is in a message and how to process it, (2) a set of encoding rules for expressing instances of application-defined data types, and (3) a convention for representing remote procedure calls and responses. UDDI provides a mechanism for clients to dynamically find other Web services. Using a UDDI interface, users can dynamically connect to services provided by external providers. The provider typically publishes a WSDL description of its Web service, and the requester accesses the description using a UDDI or other type of registry and requests the execution of the provider’s service by sending a SOAP message to it. Since all data in SOA are tagged in XML, communication between applications doesn’t depend on any particular operating system or programming language.

**Web Service Architectures for GIS**

A Web service architecture for sharing geospatial data and geoprocessing models over the Web is illustrated in Figure 1. The main objectives of the Web service architecture for GIS are to (a) maximize productivity and efficiency with geospatial data and online geoprocessing sharing, (b) overcome spatial data and GIS model duplication and maintenance problems, and (c) make it easy to integrate different GIS applications.

The Web service architecture for GIS is based on independent OGC Web services. It is composed of three elements: (1) service provider, (2) service broker, and (3) service client. The service provider supplies geospatial data and geoprocessing models, the service client allows users to search and integrate geospatial data and geoprocessing models from providers, and the service broker provides a registry for available services. The service provider uses OGC data services such as WFS (Web Feature Services), WMS (Web Map Services), and WCS (Web Coverage Services) to publish geospatial data and WPS (Web Processing Services) to publish geoprocessing models connected to existing heterogeneous GIS such as GIS1 and GIS2 (Figure 1). The service broker uses OGC WRS/CS (Web Registry Services/Catalog Services) instead of using a UDDI to register and manage the OGC data and processing services and allow users to search for these Web services over the Web. Service clients search the contents of catalog services to find the data sets and services of interest, and they also can combine the OGC Web services found through catalog Web services.

A catalog service can publish and search for collections of the resource-based metadata information, and it has two main functions—discovery and publication. Discovery means that the service requester seeks to find resources of interest through simple browsing or by sophisticated query-driven discovery that specifies simple or advanced search criteria. The catalog performs the search and returns a result set that contains all registry objects that satisfy the search criteria. The requester may then choose to retrieve representations of result set items according to some specified schema and element set. The OGC catalog service supports distributed search. That means that a catalog service can interwork with other affiliated catalogs to enlarge the total search space. When a catalog is linked to a peer catalog, it makes the resource descriptions managed by the peer implicitly available to its own clients. The propagation of request messages to the affiliated catalog is invisible to the client—it is not necessary to know where the metadata repositories are located or how they are accessed. A catalog service allows Web services to publish resources in two ways: (1) harvest operation and (2) transaction operation. Harvest operation is the basic publication, and in this operation the catalog itself attempts to harvest a resource from a specified network location, thereby realizing a “pull” model for publishing registry objects. If the catalog successfully retrieves the resource and can handle it, then one or more corresponding registry objects are created or updated. The second way of publication is transaction operation, which is enhanced publication. Transaction operation supports modifying catalog content through a public interface that allows a
“push” style of publication. A user may insert, update, or delete catalog entries according to criteria specified in the request message. Typically, this operation is subject to some kind of access control such that only authorized users may perform such actions.

As illustrated in Figure 1, the Web services in the SOA for GIS are achieved via WSDL by connecting service providers, service brokers, and service clients. The SOAP binding over HTTP is employed for communication between Web services via the Internet. The SOA ensures data interoperability through the standard exchange mechanism between diverse GIS sources connected over the Web.

The main benefit of the SOA is that it allows the sharing and integration of spatial data and geoprocessing models from diverse sources transparently across the Web. That is, the SOA allows geospatial data and GIS models to be shared and reused across applications, enterprises, and community boundaries. Thus, many existing proprietary GIS legacy databases and models may be reused and shared. With a ubiquitous set of standards in the SOA, users are capable of creating applications that can be built on top of existing
applications. In addition, the SOA allows geoprocessing to be carried out by chaining (linking) several services representing relatively independent, distributed applications. With its loosely coupled structure, the SOA permits smart and fast updating of the system’s obsolete data and models and quick integration of new data and models into the application system, thus enhancing the flexibility and reuse of spatial data and GIS models. Therefore, it may reduce the cost of developing new application programs and leverage an organization’s existing investment in data and applications.

Although the Web SOA offers the aforementioned advantages, it presently only resolves technical interoperability through Web services and standard interfaces, and it stops short of resolving the semantic heterogeneity problem in existing GIS. One possible approach to overcoming the problem of semantic heterogeneity is developing domain-specific ontologies and semantic interoperability systems. The concept of Geospatial Semantic Web has been suggested recently to address the vexing challenges of semantic interoperability.

Chuanrong Zhang

See also GIS Web Services; Internet GIS; Interoperability and Spatial Data Standards; Ontological Foundations of Geographical Data; Open Geospatial Consortium (OGC); Semantic Interoperability

Further Readings


Wetlands

Wetlands are lands that are significantly influenced by the presence of water. Although relatively rare, these fragile ecosystems, which occupy approximately 6% of Earth’s surface, are found on every continent except Antarctica. Wetlands are found in most of the world’s climatic zones, ranging from warm tropical climates to frigid arctic climates. They are present across a wide range of elevations around the world, from below sea level to mountaintops.

Wetlands are broadly classified according to topography and water salinity. Topographically, they may be present in either coastal areas or inland. When subdivided according to water salinity, they may range from saline (salinity $\geq 30.0$ parts per 1,000) to brackish (salinity 29–0.6 part per 1,000) to fresh (salinity $\leq 0.5$ part per 1,000). The salinity of coastal wetlands is influenced by distance from the ocean, tides, topography, and the presence and discharge of various sources of freshwater, such as rivers and groundwater. Examples of coastal wetlands include cordgrass ($Spartina$ sp.)–dominated tidal marshes and mangrove ($Rhizophora$ mangle, $Avicennia$ sp., $Laguncularia$ racemosa, $Sonneratia$ sp.) swamps.

The vast majority of interior wetlands are freshwater; however, saltwater interior wetlands may occur in arid regions. Interior wetlands are subdivided according to the environment in which they occur. Major classes of interior wetlands include riverine (river environment), palustrine (pond, pothole environment), and lacustrine (lake environment). Cattails ($Typha$ sp.) and rushes ($Juncus$ sp.) are plants commonly found in interior wetlands.

Regardless of the environment where a wetland is located, all wetlands share three characteristics: (1) wetland hydrology, (2) hydric (i.e., wetland soil), and (3) hydrophytic vegetation. Water within a wetland may be permanent, inundating the area year-round, or it may be seasonal or ephemeral, flooding an area only a few weeks or months of the year. Prolonged flooding, particularly during the growing period, significantly affects the soil and the vegetation of wetlands.

Given time, continued soil saturation dramatically influences the chemical and physical
composition of the soil. The upper portions of soil become anaerobic (i.e., without oxygen). Hydric soils have either an organic or a mineral texture. Organic hydric soils are composed mainly of vegetation with varying degrees of decomposition. Muck and peat are common examples of an organic wetland soil. Mineral hydric soil contains little organic matter. This type of soil develops readily identifiable characteristics, such as gleying and mottling. Gleying is a process that occurs in anaerobic, waterlogged soils where iron present in the soil is chemically reduced to iron oxide because of the lack of oxygen. This results in a soil that has a distinctive blue-gray or greenish color. Mottles may also develop from the reduction of iron. Mottles are small, generally pea-sized or less, reddish-brown or yellowish specks/spots found in dark wetland soil.

Saturated anaerobic conditions influence the type of vegetation that occurs within wetlands. Wetlands vegetation may develop morphological adaptations, which allow the vegetation to thrive in saturated conditions. Common adaptations include shallow root systems, adventitious roots, pneumatophores, multiple trunks, and buttress trunks. Adventitious roots and pneumatophores are some of the more interesting adaptations. Adventitious roots are roots that may develop from the stem or branches of a plant at points above the soil. Pneumatophores are roots that protrude through soil and surface water, thus allowing plants to obtain oxygen in an otherwise

Canada geese, common egret, and shore birds in a pothole wetland in South Dakota. Wetlands provide a haven for migrating ducks, geese, and other waterfowl.

Source: Dennis Larson, USDA Natural Resources Conservation Service.
Greenhouse gases (GHGs) are produced primarily from human activities. The net release of GHGs is generally a local or regional process, but many of the resulting effects are global. The most important GHGs are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), which are released through natural processes and human activities. Some of the most important human activities that release GHGs are fossil fuel combustion, deforestation, and the production of cement.

Wetlands are extremely important habitats for humans and wildlife. Coastal wetlands are some of the most productive ecosystems in the world, serving as nursery grounds for much of the world’s commercial fisheries. Coastal wetlands also serve as storm buffers, absorbing storm surges and waves associated with tropical and extratropical weather systems. Both coastal and inland wetlands store excess rainfall and floodwater and act as sinks and filters for waterborne contaminants such as heavy metals, and pathogens such as Escherichia coli. Many interior wetlands serve as recharge zones for groundwater aquifers. Wetlands are also critical habitats for myriad wildlife, especially waterfowl (see photo).

Even though wetlands are critical to the survival of many species of plants and animals, they are being destroyed at a very rapid rate. Globally, approximately half of all wetlands have been destroyed since 1900. Wetlands are under intense pressure from humans, who drain them for urban, industrial, and agricultural purposes. Coastal zones are under constant threat from global warming and associated sea level rise. Rising seas are inundating and destroying coastal wetlands.

Several international organizations promote wetland research, conservation, and restoration. Two of the most notable organizations are the Society of Wetland Scientists, which supports scientific wetland research, and Wetlands International, which advocates conservation and restoration. In 1971, an international convention on wetlands was held in Ramsar, Iran. The convention, known as the Ramsar Convention (Ramsar), developed an international treaty, titled the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, to conserve wetlands worldwide. To date, 158 countries have signed this treaty. Ramsar also created and maintains a list of threatened wetlands. The list, called “Wetlands of International Importance,” includes more than 1,800 wetlands located throughout the world that are considered critical to wildlife. New wetlands are added to the list annually.

Wetlands are important ecosystems that protect humans from storm surges, filter contaminants from water, and provide habitat for economically viable wildlife. These fragile environments are under increasing pressure from humans, who drain and destroy wetlands, and from changing climates. More research, conservation, and restoration are needed to protect this valuable resource for future generations.

Molly McGraw

See also Biota and Topography; Ecosystems; Groundwater; Hydrological Connectivity; Surface Water

Further Readings


WHITE, GILBERT (1911–2006)

Gilbert Fowler White was a prominent and influential American geographer, known as the father of floodplain management in the United States, although his environmental research and policy influences extended to water resources and global environmental issues. He was an advocate of practical applied research to improve the human condition. White was born in Chicago, grew up near the University of Chicago campus, and spent summers working on a ranch in Wyoming. He credited both environments with helping shape his research interests and perspectives.

Having satisfied all the requirements for a doctorate except the dissertation at Chicago, White accompanied his PhD advisor, Harlan Barrows, to Washington, D.C., in 1934 to work for the Mississippi Valley Committee of the Public Works Administration. The tenure in Washington was
anticipated to last 6 months, but 8 years later, White was still there. He worked as a staff member for a number of committees and commissions related to natural resources and flood control. The government service helped provide White with a research agenda and skills to implement the policy implications of research.

His Quaker convictions precluded his working for the federal government during World War II, so he left to complete his doctoral dissertation prior to performing relief work in France and then being interned in Germany. His dissertation, *Human Adjustment to Floods*, is seen by many as the seminal work leading to the widespread adoption of nonstructural alternatives to dams and levees to cope with flood hazards in the United States. White himself characterized his dissertation as a call to consider a broad range of possible adjustments to floods and to fully evaluate all the consequences of each adjustment. *Human Adjustment to Floods* led to the field of floodplain management.

After World War II, White became president of Haverford College, before returning to the University of Chicago in 1955 as a professor of geography. At Chicago, he initiated a program of research on natural hazards, much of which evolved from ideas put forth in his dissertation. He mentored numerous students who made their own contributions to natural hazards research, education, and policy, effectively establishing the foundations of the hazards research paradigm still practiced in geography. In 1970, White moved to the University of Colorado, where he continued his hazards research activities, became director of the Institute of Behavioral Science, and eventually founded the interdisciplinary Natural Hazards Research and Applications Information Center. The center continues to serve as a clearinghouse for hazards research and policy, helping provide a bridge between hazards researchers and practitioners.

Although best known in the United States for his contribution to natural hazards research, White was active in many other environmental spheres. His research conducted with the epidemiologist David Bradley and White’s wife, Anne U. White on domestic water use in East Africa served as a model for other researchers in other locations. White felt that international cooperation on river basin development could facilitate other forms of peaceful relations among nations and chaired an advisory group to the United Nations on the Lower Mekong River. White published prolifically throughout his career, until a few years before his death. He served on many national and international committees, commissions, and advisory groups dealing with a wide range of environmental issues, including climate change, water supply, human-made lakes, pollution, the environmental effects of nuclear war, nuclear waste storage, and hazards other than floods.

He served as president of the Association of American Geographers (1961–1962), was elected to the National Academy of Sciences (1973), and received the National Medal of Science (2000) from the U.S. president. Although White was modest about his influence on public policy, others felt that his impacts were significant, often through the actions of his students and followers or because of the way of thinking he brought to many environmental issues. White passed away in Boulder, Colorado.

*Earl J. Baker*

See also Applied Geography; Barrows, Harlan; Environmental Management; Floodplain; Floods; Natural Hazards and Risk Analysis; Sustainability Science

**Further Readings**


Whiteness

Associated with archaic terms such as Aryan, Teutonic, Anglo-Saxon, and Caucasian and often assumed to be an inherited biological reality, whiteness is in fact a socially, historically, and geographically constructed understanding of racial identity. Usually constructed against a perceived nonwhite other, there are multiple lived experiences of whiteness, varying across time and space and differing by scale. Understandings of whiteness shape both sparsely populated rural areas and multiracial urban locations, albeit in different ways, and there is no singular, essential white identity.

Whiteness is most commonly associated with pale, pinkish-colored skin and people of Northern European descent. European colonial and U.S. expansionist practices were central to the construction of modern racial whiteness. In the 19th century, U.S. national identities such as Irish and Italian were often envisaged by the elites of Northern European descent as a stepping stone between the inferior African black race and the superior white Anglo-Saxon. Strategies such as employers hiring European immigrants rather than African Americans, and the subsequent benefits of unionization, saw associations develop between whiteness and working-class identities in the United States. As a result, people of these formerly disparaged European nationalities achieved whiteness, so to speak, and gained the benefits of a white racial identity in a racially segregated society. In the 20th century, throughout the United States, associations between whiteness, wealth, and power were strengthened by the construction and maintenance of racialized landscapes such as sundown towns and whites-only suburbs.

In industrialized Western societies, a myth of color blindness developed in the late 20th and early 21st centuries, rendering whiteness largely unexamined. Consequently, discussing whiteness is, to some extent, a taboo subject, except among explicit racists whose appeals to white identities are often linked with hate groups such as neo-Nazis or the Ku Klux Klan. Recognizing the negative associations of overt appeals to whiteness, many white people avoid using the term white, instead articulating whiteness through discourses of normality, nature, nationality, culture, and landscape. For example, some espouse the need to preserve the “European” heritage or to protect specific cultures. In this manner, demands that whiteness be politically recognized are made using the language of multiculturalism and cultural pluralism and through rhetorical appeals to heritage, tradition, ethnicity, and genealogy.

An associated concept is that of white privilege. This refers to the everyday unearned structural advantages that accrue to people whom others identify as white. Often unconscious and unrecognized by the beneficiaries, arguably because of the taboo surrounding articulations of whiteness, white privilege structures Western societies in a manner that positions the values and beliefs of the white (and usually middle class) population as the norm against which the behaviors and practices of others are contrasted. Commonly associated with the practices of institutionalized racism, white privilege reconfigures understandings of racism to explain the advantages gained from whiteness. These advantages, however, vary with the shifting boundaries of whiteness and are reconfigured by class, gender, sexuality, age, and other demographic characteristics.

Euan Hague

See also Critical Human Geography; Ethnicity; Race and Racism

Further Readings

One of the more important figures of cultural geography in the early to mid 20th century, Derwent Stainthorpe Whittlesey is best known for advocating the notion of sequent occupance. He served as president of the Association of American Geographers (AAG) in 1944 and was editor of the *Annals of the Association of American Geographers* for 12 years.

Born in the farming community of Pecatonia, Illinois, Whittlesey studied at the University of Chicago, where he completed a degree in history in 1915; he then attended the School of Geography, where he studied under Ellen Churchill Semple and Harlan Barrows. After graduation, he taught at Chicago from 1920 to 1928, when he moved to Harvard to become its first human geographer; for the remainder of his career, he was professor of cultural and political geography at Harvard. He served as a consultant for the U.S. state, war, and navy departments during World War II. His interest in political affairs led him to publish *The Earth and the State* in 1939 and, with two coauthors, *German Strategy for World Conquest* in 1942. Whittlesey delved into several other topics, including agricultural development and the nature of regions and regionalism. He also studied Africa for 35 years, particularly Rhodesia (now Zimbabwe). His work historicized cultural and political issues in an era when much of geography viewed the world in static, ahistorical terms.

In 1929, Whittlesey introduced the term for which he is best known, *sequent occupance*—a technique for analyzing landscapes as the product of successive groups over time, each of which uses it in its own way and leaves a lasting imprint. Landscapes are thus created by the number of groups that occupied an area at different moments, and comprise a palimpsest. To understand the landscape was to understand the history and practices of its various groups of inhabitants, each of which created a spatiality that both reflected that of its predecessor and subsequently influenced that of its successor. Each group, he argued, carried the seeds of its own transformation; culture was thus never a frozen set of ideas or objects but was continually in motion. In framing this issue, Whittlesey drew selectively from human ecology, but he forcefully offered a social dynamic at odds with the deterministic erosional cycle of William Morris Davis, which was then the dominant means of interpreting landscapes. In this respect, Whittlesey shared much in common with Carl Sauer, that is, a view of cultural landscapes as ever changing and historically generated, as produced rather than given; both played a vital role in combating environmental determinism. Sequent occupance would later find its way into the resurrection of localities research in the late 20th century.

As president of the AAG in 1944–1945, Whittlesey published his presidential address when the annual conference was canceled to curtail wartime travel. His essay “The Horizon of Geography,” published in 1945, deftly summarized the changing scale of spatial consciousness that accompanied humanity’s ascent from hunting and gathering to the modern age: “By scrutinizing successive space-horizons from the most primitive known down to the present, it should be possible to determine the character and limits of geographic space in the present world of revolutionary technology and social adaptation” (p. 3).

One of the most famous events concerning Whittlesey was the closure of the Harvard geography department in 1948, of which he was the chair. In a period in which the discipline, dominated by empiricist chorology, was not known for intellectual vitality, the closure marked the first of a long series. The department fell under sustained attack from geologists and from Harvard’s president, who felt that geography did not qualify as a university discipline. Isaiah Bowman, the then president of Johns Hopkins University,
could have helped in this situation but chose not to do so, in part because he felt that the Harvard department overemphasized human geography and in part due to his homophobic feelings about Whittlesey, who was widely presumed to be gay. Whittlesey, however, continued to teach at Harvard until his death.

**Barney Warf**

*See also* Bowman, Isaiah; Chorology; Cultural Geography; Hartshorne, Richard; Human Geography, History of; Palimpsest; Sauer, Carl; Sequent Occupance

**Further Readings**


**WILDERNESS**

Wilderness is understood as a region that exists in its original, natural state with few or no human inhabitants. It may contain distinctive geographic features, rare ecosystems, or plant and animal species that require vast expanses of land for habitat. Since the 1970s, geographers and environmental historians have closely examined the definition of wilderness. They found that its meaning has changed significantly over time, especially in the North American context. As its definitions have changed, wilderness areas have become contested sites.

During the settlement era, Euro-Americans often feared the wilderness, as it was home to dangerous creatures and seemingly dangerous “others,” the indigenous peoples of the continent. In the 19th century, several influences reworked the meaning of wilderness. The aesthetic and spiritual ideas of Romanticism and Transcendentalism for some transformed the wilderness from a devilish place to a location where one might more easily commune with God. The perceived loss of the frontier, growth of cities, and polluting impacts of industrialization made others look to wilderness as symbolic of a rugged, independent American character that was threatened by urbanization. Wilderness became a therapeutic space.

As these definitions of wilderness took hold, arguments over the purpose of wilderness entered public discourse. In the 20th century, the preservationists, who sought to protect the ecological and aesthetic integrity of the wilderness by leaving areas untouched by development, fought against the conservationists, who strove to extract valuable natural resources using methods that would ensure their continued supply into the future. Around the world, international organizations; federal, state, and provincial governments; and nongovernmental organizations have officially protected lands as wilderness areas. In many instances, the act of drawing boundaries around wilderness areas and, furthermore, defining who and what belongs within such spaces has raised considerable controversy.

In recent years, human geographers have argued that the evolving definition of wilderness is evidence that it is a social construct. This does not mean that wild places do not exist or that their ecological, aesthetic, and spiritual qualities are insignificant but, instead, that notions of wilderness are products of human cultures. Some scholars assert that few designated wilderness areas extant today were ever uninhabited; in many cases, indigenous peoples were removed from their lands to create a wilderness that fits a narrow definition. Others point out that wilderness has class, gendered, and racial dimensions. These ideas are vigorously contested, especially by those who are concerned that resource extraction, pollution,
and land development are threatening to permanently damage or even end fragile, irreplaceable, and ecologically important natural areas. For these advocates, the scientific community cannot afford scholarly debates over definitions that might further a political agenda to tamper with wilderness.

Cheryl Morse Dunkley

See also Class, Nature and; Critical Studies of Nature; Environmental History; Ethnicity and Nature; Gender and Nature; Nature; Nature-Society Theory; Social Construction of Nature

Further Readings


WILDFIRES: RISK AND HAZARD

Analysis of the threat, hazard, and risk relative to wildfire is a spatial problem: Where does a wildfire occur relative to resources valued by humans? In the natural or built environment? Wildfires burn uncultivated vegetation in natural environments, whether mountainous forests, rural woodlands, brush lands, or prairie grasslands. In common usage, the terms threat, hazard, and risk are often interchanged and confound understanding of the important distinctions between them.
Any wildfire may be considered to pose a threat, to present the potential to do harm. Threat refers to the source that could cause damage. A wildfire threat exists where heat from burning vegetation could ignite other combustible material regardless of whether burning that material would constitute a loss. Whether a wildfire poses hazard or risk depends on whether any valued resources, natural or human-made, that could be damaged by fire are potentially in a path of fire spread. Unless some resource determined to be of value is in harm’s way, no hazard or risk is associated with a wildfire.

The term hazard may be most effectively used when planning to mitigate potential losses in some future, nonspecified time. Efforts to thin forest fuels around homes well in advance of the wildfire season constitute hazard reduction. This action is taken in the absence of an immediate threat. Fuel reduction usually occurs where it is recognized that the potential for loss would be high if a wildfire were to occur some time in the coming years.

Analysis of risk explicitly requires assessment of the probability that a loss will occur as a result of wildfire. What is the chance or likelihood that a fire will reach and damage or destroy a valued resource? The probability statement may be qualitative, based on some form of actuarial analysis, or derived from quantitative techniques such as numerical fire spread modeling. Strictly applied, risk analysis is the calculation of expected loss, the value of the threatened resource multiplied by the expected value change to that resource.

For example, if a fire is ignited on a heavily forested mountain, the mere presence of an active flame is commonly considered to present a threat. If a communications tower is downwind or otherwise in the vicinity of the flames, the fire presents a hazardous condition relative to the tower. This statement of hazard does not assume one way or the other that the fire will actually reach and damage the tower. If the tower is valued at $250,000 and there is a 50% chance that the fire will reach and destroy the tower, the tower is at risk. The expected loss is calculated at $125,000. This calculation could be extended to loss of services if a value for the loss could be clearly defined.

Analysis of hazard and risk posed by wildfire is fundamentally a two-part spatial problem. It starts with threat analysis: Where is the fire currently located, and where is it headed? The second part analyzes hazard and risk. Hazard assessment identifies the valued resources that wildfire may intersect as it spreads. Risk assessment considers the probability that valued resources will be damaged or destroyed so that the value will be changed. This spatial intersection of the potential area of wildfire spread with valued resources may be implied by observation and judgment or explicitly determined through rigorous geospatial analysis commonly conducted within geographic information systems.

Fire behavior models predict fire spread, and fundamental spatial analysis evaluates geospatial databases of values potentially at risk (Figure 1). Spatially explicit numerical models calculate the direction and rate of spread of wildfire based on the characteristics of weather, topography, and vegetation. These factors influencing and controlling fire behavior have been determined through observation and experiment. Weather characteristics include the direction and speed of prevailing winds and the influence of temperature, precipitation, and relative humidity on fuel moistures. Topographic or terrain factors include elevation, hillslope gradient or steepness, and aspect, the direction a hillslope is facing. The vegetation or the fuels that may feed a wildfire are defined by surface fuels, the distance between the ground surface and the lowest limbs, the spacing of the crowns of overstory trees, the vegetation bulk density, and the height of the dominant forest or shrub canopy. The current fire location and where the fire will probably spread are mapped with geospatial data of values potentially at risk. Many data sets are available that represent critical infrastructure such as electric power lines, oil and gas pipelines, and locations of public buildings and recreational facilities on public lands. These data sets are improving and expanding, driven by commercial and national security needs.

Assigning a value to the resources at risk may be very simple or complicated. Clear dollar values may be assigned to objects in the built environment. Dollar amounts typically represent the cost of repairing or replacing any items damaged or destroyed by a wildfire. Often, no clear market value exists for the valued natural resources. For example, what is the value of an isolated
Figure 1  Risk assessment map for the Whiskeytown Fire near Redding, California, 2008. The rainbow array represents the area of probable fire spread predicted by the Fire Spread Probability (FSPro) model of the USDA Forest Service. Fire spread is mapped relative to threat.

Source: Author.
population of an endangered plant or the value of clean water? Two problems commonly arise while assessing the hazard or risk to such resources. The first problem is what economists refer to as the valuation of nonmarket resources—a highly controversial area of economic theory. One nonmonetary, indirect solution to this is to simply summarize the amount of nonmarket resources by area, linear distance, or item count within the area into which a fire may spread. Another difficulty comes where the wildfire might ultimately benefit ecosystem health. Wildfire is a natural process within forests, grasslands, and shrub ecosystems, a process to which many species are adapted and without which they fail to thrive. Wildfire may be necessary to maintain or restore ecosystem health and functionality. This problem is compounded by the source of ignition: Is the fire caused by a “natural” lightning strike or by humans? When a fire is caused by humans, it may be considered unnatural even if the possible outcome could be beneficial to the ecosystem.

Given the conflict between the potential benefit of wildfire and the potential for loss of valued resources, the analysis of trade-off is inherent in the assessment of hazard and risk presented by wildfire. In the short-term, a wildfire may destroy a lookout tower atop a mountain. However, the same fire could lead to the regeneration of fire-dependent tree species and improve ecosystem health through trophic cascading benefits. For example, a wildfire could ultimately spur regeneration of whitebark pine, which produces seeds that provide highly enriched hibernation food for the endangered grizzly bear.

Kevin Hyde

See also Forest Degradation; Forest Land Use; Indigenous Forestry; Natural Hazards and Risk Analysis; Pyrogeography; Social Forestry; Sustainable Forestry

Further Readings


Wilson, John (1955– )

John Wilson is one of geography’s leading practitioners of geographical information systems (GIS), particularly in the context of environmental concerns. He is a professor of geography at the University of Southern California, where he chairs the department of geography, directs the geographic information science and technology graduate programs as well as the GIS research laboratory, and also holds adjunct appointments as professor in the departments of computer science and civil and environmental engineering. He received his PhD in geography from the University of Toronto, Canada, in 1986. He also holds an LLB honors law degree from the University of Canterbury, New Zealand.

From 1992 to 1997, he was a professor of geography in the department of Earth sciences, an adjunct professor of soil science in the department of plant and soil science, and the director of the Geographic Information and Analysis Center at Montana State University. His early career included positions as assistant professor (1984–1990) and associate professor (1990–1994) of geography, with corresponding adjunct appointments in soil science at Montana State University. He founded the Geographic Information and Analysis Center at Montana State University in 1989 and the GIS Research Laboratory at the University of Southern California in 1997. He has held several visiting appointments in environmental...
Wind is a fluid motion in an atmosphere. All wind is caused by pressure differences. Wind is ubiquitous but varies considerably in its spatial and temporal scales and has a significant impact on the human and physical components of Earth.

Humans have long been fascinated by the wind. For example, several references to wind are found in the Bible. In Greek mythology, Aeolus was the custodian of the four winds. Evangelista Torricelli, who invented the barometer, provided the first scientific description of wind formation in the mid 17th century. We now have the capability of measuring wind from space and have garnered enough information about wind patterns to

**Further Readings**

predict weather and generate power from wind, for example. This discussion of wind is organized around four themes: formation, types, measurement, and importance.

**Formation**

Horizontal differences in pressure can cause air movement, or wind. Atmospheric pressure, air density, and air temperature are interrelated. Warm air temperatures increase the air’s molecular velocity, decrease air density, and cause air pressure aloft to rise. Cold temperatures increase air density and cause air to sink, thus lowering the air pressure. Generally, airflow is from high to low pressure, compared across uniform height above the surface, with wind velocity increasing with increasing pressure differences. The difference in pressure between two places divided by the horizontal distance between two places is called the pressure gradient. Tightly spaced isobars (lines indicating equal pressure) on a weather map indicate increased pressure gradients. Larger pressure gradients are associated with larger pressure gradient forces. Newton’s second law of motion predicates that the relationship between pressure gradient force and wind speed is positively linear.

In addition to pressure gradient force, several other forces influence wind speed and direction. Coriolis force (after Gaspard Coriolis), or effect, is an apparent force resultant from Earth’s rotation. Coriolis force opposes pressure gradient force, causes wind deflection, and does not affect wind speed. Deflection is toward the right and left in the Northern and Southern hemispheres, respectively. Deflection magnitude depends on wind velocity and latitude. Increasing latitude corresponds with increasing deflection, with no deflection at the equator. Centripetal acceleration affects airflow around circulation centers and influences wind direction but not speed. Centripetal acceleration steers winds at right angles to the rotational center of the low pressure. The fourth force is friction, which opposes the dominant wind direction and causes a deceleration. Frictional effects are only found close (less than 1 kilometer) to Earth’s surface.

Global and upper-level wind circulation can be conceptualized using Hadley’s (after George Hadley) three-cell model in which the Hadley (0°–30°), Ferrel (30°–60°), and Polar (60°–90°) cells are found in both the hemispheres (Figure 1). The Hadley cell is a convection loop; warm equatorial air rises and moves aloft, laterally to the poles, cooling as it approaches the middle latitudes (30°). The rising equatorial air produces the equatorial trough, and surface air converges. The region of convergence is the intertropical convergence zone (ITCZ), its exact location fluctuating throughout the year between approximately 25° N and 20° S. ITCZ controls monsoons, a phenomenon primarily influencing the northeast Indian Ocean region. The region between 0° and 30° is the doldrums, and warm air and weak horizontal pressure gradients dominate. The poleward extreme of the Hadley cell at 30° N/S is dominated by convergent air aloft descending to the surface, thus increasing surface air pressure (the subtropical highs). The resultant generalized weather around 30° is warm surface temperatures and relatively cloudfree skies. Earth’s major deserts (e.g., Sahara) are found here. The horse latitudes are an informal name for 30° N/S. Ships traveling to the New World were greatly slowed from the weak pressure gradients and winds. Legend indicates that as travel time increased, food decreased and horses were eaten or evacuated overboard. Winds divert poleward and toward the equator from the subtropical high-pressure systems. The equatorward winds are the northeast (Northern Hemisphere) and southeast (Southern Hemisphere) trades; these relatively steady winds were named so because they provided sailing ships with routes during merchant trading.

The pressure and wind patterns of the Ferrel cell (after William Ferrel) are more complex than those of the Hadley cell. The poleward winds originating around the subtropical highs at 30° are the westerlies; wind deflects to the east in both hemispheres. The westerlies converge with the polar easterlies around 60°. The converging air at 60° does not readily mix, mainly because of contrasting temperatures. The boundary between the two air masses is the polar front, a low-pressure zone. The weak polar cell circulates poleward aloft, descends at the poles, and moves horizontally toward 60° on the surface (westerlies) where air rises. The latitudinal extents described in the Hadley three-cell model are
idealized. Actual locations are influenced strongly
by seasons and the different heating and cooling
characteristics of land and water.

**Types**

Jet streams are fast-flowing air currents that are
thousands of kilometers long, a couple of hundred
kilometers wide, and a few kilometers thick; they
are found between 10 and 15 km above the sur-
face. There are two jet streams: (1) subtropical,
fluctuating about 30°, and (2) polar, fluctuating
about 60° and influenced by the Rossby waves.

Surface winds range in scale from meters to
thousands of kilometers, and their air tempera-
ture differences have different causes. Land-sea
breezes typically direct wind from the land to the
water in the evenings, when lower temperatures
and higher pressure are observed on the land,
compared with higher temperatures and lower
pressure observed over the water. These winds
are strongly influenced by the high thermal holding

---

**Figure 1** Idealized global circulation according to Hadley's three-cell model, disregarding the effect of
landmasses

*Source: Author.*
capacity of water. Various regional names (e.g., mistral in Southern France and tako in Alaska) are used to describe katabatic drainage-type winds; cold dense air accumulates in high valleys or plateaus and descends (in altitude) due to gravity. “Snow-eating” winds are specific to mountain ranges in which cold, moist air ascends the windward slope, condenses, and adiabatically descends the lee slope as a warm, dry wind. Regional names include foehn in the Alps, Santa Ana in Southern California, and chinook in the Rocky Mountains.

**Measurement**

Wind is typically characterized by its speed and direction. Surface wind speed is frequently measured with anemometers that are colocated with other meteorological instruments at 10 m above the bed. Four-cup anemometers were invented in 1846 by John Thomas Romney Robinson. Modern-day cup anemometers have three cups, as the reduction in cup number allows the instrument to respond faster to changing wind speeds. If fine spatial and temporal resolution is required, hot wire and thermal anemometers are used to sample at rates in excess of 25 hertz, with minimal disruption to the wind field. Sonic anemometers measure the horizontal, vertical, and lateral flow components and are needed to study turbulence. During fine-scale and/or turbulence studies, wind velocity is often measured at multiple elevations above the ground. Wind velocity logarithmically increases from the surface, according to the “law of the wall” equation developed by Theodore von Kármán in the early 20th century. Since the 1990s, global ocean surface wind speeds have been measured from space using radar scatterometers. Jet streams and other upper-level winds are measured with weather balloons.

Units frequently used to represent wind speeds are meters per second (m/s), kilometers per hour (km/hr.), nautical miles per hour (knot), miles per hour (mph), and feet per second (ft./s). One m/s is equivalent to 3.6 km/hr., 1.9 knot, 2.2 mph, and 3.3 ft./s. The windiest place on Earth is George V, Antarctica, where speeds typically exceed 325 km/hr. Dodge City, Kansas, is the windiest city in the United States (22 km/hr.)—the “windy city,” Chicago, Illinois, only averages 16 km/hr. Jet stream velocities accelerate during winter, averaging approximately 150 km/hr., compared with summer averages of about 75 km/hr.

The Beaufort wind scale (after Sir Francis Beaufort) originated as a method for mariners to estimate wind speed from observations of the sea and is still used to categorize wind speeds. The modern scale has 12 classes; the upper extent classifies all winds greater than 73 mph (117 km/hr.).

Wind direction is most frequently measured 10 m above the surface with a wind vane. Winds are named according to the source direction, employing the 16-principle compass bearings. The wind chill factor, or a measurement of the effect of cold temperature and wind velocity on humans, is predicted and reported by the U.S. Weather Service. It is an estimate of how the temperature “feels” to humans.

**Importance**

Wind is one example of a geomorphic agent of change. Aeolian-formed landforms are estimated to cover 20% to 25% of Earth’s land surface. Wind speed and duration and fetch length influence the formation of wind, or gravity, waves (1- to 30-s periods). Wind-generated waves are created from the tangential forces created when wind travels over water. Gravitational forces act in a restorative capacity and oppose wave growth. Present-day wind on Mars is evidenced by aeolian ripples superimposed on dunes, sediment accumulation on the lee side of protruding rocks, and yardangs.

High-velocity winds may have a significant impact on human life and the environment. Mid-latitude storms form when warm tropical and cold polar air masses interact. The warm air jet-tisons vertically and cyclonically. During their most organized stage (cyclogenesis), these storms typically comprise two fronts—warm and cold—rotating counterclockwise (Northern Hemisphere) and clockwise (Southern Hemisphere) about a low-pressure system. Cold fronts produce various types of precipitation, including rain, hail, snow, and sleet.

Tropical cyclones comprise a low-pressure center with winds rotating around the eye in the same direction as observed with midlatitude
cyclones and have sustained winds exceeding 115 km/hr. The storms are hurricanes in the northern Atlantic and eastern North Pacific, typhoons in the western North Pacific, cyclones in India and Australia, and buguios in the Philippines. Storms are hundreds of kilometers wide; the eye is approximately tens of kilometers in diameter. Tropical cyclones form when upper-level winds diverge and the air aloft is leaving faster than the surface air is entering. Storms are fueled by the transfer of sensible and latent heat from tropical ocean waters to the atmosphere; therefore, storms dramatically lose strength at landfall. The Saffir-Simpson Scale ranks hurricane wind intensity from 1 to 5 and is used to estimate potential property damage and coastal flooding. Since hurricanes began to be categorized using this scale, three Category 5 tropical cyclones have made landfall in the United States: Labor Day Hurricane (1935, Florida Keys), Hurricane Camille (1969, Mississippi coast), and Hurricane Andrew (1992, Homestead, Florida); however, Hurricane Katrina (2005, Mississippi and Louisiana coasts) is the most devastating storm to date and affected the land as a Category 3 cyclone. It is believed that the changing climate will increase the frequency of intense tropical storms.

Tornadoes and “dust devils” are vertical columns of circulating air. The latter is smaller spatially, ranging from 1- to 10-m wide and from 1- to 1,000-m high, and is formed when hot surface air rises, giving way to cooler, lower-pressure air. Tornadoes vary dramatically in size; however, in the United States, a conservative average surface width is hundreds of meters, with an average ground path length of approximately 10 km. Tornadoes are classified according to the Enhanced Fujita Scale (since 2007), ranging from EF0 to EF5. EF1 and EF2 make up approximately 85% of all U.S. tornadoes, with wind speeds less than 178 km/hr. Tornadoes with wind speeds exceeding 322 km/hr. (EF5) are rare; only two have been reported—in Greensburg, Kansas (May 4, 2007) and concentrated around Parkersburg, Iowa (May 25, 2008). There has been a dramatic increase in reported tornado activity since the 1940s; however, much of that increase is due to improved detection capabilities.

Average wind speeds can severely affect the human and natural environment. The Dust Bowl in the Western United States was caused from seasonal winds eroding the agriculturally damaged soil, turned into dust. The airborne particulates had a significant impact on the respiratory systems of humans and animals across the United States.

Wind influenced global ship-borne expeditions, and thus the colonization of the New World. Modern-day transportation is still influenced by wind, including shipping vessels, commercial and private air traffic, and space flight. Airports, for example, are designed to accommodate the regional prevailing wind direction because aircraft always depart and land into the wind.

Wind-generated power is an alternative to fossil fuels. Power is generated from a turbine or wind farm, comprising a group of turbines. Consistent wind speeds exceeding 16 km/hr. are ideal. Wind turbines are typically located on land in mountainous regions, near the coast, or offshore, the latter presently exclusive to Europe. Wind farms have relatively minor environmental impacts but are damaging to migratory species and local aesthetics, and they increase noise and light pollution.

Jean T. Ellis

See also Atmospheric Circulation; Atmospheric Energy Transfer; Atmospheric Pressure; Chinooks/Foehns; Dunes; Fronts; Hurricanes, Physical Geography of; Tornadoes; Wind Energy; Wind Erosion

Further Readings


The wind is a natural energy resource that has been used by humans on a modest scale for hundreds of years. Recently, however, concerns about climate change and diminishing reserves of fossil fuels have resulted in an increasing interest in wind as a major contributor to future energy needs. This renewed interest has not been without controversy, and major obstacles remain to realizing the full potential of wind as a modern energy resource. Doing so will require significant modifications to our energy infrastructure. It may also require some unpleasant compromises and difficult decisions about how we value Earth’s resources.

The Natural Phenomenon

Earth’s winds are generated by seasonal and geographic variations in planetary heating, resulting in the formation of weather systems that redistribute heat around the globe. Wind can be used to perform work because air has mass, and thus, as it moves it has kinetic energy. The amount of kinetic energy (KE) possessed by a given volume of air with mass (M) and velocity (V) is described by the relationship KE = 0.5ρV^2.

Earth’s winds are dissipated by their interaction with the planet’s surface, which acts as a source of friction. Because of friction, winds on our planet are typically stronger and more consistent the higher one travels into the atmosphere. For the same reason, near-surface winds are typically higher in areas where there are few surface obstructions, such as on the ocean, treeless plains, and glacial plateaus. The twin influences of altitude and terrain can sometimes result in dramatic spatial variations in average wind speed over short distances. In addition, the wind speed varies considerably over time, so wind is considered an intermittent energy resource.

Generating Electricity From Wind

Although in the past wind energy was used to propel sailing ships, pump water, and grind grain, it is currently used almost exclusively to generate electric power. Turbines used to generate electricity come in many shapes and sizes. The most common modern design uses three vertically oriented blades to drive a shaft oriented in the horizontal direction, usually termed a three-blade, horizontal-axis turbine. Other varieties exist (e.g., different types of vertical-axis turbines) but are comparatively rare. Modern wind turbines are typically measured by their ability to generate electric power, termed rated capacity. The rated capacity is the maximum amount of power that the turbine can instantaneously produce under ideal conditions. Modern turbines range in power output from several hundred watts (W) to several megawatts (MW). One MW of electricity-generating capacity can serve 200 to 300 average homes. Today, the nation with the largest installation and rated capacity of wind turbines, or “wind farms,” is Germany, with the United States and Spain a distant second and third.

The capacity of a wind turbine is determined to a large degree by the length of its blades and the area they sweep, termed the swept area (A). The power (P) in the area swept by the blades is determined by the relationship P = 0.5ρAV^3, where ρ equals the density of air (in kilograms per cubic meter, kg/m^3) at sea level. To arrive at the actual rated capacity of a wind turbine, additional coefficients must be added to describe the efficiency of the turbine. Turbines used for commercial power generation often top 400 feet from the base of the tower to the tip of the blades, allowing for longer blades and a larger swept area as well as giving them access to stronger, less turbulent winds away from the ground.

Advantages

The theoretical potential of wind energy is one reason why it is seen as an attractive energy resource. The amount of energy contained in Earth’s winds is enormous on the human scale. Some estimates indicate that in theory there is enough wind energy potential in the United States to serve all the country’s current energy consumption, not just electricity usage. Areas of high wind energy potential are widespread throughout the world, although areas of high potential
are frequently concentrated in certain regions such as the U.S. Great Plains.

Complementing its widespread availability and potential, wind energy is attractive because it is a renewable resource and because it does not produce any of the harmful emissions associated with fossil fuel electricity generation, including carbon dioxide associated with climate change. A more recently realized benefit is that the cost of wind-generated electricity is generally lower than the cost of other renewable alternatives. In fact, wind even compares well with some types of fossil fuel in electricity generation, particularly natural gas.

**Drawbacks**

A chief drawback of using wind to generate electricity is that it is an uncontrollable, intermittent resource. Electricity cannot be effectively stored for long, so supply must balance demand at all times to keep the electric grid functioning. In some cases, wind power may not be available when it is needed, creating the need for expensive backup generation. Compounding this problem, electricity demand is typically highest on hot summer afternoons, which often does not coincide with peaks in wind power.

A further disadvantage of wind power is that wind farms must be sited in areas with good wind resources to be effective. Unfortunately, more often than not such areas are long distances away from the population centers where the electricity is needed. Developing electricity transmission infrastructure to transport wind power is a long and expensive process. An additional drawback is that utility-scale wind turbines are large, highly visible, and intrusive. Some people consider them ugly and argue that they destroy the beauty of treasured landscapes. Others believe that they pose a threat to wildlife, particularly birds and bats. Both these issues are often hotly debated in areas where wind farms are proposed.

*Justin R. Barnes*

*See also* Anthropogenic Climate Change; Energy Policy; Energy Resources; Renewable Resources; Wind
From the sand seas of the Sahara to the loess plateau of China, to the yardang fields of Iraq and the dune fields of the Lençóis Maranhenses in Brazil, wind erosion has led to the development of distinctive and often dramatic landscapes. Many of the most recognizable of these landscapes, the sand seas and dunes, for example, are the product of the deposition of wind-eroded material. Wind erosion has also shaped landforms on Mars. Although wind does not have the erosive power of flowing water or ice, its pervasiveness compensates for that lack of force. It has been estimated that as much as a third of the land area of the Earth is susceptible to wind erosion (with the continents of Asia and Africa most at risk). Catastrophic wind erosion of soils in the Great Plains of the United States during the Dust Bowl era of the 1930s caused the infamous “black blizzard” dust storms and also led to the creation of the U.S. Department of Agriculture and the (then) Soil Conservation Service. This discussion of wind erosion is organized around four central themes: (1) erosion processes, (2) transport processes, (3) erosional landforms, and (4) wind erosion hazards.

### Erosion Processes

Wind causes erosion mainly through two mechanisms: deflation and abrasion. Deflation is the direct removal of unconsolidated sediments from a surface. Abrasion occurs when the wind is carrying a sediment load that can work on and reshape an otherwise resistant surface. Once materials have been eroded, they are then subject to transportation by the wind and deposition in another location.

### Deflation

The wind is able to deflate materials when the force it exerts on a surface exceeds the resisting forces acting to stabilize the particles. For a dry sand surface, there is a physics-based relationship that balances the resisting force of gravity against the driving force of the wind. The state where the resisting and driving forces are in balance is termed the **threshold condition**. Quantification of the threshold state is fundamental to predicting wind erosion and is simplest when sediments are cohesion-less. When they are not, the process becomes much more complicated. If the sand is wet, for example, then there is an added resisting force caused by surface tension binding the grains. The presence of salt crusts or algae will also increase the necessary threshold wind speed.

For dust particles (i.e., silts and clays), establishing the threshold condition is more complicated. Such particles may be bound to each other by electrostatic forces, for example. For soils, the initiation of motion also depends on the characteristics of clods, such as size, organic content, and moisture content. For agricultural soils, there are also larger-scale controls such as cultivation practices or the presence of wind shelter belts. The Wind Erosion Prediction System is a model developed to account for these and other factors, based on simulation of field conditions such as particle size, clod processes, moisture, and organic content; wind speed and threshold conditions; and management practices, among other things.

### Abrasion

Aeolian abrasion is caused by the impact of wind-borne sand or dust particles on a lithified or cohesive surface. Abrasion occurs when the resisting force, in this case, the strength of the surface material, is less than that imparted by the impact of grains. Saltating sand grains may affect igneous
or metamorphic rocks with enough force to generate microscopic fractures so that small pieces of the parent rock become susceptible to chipping away—a natural sand-blasting process. Abrasion of sedimentary rocks is more apt to occur as a result of wearing away of the cementing materials that bond individual grains, thus releasing those grains from their matrix. The rate of abrasion is a function of the cube of wind speed and the size and availability of grains for transport. Abrasion is most common in dry windy climates, where there is minimal vegetation to stabilize surfaces and reduce surface wind speeds. For these reasons, abrasion is an exceptionally active process on Mars, where wind speeds are quite high and there is an abundance of unconsolidated sediment and no vegetation.

### Transport Processes

Once particles begin to move, their transport rate, \( Q \), is a function of the cube of wind speed, the threshold condition, and the size and density of the grains. Once the shear velocity exceeds the threshold value, transport increases rapidly with additional increases in wind speed. The blowing sediments move in four ways: creep, reptation, saltation, or suspension. Creep refers to the movement of particles while in almost constant contact with the surface—by rolling, for example. Reptation is the sporadic movement of grains in short hops close to the surface caused by the impacts of other grains. Grains saltate by bouncing across the surface in trajectories that are long compared with their height and with heights that are great compared with those of reptation. Saltating particles are only occasionally in contact with the surface. Most aeolian sand transport is via the mode of saltation. Suspension occurs when particles travel mainly without contacting the surface, supported in the air by turbulent motions that exceed the gravity force. Most fine particles (dust) are transported via suspension.

For a given location on a sediment surface, erosion will occur if the quantity of sediments being removed downwind exceeds the quantity being received from upwind, regardless of the wind speed. Variations in transport rates are caused by changes in sediment availability or changes in wind speed. Changes in sediment availability are associated with surface conditions. If the surface upwind of a location has no sediments or the transport potential of sediments is limited by cohesion, then the entire transport demand must be fed by localized erosion. More subtle changes in sediment supply are caused by variations in grain size (because of their influence on threshold shear velocity) or changes in surface slope—it is harder to move grains uphill than downhill.

Changes in the near-surface wind speed are caused by changes in surface roughness, such as those caused by the development of ripples, or by the presence of obstructions such as vegetation. Dense stands of dune grasses can stop sand transport because local wind speeds can be reduced to zero. At larger scales, changes in the wind regime may result from topographical control of wind speeds and directions or changing weather patterns. Winds are accelerated, decelerated, and steered around mountain ranges and through valleys, for example. These controls may effect the movement of either sand or dust.

### Landforms of Erosion

Erosional landforms are of two general types: (1) those associated with deflation and (2) those associated with abrasion. In the former case the resulting forms are depressions, whereas in the latter case the resulting forms may stand above the surrounding landscape.

### Deflation Forms

Blowouts and pans are the two most common erosional forms caused by deflation. Blowouts are scour forms that occur in vegetated coastal dune systems, usually in trough or saucer configurations. Trough blowouts occur in foredunes when the wind erodes a gap through the dune (see foredune system photo). Trough blowouts are frequently associated with the development of parabolic dunes, as the blowout becomes a pathway for windblown sand to pass through the dune. Such blowouts may deflate until erosion is prevented because the sand surface becomes armored by lag deposits of coarse sediments or shells or because the water table is reached. Saucer blowouts occur in back dune systems where there is localized failure of vegetation, which...
WIND EROSION

exposes the underlying sand to the wind. Saucer blowouts are depressions that are elongated along the axis of the dominant wind transport direction, but where winds are highly variable, these blowouts become nearly circular in outline. Erosion of these blowouts is also limited by armored surfaces or the water table.

Pans are shallow, wind-eroded depressions with maximum dimensions of tens of meters to tens of kilometers. They occur in arid to semi-arid environments, where the sparse vegetation leaves much of the surface exposed to erosional winds. Large pans tend to form in the bottom of enclosed drainage basins. Their origins are often complex, involving the interplay among geological structure, internal drainage patterns, weathering, pedogenesis, climate, and wind. In cases where the role of wind is central to pan formation,
there are usually downwind sand dunes or lunettes (dunes where the clay content of the sediments exceeds 20%). Pans of this type are found in the Basin and Range provinces of the Western United States; Western Australia and New South Wales, Australia; Northern and Southern Africa; Manchuria; the pampas of Argentina; and Mongolia, for example. Many pans are seasonally flooded, and if they are large enough, their shorelines are subject to erosion and reworking by wind waves. Where wind waves modify pans substantially, the long axis of the pan tends to be perpendicular to the dominant wind direction.

Small pans are formed by deflation, usually of soils. Deflation pans occur in sets, often in large numbers densely distributed on the surface, where they may be the most conspicuous landscape element—especially when they are flooded or lined with saline soils (see Western Australia photo). Fields of small pans occur in Australia, the U.S. Great Plains, Botswana, South Africa, and China, for example.

Deflation surfaces develop when wind removes fine grains from a particle size distribution, leaving behind a lag deposit, or armoring, of sediments that are too large to be blown away, or where crusting, as by salts, occurs to stabilize a surface. In coastal environments, deflation surfaces form on washover fans. Such surfaces may form on exposed glacial till surfaces, on or adjacent to dry lake beds or streams. Some desert pavements may be caused by deflation, although other processes may be active as well. Extensive
armored surfaces are called hammada or reg, especially in North Africa, Australia, and Asia.

**Abrasion Forms**

Erosion of cohesive or lithified surfaces creates forms of two general types: ventifacts or yardangs. Ventifacts (“wind made”) are any of several characteristic wind abrasion features formed on bedrock outcrops or on individual stones. The main shapes associated with ventifacts are facets and flutes, and there are several minor forms, including pits and sills. The classic ventifact shape is the dreikanter—a stone with three facets. Each facet is believed to have formed at right angles to the dominant wind direction, with multifaceted ventifacts resulting from the rotation of the stones, the occurrence of abrading winds from more than one direction, or abrasion caused by secondary flows. Flutes are channelized scours that develop in parallel sets oriented parallel to the dominant wind direction. Their formation is attributed to abrasive (probably dust-carrying) vortices. Ventifact characteristics such as orientation are used in the reconstruction and interpretation of paleowind climates. Ventifacts have been used to reconstruct wind regimes on Mars.

Yardangs (see Mars photo) are streamlined, wind-sculpted forms that vary in length from less than a meter (m) to tens of kilometers (km) and are 4 to 10 times as long as they are wide. They are oriented parallel to the dominant wind direction. Sculpting of yardangs by wind action is usually confined to the lowest 1 or 2 m of the exposed surfaces, whereas a suite of other subaerial processes may operate on the higher slopes of the landform. Most yardangs are eroded from cohesive sediments such as silts, clays, or chalks, but they may also form in sandstone or limestone. The local relief increases as material is weathered, abraded, and blown away from the depressions that separate individual yardangs.
Yardangs usually occur in sets, or fields, because their development is controlled by regional wind conditions and local geology. Fields of mega-yardangs (with individual lengths exceeding 1 km) may cover thousands of square kilometers and are found mainly in hyperarid climate regions such as Namibia, Chile and Peru, interior China, Chad, the Middle East, and North Africa. Mega-yardang fields are also common on Mars.

**Wind Erosion Hazards**

Hazards as a direct result of wind erosion include loss of agricultural soils, migration of sands over infrastructure or valued resources, increased respiratory disease, and poor visibility, to name a few. The loss of agricultural soils is a global problem affecting food security, especially in marginal, semiarid environments such as the Sahel. Problems may arise because of the direct loss of agricultural productivity caused by erosion of topsoil or at downwind locations because of the indirect impact of deposition of sediments on crops or in waterways, for example, or by the transport of toxic materials such as pesticides and herbicides. It has been estimated that the magnitude of the offsite costs of blowing dust may exceed 40 times that of the onsite costs.

Blowing sand and migrating dunes have buried or threatened settlements in environments as disparate as Ireland, Denmark, the Western United States, Brazil, and North and South Africa. In some cases, this led to complete abandonment of sites. There is a similar threat to roads, railroads, and agricultural lands in many of these places and also in others, such as the Takla Makan of China, Australia, and New Zealand. Atmospheric dust can produce human and animal health hazards at a great distance from its source, especially respiratory diseases such as asthma, emphysema, and lung cancer. Blowing dust can reduce visibility catastrophically, leading to traffic accidents. In less dramatic cases, the reduced visibility requires daytime illumination of street light systems.

*Douglas J. Sherman*

---

**Further Readings**


---

**WINE, GEOGRAPHY OF**

An excellent way to comprehend a region’s geography is to study its wine. Wine production is inextricably intertwined with the physical, cultural, and economic geography of a region; in essence, to drink a wine is to taste its geography. So widespread is the influence of wine in geography that a review of the geographical literature and an inspection of papers at professional meetings show that most subfields of geography are represented. Up-to-date references are available at the Association of American Geographers’ Wine Specialty Group Web site www.geographyofwine.org.

Wine has been a research topic in geography since the ancient Greek and Roman geographers. Historical geographers pinpoint the home of the wine grape, *Vitis vinifera*, as southwest Asia, and its diffusion and history have been documented in works by Sauer, Unwin, and McGovern. *Vitis*
*vinifera* is a remarkably adaptable plant with many subvarieties, each with a preferred environment, providing geographers with a fertile research opportunity.

The geographical nature of wine can be appreciated by looking at wine labels. The most prominent identifier is the source region of the wine—for example, Bordeaux, Burgundy, Champagne, Barolo, Rioja, Chianti, Brunello di Montalcino, and Valpolicella. European wines are named by the geographic region of production and not by the grape variety. Most Americans recognize the name Champagne, but few know that their favorite bubbly can only be produced in one small region of France or that it is made from Pinot Noir, Pinot Munier, and/or Chardonnay grapes. Over hundreds of years of experimentation, European winemakers have identified the best grapes in a particular region. The grape variety is not mentioned on the label; they just assume that one knows the contents by the geographical name. Red wine from Burgundy is made from Pinot Noir, Chianti from Sangiovese, and Barolo from Nebbiolo. New World wineries have little history and are still experimenting; therefore, the grape variety is prominently displayed.

The French belief that geography has a great impact on wine is epitomized by their use of the word *terroir* to define the sum total of all physical and cultural aspects that give a wine its characteristics. The concept of *terroir* dictates that geography gives wine a sense of place and that the wine is unique from wine produced elsewhere. *Terroir* is a powerful geographical concept because it synthesizes the spatial elements of the natural environment with the socioeconomic ones.

There are many variables influencing *terroir* or the geography of wine. Of prime importance are the physical variables, including climate, microclimate, air drainage, solar prospect, water drainage, geology, topography, altitude, and soil conditions. There are also socioeconomic factors, including grape-growing methods, wine-producing techniques, group pressure for a specific style, the local yeast influence, the type of wood used in barrels, and even how wine pairs with local food.

The sum total of all these factors is what makes a red Burgundy unique. The same Pinot Noir grape grown in California, New York, New Zealand, or Washington will produce a wine with a different style, aroma, and taste. Not only do
the French think that a Pinot Noir from Burgundy tastes different from one produced in California, but they also believe that wines produced from different parts of a vineyard will vary because of the microgeographical conditions.

Many excellent books and articles are available on terroir. Not only does the environment influence the wine, but the wine can influence the cultural geography of an area, resulting in a wine landscape as described by geographers including Peters and Sommers. Terroir is the true essence of the geography of wine for it brings together the physical and cultural aspects that form the geographical imprint of a wine region. The idea of terroir is so accepted that several countries have a legally binding set of rules defining specific regions. The French have the Appellation d’origine contrôlée, the Italians the Denominazione di Origine Controllata, and the Americans the American Viticultural Area (AVA). There were 190 AVAs in the United States as of May 2008. Theoretically, one can taste the difference between a Cabernet Sauvignon produced in the Napa Valley and one made in the Sonoma Valley because of the uniqueness of the terroir.

Books and journal articles on the geography of wine abound. The classics are by de Blij and Unwin. Other excellent books by geographers include Peters’s work on wine landscapes and several regional books by Baxevanis and Sommers. Many books are written in a geographical format by nongeographers, with the Wine Atlas of the World (2007) by Johnson and Robinson being an excellent reference. An especially useful geographically organized collection of books is the Wine for Dummies series by Ed McCarthy and Mary Ewing-Mulligan.

Geographical journals have a good selection of articles on the geography of wine. Although not a geographical journal per se, the Journal of Wine Research has many articles on geography and terroir. Several recent articles highlight weather and climate (e.g., the Niagara Peninsula lake effect, global warming). Other articles highlight the use of remote sensing and using geographic information systems (GIS) to analyze the best places to plant vineyards, how to protect vineyards from insect pests, and how to assess their productivity.

In conclusion, whether it is regional analysis, comparative studies, terroir, climate, GIS analysis, diffusion studies, economic analysis, or studying cultural winescapes, the geographer is uniquely equipped to study the geography of wine.

Percy H. Dougherty

See also Wine Terroir

Further Readings


WINE TERROIR

Terroir is a concept introduced by French winemakers to portray the characteristics of the place where grapes are grown that help define a wine’s aroma, flavor, and other components sensed by the consumer. A wine that reflects its geographic origin thus expresses its terroir. The terroir is essentially the physical geography of the vineyard
as a function of the ecological and physiological response of the grapevine to its site, including the climate, geology, soil, and topographic factors that may influence vine growth, rooting, crop load, and fruit ripening. Wine growers around the world understand the importance of terroir and how it is expressed in the wines, choosing to cultivate specific wine varietals on sites that will produce the best wines. Through careful wine tasting, consumers learn to recognize wines by their origin and detect this sense of place or appellation of origin in tastings. Many winemakers choose to let the essence of terroir shine through in their wines versus masking these characteristics through winemaking practices.

**Physical Geography and Wine Growing**

The physical geography of an agricultural field, and in this case a vineyard in reference to wine grapes, exerts important controls on viticulture, with subtle differences in climate, geology, soil, and topography reflected in the wines produced from grapes grown at different sites. These site characteristics may act in a singular fashion or in tandem, such that grapes produced in adjacent vineyards on different soils, but with the same climate, produce wines with different characteristics, or soil and climate may act mutually to change the character of wine grapes along a gradient up valley, where both climates and soils change.

Terroir is a concept introduced by the French in their Appellation d’origine contrôlée (AOC) system and is now used by winemakers worldwide to explain the essence of place as a function of the physical geography of the vineyard where the grapes for any particular wine are grown. French viticulturalists have shown that distinct differences in wine-growing districts and vineyards in Bordeaux, for example, produce very different wines as one proceeds inland up the Garrone and Dordogne rivers across river and glaciofluvial landforms and soils of different types and ages. Winegrowers in other regions of the world, including California, New Zealand, South Africa, and Germany, have used this same concept of vineyard geography to develop vineyards and produce wines best suited to the site. Agencies that regulate the naming of agricultural regions and the labeling of wines have established similar geographically based appellation of origin systems in various countries, such as the American Viticultural Areas program in the United States.
Because of the impact of vineyard geography on fruit composition, and subsequently on the flavor and other characteristics of the wine, vintners have long been interested in the effects of climate and soils on wine. Researchers have shown that climate, that is, the surface environment of the vine (canopy zone), is an important factor that affects fruit composition and wine quality and is intimately tied to the concept of the vintage (e.g., wine quality in a given year or harvest). The length of the growing season, the intensity and duration of solar radiation, temperature extremes, growing degree-day totals, precipitation events, wind speeds, and other aspects of the vineyard climate affect vine flowering, leaf canopy development, fruit set, crop load, and grape maturation. Viticulturalists can manipulate the vine canopy (through trellising, pulling leaves and shoots, cluster thinning, and other practices) to influence the microclimate of each plant, yet the regional climate effects cannot be changed (such as excessive summer heat or late-growing-season rainfall).

The soil—that is, the subsurface environment of the vine (rooting zone)—is also a primary factor affecting vine vigor and fruit composition, and the chemistry, quality, flavor, and aroma of the wine. Since it is the underground environment of the vine, it is more difficult for the viticulturalist to manipulate this part of the ecosystem, with even tillage of the soil and the addition of soil amendments not penetrating nearly to the depth that most vines root to. The fruit of the vine thus very much reflects the nature of the soil where it is grown and any related characteristics of the geology and geomorphology of that site that may influence soil texture, nutrients, water-holding capacity, and other parameters. The soil system interacts with the plant’s root system to control the water, gas, and nutrient flux in the root zone to the shoots, leaves, and fruit in the grapevine’s canopy. Many of the metabolic and biosynthetic processes remain poorly understood for grapevines and most other woody plants (including agricultural crop plants), thus the physiological impact of the soil on the vine remains largely unknown in a mechanistic sense.

It is encouraging that both chemical and descriptive (i.e., human sensory) evaluation of wines often allows discrimination of wines by geographic origin, implying that the climate, geology, and soils are significant controls of grape and wine composition, even overriding whatever techniques the winemakers use in making the wine. Research has shown that unusual soils produce unusual wines and that an area that has uniform climate, geology, and soils across it (such as a single alluvial fan in a small valley or a mountain top surface) has very similar wines that can be discriminated through both descriptive analyses and multivariate ordination techniques. Doing controlled experiments, researchers have shown that terroir is a valid scientific concept that determines the flavor, aroma, and other characteristics of wines. In other words, place matters, and geography matters.

Deborah L. Elliott-Fisk

See also Agroecology; Climatology; Soils; Wine, Geography of

Further Readings


WISE USE MOVEMENT

The Wise Use movement was a coalition of broadly anti-environmental and antifederal organizations and political movements active in the United States from roughly the late 1980s through the late 1990s. The term wise use was strategically borrowed from Progressive-era conservationists, for whom it functioned very much like sustainable development, in both its ambiguity
and its emphasis. The Wise Use movement had three wings. The first, based in the rural West, centered on efforts by rural commodity producers to maintain their historical, privileged access to many public lands in the region for production. The second, the property rights movement, argued that governmental regulations affecting private property constituted a legal “taking” of a portion of that property, for which owners should be compensated. The third, centered in Washington, D.C., was a coordinated effort by regulated industries to repeal, weaken, or prevent many major national and international environmental laws and treaties. Each of these wings existed before and after the Wise Use movement per se; what distinguished the movement was their temporary alliance and commitment to a united agenda.

Wise Use was strongest in the rural West, where it was in part a cultural and political response to regional restructuring. Since 1980 or so, the rural West had seen dramatic declines in primary production industries and the concurrent growth of a service economy, rapidly increasing environmental priorities on public lands, and major demographic and political shifts. In reaction, Wise Use claimed to be a grassroots social movement, rooted in a regional culture, responding to overly intrusive outsiders. It defined itself mainly in opposition to the environmental movement and federal agencies governing land uses, which it portrayed as outsiders infringing on local rights to livelihoods and self-determination. Wise Use had a surprising amount in common with many social movements in the global South centered on resource access and control, examined in the literature of political ecology: For example, it emphasized cultural identity, local knowledge as an alternative to expert science, reinventions of community and tradition, and defenses of local claims against state authority. It was also part of a broader trend toward the neoliberalization of environmental governance.

The Wise Use movement lost cohesion in the late 1990s for three reasons. First, its three wings diverged as it became clear that pursuing their respective goals demanded different sorts of actions in different arenas. Second, groups focused on public lands realized that confrontational approaches were proving counterproductive, and many began to seek the same ends via participation in collaborative management instead. Third, the two presidential administrations of George W. Bush (2001–2009) were highly sympathetic to Wise Use’s goals, and indeed were staffed in part by individuals with connections to it, removing participants’ motivations for an antifederal stance.

James McCarthy

See also Common Property Resource Management; Environmental Management; Environmental Management: Drylands; Environmental Social Movements; Neoliberal Environmental Policy; Political Ecology; Resource Management

Further Readings


WITTFOGEL, KARL (1896–1988)

Karl August Wittfogel was a well-known German American historian and a sinologist. Concerned primarily with humanity’s relationship with nature, his work influenced geography, anthropology, and urban studies. The environmental historian Donald Worster credits Wittfogel with pointing out that nature was not passive but formed a strong force in shaping the history of humanity. Wittfogel is also known for his early Marxist thought and his later critique of Marxism.

Wittfogel was born in Woltersdorf, Germany, and received his PhD from the University of Frankfurt in 1928. In the 1920s and 1930s, he was an active communist and an avid critic of fascism. When Hitler gained power in Germany in
1933, Wittfogel became a target of the Nazis. He was imprisoned in a concentration camp until international support prompted his release. Wittfogel moved to the United States and acquired U.S. citizenship in 1939. He taught first at Columbia University and then at the University of Washington until he retired from teaching in 1966.

Wittfogel is primarily known for his view that water played a critical role in early civilizations, states, and cities. He was especially concerned with Asian civilizations. Wittfogel explains these views in his 1956 essay “The Hydraulic Civilizations” and in his most famous work, *Oriental Despotism: A Comparative Study of Total Power*, published in 1957. One central point of Wittfogel’s hydraulic civilization thesis is that arid and semiarid societies required tremendous amounts of control and stern management of water resources. Wittfogel believed that water was a key resource for civilizations. Water was needed for irrigation and was vital for agriculture in arid and semiarid regions and often required large engineering projects that were built with forced labor. Wittfogel believed that this factor was especially important in the early development of Asian civilizations. He notes that other resources, such as soil and air, are as important to agriculture as water, but water differs in one principal way. Water can be stored. In Wittfogel’s opinion, the control of water resources was such an important factor in the survival and development of Asian civilizations that he refers to them as hydraulic civilizations. Wittfogel believed that the control over water gave governments enormous power over people. According to Wittfogel, the rulers of civilizations in arid and semiarid areas eventually acquired a tremendous amount of control. Governments ruled strictly and monopolized their economies through “hydraulic government.” The word *despotism* in the title of his well-known work refers to this harsh control over the lives of masses of people. Some, such as Neil Smith, view his concern with Asian despotism as a slightly veiled critique of communism.

Jessey Gilley

*See also* Environmental Determinism; Environmental Perception; Hydrology; Marxism, Geography and; Orientalism

---

**Further Readings**


---

**WOOD, DENIS (1945– )**

Denis Wood is an artist, writer, cartographer, psychogeographer, and independent scholar. A former professor of design at North Carolina State University, Wood writes extensively on the nature of maps, mapping, and mapmaking processes. He has helped establish the subdisciplinary field of critical cartography, refining and extending J. B. (Brian) Harley’s questioning of the objective neutrality of maps. Wood explores the social and political implications of mapmaking through playfully antagonistic prose, polemically undermining the authority of Western scientific cartography. He develops a theoretically rigorous critique of the power of maps, drawing on poststructural thinkers Michel Foucault and Jacques Derrida, the linguist Ferdinand de Saussure, the literary theorist and semiotician Roland Barthes, and the developmental theorist Jean Piaget. Wood is responsible for broadening the definition of maps as cultural products inherently imbued with power.

Eschewing the criterion of accuracy, Wood reads maps as narrative texts and members of a broad family of representations alongside landscape portraits and detective stories. After early research studying experimental maps, mental maps, and map literacy acquisition, Wood turned to semiotics to cast maps as sign systems coproduced with specific sociohistorical contexts. Maps are inherently subjective propositions that work...
within a discursive system of coded representations to link an imagined territory with associated phenomena. A false distinction between maps and other forms of representation limits the creative, emotional potential of maps gained through a narrative understanding.

Wood relentlessly attacks cartographers for their legitimization of scientific maps. The professionalization of mapping masks political interests under pretenses of unbiased, distanced neutrality. Through claims to objectivity, maps portend to represent a world of facts as they really are rather than as purposively selective fictions that create the world as much as they closely resemble it. The presupposition of accuracy obscures the politics embedded within maps and empowers them as weapons of domination, reproducing society and legitimizing the status quo.

While modern cartography has served the interests of the State and the dominant elite, counter-mapping practices also employ the power of maps for resistance. Wood calls for the death of cartography and the return of mapping to the status of a universal birthright of humanity. His recent collaborative work with John Krygier assists nonprofessionals with map design through visually rich narratives, graphical guides, and a Web site dedicated to do-it-yourself (DIY) cartography.

Richard Donohue

See also Cartography; Countermapping; Critical GIS; Critical Human Geography; Harley, Brian; Monmonier, Mark; Pickles, John

Further Readings


Wood and charcoal provide the major energy resources for most residents of developing countries, especially for cooking and heating. To these people, the real energy crisis is the disappearing sources of inexpensive or free wood for fuel, along with deforestation. The persistence of mass poverty in regions such as sub-Saharan Africa limits access to these resources. Pitfalls in energy sustainability erode gains in the potential for human development and environmental sustenance.

Access to adequate and appropriate energy resources has implications for the economic, social, and ecological dimensions of both local and global development. Energy is a necessary requirement for sustainable development. The commercial energy sector has powered recent gains in global economic growth and has been the main driver in the globalization of the world economy. Nations with a high proportion of modern and conventional fuels in their energy mix, such as those in the global North, tend to have highly advanced economies. Conversely, nations in the South, with a high proportion of traditional fuels, have generally faced complex human development challenges in providing livelihoods and environmental quality. The relationship between energy and economic development is not necessarily direct; however, energy is a critical input in the development framework.

To sustain the existing expanding economies and to accommodate new and potentially high-demand entrants from the developing world, energy supplies need to expand. While global energy supplies are experiencing relatively low or even flattening growth rates, demand levels are escalating. Recent aggressive participation in global energy markets by giant economies with hitherto low demand streams, such as China and India, could
exacerbate this situation. Conservation measures have not made up for the gaps in energy supply. This trend could make many other countries less competitive in global markets for reasonably priced energy resources. While international markets have a robust capacity to balance energy supply and demand levels, adverse supply constraints could stretch the resilience of the system beyond the normal efficient allocation mechanisms. The looming threat of global climate change adds a new urgency for policymakers to broaden the range of energy strategies to include sources that were previously discounted, including woodfuel.

Woodfuel has been perceived to play a minimal role in models of modern socioeconomic development, but this is simply a world economic view. Regionally, wood caters to the needs of the majority of the rural population in developing nations. The sizable urban population there also depends on woodfuel, especially charcoal; and electric power supplies are erratic, overpriced, and nonexistent in large sections of the ever-expanding spontaneous settlements. Furthermore, cheap alternatives such as liquefied petroleum gas are not easily accessible, and substandard equipment and inadequate safeguards make them potential hazards in the cramped living spaces of slums.

In the developed world, only a relatively small amount of both value-added and raw wood is used to generate electricity. It is still used for limited-space heating in the northern regions and may even provide fuel for gourmet cooking. Wood is by no means the primary source of energy, and the vast majority of the population does not use it directly since cheap commercial fuels are readily available.

For the majority of the world’s rural population, especially in sub-Saharan Africa, wood of all types and forms is the primary fuel source. This includes high-oil-producing countries such as Nigeria, Angola, and Gabon. Rural sub-Saharan Africa has an estimated electrification rate of only 7.5%, and therefore, an estimated 70% to 90% of the population depends on biomass fuels, principally wood. South Asia, with the next lowest rate, had an electrification rate of 30.1% in 2005. The World Energy Council noted that while Africa has nearly 13% of the world’s population, its share of the world’s primary energy consumption is only 3%. These facts and similar others demonstrate a real need for expanded access to the commercial energy sector through development, as well as policy, research, and technological
attention to woodfuel, which is often readily available.

Considered inefficient and often unsustainable, woodfuel has nonetheless enabled the poor countries of the world to survive socioeconomically and ecologically. The energy budgets of most developing countries confirm this. In effect, woodfuel has saved these cash-starved economies trillions of dollars in deferred energy imports over the years. Such savings have benefited other areas of national needs such as education, health care, and general infrastructure. Meanwhile, the low participation of these developing countries allowed many of the energy-intensive economies to buy fossil fuels at reasonable prices. The principal use of woodfuel may have prevented millions of tons of greenhouse gas emissions, compared with the dominant use of fossil fuels. This idea is supported by the fact that in the relatively sparsely populated moist forests and woodland regions, deadwood, rather than green standing biomass, is harvested for fuel. Fuel impacts on direct forest loss, in this context, is also negligible.

In all policy considerations, wood has limitations in economic growth. Inappropriate wood harvests, of course, may also trigger ecological problems such as deforestation. For all practical purposes, no modern economy can compete successfully in the global economy as it is now with raw woodfuel as its energy base.

In spite of inherent limitations, wood should be one of the alternative mainstream fuels. As global attention is drawn to the impacts of the biofuels on food prices, wood cellulose and other wood derivates should receive scientific and technological attention. The routine use of wood in rural areas of the developing world is generally for household purposes. Research policy should focus on its calorific value, profitability for long-distance transport, smoke emissions reduction, and incentives for fuelwood farms. It is imperative that the private sector be encouraged as a necessary partner.

William Y. Osei

See also Agroforestry; Community Forestry; Deforestation; Forest Degradation; Forest Fragmentation; Forest Land Use; Renewable Resources; Sustainable Development

Further Readings


WOODLOTS

See Forest Fragmentation

WORLD BANK

The World Bank (often called simply “the Bank”) is one of the Bretton Woods institutions, including the International Monetary Fund (IMF), that have their roots in the post–World War II meeting of eminent economists in Bretton Woods (New Hampshire) to discuss the rebuilding of Europe. While the Bank was to provide longer-term funds for investment in productive endeavors, the IMF was to provide short-term balance-of-payments relief.

What is often referred to as the World Bank is part of the World Bank Group, which is made up of the following five development institutions: (1) International Bank for Reconstruction and Development (IBRD), (2) International Development Association (IDA), (3) International Finance Corporation (IFC), (4) Multilateral Investment Guarantee Agency (MIGA), and (5) International Centre for Settlement of Investment Disputes (ICSID). The World Bank comprises only the IBRD and the IDA. Although the IBRD and IDA share the same staff and headquarters in Washington, D.C., each has a different focus: The IBRD assists middle-income and creditworthy poor countries, while the IDA focuses on the world’s
poorest countries (i.e., those with per capita income of less than US$1,065 in 2008). The IBRD also has a much larger country membership and a broader mission than the IDA. It provides its client countries with loans, guarantees, and analytical and advisory services. The IBRD’s financial strength enables it to borrow in capital markets at low cost and to offer clients favorable borrowing terms. The IDA provides interest-free, long-term loans, called credits, and grants to governments of the world’s 82 poorest countries, which have little or no capacity to borrow on market terms. The IDA’s lending is financed by contributions to the IDA from donor countries, the IBRD’s net income transfers, grants from the IFC, and IDA loan repayments. IDA funds are used to finance poverty reduction programs and are allocated to countries based on anticipated “development effectiveness,” and the Country Assistance Strategy is used for distributing the money within the country (Table 1).

Each of the World Bank Group institutions is owned by its member countries, which are shareholders. The Bank is supervised and directed by a 24-member Board of Governors. The voting power of the individual executive director is based on the shares of the countries they represent. The United States, Japan, Germany, France, and United Kingdom each appoint one executive director, and collectively, these five countries control 37.4% of the total votes. The president of the World Bank Group has a 5-year term and is selected by the executive directors. While this formal structure gives the impression of balance in the relative power of owner nations, in reality the United States has the greatest influence because, as the largest contributor, it selects the president (who by tradition has always been a U.S. citizen), who is then approved by the Bank’s executive directors (the managing director of the IMF has also traditionally been European). The Bank’s leadership has been a source of criticism by those who argue that the developing country clients have no say in selecting its leader.

Since the establishment of the Bank in 1944, its development philosophy has gone through several transformations. The first major transformation, following the implementation of the US$12 billion Marshall Plan for the postwar reconstruction of Western Europe, was a shift in focus to the development needs of developing countries. The second transformation, which occurred under Bank President Robert McNamara (1968–1981), shifted the focus of the Bank’s loans from investments in infrastructure to broader support for development projects involving human development and economic transformation, paving the way for the Bank’s initiation of structural adjustments programs (SAPs) during President Alden Clausen’s (1981–1986) tenure. Implemented in the 1980s and 1990s, SAPs sought to promote economic development through trade liberalization and free market enterprise. The Bank’s development philosophy was heavily criticized during its 50th anniversary, in 1994, under the slogan “50 years is enough.” Moreover, the Bank was criticized for promoting and financing inequitable and unsustainable development that creates (rather than reduces) poverty and destroys the environment and for being undemocratic because it denied citizens of poor countries a role in making the major development decisions affecting their societies. These

<table>
<thead>
<tr>
<th></th>
<th>IBRD</th>
<th>IDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year established</td>
<td>1944</td>
<td>1960</td>
</tr>
<tr>
<td>No. of member countries</td>
<td>185</td>
<td>167</td>
</tr>
<tr>
<td>Fiscal 2008 lending/commitments</td>
<td>$13.5 billion for 99 new operations in 34 countries</td>
<td>$11.2 billion for 199 new operations in 72 countries</td>
</tr>
<tr>
<td>Cumulative lending/commitments</td>
<td>$446 billion</td>
<td>$193 billion</td>
</tr>
</tbody>
</table>

Table 1 Some basic facts (as of June 30, 2008) about the IBRD and IDA, two of the largest development agencies in the world

criticisms led to a final transformation under James Wolfensohn’s presidency (1995–2005), marked by the emergence of the “Comprehensive Development Framework” approach based on four principles: (1) a holistic long-term strategy; (2) domestic ownership, both “owning” and directing the development agenda; (3) a stronger partnership among governments, donors, civil society, the private sector, and other development stakeholders; and (4) a transparent focus on development results to ensure better poverty reduction. Today, the Bank virtually sets the global development agenda, which is currently focused on reducing poverty in developing and transition countries.

These transformations have been accompanied by a change in the composition of the Bank’s staff. From a once homogeneous staff of engineers and financial analysts based only in Washington, D.C., the Bank now has a multidisciplinary and globally diverse staff, nearly 36% of whom are based in 120 offices around the world.

The Bank’s dominance in setting the international development agenda stems from its enormous financial power. As the largest bank of its type, the Bank had, for instance, an administrative budget of $2.1 billion and a combined IBRD and IDA funding commitment of $24.7 billion in Fiscal Year 2008, easily exceeding the resources of any other international development agency. Moreover, as convener of almost all the existing consortia or consultative groups, such as the “donor” clubs, it coordinates the overall aid programs of bilateral donors as well as IMF lending to individual countries.

Francis Owusu

See also Development Theory; International Monetary Fund; Neoliberalism; Structural Adjustment; World Trade Organization (WTO)

Historical Development of the Term

Although the term world city was used by Goethe, its meaning differed from today’s conception of a world city, as it then signified a place of political and cultural importance. World city research in the contemporary study of geography focuses strongly on economic processes, although political, cultural, and social processes inform some aspects of the research. Moreover, the research is strongly shaped by disciplines other than geography, especially urban planning and sociology.

In the 20th century, Patrick Geddes also used the term world city in his book Cities in Evolution, which was published in 1915. However, the
Figure 1  Global and world cities

British urban planner Peter Hall provided the first systematic analysis of world cities in 1966, when he published his book *The World Cities*. Hall analyzed seven cities, which were of overwhelming economic importance in the world economy at the time, but he focused on their internal structures and organization as well as national and regional roles, with relatively little attention to linkages between these world cities. Understanding world cities as part of a network of world cities did not happen until the 1980s, when researchers at the University of California, Los Angeles, among them the urban planner John Friedmann, published their hypothesis of a world city network. This reorientation in world city research was a direct response to changes in the world economy since roughly the 1970s, which saw a shift from Fordist production methods to more decentralized and flexible methods as well as a reduction in trade barriers and increased economic globalization.

A further major development in world city research came in the early 1990s, when the sociologist Saskia Sassen published *The Global City: New York, London, Tokyo*. One of the major contributions of that book was the identification of producer services as command-and-control functions in the world economy. Producer services have subsequently become and continue to be a core analytical component of world city research. The label “global city” was intended to mark a conceptual difference from “world city,” in that a global city is not merely a dominant city in the world but the processes articulated in it are truly global, intercity linkages. Various rankings of a world city network were produced using producer services as an analytical cornerstone. This work was significantly advanced by the geographer Peter Taylor and the Globalization and World City (GaWC) Research Group founded in the late 1990s at Loughborough University in the United Kingdom.

**World City Network**

World cities are the command-and-control centers of the global economy but are not individually in a position to fulfill these command-and-control functions. Instead, they are also highly dependent on each other—that is, they not only compete for the same business but also rely on each other in fulfilling the capital commanding functions in the global economy and thus constitute a system. The geographic distribution of cities remains of central importance for this system regardless of considerable improvements in telecommunications over the past two or three decades. The most regularly mentioned world cities at the top of the urban hierarchy, New York, London, and Tokyo, for example, are located in three distinct world regions and time zones and are thus in a position to collectively influence business in the Americas, Europe-Africa, and the Asia Pacific Region at any time, whereas one individual city could not do so. Los Angeles, Chicago, Toronto, Paris, Frankfurt, Amsterdam, Hong Kong, Singapore, and Sydney, among others, are often cited as other major world cities.

These world cities have in common that they host the largest stock exchanges and the headquarters of the world’s largest banks and other transnational producer services firms. Through these producer services or command-and-control functions, world cities fulfill core functions within the world economy. Strong links thus exist between world-systems theory, which conceptually divides countries into core, periphery and semiperiphery economies, and world city research, although the former focuses on the nation-state as the main unit of analysis and the latter on cities. World cities are often ranked into alpha, beta, gamma, and delta groups, based on the concentrations of producer services in them. Depending on changes in these concentrations, cities retain both upward and downward mobility within the system.

**The Internal Structure of World Cities**

The internal structure of world cities is characterized by an advanced telecommunication infrastructure, a large stock of high-end office space, a large proportion of urban amenities, spectacular architecture, and signature buildings as well as highly polarized labor markets. Moreover, the hosting of cultural festivals, sports events, and other mega events, such as the Olympics or Expos (world exhibitions), are means for cities to attract business and tourists and thus attain (or maintain) world city status.
Office space and infrastructure are essential prerequisites in attracting the offices, especially regional or global headquarters, of large transnational corporations, which give a city the status of a world city. However, cultural amenities, such as theaters, museums, concert halls, and sports arenas, are of similar importance in attracting global managerial staff and professionals to work in a city. Similarly, mega events, with their substantial global media reach, are tools for promoting a city and showcasing its attractiveness and achievements. Spectacular architecture provides an image of a city to promote it through the global media.

Partly as a result of this economic structure, world cities are characterized by a highly polarized labor market. On the one hand, a large number of professionals and managerial staff in transnational corporations receive high incomes with additional benefits, enabling them to enjoy many of the cultural amenities, while on the other hand many low-income workers struggle to find adequate housing, schooling for children, and often food. These workers often earn a minimum wage (or in case of illegal employment, below minimum wage) and find employment in low-end service jobs, such as cleaning, food services, or domestic labor. Both labor markets, high and low income, are highly international and depend on migrant workers—transnational professionals on the one hand and economic migrants on the other. The process of social polarization is also a result of post-1970s state restructuring and the reduction of social redistribution by nation-states.

Critique of the Concept

The concept of the world city has been critiqued as being West-centric and too focused on economic processes of globalization rather than on a broad cross-section of different processes, including cultural, political, and social ones. The focus on producer services privileges a narrowly defined subsection of the global economy, resulting in a focus on a small number of cities, while other important global or regional economic circuits are excluded from the analysis. Few cities that are routinely included in world city rankings are in the global South. Moreover, critics charge that through rankings of world cities, it is implicitly suggested that the cities at the top of the urban hierarchy are the examples or standards, while other cities are the followers that should attempt to develop in the same way. Supporters of world city research point to its theoretical tradition in world-systems theory and stress that the rankings are an expression of power and influence in the world urban system rather than an indication of which cities have developed “correctly.”

Björn Surborg

See also Globalization; Producer Services; Taylor, Peter; Urban Geography; Urban Hierarchy; Urbanization; World-Systems Theory

Further Readings


WORLD COURT

The World Court is the common name for the International Court of Justice (ICJ). It is the main judicial organ of the United Nations (UN) and is headquartered at the Peace Palace in The Hague (the Netherlands). It began functioning in 1946.
Its predecessor was the Permanent Court of International Justice (PCIJ), established in 1920 by the League of Nations. The Court’s earlier roots can be traced back through The Hague Peace Conference of 1899, the Alabama Claims arbitration in 1872, and the Jay Treaty of 1794 between Britain and the United States.

Fifteen judges serve on the World Court. They are elected for 9-yr. terms by the UN General Assembly and the Security Council and are eligible for reelection. Candidates must receive an absolute majority of votes in both bodies. For continuity, one third of the Court is elected every 3 yrs. Once elected, the Court’s judges then elect a president and vice president. The Court’s official languages are English and French.

The judges must represent the world’s main forms of civilization and legal systems. No more than one person of a single state (i.e., country) may serve concurrently as a judge. Presently, three judges are from Africa, two are from Latin American and the Caribbean, three are from Asia, five are from Western Europe and other states, and two are from Eastern Europe. Judges are not delegates of their respective countries but instead are obligated to act impartially and conscientiously. For Court cases concerning a country that does not have a judge on the Court, a country may request that an ad hoc judge from it or another country be added for such cases. Ad hoc judges also must agree to be impartial in their decision making.

The World Court has two main functions: (1) issuing advisory opinions and (2) settling contentious cases. The first centers on legal questions submitted to it by the UN’s five organs and
16 specialized agencies. The second is an application of international law to settle legal disputes brought to it by countries’ governments. The Court only accepts contentious cases from countries that are members of the UN and parties to the Statute of the Court or countries that accept the Court’s jurisdiction. Its judgment is delivered publically and is considered final, binding, and not subject to appeal. Advisory opinions are also delivered publically but are not considered binding.

Between 1946 and mid 2008, the Court delivered 25 advisory opinions, 97 judgments, and had 12 pending contentious cases. Judgments have concerned issues such as political boundary disputes, territorial sovereignty, noninterference in the internal affairs of states, rights of passage, diplomatic relations, and human rights.

George W. White

See also Borders and Boundaries; Human Rights, Geography and; Identity, Geography and; International Criminal Court; Justice, Geography of; Law, Geography of; Sovereignty; State

Further Readings

International Court of Justice: www.icj-cij.org/homepage/index.php?p1=0

The World Health Organization (WHO) was one of the earliest bodies created by the United Nations. The WHO effectively began in 1948, when its constitution came into force, and to this day it continues to spearhead global public health initiatives. Over the years, the WHO has played a key role in the organization and promotion of global programs to eradicate infectious diseases, including smallpox, polio, and measles; in helping developing countries, in particular, to build their public health care systems; and in the development of surveillance systems for and responses to highly infectious emergent diseases (e.g., Ebola).

Arguably, the WHO’s greatest contribution to date is the role it has played in transforming the thinking on the development of primary health care. In 1978, the WHO organized the Primary Health Conference in Alma Ata, where WHO member countries declared,

The Conference strongly reaffirms that health, which is a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity, is a fundamental human right and that the attainment of the highest possible level of health is a most important worldwide social goal whose realization requires the action of many other social and economic sectors in addition to the health sector. (Alma Ata Declaration, first principle)

These words shifted the focus of research and practice away from a narrow concept of health as the absence of disease to a much broader focus on physical, mental, and social well-being; acknowledged that to understand health, research and practice must address the social and economic determinants of health; and raised health status to the level of other fundamental human rights. In other clauses, the Alma Ata Declaration sets out the responsibilities of governments to attain the goal of health and declared that the elimination of health inequalities within and between countries needed to be attained.

The WHO definition of health, its focus on the social and economic determinants of health, its advocacy of health as a right, and its goal of reducing health inequalities all found their way into the writing, research agendas, and critical debates of the 1990s among medical geographers. While medical geography continues to exist as a subfield of geography, it can be argued that the ideas that came out of the Alma Ata Conference help set the stage for the development of health geography in the latter part of the 1990s, with the take-up of key concepts from critical geography and an emphasis on place, gender, disability, population health, and the use of qualitative methods. Today, both medical and health geographers
continue to look to the WHO for its leading role in the global efforts to eradicate disease and promote health.

Mark W. Rosenberg

See also Health and Health Care, Geography of; Medical Geography; United Nations

Further Readings

World Health Organization: www.who.int/en

WORLD SUMMIT ON SUSTAINABLE DEVELOPMENT

The World Summit on Sustainable Development (WSSD), which convened in Johannesburg, South Africa, from August 26 to September 4, 2002, aimed to reaffirm and assess the progress of the multilateral commitments launched at the Rio Conference 10 years earlier. Specifically, the WSSD was designed to evaluate the progress of the Millennium Goals and Agenda 21 and to set new priorities and goals to counter global poverty and environmental degradation in the coming years.

United Nations (UN) Secretary General Kofi Annan identified five priority areas for action at the Summit: (1) water and sanitation, (2) energy, (3) health, (4) agriculture, and (5) biodiversity.

The United Nations Commission on Sustainable Development served as the central organizing body of the WSSD. A 10-member steering committee (representing each region of the world) guided the process and attempted to raise political support for the summit. Four preparatory meetings were also held prior to the WSSD, three in New York City and one in Bali, Indonesia.

The WSSD is one of a series of UN global earth summits popularized since the Stockholm Summit in 1972. It was the largest summit to date, with more than 100 heads of state and an estimated 25,000 participants (from 180 countries) representing governmental, business, and activist organizations. The WSSD differed from the previous summits in two important ways: (1) it adopted a sustainable development approach, which widened the environmental goals to include poverty alleviation, and (2) it created opportunities for greater civic engagement through the organization of a parallel stakeholder’s forum conference. Stakeholders included businesses, women and children, trade unions, indigenous leaders, local representatives, farmers, and the scientific community.

Despite this new approach and the unprecedented number of attendees, the WSSD was widely criticized for failing to devise a specific time frame and funding provision for the implementation of their goals. Many blame summit fatigue for the lack of results. Others blame the increasingly neoliberal approach to global governance and the subsequent weakening of the sustainable development ideology. Furthermore, the events of September 11, 2001, and the subsequent War on Terror, along with the credit crisis of 2008, have contributed to widespread unilateral policies that prioritize military and financial security over global environmental conservation and sustainable development.

Emma S. Norman and David L. Carr

See also Civil Society; Environment and Development; Neoliberal Environmental Policy; Sustainable Development; United Nations Conference on Environment and Development

Further Readings

One of the major models of how the global system of states and markets operates, world-systems theory, introduced by the sociologist Immanuel Wallerstein in the 1970s, is an enormously influential perspective on the changing structure and dynamics of the world economy. In many respects, it retains a fundamentally Marxist version of the world, one that puts production, class, uneven development, and historical context at the center.

The focus of world-systems theory is on the entire world rather than on individual nation-states. This view maintains that one cannot study the internal dynamics of countries without also examining their external ones; thus, the boundary between foreign and domestic effectively disappears. This stance notes that all regions are interconnected; that is, they never exist in isolation. Moreover, this focus notes that the growth of the West occurred in interaction with other parts of the world, not through its inherent internal dynamism, thus serving to oppose the widespread Eurocentrism of much of social science.

World-systems theory distinguishes between large-scale, precapitalist world empires, such as the Romans, Mongols, or Ottomans, all centralized political systems that appropriated the social surplus from their peripheries through the state, and the capitalist world system, in which there is no single political entity to rule the world but a multiplicity of entities of varying sizes and degrees of sovereignty; that is, there is a single market but multiple political centers, meaning that there is no effective control over the market. With the rise of capitalism, the primary political units shifted from empires and city-states to nation-states. The political geography of capitalism is thus not the nation-state but the interstate system. Occasional attempts to reassert a world empire included the Hapsburgs, Napoleon, and Germany in World Wars I and II, each of which represented a temporary contraction in the world system but a permanent reconfiguration in its hierarchy of states.

Wallerstein held that the world system arose in the “long 16th century” (1450–1650) and gradually enveloped all other parts of the globe. Until the 19th century, various parts of the world affected one another; as they become locked into a single, worldwide division of labor, however, they became increasingly reliant on each other. However, recent variations of world-systems theory have extended the concept “backward” in time to include increasingly earlier social formations. For example, Andre Gunder Frank held that even Neolithic mini systems constituted a world system of sorts. Janet Abu-Lughod offered a celebrated concept of a late-13th- and early-14th-century system, which connected China, India, the Arab world, and medieval Europe via the Silk Road routes and maritime trade across the Indian Ocean but was ended by the bubonic plague. Indeed, many world-systems theorists argue that prior to the 19th century, the world economy was primarily Asian in nature.

World-systems theorists maintain that capitalism takes many forms and uses labor in different ways in different regions. In the global core, labor is predominantly waged (i.e., organized through labor markets), while in developing countries there is considerable use of nonfree labor, ranging from slavery to indentured workers to landless peasants working on plantations. Some critics of Wallerstein, particularly Robert Brenner, argue that his view prioritizes trade over the commodification of labor, leading to allegations that he is “neo-Smithian” in his worldview. World-systems theorists counter that the world economy structures places in such a way that high-valued goods are produced in the core and low-valued ones in the periphery. The search for profits through low-cost labor drives the world system forward to expand into uncharted territories.

Unlike the bifurcation between developed and less developed countries that both modernization and dependency theories advocate, in world-systems
theory there is a tripartite division among core, periphery, and semiperiphery. The core and periphery are the developed and undeveloped countries, or First and Third worlds, respectively: One is wealthy, urbanized, industrialized, and democratic, the other rural, impoverished, agriculturally based, and dominated by authoritarian governments. The semiperiphery has characteristics of both core and periphery and includes states in the upper tier of the less developed world, such as the newly industrializing countries in East Asia, Brazil, and Mexico. Core processes generate high wages, high levels of urbanization, industrialism and postindustrialism, advanced technology, and a diversified product mix. In the world periphery, the world system creates low wages, low levels of urbanization, preindustrial and industrial technology, and a simple production mix. In between are states that are part of the semiperiphery, where both sets of processes coexist to a greater or lesser degree. The theory suggests that semiperipheral countries are exploited by the core countries with regard to raw material and product flows while at the same time the peripheral regions are also exploited. However, unlike dependency theory, world-systems theory allows for some degree of mobility within the global economy: Thus, capitalism does not inevitably breed poverty; rather, its effects are contingent and historically and geographically specific. However, the possibilities of development are limited, and the development of one country via industrialization is likely to coincide with the underdevelopment of another.

World-systems theory pays particular attention to the role of a single hegemonic state that dominates the global political and economic system. The hegemon sets the rules of the game, so to speak. Hegemony exists when one core power enjoys supremacy in production, commerce, and finance and occupies a position of political leadership. The hegemonic power is the leading trading and investment country, its currency is the universal medium of exchange, and its city of primacy is generally the financial center of the world. Because of its political and military superiority, the dominant core country maintains order in the world system and imposes solutions to international conflicts that serve its self-interests. During the period of Spanish dominance in the 16th and 17th centuries, for example, mercantilism was the dominant ideology. In the 17th century, the Dutch enjoyed a brief window in which they controlled Indonesia, South Africa, Curacao, and New Amsterdam (later New York). Under the Pax Britannica of the 19th century, when Britain controlled one quarter of the Earth’s surface, free trade was the norm. And since the rise to dominance of the United States, especially since World War II, neocolonialism has been the typical pattern (although during the Cold War there were two superpowers and a bifurcated world system). Consequently, hegemonic situations are characterized by periods of relative peace (e.g., the 19th century). During a power’s decline from hegemony, rival core states, which can focus on capital accumulation without the burden of maintaining the political and military apparatus of supremacy, catch up and challenge the hegemonic power. Thus, in the early 20th century, Germany challenged Britain for global leadership, with catastrophically violent results.

The rise and fall of hegemonic powers is sometimes tied by world-systems theorists to long-term cycles or Kontratief waves, a view that attempts to correlate upswings and downswings with changes in hegemonic status. Moreover, hegemonic powers may overextend themselves militarily, leading to an erosion of their economic base. When powers in the core have conflicts among themselves, they open opportunities both for new hegemons and for countries on the periphery: the Napoleonic Wars of the early 19th century and World War II in the 20th century were thus openings for nationalist anticolonial movements worldwide, first in Latin America and later in Asia and Africa. World-systems theory thus allows for resistance and decolonization and notes that hegemonic power is always contested.

Geographers have been attracted to world-systems theory because of its sensitivity to spatial differences in historical experience and the ways in which it allows regions to be contextualized within a global setting. The view offers significant insights into the possibilities of development (or lack thereof), the constraints to individual actors such as nation-states or transnational corporations, the origins of war, and phenomena such as trade and economic crises. World-systems theory in various forms thus forms an integral part of
human geography and has become woven into most of the discipline’s conceptualization of how the global economy and geopolitical apparatus function.

Barney Warf

See also Colonialism; Dependency Theory; Development Theory; Geopolitics; Globalization; Imperialism; Marxism, Geography and; Modernization Theory; Nation; Nationalism; Newly Industrializing Countries; Trade; Uneven Development; World Cities

**Further Readings**


The World Trade Organization (WTO) is a multistate organization formed to administer a set of interlocking international agreements, which are concerned primarily with trade regulation. It also functions as a forum to negotiate changes and additions to these agreements. It officially came into existence on January 1, 1995. As of July 2008, there were 153 members, including most but not all of the world’s sovereign governments. The WTO is explicitly committed to lowering trade barriers and to general economic liberalization. It plays a key role in international political economy and in contemporary geopolitics.

Most of the constituent agreements of the WTO took their present form during a series of multilateral negotiations known as the Uruguay Round, taking place from 1986 to 1994. These built on and incorporated an older set of international agreements known as GATT (General Agreement on Tariffs and Trade), dating from 1947. The Uruguay Round agreements regulate a vast sweep of international economic policy, including tariff levels, the use of non-tariff trade barriers, subsidies, copyright law, trade in services, and foreign investment. In addition, trade in agriculture and textiles were deemed exceptional and were subject to separate agreements. The foundational WTO agreements also included provisions for their own alteration and augmentation in expected future negotiations. Ministerial meetings of the WTO are held about once every 2 years in different locations around the world to conduct these negotiations, the most recent being held in Hong Kong in 2005. Thus far, few changes have been made to the original agreement other than time-dependent clauses from the Uruguay
Round kicking in (e.g., the expiration of the Agreement on Textiles and Clothing in 2005).

In addition to the biannual ministerial meetings, most WTO members maintain permanent missions in Geneva, where they meet as the General Council of the WTO and staff various subcommittees. WTO headquarters in Geneva also house a permanent bureaucracy known as the Secretariat, which arranges meeting logistics, handles the circulation of documents, and dispenses implementation advice to developing country members. The highest office in the WTO is that of director general, a post currently held by Pascal Lamy, a French citizen.

In the event of a formal trade dispute between members, the General Assembly meets as the Dispute Settlement Body (DSB). The dispute settlement procedure involves an expert panel constituted specifically to evaluate and issue recommendations on each case and a permanent standing seven-member Appellate Body to hear appeals. The DSB itself has the final say as to whether or not to adopt the recommendations of the panel and the Appellate Body. In the case of a guilty verdict, the county at fault must render compensation to the winning country; if no compensation can be agreed to, then the winner of the dispute is authorized to level limited trade sanctions against the offending country. The General Assembly also meets as the Trade Review Body to conduct periodic evaluations of each member country’s current economic policies.

Members of the WTO incorporate most of the world’s population and economic wealth. About 40 of the world’s recognized countries are not members of the WTO, notably Russia. The accession of China to the WTO in 2001 was considered a pivotal event in the growth of the WTO. Members of the WTO generally constitute sovereign states. The major exception is the European Union (EU), which is recognized as a member in itself, separate from its own member states, which also hold individual membership in the WTO. For most purposes, the 27 members of the EU choose to negotiate as a bloc. Other informal groupings of countries exist within the WTO, which often meet among themselves prior to Ministerial Meetings to hammer out a common position on specific issues. Some of the most important of these blocs include the Quad, consisting of the most powerful economies: the EU, the United States, Japan, and Canada; the G20, consisting of about 20 (membership tends to fluctuate) of the larger developing economies, formed mainly to advocate for stronger rules against agricultural subsidies; and the G33, another coalition of developing countries formed to advocate for special and differential treatment for developing economies in the application of WTO rules.

WTO negotiations have often been contentious. Two ministerial meetings (Seattle 1999 and Cancun 2003) are notable for having broken down without producing a consensus agreement. Since Seattle, ministerial meetings have attracted large, organized protests from labor, environmental, and antineoliberal groups, among others. Since at least 2001, when the series of negotiations known as the Doha Round began, talks have been repeatedly deadlocked over the issue of agricultural subsidies, which many (mostly developing) states see as blocking their access to markets in the EU and the United States. This is part of a wider issue involving the widespread sentiment that WTO rules are biased against developing economies. Other controversial issues include the inclusion or noninclusion of labor and environmental standards in WTO rules, procedural transparency in WTO meetings, the copyrighting of genetic materials, pharmaceutical patents and the availability of life-saving drugs, special and differential treatment for developing countries, and the rights of governments to discriminate against foreign-owned companies.

Chris Blackden

See also Antiglobalization; Globalization; International Monetary Fund; Neoliberalism; Structural Adjustment; Trade; World Bank

Further Readings


Dawn Wright is a professor in the department of geosciences and an adjunct professor in the College of Oceanic and Atmospheric Sciences at Oregon State University (OSU). Wright is a dedicated researcher, educator, and proponent of geographic concepts and spatial thinking who has made significant contributions in the fields of geographic information science (GIScience) and the coastal and marine sciences, as well as in the broader field of geography.

Wright’s research includes issues of application and analysis in the use of geographic information systems (GIS) with oceanographic data, particularly data modeling, spatial analysis, and data conversion; the processing, production, visualization, and interpretation of seafloor maps; marine data modeling, metadata, ontologies, and vocabularies; and cyberinfrastructure, particularly geographic/geospatial semantic Web issues and the related use of tools such as Web portals and Web services. She is highly regarded worldwide for her work in the areas of GIScience and coastal and marine GIS.

Wright received her bachelor’s degree in geology from Wheaton College (1983), master’s degree in oceanography from Texas A&M (1986), and PhD in physical geography and marine geology from University of California, Santa Barbara (UCSB) (1994) under the advisement of Raymond Smith. Her research has been funded by the National Science Foundation, the National Oceanographic and Atmospheric Administration, and the U.S. Department of Agriculture and has been published in multiple books and peer-reviewed journals. One of her best-known works was as lead author of the 1997 article “Demystifying the Persistent Ambiguity of GIS as ‘Tool’ Versus ‘Science,’” a discussion and analysis of the perception of GIS among geographers in the early 1990s. She also helped develop the ArcGIS Marine Data Model, published in 2007.

Wright teaches introductory and advanced courses in GIS, as well as seminars in geography, GIScience, and marine-related topics, and has served on many graduate student committees at OSU. In addition to research, her work is also largely defined by her service to the broader research community. She currently serves as chair of the University Consortium on Geographic Information Science Research Committee, as an Association of American Geographers National Councillor, on the National Academies Ocean Studies Board, on the editorial boards of several journals, including Transactions in GIS and the International Journal of Geographic Information Science, and as director of the Geographic Information Science Certificate Program at OSU.

Numerous awards have recognized Wright’s academic work and her contributions to science and the community. She received a 1995 National Science Foundation Faculty Early Career Development Award, was awarded a 2004 Fulbright grant to Ireland as a Senior Specialist in Information Technology, was given the Raymond C. Smith Distinguished Alumni Award in 2007 by the UCSB Department of Geography, and was selected as the 2007 U.S. Professor of the Year for the state of Oregon by the Carnegie Foundation for the Advancement of Teaching, among others. She has given invited seminars, talks, and keynote addresses at diverse conferences such as GeoTech; GIScience; Technology, Entertainment, and Design; and the Environmental Systems Research Institute Education User Conference and has published many invited articles and book chapters.

Dylan Keon

See also GIScience; Oceans; University Consortium for Geographic Information Science

Further Readings

John Kirtland Wright, historian and geographer, spent most of his career as a professional geographer with the American Geographical Society. In his many roles at the society (including research associate, director, and, more important, editor of the society’s journal, *Geographical Review*), he published more than 500 documents. Many of these were book reviews and “Notes” of one or two pages, a regular feature in the *Geographical Review*. These notes and reviews covered a diverse array of topics, including many aspects of physical, human, and regional geography, as well as geographical methods and techniques. No area in geography was omitted: Topics ranged from Ancien Régime, Antarctica, and Eratosthenes to linguistics, migration, the Pyrenees, and the Zuider Zee. It has been pointed out that his ideas and contributions are interwoven into the entire fabric of geography, into the canvas, not just splashes of paint on the surface.

Operating outside academia, many of his ideas emerged late in his career as mainstream concepts in geography, and their diversity and foresight laid foundations for intellectual structures throughout the discipline. *Aids to Geographical Research*, with Elizabeth Platt (first published in 1923, with a second edition in 1947) and other bibliographically focused resources, including the *Research Catalogue* of the AGS, were facilitators for research in the discipline. Many of his conceptual innovations deal with exploiting the relationship between history and geography. Beginning in 1925, “The History of Geography: A Point of View” was followed by “A Plea for the History of Geography” and *The Geographical Basis of European History*. This theme continued in his publications and presentations while he worked with the effective organization and presentation of statistical data; in 1937, he examined “Some Measures of Distributions.” Works that followed were nonstatistical forerunners of the quantitative revolution. His 1944 paper on the “Terminology of Map Symbols” became the basis for the organization and symbolization of data on maps in academic cartography. Cartographic concepts and processes were examined from the organization of data for mapping to the perceptual and cognitive processes of the map reader. Decades of consideration of the statistical and graphic organization of geographical information resulted in work on human nature and the impact of aesthetic feeling, imagination, and subjectivity in geography.

At the outset, given the opportunity as he began his graduate studies at Harvard, he chose not to specialize in geography, which at the time involved the study of “nature-minus-man.” He decided to make his study of history geographical, which he did for half a century. He looked from a variety of perspectives at *terrae incognitae* (unknown lands), which made the use of imagination critical to geographical exploration and mapping. The results of exploration involve interpretations, modifications, and inventions, all involving aspects of the imagination. His ideas were seminal in the movement that has been called the “cognitive reformation” of American geography, involving environmental perception, cognition, and behavior. One can turn to the 1966 series of essays in *Human Nature in Geography* and find that he was ahead of the developments that would occur throughout the discipline during the 20th century.

The breadth of his perspective not only of the discipline but also of geography as a whole is embodied in geosophy, the study of geographical knowledge from any or all points of view.

*George F. McCleary Jr.*

See also American Geographical Society; Cartography; Cartography, History of

Further Readings


Writing is the means by which geographers have traditionally represented the physical, cultural, and social worlds as they perceive, measure, and understand them. It is a conventional tool, the use of which entails uncertainty and perceptual bias. The contingent nature of understanding conveyed through the written word is a bedrock tenet of poststructural academics, but the idea that all language is fundamentally metaphoric or “figural” is an old one, with roots in the writings of both Plato and Friedrich Nietzsche. The recognition of writing’s fraught nature in geography dates back to Immanuel Kant. Writing today is undertheorized by geographers and is largely used either unreflectively or to predictable political ends.

As Jacques Derrida indicated, writing as a tool is intrinsically imbricated in power-creating systems. Every system of symbols to represent concepts entails the embrace of a dialectical and recursive methodology that works to obscure its own mechanisms and the power relations that underlie them. While contemporary social scientists tend not to focus on the embedded nature of written understandings, the roots of the modern discipline of geography lie in a nuanced grasp of the necessarily metaphoric nature of description and depiction in conveying both measurable and perceptual aspects of particular places. Geography is crucially the expression and transmittal of understandings of places and spaces as much as it is those understandings per se.

Ralph Hall Brown played a central role in conveying the centrality to geography of not simply the physical realities of a given location but also the evolving human understanding of a place’s significance and structure. That is, he was concerned with the context of knowledge about places and how it develops over time. Recognizing that character and culture were significant influences on both knowledge and action, Brown used fiction as a lens through which to assess the state of geographical knowledge in a particular time and place. His best-known work, *Mirror for Americans*, published in 1943, is an analysis of a fictional colonial-era protagonist, whom Brown used to both humanize colonial conceptions of American geography and stress their contingent and contextual nature.

With the quantitative turn, the literary and discursive treatment of geographic perception was often considered to be insufficiently rigorous. Geography began to purport to be one of the sciences that measured rather than one of the arts that perceived. Yet many geographers—including Brown, J. Wreford Watson, Douglas Pocock, Marwyn Samuels, and especially Yi-Fu Tuan and Donald Meinig—remained committed to a conception of geographic perception that required nothing short of a literary sensibility. Tuan particularly stressed the need for geographers to cultivate, among other qualities, the empathy and insight that any good writing exhibits. Similarly, Meinig held that geographic writing had to become overtly novelistic in order to cultivate relevance and an audience.

Tuan and others promoted a focus on experiential knowledge that had linguistic implications. Just as geography moved into the social world, writing itself came to be recognized as something that entails more than just transcription and analysis of books, maps, and surveys. Both the built environment and language are vectors for individual expression and emotion and can define and shape consciousness and sensibility. Neither is merely the by-product of macroeconomic priorities or microeconomic decisions. Geography’s focus on “being in the world” led to its embrace of a necessary incompleteness—an eternally deferred final understanding that is intrinsic to writing as well. Language itself is an important power in constructing places (and, by implication,
in constructing the power that those places then exert). Spatial patterns can therefore be seen as not dependent on actual geography alone but rather as a product of the metaphors used to describe their parts.

This foregrounding of writer qualities and self-awareness found particular expression in the impressionistic works of Gunnar Olsson and the self-conscious typographic experiments of Allan Pred, which attempted to convey the feel of a place through placement and treatment of words on a page as much as through their content. A utilitarian backlash against the “New Mandarin” style was in large measure successful, as geographic writing has subsequently become essentially indistinguishable from generic social science prose.

Nevertheless, many recent conceptions of academic writing do take it as given that “objective” discourse itself has lost validity and that all expressions are socially constructed. The modernist voice that presumed a reader who was basically nonexistent as an individual, requiring only rationalist demonstration rather than any appeal to social or personal interests, has been discredited, and books or articles themselves are seen as unavoidably contingent in both content and form. Any theoretical construction is then simply spatially embedded practice, which implies that perspective is directly reliant on position, which itself is a product of social discourse.

Such an incomplete perspective is doubly endemic to geographic discourse in that it comes to grips with the relations between the structural and the experiential, or between what a place “is” and what it “is like.” Academic prose may be a useful medium through which to cogently lay out the structural aspects of social situations, but social experience itself is a distinctive phenomenon whose transmittal requires a medium that forthrightly encompasses subjectivity. Such writing is the cognitive nexus between what happens and how geographers begin to make sense of it, and “higher” thinking itself is premised on the metaphoric understanding of the world that we reflexively apply to the world’s stimuli. Moreover, contingent experience, circulated images, and stories about places are all central in comprehending the meaning of complex environments, and they all require interpretation in addition to generalization.

Recent geographic scholarship has tended to emphasize the quality of writing, confusing it with reporting and using it as source material for interrogating social structures. Geographical approaches to literature, for example, often tend to treat it as symptomatic of society’s ills, as if it were simply another tool of a broader social hegemony or a “cultural product.” From this perspective, writers are blind to the social forces they depict, and their work as a whole is merely what the literary scholar Robert Alter refers to as a reflex of ideology. Such a perspective confuses the contents of a book and its function as literature, misreading representations of experience as experience itself.

This approach creates an impoverished discourse wherein only a certain privileged language, such as social scientific tropes, attains status as legitimate geographic argument. The limited geographic linguistic palette of the present moment is a barrier to the discipline’s ability to effect broad change. The language spoken by geographers often does not speak to common experience or to structural engagements as they are broadly understood. For example, we need only contrast the ease with which nongeographers speak of the weather to the difficulty that many geographers have in speaking with precision about place and its complications. We can speak, for example, of it “raining cats and dogs,” but similar metaphors to describe complicated landscapes (whether physical, social, or economic) do not hold the same currency. The embrace of metaphor in popular meteorology has helped foster the illusion of popular understanding and thus of popular engagement—simply put, many people feel that they have an intuitive understanding of the weather, while far fewer would claim such an understanding of any geography beyond the local.

Timothy Mennel

See also Discourse and Geography; Humanistic Geography; Literature, Geography and; Postmodernism; Pred, Allan; Representations of Space; Symbolism and Place; Text/Textuality; Tuan, Yi-Fu
Further Readings


Xeriscaping is an approach to landscape design that integrates the resource conservation objectives of communities in dry environments and water-stressed urban areas. The principal management objective of xeriscaping is to create a landscape that is water conserving and requires little or no irrigation. The term was coined by the Denver Water Department in 1981 and has been widely adopted by state, county, and city governments that promote alternatives to the common water-intensive turfgrass landscapes of North America. Xeriscaping has gained in popularity as an environmentally friendly and aesthetically pleasing alternative to such conventional landscaping. As the term has entered popular discourse, xeriscaping is increasingly used as an umbrella term for landscaping that encompasses a range of environmental objectives. These objectives extend beyond water conservation and include the reduction of chemical pesticide and fertilizer runoff, the restoration of indigenous plant communities, and the development of wildlife habitat to increase urban biodiversity. Furthermore, the term is often used to refer to water conserving landscapes within nonxeric environments. Given the importance of the residential lawn as an agent of environmental change and a cultural icon, the diffusion of xeriscaping is important as a harbinger of environmental attitudes, environmental consciousness, and resource management practices of urban and suburban North Americans.

**Landscape Management Practices**

Xeriscaping encompasses a range of landscape management practices selectively adopted to conserve water. The precise selection of particular combinations of landscape elements and management practices is adapted to local and site conditions but typically integrates soil management, composting, mulching, and the planting of drought-tolerant plants with deep root systems. Xeriscaping practices vary by region depending on climate, native vegetation, soil types, land use, and other environmental factors. Landscape plans are typically developed to suit particular characteristics of a residential yard, such as soil types, exposure, slope, and grade, in order to maximize water retention. Xeriscaping often requires conversion of an existing turfgrass lawn to new ground covers that typically include native and drought-resistant grasses, shrubs, trees, and nonliving surfaces. Mulches are often used to retain water and control weeds. Retention of areas of turfgrass is compatible with xeriscaping principals if located in appropriate water-use zones. Those who adopt xeriscaping often integrate personal aesthetic preferences into landscape design. Xeriscaping advocates often emphasize
Xeriscaping

the individuality of landscape design that can be incorporated into landscape plans, in contrast to the relatively uniform conventional lawn.

Other Environmental Benefits

Although the term suggests management for reduced water consumption, xeriscaping is commonly associated with a range of environmental objectives that residents seek to realize through their landscape choices. Due to health concerns, especially for children and pets, eliminating or reducing applications of chemical pesticides has been highlighted as a benefit of xeriscaping. Regional environmental impacts of landscaping choices are also highlighted by xeriscaping proponents. For example, in coastal Florida, environmental scientists believe that the incorporation of native vegetation into residential landscaping practices will reduce the impact of nonpoint source pollution on coastal ecosystems. However, additional environmental amenities, such as the restoration of wildlife habitat and increased urban biodiversity, can be problematic for residents who fear that wildlife may interfere with their enjoyment of their yards.

Funded in part by a grant from the Arizona Department of Water Resources, the Tempe Women’s Club Park was converted to a Xeriscape Demonstration Garden in 1995 to promote low-water-use plants and desert landscaping practices.

Source: Richard Bond, City of Tempe Water Conservation Program.
Geography of Xeriscaping in North America

The popularity of xeriscaping—as well as the particular forms xeriscaped landscapes have taken—is partly a reflection of efforts by state, county, and city governments to promote resource conservation in residential landscaping. Initially, such efforts were primarily concentrated in the mountain west, southwest, and southeast portions of the United States. In these states, recent migrants from the Midwest and the Northeast have often reproduced landscape patterns similar to those in their home regions without recognition of the limitations of available water resources. Currently, most U.S. states sponsor public education or extension programs that promote xeriscaping as a means of reducing water consumption and addressing other local and regional environmental problems.

Social Dimensions of Xeriscaping

Land area under turfgrass lawn in urban and suburban North America has expanded greatly over the past three decades and unquestionably dominates the American residential landscape. The more recent and more modest trend toward adoption of xeriscaping thus represents an important alternative to the turfgrass lawn. Xeriscaping might thus be seen as a reaction to the uneasy relationship that North Americans have with their lawns, including their concerns about domestic water consumption and health and safety concerns associated with chemical-intensive turfgrass landscaping. Moreover, the growth of xeriscaping raises important questions about the environmental aesthetics of North American residential landscapes and the values and perceptions of socio-environmental spaces as reflected in landscaping decisions.

Despite its growing popularity, the continued diffusion of xeriscaping practices faces legal, cultural, and financial obstacles. Although many states have gone so far as to develop county extension programs to assist homeowners in integrating xeriscaping principles into their landscaping practices, city ordinances and deed community regulations may restrict the conversion of conventional landscapes into xeriscaped landscapes.

Cultural values are often at stake in such landscape conversions, and resistance by neighbors is common. Cultural obstacles are often created by pressure from neighbors who fear a break with the uniformity of neighborhood lawns. Additional concerns cited by neighbors of those who adopt xeriscaping include fear of declining property values as a result of unkempt yards and fears of unwanted wildlife.

The transformation of turfgrass lawns into xeriscaped yards often requires that homeowners make significant time and financial investment in their yards. Even established xeriscaped landscapes may require substantial maintenance. Many residents rely on private landscaping firms that specialize in environmentally friendly landscaping for advice and guidance. Such expenses represent a financial barrier to the adoption of xeriscaping by low-income households. Thus, the diffusion of xeriscaping and the above obstacles to wider adoption reflect the cultural, political, and economic complexities that accompany shifts toward urban environmental sustainability.

Thomas A. Smucker

See also Environmental Management: Drylands; Landscape Design; Land Use; Water Needs

Further Readings


ZELINSKY, WILBUR (1921– )

Wilbur Zelinsky is an iconic cultural and population geographer who focuses on finding big-picture geographical manifestations of human meaning in every detail and facet of American life. He is an expert in field-based exploration, archival research, quantitative and qualitative analyses, cartographic representation, and clear and direct writing. His work reflects an unusual originality and continues to inform scholars in many disciplines.

Zelinsky was born in Chicago and began his academic career at Wright Junior College. He completed his baccalaureate at the University of California at Berkeley in 1944, earned a master’s degree from the University of Wisconsin in 1946, and returned to Berkeley for his PhD, which he completed in 1953. His early work experiences trained him for observation and analysis. He was a map draftsman in various firms during World War II, a terrain analyst for the Army Corps of Engineers in Occupied Germany in 1946, and an industrial location analyst for the Chesapeake & Ohio Railway from 1954 to 1959. His academic appointments include the University of Georgia from 1948 to 1952, the University of Wisconsin as a researcher from 1952 to 1954, Wayne State University as an adjunct professor from 1954 to 1959, and Southern Illinois University from 1959 to 1963. He joined the geography department at Pennsylvania State University in 1963, where he has remained ever since. He was department head from 1970 to 1976, assumed emeritus status in 1987, and continues as an active scholar.

Zelinsky’s publication record includes more than 200 books, atlases, chapters, articles, reviews, and reports, not counting reprints and second editions. Topics he has studied include cemeteries and cemetery names, energy consumption, food ways, log houses, migration, nationalism, personal names, place names, rural population distribution, settlement patterns, town forms, and vernacular regions. His first published article in 1948 was perhaps the first by any geographer on African Americans. His hypothesis of the mobility transition (an increase in rural to urban migration followed by an increase in intra- and interurban migration with modernization) is a significant complement to the concept of demographic transition (a decrease in death rates and, subsequently, birth rates occurring with modernization) both operationally and intellectually. He was the first geographer to write about the place of women in the profession. His 1974 presidential address to the Association of American Geographers (AAG), “The Demigod’s Dilemma,” was an important early humanistic call to rethink overly scientistic premises in the social sciences. His scholarly focus in recent years has been the landscape effects of religion and the meaning of ethnicity.

Zelinsky was president of the AAG from 1972 to 1973, and honors include the AAG’s 1966
Award for Meritorious Contributions to Geography, a Guggenheim Fellowship from 1981 to 1982, and the 1993 Jackson Prize for the revised edition of his best-known work, a slim book titled *The Cultural Geography of the United States*. He received the American Geographical Society’s Cullum Medal in 2001 and the AAG Presidential Achievement Award in 2006.

Joseph S. Wood

*See also* Cultural Geography; Ethnicity; Fieldwork in Human Geography; Population Geography; Religion, Geography and

**Further Readings**


---

**ZONING**

Initially introduced in New York in 1916 and quickly spreading to nearly all large American urban areas, zoning is a practice of municipal or county government land segregation according to use, density, building height, and lot size. Zoning is a police power permitting governments the right to refuse permission to use land in ways differing from the zoning code. Zoning is often equated with city and county planning processes but functions differently in reality. Zoning is considered a “negative” tool in that cities only have a right to deny a land use application rather than designating exactly what the property can be used for. Zoning has been studied by political geographers interested in the exercise of governance and by economic geographers interested in the consequences of these laws on land values and economic activity. Zoning has also been extended to classifying and preserving the physical attributes of land on flood plains, steep slopes, and wetlands, and other characteristics. The idea of zoning has also been expanded to consider more generally the spatial isolation of populations or activities by local governments and policing activities.

Discursively, zoning is often tied to the idea of social disorganization and the apparent need to reconstitute order in cities. Such arguments hinge on the assumption that an increasingly complex urban life necessitated the need for “order” and the separation of private dwellings from buildings for commercial and industrial use. Historians of zoning regulations have diverging arguments about the original function of these laws. Some argue that zoning was meant to prevent the encroachment by the lower classes and people of other ethnicities on high-land-value neighborhoods, such as garment workers in New York and Chinese laundries in California. Conversely, other scholars argue that zoning laws were meant to protect the lower classes from the deleterious health effects of industrial production and over-crowding. Whether the original crafters of the American zoning law had socially progressive intentions in mind or not, the discourse of “order” and the desirability of “separation” have been enormously important in shaping public understanding of zoning. “Order” has turned out to mean many things in zoning, from regulating new development to redirecting nearly all capital production to licensed, commercially zoned districts. This discourse continues to inform and justify daily practices of zoning and can be evidenced in much of the research on zoning.

Political geographers have couched zoning in the larger context of governance and used it to reveal power relations and social inequities. Such geographers consider the wider political processes that allow counties and municipalities to use zoning laws to manage behavior through enforcement practices, to enforce state power over privately held property, and to generate spatial data on property. These articulations produce a
**Figure 1** Map of zoning districts within the city of San Leandro, California

ZONING

legalized and enforceable landscape, dictating what activities citizens can perform and where. Political geographers regard regulatory agencies generally, and zoning particularly, as a way to produce a regulated urban landscape, cultivate legitimacy, and produce governable populations. Some zoning literature focuses on the regulatory enforcement, that is, the multiple ways the state shapes society through local enforcement, ideologies, and policies.

Economic geographers have focused on the effects of zoning laws on land values and optimal zoning designations for wealth accumulation. Such analysis of zoning has frequently taken the form of large-scale quantitative studies, often with Houston, the only major American city without zoning laws, serving as a foil.

The legal geographies literature has provided important groundwork to consider the ways law generally is spatially produced at different scales. Scholars of property have looked to zoning regulations to better understand the relationship between property, citizens, and the state. Geographies of social control have taken the zoning concept of separation and isolation and used it in different ways to explore social exclusions. Social control literature has focused on the “zoning” of people, applying the logic of land use law and exclusion to individuals or classes of people. Researchers of social control have emphasized the way particular groups or behavior have been legally defined, isolated, and located by the law. Geography and social control literature has focused on the exceptions built into the law by focusing on marginal populations such as the homeless, sex workers and adult businesses, political activists, and drug culture participants.

Criticisms of Zoning

Zoning has been tied to exclusionary practices intended to limit affordable housing and housing plurality. This constraint often takes the form of inflated property size restrictions and low-density requirements, presenting obstacles to mixed-income housing and, effectively, achieving some degree of racial segregation. Such results arguably reinforce class divisions and limit opportunities to attain housing equity. More recently, inclusionary zoning practices have attempted to provide more affordable housing options and grant incentives for developers to produce a range of affordable to moderately priced properties. Inclusionary zoning establishes municipal and county ordinances that mandate a certain percentage of affordable housing be developed among otherwise market-rate housing. Such practices are an attempt to bypass the economically exclusive practices of zoning laws. Inclusionary zoning has been criticized by developers for adding onerous regulations and by affordable housing advocates for placing unrealistic expectations given the powers afforded to zoning. Furthermore, criticism has been lodged about the ways such laws are administered. Zoning laws are non-retroactive, producing an uneven landscape of conforming and nonconforming properties.

Globally, cities and countries frequently have land use regulations and reviews of new development projects, though the police-power based zoning seen in American cities is infrequently implemented. The American model of zoning was initially imported from Germany. Zoning regulations were adopted in Canadian cities subsequent to their adoption in the United States.

Elizabeth Underwood-Bultmann

See also Land Use Planning; Suburban Land Use; Urban Land Use; Urban Planning and Geography; Urban Policy; Urban Sprawl

Further Readings


ATLAS OF THE WORLD: A BRIEF CARTOGRAPHIC OVERVIEW

The Encyclopedia of Geography includes the following 18-page atlas as a convenient source for political maps of the world. This section also includes a global topographical map of the world and examples of some of the principal map projections used in depicting the world. In addition, the A–Z entries include numerous world maps relevant to both physical geography (e.g., angiosperm family richness, global distribution of deserts, ecoregions, the Köppen-Geiger climate classification) and human geography (e.g., colonial migrations, human development, famine-prone regions, Internet penetration rate). See the entries under “World maps” in the index at the end of this volume for a complete listing.

The maps included here offer a basic overview; however, space limitations do not allow for detailed depictions of countries and major cities. The College Atlas of the World published by Wiley and National Geographic is a useful source not only for more extensive political maps and other information in human geography but also for a global view of many aspects of physical geography.

For more detailed maps in human and physical geography:


For a detailed description of the government, political parties, legislature, and communications in each nation:


For updated information on the global population:

The International Data Base of the U.S. Census Bureau, available online at www.census.gov/ipc/www/idb. Click on the Data Access tab on this Web site to view a variety of demographic indicators for each country, including past, present, and estimated population from 1950 to 2050. Country data can be viewed both as a table and as a population pyramid. The U.S. and World Population Clocks, which are constantly updated, can be found at www.census.gov/main/www/popclock.html.

Contents of the Atlas

Political Maps:

<table>
<thead>
<tr>
<th>Map Type</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Map, Mollweide Projection</td>
<td>3152–3153</td>
</tr>
<tr>
<td>Africa</td>
<td>3154</td>
</tr>
<tr>
<td>Antarctica</td>
<td>3155</td>
</tr>
<tr>
<td>Arctic Region</td>
<td>3156</td>
</tr>
<tr>
<td>Australia, New Zealand, and Oceania</td>
<td>3157</td>
</tr>
<tr>
<td>Asia</td>
<td>3158</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>3159</td>
</tr>
<tr>
<td>Western Europe</td>
<td>3160</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>3161</td>
</tr>
<tr>
<td>Caribbean</td>
<td>3162</td>
</tr>
<tr>
<td>North America: United States and Canada</td>
<td>3163</td>
</tr>
<tr>
<td>North America: Mexico and Central America</td>
<td>3164</td>
</tr>
<tr>
<td>South America</td>
<td>3165</td>
</tr>
<tr>
<td>Topographical Map of the World</td>
<td>3166–3167</td>
</tr>
<tr>
<td>Map Projections</td>
<td>3168–3169</td>
</tr>
</tbody>
</table>

Map Sources

Political map of the world, Mollweide projection: © Map Resources.

Political maps of Africa, Antarctica, Australia, Asia, Southeast Asia, Oceania, Western Europe, Eastern Europe, Oceania, North America, the Caribbean, Mexico, Central America, and South America: Adapted by Sandra Sauvajot from Maps for Graphic Design, © Map Resources.

Political map of the Arctic: Perry-Casteñada Library Map Collection, University of Texas Libraries.

Global topographical map: © Map Resources.
World Map, Mollweide Projection
Africa
Antarctica

- Antarctic Circle
- Ross Ice Shelf
- Ronne Ice Shelf
- Filchner Ice Shelf
- Amery Ice Shelf
- Ross Sea
- Weddell Sea
- Bellingshausen Sea
- Amundsen Sea
- Davis Sea
- South Pole
- Coldest place on Earth (Avg. annual temp. ~70.1°F)
- American Highland
- Enderby Land
- Graham Land
- Enderby Land
- Wilkes Land
- Marie Byrd Land
- Ross Ice Shelf
- Antarctic Circle
- New Schwabenland
- Queen Maud Land
- Ellsworth Land
- Roosevelt Island

- Claim regions:
  - British Claim
  - Argentine Claim
  - Chilean Claim
  - Australian Claim
  - French Claim
  - New Zealand Claim
  - Norwegian Claim (undefined limit)
Arctic Region
Australia, New Zealand, and Oceania
Asia
Eastern Europe
North America: United States and Canada
North America: Mexico and Central America
South America
Topographical Map of the World
ATLAS OF THE WORLD: A BRIEF CARTOGRAPHIC OVERVIEW

Kermadic Trench
Tonga Trench
Aleutian Basin
Northwest Pacific Basin
Central Pacific Basin
Peru Basin
Chile Basin
Labrador Basin
Mendocino Fracture Zone
Charlie - Gibbs Fracture Zone
Mariana Trench
Hawaiian Ridge
Aleutian Trench
Kamchatka Trench
Pacific - Antarctic Ridge
Clarian Fracture Zone
East Pacific Rise
Mid-Atlantic Ridge
Andes Mountains.

ATLANTIC OCEAN

PACIFIC OCEAN

Yukon
Negro
Amazon
Madeira
Orinoco
Parana
Paraguay
Argentina
Buenos Aires
Paraguay
Rio Grande
Mississippi
Great Lakes
Great Slave L.
Great Bear L.
L. Winnipeg
Chukchi Sea
Beaufort Sea
Caribbean Sea
Hudson Bay
Gulf of Alaska
Baffin Bay
Gulf of Mexico

1000 Kilometers
Parallel scale at
0 north 0 east
1000 Kilometers
Parallel scale at
30 north 0 east
1000 Kilometers
Parallel scale at
60 north 0 east
Map Projections

Cartographers use a variety of projections to represent the spherical surface of Earth on a flat map. Because it is mathematically impossible to render a globe on a plane without changing the spatial configuration of the data involved, all such mapping involves some degree of distortion, so in choosing a projection, the cartographer will consider what properties are most important to preserve, at the cost of some other properties. For example, projections may accurately represent or distort the area (equivalence), shape (conformality), direction, distance, and scale of Earth’s features, but not all of these simultaneously. Projections are important because maps shape how we view the world, and their distortions often enter into our geographical imaginations. Different types of projections are useful for different cartographic purposes. See the Map Projections entry in this encyclopedia for a detailed description of different types of projections.

The majority of the maps in this encyclopedia use the Mercator projection, developed in the 16th century by Gerardus Mercator, a Flemish cartographer. Intended for navigation, it uses a rectangular grid that shows constant bearings as straight lines, and hence became popular among navigators. It remains the most commonly used map projection today, reproduced in countless classrooms, atlases, and textbooks. However, the Mercator projection greatly exaggerates the size of areas at higher latitudes (for example, Greenland is only as eighth as large as South America, but its area appears much greater on a Mercator map). In 1989, several North American geographical organizations passed a resolution urging the use of alternative projections.

The Mollweide projection, created in 1805 by the German mathematician Carl B. Mollweide, is a more accurate representation of the size of areas, but distances and shapes are distorted.

The Fuller dymaxion projection, created by R. Buckminster Fuller in the mid 20th century, is useful in showing the interconnectedness of Earth’s landmasses and has less distortion of areas than the Mercator projection. It is used in this encyclopedia to show Earth’s cryosphere (see Ice entry).

Developed in 1923 by John Paul Goode, the interrupted Goode homosoline projection presents the world in discrete regions in order to minimize distortions of size and shape. It is useful for showing raster data, in which a geographical area is divided into cells identified by row and column.

Mercator projection: This projection distorts the size of regions far from the equator. For example, Greenland appears to be larger than South America, but in fact, South America is eight times larger.

Source: Barney Warf.
**Mollweide projection:** A Visible Earth image collected by the Earth Observatory experiment of the U.S. government’s NASA space agency. The reticle is 15 degrees in latitude and longitude.

*Source:* National Aeronautics and Space Administration.

---

**Buckminster Fuller or “Dymaxion map” projection:** Earth’s cryosphere. Snow cover extent for Northern Hemisphere is represented by the 1966–2005 February average, for Southern Hemisphere by the 1987–2003 August average. Sea ice extent for Northern Hemisphere is represented by the 1979–2003 March average, for Southern Hemisphere by the 1979–2002 September average. Permafrost data for mountain areas and for the Southern Hemisphere are not represented in this map; neither are river and lake ice.


---

**Interrupted Goode homolosine projection:** A Goode projection of a Visible Earth image collected by the Earth Observatory experiment of the U.S. government’s NASA space agency.

*Source:* National Aeronautics and Space Administration.
Entry titles and their page numbers are in bold.

AAG. See Association of American Geographers (AAG)
Aalbers, Manuel, 5:2710
Abercrombie, Patrick, 3:1363
Abler, Ronald, 1:1–2
academic career of, 1:1
communication work of, 1:1
governance work of, 3:1357
professional affiliations and service of, 1:1, 4:1975
ABMs. See Agent-based models (ABMs)
Absolute space, 1:2–4
Cartesian/Euclidean notion of space and, 1:3
René Descartes, Cartesian rationalism and, 1:3
Euclidean geometry and, 1:2
Hipparchus, Earth’s 360° circumference and, 1:2
Newton and Leibniz debate, 1:2–3
Plato’s views, 1:2
relative space rs., 1:2, 5:2402
Academics for Justice, 1:96
Accessibility, 1:4–5
accessibility in geographic information systems and, 1:5
accessibility studies and, 1:4–5
aggregate accessibility measures (Garrison) and, 1:4
aviation and, 1:179–182
before-and-after studies of, 1:4
GIS in transportation and, 3:1311–1312
individual (space-time or disaggregate) measures of, 1:3
proximity (zonal or aggregate) measures of, 1:3
time-space accessibility measures of, 1:5
Acemoglu, Daron, 5:2218
Acid rain, 1:5–7
ambient air quality and, 1:69
coal-fired power plants, cooper smelters and, 1:6
definition of, 1:5
ecosystems disturbed by, 1:7
emissions trading program (U.S.) and, 1:7
freshwater aquatic environments affected by, 1:7
hydrogen and oxygen biogeochemical cycle and, 1:205–206
long-range control programs and, 1:7
monitors of, 1:6–7
natural sources as precursors of, 1:6
sulfur dioxide and, 1:153
trees damaged by, 1:6 (photo)
Ackerman, Edward, 4:1897, 5:2238
Actor-network theory, 1:8
agency views of, 1:8
commodity chains and, 1:524
critical human geography and, 1:8
critical studies of nature, post-humanism and, 2:623–624
depth-green, deep-ecology philosophies and, 2:624
gay and lesbian geographies and, 3:1185
gender and nature and, 3:1196
human and nonhuman actors focus of, 1:8
hybrid geographies and, 3:1503
Bruno Later and, 1:8, 2:649, 5:2272
physical applications of, 1:8
poststructuralism and, 5:2272–2273
proponents of, 1:8
relational view of spatiality of, 1:8
rural development and, 5:2490–2491
We Have Never Been Modern (Latour) and, 2:649
Adams, John, 3:1357
Adaptation to climate change, 1:9–12
adaptation targets and, 1:10–11
agricultural irrigation and, 1:10
autonomous vs. planned adaptations and, 1:9–10
avoidance of disaster-prone areas, 1:10
Bali Action Plan and, 1:9
biodiversity adaptations and, 1:11
climatically sensitive systems and, 1:9
crop insurance and, 1:11
crop replacements and, 1:10
drought early warning systems and, 1:11
drought risk and hazard and, 2:790–794
ecosystem services and, 1:11
education about, 1:10
environmental management goals and, 1:9–10
extreme events, 1:10–11
greenhouse gas levels increase and, 1:9, 1:11
human migration barriers and, 1:11
human population growth issue and, 1:11
new pest species and, 1:10
no-regrets policies and, 1:9, 1:10, 1:11
policy-level adaptations and, 1:10–11
public health infrastructure element of, 1:10
regional case studies and, 1:9
shoreline protection tactic and, 1:10
species level adaptation and, 1:11
strategies of, 1:9
tillage practices changes and, 1:10–11
United Nations Millennium Ecosystem Assessment and, 1:11, 2:862–863
water crises measures and, 1:11
See also Adaptive harvest management; Climate change; Climate policy
Adaptive harvest management, 1:12–14
active vs. passive management and, 1:13
commercially harvested resources focus of, 1:12
community-based natural resource management and, 2:549–551
criticisms and challenges, 1:13
ecological data analysis and, 1:13
harvested populations and, 1:13
learning process feature of, 1:12–13
positive vs. negative feedback loops and, 1:12–13
social processes measurement and, 1:13
species and resource sustainability and, 1:12
Adaptive radiation, 1:14–15
archipelagoes, island-like systems and, 1:14, 1:106
Burgess Shale, Canadian Rocky Mountains fossil evidence and, 1:14
cichlid fishes in East African lakes and, 1:15
colonization of isolated ecosystems and, 1:14
evolution vs., 1:14
extinction rates and, 1:14
Galapagos Islands example of, 1:14–15
horses, evolution of, 1:14
mass extinctions, 1:15
rapid speciation element of, 1:14
Aden, 2:1054
Adiabatic temperature changes, 1:15–17
adiabatic heating and cooling conditions and, 1:15
air temperature and relative humidity relationship, 1:16
atmospheric energy variations and, 1:16
atmospheric pressure and, 1:15–157
chinook/foehn winds and, 1:394–395
cloud formation and, 1:15
condensation and evaporates rates and, 1:15
dew point, condensation and, 1:16
dry adiabatic lapse (DALR) rate and, 1:15–16
dry climate and, 1:430
explanation of, 1:15
lapse rates and, 4:1757–1761
latent heat and, 1:15, 4:1761–1762
mountain climate and, 1:443–449
moving vs. still air and, 1:16
rising and subsiding air and, 1:15
saturated adiabatic lapse rate and, 1:16–17, 1:17 (fig.)
temperature and pressure changes elements of, 1:15
temperature changes in air passing over mountain and, 1:17 (fig.)
temperature drop, atmospheric pressure drop and, 1:15
See also Atmospheric composition and structure; Atmospheric energy transfer
Adorno, Theodore, 4:1862, 5:2230
Aerial imagery: data, 1:17–22
Airborne Real-Time Cueing Hyperspectral Enhanced Reconnaissance (ARCHER) and, 1:18
airborne remote sensing and, 1:17
aircraft photography and, 1:15
American Society of Photogrammetry and, 1:15
Amnesty International, Eyes on Darfur project (satellite image), 3:1200
applications of, 1:21–22
atmospheric remote sensing and, 1:157–161
black-and-white film uses and, 1:18
collection and distribution agencies and, 1:19–20
color film development and, 1:18
color infrared photography and, 1:15
data sources and, 1:19–20
data types and, 1:19
Deepwater Horizon oil spill (satellite image), 4:2074
digital imagery advantages and, 1:19
dust storm in Sahara Desert and, 1:21 (photo)
early aerial photographs and, 1:15
hyperspectral remote sensing (aerial imaging spectroscopy) and, 1:18
image texture and, 3:1540–1541
innovations in, 1:18–19
land use and cover change, 4:1737
LiDAR-intensity imagery and, 1:19, 4:1778–1779
light detection and ranging (LiDAR) and, 1:18, 1:19
multispectral aerial imagery and, 1:15
oblique vs. vertical images and, 1:19
orthophotography and, 1:19
panchromatic imagery and, 4:2112–2115
paper, film, and digital data sources of, 1:19
photogrammetric methods and, 4:2173–2175
side-looking airborne radar (SLAR) and, 1:18, 1:19
social impacts of, 1:22
traditional cameras and, 1:18
typhoons in western Pacific Ocean and, 1:20 (photo)
See also Aerial imagery: interpretation; Image specific subject; Remote sensing
Aerial imagery: interpretation, 1:22–25
atmospheric remote sensing and, 1:157–161
context of site and association elements in, 1:24
detection, identification, measurement, and problem solving tasks of, 1:23
false color digital ortho quarter quad, Del Mar, California, 1:24 (fig.)
human vs. computer interpretation and, 1:25
image interpretation and, 3:1534–1536
image texture and, 3:1540–1541
intensity, hue, and saturation elements in, 1:23
interpretive elements of, 1:23–25
LiDAR and airborne laser scanning and, 4:1778–1779
oblique views and, 1:23
pattern, height, and shadow elements in, 1:24
photogrammetric methods and, 4:2173–2175
remotely sensed information linkage to ground information function of, 1:23
size, shape, and texture elements of, 1:23–24
spatial resolution element in, 1:23
spectral wavelength variations element of, 1:23
tone and color elements of, 1:23
types of, 1:23
See also Aerial imagery: data; Remote sensing
Afghanistan antiglobalization, anti-U.S. sentiment in, 1:97
basin and range topography in, 1:186
Cold War and, 1:504
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
nation-state after colonialism in, 1:517
NATO actions in, 4:2048
opium and heroin production in, 2:797

Africa
AA.G specialty groups focus on, 1:122
adults and children living with HIV in 2007 in, 3:1437 (fig.)
African AIDS Epidemic (HIV) and, 3:1437
African Charter of Human and Peoples Rights, 3:1480
African monsoon and, 4:1941
Afro-Asiatic languages and, 4:1750 (fig.)
Amnesty International, Eyes on Darfur project (satellite image), 3:1200
Animal domestication, 2:783
aquaculture in, 1:103
Association for Promoting the Discovery of the Interior Parts of Africa, 2:1057
basin and range topography in, 1:186
borderlands in, 1:292
bush fallow farming in, 1:301, 1:302
“calabash chalk,” (geophagy) and, 3:1248–1249
cholera in, 1:401, 1:402
cold climate adaptation research in, 1:9, 1:464
coastal zone and marine pollution and, 1:501
Cold War and, 1:504
colonial migrations, 1500–1914, 3:1542, 3:1543 (fig.)
colonial public water systems in, 5:2317
colonization of, 1:512–513, 1:516, 2:1027, 5:2216–2217
Congo River basin, tropical rain forests of, 1:132
Convention Governing the Specific Aspects of Refugee Problems in Africa, 5:2378
decolonization in, 2:691, 2:692
deforestation in, 2:696, 2:698
democratization in, 2:702
desertification in, 2:717, 2:972–973
developing countries in, 2:725 (fig.)
drought in, 2:727, 2:787
dry climates in, 1:429, 1:430 (fig.)
ecological footprint and biocapacity of, 2:827 (table)
environmental history studies in, 2:929
exploration of, 2:1057
export processing zones in, 2:1067
Vasco da Gama’s circumnavigation of, 2:1054, 3:1178–1179
gender inequalities in, 3:1589
geochemical energy use in, 3:1267 (fig.), 3:1269
German colonies in, 1:509
Heart of Darkness (Conrad) and, 4:1787
HIV/AIDS epidemic in, 2:727, 3:1437–1438, 3:1437 (fig.)
hunting and gathering tribes in, 3:1492
import substitution industrialism (ISI) in, 3:1550
indigenous forestry in, 3:1569
installed generating capacity values since 1950 in,
3:1511, 3:1511 (table)
land degradation in, 4:1680, 4:1680 (table), 4:1682 (photo)
land inequalities in, 4:1693
landlocked countries in, 2:726
land privatization in, 5:2494
life expectancy in, 3:1410
midlatitude grasslands in, 1:228, 1:228 (fig.)
military expenditures in, 4:1899 (table)
mixed farming in, 4:1917 (photo)
nationalism in, 1:517
nation-states after colonialism and, 1:517
natural growth rate in, 4:1981
natural openness to trade in, 5:2218
Negroid movement and, 2:1029
nomadic pastoralism in, 2:597
political geography in, 1:512
political map of, 6:3154
population growth of, 5:2233 (fig.), 5:2241
Portuguese colonies in, 1:509
post-glacial period in, 1:459
potential water availability in, 2007, 2050, 6:3059 (fig.)
potentiality of, 5:2274
prehistory of, 2:1050
railroads in, 5:2363
refugees, 5:2378
renewable water resources and availability in, 6:3057 (table)
soil erosion in Baringo District, Kenya, 4:1682 (photo)
soil and water resources of, 5:2682
sustainable development for, 2:1005
Third World debt crisis and, 2:688
transboundary hazardous waste dumping in, 1:384
tropical arid deserts in, 1:221
tropical deciduous forest in, 1:231, 1:232, 1:232 (photo)
tropical monsoon climate in, 1:434
tropical rain forest of, 1:132
tropical/subtropical hyperarid deserts in, 1:222
transboundary desertification in, 2:717–718, 2:972, 2:989
“white man’s burden,” 2:1027
women’s lives in, 1:1097
See also African Union (AU); Sub-Saharan Africa; specific nation

African Union (AU), 1:25–26
economic development focus of, 1:25
functions of, 1:25
human rights and social justice issues and, 1:25
membership of, 1:25
New Partnership for Africa’s Development (NEPAD) developed by, 1:25
Organization of African Unity (OAU) precursor of, 1:25
pan-Africanism with practical orientation focus of, 1:25
peacekeeping focus of, 1:25
supporters and critics of, 1:25

Agamben, Giorgio, 1:26–27
“coming community” theory of, 1:27
ethics and biopower issues focus of, 1:26
existing space views of, 1:26
homo sacer (“bare life”), 1:26–27
hybridity-animality of human beings, 1:27
Nazi Holocaust focus of, 1:26
philosophical areas of, 1:26
power relations focus of, 1:26
spaces inside vs. outside the law and, 1:26

Agarwal, Anil, 3:1875
Agarwal, Bina, 2:819–820
Agassiz, Louis, 4:2180
Agent-based models (ABMs), 1:27–31
abstract vs. empirical spatially explicit ABS, 1:29
“action at a distance,” 1:29
actor-network theory and, 1:8
agent-agent interaction and, 1:29
agent architecture and, 1:28–29
agent attributes, 1:28
agent behavior rules in, 3:1215
agents and environments elements of, 1:28–29
applications of, 1:29–30
cellular automata vs., 1:29
city growth and change and, 1:187
complex systems observation and, 1:28
components of, 1:28–29
computer programs as agents and action units of, 1:27
construction process of, 1:30
decision making and, 1:29
digital representations of systems and, 1:27
direct representation of individual behavior element of, 1:29
derogous interrelationships in, 1:29
geocomputation and, 3:1215
heuristics and, 1:29
land use and cover change models and, 4:1738
object-oriented programming used in, 1:28
reactive vs. proactive models and, 1:29
real-world geographic problems applications of, 1:29–30
relocation of agent factor and, 1:28
slum formation, analysis of, 1:28
spatially differentiated environment of, 1:27
spatiotemporal resolution of, 1:29
Agglomeration economies, 1:31–32
benefits of, 1:31
capitalism, 1:32
central business districts, 1:378–379
clusters and, 1:480–482
division of labor and, 2:780–781
economies of scale and, 2:853–854, 5:2395
economies of scope and, 2:854–855
factors affecting location of firms and, 3:1077–1080
flexible production and, 1:32, 3:1125–1127
incubator zones and, 3:1551–1553
industrial districts and, 3:1576–1577
industrialized agriculture and, 1:43
innovation geographies and, 3:1597–1599
learning regions and, 4:1766–1768
marketing linkages of, 1:31
in primate cities, 5:2291
production linkages and, 1:31
R&D geographies and, 5:2435
regional science and, 5:2395
Allen Scott’s work and, 5:2519
service linkages and, 1:31
urbanization economies feature of, 1:31
vertically disintegrated production feature of, 1:31
AGILE. See Association of Geographic Information Laboratories for Europe (AGILE)
Aging, the aged. See Elderly, geography and the
Aglietta, Michel, 5:2399, 5:2401
Agnesi, Battista, 4:1814 (fig.)
Agnew, John, 1:32–33
critical geopolitics work of, 1:32, 3:1252, 3:1420
dimensions of place and, 5:2574
electoral geography work of, 2:883
European Union elitism views of, 2:1037
human geography work of, 1:32–33, 3:1199–1200
international political economic work of, 1:32
place-based electoral geography work of, 1:32
publications of, 1:32
stateless hegemony, 3:1420
“territorial trap,” international relations work of, 1:32
Agrawal, Arun, 1:530
Agricultural biotechnology, 1:33–35
agrobiodiversity and, 1:49–50
bioreactors to feed the poor (early 1900s) and, 1:33
biotechnology definitions and, 1:33
“Coordinated Framework” management and regulation of, 1:34
ecological risk and, 1:34, 1:278–279
Ecological Society of America criticism of, 1:34
genetically modified organisms and, 3:1197–1199
genetic engineered organisms (GEOs), DNA manipulation and, 1:33–34
geographies of food and, 3:1144–1146
herbicide-tolerant seeds controversy and, 1:34
“ice minus” bacterium development example of, 1:33–34
organic agriculture and, 4:2094–2096
Posilac (bovine growth hormone) controversy and, 1:34
regulation of, 1:33–34
risk categories of, 1:34
social and environmental controversy, 1:33
See also Adaptation to climate change
Agricultural intensification, 1:35–36
biodiversity affected by, 2:938
capital vs. labor increases and, 1:35
Conditions of Agricultural Growth (Boserup) and, 1:36
definitions of, 1:35
“extensive” to “intensive” systems scale and, 1:35
forest clearance impacts and, 2:938
global food demands and, 1:35
Green Revolution controversy and, 1:35
interrelating factors of, 1:36
population growth rates and, 1:35–36
preindustrial agriculture vs., 1:47–49
rise of complex societies and, 1:35
societal and environmental change processes and, 1:35
Soviet collective farming and, 2:543
sustainable food production, land use systems and, 1:35
See also Adaptation to climate change; Agricultural land use;
Agriculture, industrialized
Agricultural land use, 1:36–43
agricultural intensification and, 1:35–36
agrobiodiversity and, 1:49–50
biofuels production and, 1:201–204
categories and classifications used in, 1:36–37, 1:37 (fig.)
cellular automata used in, 1:370, 1:371 (fig.)
climate extreme events adaptations and, 1:10
coastal dead zones and, 1:486–488
crops and livestock production uses, in 1:36
factors driving change in, 1:39, 1:41–42
land covers, 1987 census of agriculture and, 1:40 (fig.)
land use conversions and, 1:37, 1:38 (table)
land value factor and, 1:37
mixed farming and, 4:1914–1917
protecting agricultural land and, 1:43
shares of land in major uses, U.S., 1:41 (fig.)
shifts between cropland and forest land, U.S., 1982–1997
and, 1:37, 1:38 (fig.)
as world's largest economic sector, 1:36
See also Adaptation to climate change

Agricultural maps
U.S. cropland and forestland shifts, 1982–1997, 1:38 (fig.)
U.S. land covers, 1987 census of agriculture, 1:40 (fig.),
1:40 (table)
U.S. shares of land in major uses, 1:41 (fig.)

Agriculture, industrialized, 1:43–47
agriculture biotechnology and, 1:43–44
biofuels issues and, 1:47
biological homogenization issues and, 1:43–44
centrated animal-feeding operations (CAFOs), "factory farms" and, 1:44, 1:45 (photo)
decaying share of total workforce, "de-peasantization" and, 1:43
economies of scale issues and, 1:44
external costs of and subsidies for, 1:45–46
as foundation of modern societies, 1:43
geographies of food and, 3:1144–1146
global food prices increase and, 1:47
harvesting corn silage, 1:46 (photo)
livestock revolution and, 1:44
methane emissions issue and, 1:45
Montfort feedlot, Greeley, Colorado, 1:45 (photo)
multinational corporations' role and, 1:44–45, 5:2220
nitrogen cycle and, 4:2028–2029
Ogallala Aquifer and, 1:44
social issues associated with, 1:46–47, 1:58
soil fertility issues and, 1:43–44
Soviet collective farming and, 2:543
yield gains vs. ecological problems and, 1:43–44
See also Agrofoods; Environmental impacts of agriculture

Agriculture, preindustrial, 1:47–49
agricultural intensification and, 1:35–36
Asian rice paddy cultivation and, 1:48–49, 1:48 (photo)
centers of domestication and, 1:374–378
crop rotation and, 2:627–630
cultivation techniques and, 1:48, 2:696
domestication of plants and, 2:784–786
human or animal labor power used in, 1:47
nomadic herding and, 1:48, 4:2029–2032
peasant-based production and, 1:48
slave-based and feudal social systems and, 1:48
subsistence vs. profit production of, 1:47–48

Agrobiodiversity, 1:49–51
biophysical landscape diversity and, 1:50
crops diversity and, 1:50
definition of, 1:49
diversity of socioeconomic processes and, 1:50
domestication of plants and, 2:784–786
genetically modified organisms and, 3:1197–1199
government policies and, 1:50
hybridization of plants and animals and, 3:1504–1506
indigenous ecological knowledge and, 1:50
slash-and-burn agriculture and, 1:49
small-landholding agricultural biodiversity and, 1:49–50
See also Adaptation to climate change; Agrofoods;
Crop genetic diversity

Agrochemical pollution, 1:51–53
air-curtain orchard sprayer, apple tree pesticides, 1:52 (photo)
biaccumulation concept and, 1:52
biological magnification and, 1:52, 1:53
chemical spills, environment, and society and, 1:382–384
DDT and, 1:52, 1:53
drift and runoff effects and, 1:53
effects of, 1:51–52
environmental justice campaign against, 2:960
fungicides use and, 1:53
Green Revolution controversy and, 1:52
heavy metals list and, 1:51
herbicides use and, 1:53, 3:1420–1421
in India, 1:52–53
insects resistance to pesticides and, 1:52
nitrates and phosphates fertilizers and, 1:51
nonpoint sources of pollution and, 4:2039–2040
nontarget organisms destruction and, 1:52
organophosphates, 4:2100–2101
pesticide residues in humans and, 1:53
types of agrochemicals and, 1:51
water filtration and, 3:1115

Agroecology, 1:54–58
adaptation to climate change, extreme events and, 1:10
agrochemical pollution and, 1:51–53, 2:939
agroecosystem schematic diagram and, 1:55 (fig.)
agroforestry and, 1:55, 5:2579
agroforestry home garden example, Tasco, Mexico, 1:55, 1:56 (photo), 1:57
alternative food network initiatives and, 1:57
Community Agroecology Network (CAN) and, 1:57
critiques, challenges, and future trends, 1:58
definition of, 1:54
early work in, 1:54
energy flow process of, 1:55
farmer organizations and social movements and, 1:57
food system focus of, 1:54, 1:57
geographies of food and, 3:1144–1146
influential individuals in, 1:54
interdisciplinary approaches, 1:54, 1:58
local or indigenous agriculture and, 1:54
natural ecosystem and traditional agricultural models and, 1:54–56
new pest species and, 1:10
nutrient cycling process of, 1:56
organic agriculture and, 4:2094–2096
participatory action research and, 1:57
permaculture and, 4:2152–2153
plantations and, 5:2192–2195
population-regulating mechanisms process of, 1:56
production and farmer profit reductions issue and, 1:58
research-NGO partnerships and, 1:57
resilience/stability processes of, 1:56
small-scale and peasant agriculture focus of, 1:57
social, economic, and cultural basis of, 1:56–57
sustainability and, 1:10, 1:57
sustainable agroecosystems and, 1:54
See also Adaptation to climate change; Agrofoods

Agrofoods, 1:58–60
“fast” foods and, 1:59
final consumer factors and, 1:59
food distribution factors and, 1:59
food production process factors and, 1:58–59
foods high in carbohydrates issue and, 1:59
“fractions” of whole produce and, 1:59
“functional foods” (nutraceuticals) and, 1:59–60
geographies of food and, 3:1144–1146
“nonfood foods” and, 1:59
organic agriculture and, 4:2094–2096
transformation of foods and, 1:59

Agroforestry, 1:60–62
agriculture vs. forestry concepts and, 1:60
See also Adaptation to climate change; Agrofoods

INDEX 3175
ancient agroforestry systems and, 1:61
cultural, demographic, and environmental processes in, 1:61–62
definition, 5:2579
indigenous agriculture and, 3:1557, 5:2579
indigenous agroforestry and, 1:60–62, 5:2579
planting peanuts, Mali, West Africa, 1:61 (photo)
“scientific agroforestry” field of study and, 1:60
social conservation and, 5:2579
social factors in, 1:62
space and time elements of, 1:60
taungya system (southeast Asia), 1:60
AGS. See American Geographical Society (AGS)
AIDS. See HIV/AIDS, geography of
Airborne Real-Time Cueing Hyperspectral Enhanced
Reconnaissance (ARCHER), 1:18
Air masses, 1:62–65
Arctic air masses, Antarctica and Siberia, 1:63
classification system of, 1:63–64
deep moist convection (DMC) and, 1:64
definition of, 1:62
differential advection, 1:63–64
dryline or Marfa front concepts and, 1:63
equatorial vs. superior air and, 1:63
migration rate of air mass factor and, 1:65
source regions of, 1:63
subtropical vs. ocean surfaces and, 1:63
surface moisture factor and, 1:64
surface temperature factor and, 1:64
topography factor and, 1:64–65
trajectory of air mass factor and, 1:65
vertical character of primary air mass types and, 1:63
Air quality. See Ambient air quality; Atmospheric pollution
Alaska
Arctic National Wildlife Refuge, domestic fuel supply in, 2:901
Barrow, 1:450
beaver dam in, 1:274 (photo)
boreal forests usage in, 3:1164
circumpolar peoples’ environmental knowledge systems research and, 3:1566
Columbia Glacier in, 3:1328
Captain James Cook’s exploration of, 2:576
fjords in, 3:1121
Gilkey Glacier in, 3:1330 (photo)
glacier in, 3:1333
Ice Ages and, 1:457
ice caps and ice fields in, 3:1328
Melvin Marcus’s glaciology work in, 4:1850
permafrost in, 1:215, 4:2154
polar climate in, 1:450, 1:451
rat eradication from Rat Island, Alaskan Aleutian Island Chain and, 2:992
Red Dog zinc open-pit mine in, 4:2087
Russian colonization of, 1:512
sea ice minimum in, 2003–2005, 3:1525 (photo)
shrub tundra of, 1:248
subarctic climate in, 1:441
sustainable agriculture, lingonberry field, 6:2745 (photo)
Trans-Alaska Pipeline System, 4:2151 (photo)
tundra polygons, northern slope, 4:2130 (photo)
tundra vegetation in, 1:248 (table)
tussock and sedge-dwarf shrub tundra of, 1:248
wet tundra of, 1:249
Albania
COMECON membership of, 2:593 (table)
comparative indicators of unmet basic needs in, 2003, 5:2644 (fig.)
economically active females in, 3:1190 (table)
particulate matter pollution in, 1:151
Albedo, 1:65–66
albedos of natural surfaces and, 1:66 (table)
clouds and, 1:479–480
deforestation and urbanization factors in, 1:66
explanation of, 1:65
geographic and seasonal variations in, 1:66
glaciers and, 3:1323
global environmental change and, 3:1335
planetary albedo, 1:65–66
cold climate and, 1:449
seasonal changes factor in, 1:66
solar zenith angle factor in, 1:66
Albrecht, Jochen, 1:72
Aleksandrova, V., 1:247
Alexis, Alberto, 5:2217
Alexander, Lewis, 5:2307
Alexander the Great, 2:1051
Algeria
anticolonialism in, 1:94
Isabelle Eberhardt exploration of, 2:1057
economically active females in, 3:1190 (table)
France colonization of, 1:514
guerrilla conflicts in, 2:692
independence of, 1:517, 2:692
oil exports from, 4:2073
OPEC membership of, 4:2099, 4:2100 (fig.)
poverty rates in, 5:2274
al-Idrisi, 1:66–67
Geographe Nubien (the Nubian geographer) name and, 1:66
IDRISI based geographic analysis system and, 1:67
longitudes and latitudes used by, 1:67
world geographies written by, 1:66
world map of, 1:67, 1:351 (fig.)
Alker, Hayward, 2:824
Allen, Chris, 4:2168
Alps, 3:1087
Altieri, Miguel,
Marxist geographies work of, 5:2270, 5:2706
Marxist geography work of, 4:1863
Altvie, Miguel, 1:54
Altitude, 1:67–68
absolute altitude and, 1:68
adiabatic temperature changes and, 1:15–17, 1:17 (fig.)
angular altitude and, 1:68
barometric altitude and, 1:68
definition of, 1:67
elevation and height, 1:68
meridional altitude and, 1:68
Amazon River, Amazonia
diversity of, 3:1172
biota and climate of, 1:264
contemporary frontier of, 3:1171–1172
deforestation in, 1:319, 1:527 (fig.), 2:696, 2:698, 4:1697
domestication of camu camu trees in, 3:377, 3:377 (photo)
ecosystem decay of, 2:838
extractive reserves in, 2:1072–1073
floodplain crop cultivation and, 3:1132
floodplain of, 3:1129 (photo)
flowing through Amazon rain forest, 5:2473 (image)
global climate regulation factor and, 3:1172
Alexander von Humboldt’s travels in, 3:1482
hunting and gathering tribes in, 3:1492
indigenous environmental practices in, 3:1568
indigenous forestry in, 3:1569
land use and cover change in, 4:1736
malaria and, 4:1817
mercury from gold mining and, 4:2087
resource exploitation in, 5:2220
sustainable forests in, 3:1164
tragedy of the commons example in, 1:527 (fig.)
tropical rain forest of, 1:234, 1:453, 1:454
tropical savanna climate in, 1:455

**Ambient air quality, 1:68–70**
acid rain and, 1:69
air particle monitor and, 1:69 (photo)
atmospheric particulates and, 1:149–151
atmospheric pollution and, 1:151–155
carbon dioxide levels and, 1:68–69
definition of, 1:68
emission of polluting substances into the air and, 1:69
Lake Nyos disaster, Cameroon, West Africa, and, 1:68–69
London’s “killer fog” example and, 1:69, 1:70
Los Angeles smog and, 1:69
mixed layer of pollutants and, 1:69
mixing depth or mixing height of pollutants and, 1:70
ozone levels and, 1:70
photochemical smog and, 1:70, 4:2171–2173
pollutant removal processes and, 1:70
pollution potential of the atmosphere and, 1:69
quality as objective, 1:68
secondary pollutants and, 1:70
synoptic conditions and, 1:69–70
thresholds of pollutants, WHO standards of, 1:68
vertical temperature atmospheric structure and, 1:69
American Association of Geographers, 3:1492
American Cartographic Association, 4:1939

**American Geographical Society (AGS), 1:70–71**
“AGS Fliers’ and Explorers’ Globe” and, 1:70
Arctic, Antarctic, and Andean exploration and, 1:70
exploration and cartography work of, 1:71, 3:1463
founding and mission of, 1:70, 4:2180
*Geographical Review* journal of, 3:1463
library, 1:71
Transcontinental Excursion sponsored by, 1:71
Wilson’s “14 Points,” Paris Peace Conference and, 1:70
John Kirtland Wright and, 6:3138
See also American Geographical Society (AGS); noted members;

**Association of American Geographers (AAG)**
American Geographical Society (AGS): noted members
Isaiah Bowman, 1:295, 3:1465
Törsten Hagerstrand, 3:1398
Hou Renzhi, 3:1444
Melvin Marcus, 4:1850
John Russell Mather, 4:1871
American Geophysical Union, 3:1245
American Geophysical Union, 3:1245
American Geophysical Union, 3:1245
American Planning Association, land-based classification standard system of, 4:1730–1731, 4:1730 (tables), 4:1731 (tables)
American Society for Environmental History, 2:929
American Society of Landscape Architects, 4:1699
American Society of Photogrammetry, 4:115
Americans with Disabilities Act, 1:5
Amin, Ash, 5:2268, 5:2352

**Amnesty International, 1:96, 3:1480**
Eyes on Darfur project, 3:200
Analytical operations in GIS, 1:71–72
automatic generation of scripts and, 1:72
buffer operation in, 1:7
database queries and, 1:71
data editing and, 2:680–681
data format conversion, 2:681–682
data querying, 2:684–685
geostatistics and, 3:1261–1265
GIS design and, 3:1290–1293
Map Algebra operations and, 1:72
object-centered operations and, 1:72
overlay operation example of, 1:71–72, 1:72 (fig.)
universal GIS operations and, 1:72
See also GS specific subject

**Anarchism and geography, 1:73–74**
alter-globalization and environmental direct-action movements and, 1:73, 1:74
anti-authoritarianism and, 1:73
*Antipode* journal and, 1:73
current scholarship trends in, 1:74
definition of anarchism and, 1:73
early anarchist geographers and, 1:73
individualism, ecological preservation elements of, 1:73
Peter Kropotkin’s work in, 1:73, 4:1668–1669, 5:2211
mutual collaboration and decision making elements of, 1:73
radical geography of 1960s and 1970s and, 1:73–74
Élisée Reclus’s work in, 1:73, 5:2371–2372
Situationist International (SI) political and artistic movement and, 1:73–74
voluntary and self-sustaining society focus of, 1:73

**Anaximander, 1:74–75**
Anaximander’s map (re-creation), 1:74 (fig.), 1:75
authored works attributed to, 1:74
equinoces discovered by, 2:1009
first map of the world, 3:1460
gnomon invented by, 3:1460
hydrological cycle understood by, 1:74
natural phenomena studied by, 1:74
Anderson, Benedict, 3:1527
Anderson, James, 4:1728
Anderson, Kay, 3:1530, 5:2338, 5:2340
Anderson, Nels, 4:2121
Andreev, V., 1:247
Andropov, Uri, 2:594
Angola
colera in, 1:402
Cold War and, 1:505
economically active females in, 3:1190 (table)
independence of, 4:2099, 4:2100 (fig.)

**Animal geographies, 1:75–79**
animal agency and subjectivity and, 1:78–79
animal rights, 1:75–76
animals, culture and society and, 1:75–77
anthropocentric, human thinking and, 1:78
Bruce Braun and, 2:831
conceptual boundaries and, 1:77–78
coupled human and animal systems and, 2:597–598
cultural geography subfield, 1:73
domestication of animals and, 2:781–783
dream (Franz Marc) and, 1:76 (painting)
edgar (Franz Marc) and, 1:78 (painting)
ethics, humans, and other animals and, 1:78–79
feminist environmentalist geographies and, 3:1092–1094
human-dolphin encounter spaces example and, 1:77
material boundaries and, 1:77
moral status of animals, 1:78–79
reconceptualizing animals as strange people and, 2:832
social theory and geography interplay and, 1:75
speciesism and, 1:76
Sarah Whatmore and, 2:831, 2:832
Jennifer Wolch and, 2:831
zooeography and, 1:75
Annales School (of history), 1:79–80
areal differentiation and, 3:1465
Lucien Febvre and, 3:1090
founders, founding of, 1:79
genres de vie “geohistorical” approach of, 1:80
geographical landscapes and, 1:79
La terre en Révolution humaine (Febvre) and, 1:80, 3:1090
layered view of historical time and, 1:80
“longue durée,” 1:80
Possibilisme, 1:80, 3:1465
Anselin, Luc, 1:80–81
academic appointments of, 1:81
award and honors received by, 1:81
books and publications of, 1:80
Walter Isard’s influence on, 1:6128
regional science studies of, 1:81
Spatial Econometrics written by, 1:80, 5:2393, 5:2635
spatial software developed by, 1:80
Antarctica
air temperatures in, 1:451
circumpolar Antarctic cyclone belt and, 1:451
Captain James Cook’s exploration of, 2:576
daily values of total column ozone, 5:2700 (fig.)
exotic species in, 2:1048
exploration of, 2:1055
glacial/interglacial cycles in, 1:457
Ice Ages and, 1:457
ice sheets, rising temperatures and, 1:92, 3:1344, 3:1526, 5:2204
ice streams in, 3:1326
katabatic winds of, 1:451, 4:2149
polar climate in, 1:449, 1:451
polar desert in, 1:451
political map of, 6:3155
rates of surface elevation change from satellite measurements, 5:2207 (fig.)
sea ice, ice shelves, and ice sheets areas of, 3:1324 (fig.), 5:2205, 5:2206 (fig.)
sub-Antarctic islands and, 1:451
temperature increases in, 1:452
Wilkins Ice Shelf and, 5:2207, 5:2208 (fig.)
See also Ice
Antevs, Ernst, 1:81–82
clay-varve glacial dating method and, 1:82
climate variations and tree rings analysis work of, 1:82
glacial geology and geomorphology work of, 1:81–82
human-environment interaction work of, 1:82–83
paleobotanist work of, 1:82
pluvial lakes and arroyos studies of, 1:82
science of pollen and spores work of, 1:82
Anthony, Susan B., 3:1095
Anthropocene geologic epoch, 3:1334
Anthropogenic climate change, 1:82–92
acidification of surface oceans and, 1:91
atmospheric energy variations and, 1:161–165
aviation factor in, 1:182
carbon dioxide concentration, Hawai‘i monthly average, 1:183 (fig.)
cities and, 2:943
climate change projections and, 1:90–92
climate models, 1:85–86
climate models, their uses, 1:87–89, 1:88 (fig.), 1:89 (fig.)
complexity of climate models illustration, 1:88 (fig.)
confidence levels in IPCC findings and, 1:84 (table)
drought risk and hazard and, 2:790–794
extreme weather projections and, 1:92
future global CO₂ emissions projections, 1:87 (fig.)
future precipitation changes and, 1:90
global climate change scenarios and, 1:84–85, 1:86 (fig.)
greenhouse gas emissions scenarios and, 1:84–85, 1:86 (fig.)
“ice-albedo feedback” loop and, 1:89–90
Intergovernmental Panel on Climate Change (IPCC) and, 1:82, 5:2204
IPCC assessment reports and, 1:82–83, 5:2554 (fig.)
IPCC Special Report on Emissions Scenarios (SRES) and, 1:84, 5:2553
Keeling Curve and, 1:82, 1:83 (fig.)
Kyoto Protocol and, 1:83, 2:900
melting ice and rising sea level projections and, 1:90, 1:92
mountain glaciers affected by, 3:1328–1333
negative feedback mechanism and, 1:90
one-dimensional climate models and, 1:87
Paleoclimate Modeling Intercomparison Project and, 1:86
“permafrost-climate feedback” loop and, 1:90
physical climatology and, 1:472
Poles, North and South and, 5:2203–2209
positive feedback mechanism and, 1:89–90
potential future climate changes and impacts, 1:84–85, 1:85 (fig.)
precipitation change projections and, 1:90, 1:91 (fig.)
solar and terrestrial radiation and, 5:2346–2349
species extinctions and, 2:1070
three-dimensional “general circulation models” (GCMs) of, 1:87, 1:89 (fig.)
total global annual CO₂ emissions 1900–2100, 1:85 (fig.)
unknowns in predicting climate change and, 1:92
“water vapor feedback loop” and, 1:89, 1:91
See also Atmospheric composition and structure; Climate change; Climate policy
Anthropogeography, 1:93
Anthropogeographie (Ratzel, 1882) and, 1:93
environmental determinism and, 2:916–918
Influences of Geographic Environment (Semple) and, 1:93, 3:1464, 5:2531–2532
prevailing cultural discourses and, 1:93
social Darwinism, 1:93
Antiglobalization, 1:94–98
Americanization and, 1:94–95
anti-intellectualism of U.S. culture and, 1:95
antisystemic movements and, 1:99–100
environmental groups and, 1:96
grassroots antiglobalization and, 1:95–96
historic globalization resistance examples and, 1:94
Jihad vs. McWorld (Barber) and, 1:94
NGOs (nongovernmental organizations) and, 1:94, 1:96
nonviolent antiglobalization and, 1:94–95
radical Islamists and, 1:97
religious fundamentalism and, 1:97
tribal and indigenous cultures preservation and, 1:96
U.S. celebration of violence and, 1:95
U.S. tolerance of inequality and social injustice and, 1:95
violent antiglobalization and, 1:96–97
in Western Europe, 1:94–95
World Trade Organization protests, Manila and, 1:95 (photo)
xenophobic violence against immigrants and, 1:97
See also Globalization

Antipodes, 1:98–99
antichrone austral hemisphere zone and, 1:98
biblical topography issues and, 1:98
Christian Purgatory and, 1:98
definitions of, 1:99
Plato’s reference to, 1:98
Renaissance imaginary and, 1:98
theory of zones, geographic speculation and, 1:98

Antisystemic movements (ASMs), 1:99–100
antiglobalization and, 1:94–97
Critical Mass organization, San Francisco and, 1:100
definition of, 1:99
global scope of resistance of, 1:99
“Guerrilla Gardening,” Washington D.C. and, 1:100
humor and absurdism of civil disobedience direct action
and, 1:100
“Mayday Monopoly” protests, London and, 1:100
methods and tactics of protest and, 1:100
participatory forms of democratic practice elements of, 1:99
patterns and aspects of protest and, 1:99
post-1945 period, 1:99
Reclaim the Streets, street parties/theater and, 1:100
Seattle anti-WTO protests and, 1:100
“situationist” Paris student dissent movement and, 1:100
small-scale vs. large mass demonstrations and, 1:100
violent tactics issue of, 1:100

APEC. See Asia-Pacific Economic Cooperation (APEC)

Appleton, Jay, 4:1716

Applied geography, 1:100–102
careers in, 1:102
Christaller’s central place theory and, 1:409–410
Committee on Applied Geography definition of, 1:101
controversy, 1:101
cost-benefit analysis used in, 2:592–593
examples of, 1:101
godemographics and, 3:1215–1217
geographic science and human behavior and, 1:100
natural and social sciences merger and, 1:100
theory to skills transition and, 1:101

Aquaculture, 1:102–104
agricultural intensification and, 1:102
“blue revolution,” 1:103–104
definition of, 1:102
development and evolution of, 1:102–103
economies of scale and, 1:104
fisheries, Chios Island, Greece, 1:103 (photo)
fish farming and, 3:1119–1121
Food and Agriculture Organization (FAO) and, 1:102, 5:2193
GIS remote sensing technology and, 1:104
impacts of, 1:103–104
industrialization of, 1:103
marine and freshwater culture activities of, 1:102
marine aquaculture and, 4:1853–1855
negative impacts of, 1:104
research trends in, 1:104
seafood market demand increase and, 1:102
sociocultural and cultural impacts of, 1:104
state-supported industrialization of, 1:102
for subsistence purposes, 1:103
See also Marine aquaculture

Arabia
colonization of, 1:513–514
dromedary camel domesticated in, 2:783

Archipelago, 1:105–106
definition, explanation of, 1:105
evolutionary study and, 1:106
Galapagos Islands adaptive radiation example
and, 1:14–15, 1:106
individual countries as, 1:105
Isles of Sicily archipelago, 1:105 (photo)
small islands and, 3:1634–1637
world’s largest archipelagos and, 1:105

Architecture and geography, 1:106–108
Berkeley School of cultural geography and, 1:106
embodied geographies of architectural inhabitation, 1:108
folk architecture and the vernacular landscape and, 1:106
green building and, 3:1367–1369
David Harvey and, 1:106–107
inhabiting architectural spaces and, 1:107–108
J. B. Jackson and, 1:106
landscape architecture and, 4:1698–1701
landscape design and, 4:1703–1705
Landscape magazine (Jackson) and, 1:106
hotel lobby interior and, 1:107 (photo)
new urbanism and, 4:2024–2027
polyvocal methodology, 1:108
power and, 1:106–107
user consumption of architectural environments, 1:108

Archive of American Folk Song, 4:1968 (photo)

Arctic
amplified warming in, 5:2204
Arctic Climate Impact Assessment and, 3:1566
Arctic National Wildlife Refuge in, 6:3093 (photo)
extoration of, 2:1055
glaciers in, 3:1333
high arctic and, 1:450
Ice Ages and, 1:457
nomadic pastoralism in, 2:597
polar climate in, 1:449–450
polar desert of, 1:451
polar semidesert in, 1:249, 1:451
political map of, 6:3156
precipitation in, 1:450–451
sea ice minimum, 1979–1981, 3:1524 (photo)
sea ice minimum, 1982–2008, 5:2205 (hg.)
temperature increases in, 1:452
tundra of, 1:247
tussock and sedge-dwarf shrub tundra of, 1:249
See also Ice

Arctic Ocean
air masses of, 1:63
William Baffin, exploration of, 2:1055
permafrost degradation and, 4:2157
polar climate in, 1:450
rising temperatures, positive feedbacks and, 1:462
sea ice decline in, 1:462

Arendt, Hannah, 5:2378

Argentina
Buenos Aires as primate city, 5:2291 (photo)
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
glaciers in, 3:1332
human rights violations in, 3:1480
poverty rates in, 5:2274
silver trade and, 1:511
squatter settlements in, 5:2682
state-funded infrastructure projects and, 3:1551
Zonda wind in, 1:384

Argumentation maps, 1:108–110
argumentation theory and, 1:108–109
cartography and GIS concepts and, 1:109
gecollaboration and, 1:109
geographic data modeling and, 1:108–109
geospatial data modeling principles and, 1:108
issue-based information systems and, 1:109
participatory planning using GIS technology and, 1:108–109
Toulmin argumentation model and, 1:109

Arid topography, 1:110–116
alluvial fans, 1:113
arroyos in American southwest, 1:113
badlands, 1:114
baja landform of alluvial fans, 1:114
desert lakes, 1:115–116
desert pavement and, 1:113
desert piedmonts, 1:114–115
desert plants, Eastern Utah, 1:115 (photo)
dry climate and, 1:428–435
low relief, shield and platform setting of, 1:111–112, 1:112 (photo)
mas wasting, 1:113
mountain and basin desert setting of, 1:111, 1:111 (photo)
paleolakes, 1:116
pediments, 1:113–114
physical geography of, 1:110
piping process of badlands and, 1:113
playas terminal lakebeds, 1:115
rain storm effects on, 1:110
rockfall, rockslides, 1:113
sand dunes, 1:116
sheetwash, 1:113
structural setting of, 1:110–111
surface runoff and desert streams, 1:113–114
terminal lakes, Dead Sea (Israel) and Caspian Sea, 1:115
volcanic and tectonic, large-scale relief features of, 1:110–111, 1:111 (photo)
weathering, rock varnish, and crusts, 1:112–113, 2:719–722
wind erosion and, 1:116

Aristotle, 1:116–117
air, water, earth, and fire planet elements and, 1:116
animal and plant distributions views of, 1:117
earth’s habitable zone views of, 1:116–117
environmental determinism views of, 1:2
geospatial model (immobile Earth as center of universe) and, 1:116, 3:1460
ideal size of political unit views of, 5:2217
Meteorologica text of, 1:117
stream erosion in landscape formation and, 3:1245

Arizona
azurite and malachite secondary copper minerals, Bisbee, 4:1910
Church Rock Mine open-pit mine in, 4:2087
Gus Pearson Natural Area, Flagstaff, 3:1167 (photo)
hogan, Navajo Indian Reservation, 3:1571 (photo)
sediment data collection, Little Colorado River, Grand Canyon, 5:2532 (photo)
sustainable aquifer management in, 3:1389
Tempe Women’s Club Park, Demonstration Garden, 6:3144 (photo)

Armenia
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)

Armstrong, Marc, 1:117–118
computational geography work of, 1:117
GIScience work of, 1:117
parallel processing methods for geographic problem solving and, 1:117
spatial multicriteria evaluation work of, 1:117

Arnstein, Sherry, 4:2126–2127

Art and geography, 1:118–121
Aether: The Journal of Media Geography and, 1:118
art tourism and, 1:119
cartography definition and, 1:118
creative industry reshaping geography and, 1:119–120
creative literature and, 1:118
denominations of, 1:119
Denis Cosgrove and, 2:590
desert biome in, 4:1880
humanistic geography and, 1:118
landscape paintings and representation and, 1:118
OJ (Obstruction of Justice) House and the Oval Room display, city of Detroit, 1:120 (photo)
photography and, 4:2176–2178
portrayal of cities through art and, 1:119
production of art and, 1:118
urban space transformation and, 1:119–120
You Are Here: The Journal of Creative Geography and, 1:118

Arthur, Brian, 4:2133

Aruba, 1:512

ASEAN. See Association of Southeast Asian Nations (ASEAN)

Asia
acid rain in, 1:6–7
adults and children living with HIV in 2007 in, 3:1437 (fig.)
Afro-Asiatic languages and, 4:1750 (fig.)
agricultural industrialization in, 1:47
aquaculture in, 1:103
Asian monsoon and, 4:1940–1941
Association of Southeast Asian Nations (ASEAN) and, 1:126–131, 1:127 (fig.)
automobile industry in, 1:169
basin and range topography in, 1:186
Bering land bridge, North America and, 1:213
boreal forests in, 1:214–217
as center of domestication (East Asia), 1:376
China’s foreign direct investment in, 3:1153
cholera in, 1:401
climate change adaptation research in, 1:9
colonialism, end of, 1:517
colonialism of, 1:514–515
colonial migrations of, 1500–1914, 3:1542, 3:1543 (fig.)
COMECOM membership and, 2:593
decolonization in, 2:691, 2:692
deforestation statistics in, 2:696
democratization in, 2:702
desert biome in, 1:218
development zones in, 2:1067
foreign aid to, 3:1152
forest fragmentation in, 3:1159
gender inequalities in, 3:1589
Great American Exchange and, 3:1362
Greek exploration of, 2:1051
green building programs in, 3:1369
humid continental climate of, 1:439
hydroelectric power in, 3:1509
\( i.e. \) wind in, 1:384
import substitution industrialism (ISI) in, 3:1550
installed generating capacity values since 1950 in, 3:1511, 3:1511 (table)
land degradation estimates in, 4:1680 (table), 4:1681
land privatization in, 5:2494
marine aquaculture in, 4:1853
midlatitude deciduous forest in, 1:223–225
military expenditures in, 4:1899 (table)
natural bridge to North America and, 2:1050
newly industrializing countries in, 4:2022 (fig.)
nomadic pastoralism in, 2:597
polar climate in, 1:449
political map of, 6:3158
population growth of, 5:2233 (fig.), 5:2241
potential water availability in, 2007, 2050, 6:3059 (fig.)
prehistoric exploration of, 2:1050
renewable water resources and availability in, 6:3057 (table)
rice paddy cultivation in, 1:48–49, 1:48 (photo)
severe midlatitude climate in, 1:439, 1:440 (fig.)
silver trade and, 1:511–512
Sino-Tibetan language family in, 4:1751, 4:1752 (fig.)
soil erosion in, 5:2585
squatter settlements in, 5:2682
temperate, semiarid deserts in, 1:219
temperate arid deserts in, 1:221
temperate hyperarid deserts in, 1:222
Third World debt crisis and, 2:688
transboundary hazardous waste dumping in, 1:384
tropical arid deserts in, 1:221
tropical monsoon climate in, 1:454
tropical rain forest of, 1:234
tropical scrub in, 1:244
tropical/subtropical semi-arid deserts in, 1:219
tundra of, 1:247
undernourishment in, 3:1488 (table)
water stress ratio in, 3:1516
women’s lives in, 3:1097
See also Asia-Pacific Economic Cooperation (APEC);
specific nation

Asia-Pacific Economic Cooperation (APEC)
Australia’s role in, 1:121
criticisms of, 1:121–122
decision making by consensus of, 1:121
diversity of membership limitations of, 1:121–122
interdependence among Asia-Pacific economies and, 1:121
membership of, 1:121, 1:122 (fig.)
nonbinding commitment basis of, 1:121
trade and investment liberalization agenda of, 1:121
trade blocs included in, 1:121
treaty obligation non-requirement of, 1:121

ASMs. See Antisystemic movements (ASMs)

Association of American Geographers (AAG), 1:122–123
AAG Center for Global Geography Education project, 3:1234
activities sponsored by, 1:122
Communications Geography Specialty Group of, 2:541
Conference of Latin Americanist Geographers (CLAG) and, 2:567–568
Cultural Ecology Specialty Group of, 2:632
Environmental Perception and Behavioral Geography (EPBG) Group of, 2:978
founding of, 3:1464
geographic research focus of, 1:123
guemorphology and, 3:1245
Guidelines for Geographic Education
(AAG and NCGE) and, 1:123
journals of, 3:1464
as a nonprofit scientific and educational society, 1:122
organization of, 1:122
Political Ecology Specialty Group of, 2:633
professional development programs of, 1:123
publications of, 1:122–123
spatial analysis, business geography and, 1:305
specialty groups of, 1:123

See also Association of American Geographers (AAG): noted members;
Canadian Association of Geographers (CAG)

Association of American Geographers (AAG): noted members
Ronald Abler, 1:1
John Agnew, 1:32
Brian Berry, 1:193
Isaiah Bowman, 1:296
Harlan Burrows, 1:185
Anne Buttimer, 1:308
Andrew Clark, 1:417
Reginald College, 3:1349
William Morris Davis, 2:687, 3:1464
Törsten Hagerstrand, 1:3198
Richard Hartshorne, 3:1403
John Brinkerhoff Jackson, 4:1642
R. J. Johnston, 4:1643
David Ley, 4:1777–1778
Melvin Marcus, 4:1830
John Russell Mather, 4:1871–1872
Richard Morrill, 4:1945
James Parsons, 4:2121
Lewis Peirce, 4:1772–1773
Ellen Churchill Semple, 5:2531–2532
Griffith Taylor, 6:2777
Glenn Trewartha, 5:2245, 5:2246, 6:2882–2883
Gilbert White, 6:3095
Derwent Whittlesey, 6:3097
Wilbur Zelinsky, 6:3147–3148

Association of Geographic Information Laboratories for Europe (AGILE), 1:123–126
annual conferences of, 1:126
European GIS conference series of, 3:1286
European Science Foundation GISEDA Scientific Programmers and, 1:123
Exhibition on Geographical Information Systems Conferences and, 1:123
GIScience research topics and, 3:1288 (table)
governing organization of, 1:126
membership of, 1:123, 1:124–125 (table)
mission of, 1:126, 3:1286
organizational liaisons of, 1:126
publications of, 1:126

Association of Southeast Asian Nations (ASEAN), 1:126–131
APEC and, 1:121
ASEAN Free Trade Area (AFTA), 1:127, 1:130–131
ASEAN Regional Forum (ARF), 1:127, 1:130
Asian Development Bank and, 1:128
constructivist theory of international relations and, 1:129–130
economic profiles of ASEAN countries, 1:128, 1:129 (table)
foreign direct investment issues (China and India) and, 1:130
historical context of, 1:127–128, 1:128 (table)
institution building issue and, 1:128–129, 1:131
intra vs. extraregional trade and, 1:129
membership of, 1:127, 1:127 (fig.)
NAFTA and EU and, 1:127, 1:128
postcolonial southeast Asia conditions and, 1:128
preferential trade arrangements (PTAs) ad, 1:130
regionalism model of, 1:126–127, 1:127 (fig.), 1:128–130
“relational control” foundational model of, 1:127–128
security issues and, 1:129
supranational integration feature of, 6:2727
tariff reduction exclusions and, 1:130
views on sovereignty, 1:129–130
Atlanta, Georgia
airline hub in, 1:181
CO₂ emissions in, 3:1377
suburban development pattern in, 5:2714 (fig.), 5:2715
Atlantic Ocean
Antarctic Convergence zone and, 1:451
atmospheric energy variations and, 1:163–165
coastline landforms of, 4:1689
Dansgaard-Oeschger Oscillations and, 1:457–458
Hadley cell and, 3:1395–1397
Edmond Halley’s 1700 chart of, 1:357 (fig.)
Hurricane Katrina and, 3:1493
major tectonic areas of, 5:2196 (fig.)
Medieval Warm Period climate change in, 1:459
mild, midlatitude climate and, 1:436–437
Norwegian Current of, 1:450
ocean-atmosphere variabilities drought factor in, 2:792
polar climate in, 1:450
staghorn coral faunal relic and, 1:470
Atmospheric circulation, 1:131–136
bora, mistral, coho winds and, 1:135
Coriolis force and, 2:586–587
dust devils and, 1:135
duststorms, sandstorms and, 1:135
equatorial trough, intertropical convergence zone (ITCZ) and,
1:132, 1:453, 4:1940
extratropical cyclones and, 2:650–654
Ferrel cells of the midlatitudes and, 1:132–133
Hadley cells of the tropics and, 1:132, 3:1395–1397
high-latitude polar cells and, 1:133
hurricanes, typhoons, cyclones and, 1:134
jet stream upper tropospheric winds and, 1:133
katabatic winds and, 1:135, 4:541, 4:2149
mesopause region and, 1:139–140
mortality and, 1:134, 4:1940–1945
mountain and, 1:443–449
ocean circulation and, 4:2058–2064
photochemical smog and, 4:2171–2173
planetary scale features of, 1:135–136
polar cells of the high latitudes and, 1:132–133
polar or midlatitude jet stream and, 1:133
Ross by waves (midlatitudes) and, 1:133, 1:134
Santa Ana wind and, 1:135
sea breezes, lake breezes and, 1:134–135
solar energy (insulation) factor in, 1:131
spatial and temporal classification system of, 1:132
subtropical high-pressure zone and, 1:132
subtropical jet stream and, 1:133
synoptic and dynamic climatology and, 1:472–473
synoptic scale systems and, 1:133–134
thermals and, 1:135
tornadoes and, 1:135–136
tropopause element in, 1:132
valley breeze and, 1:135
waterspouts and, 1:135–136
See also Atmospheric moisture; Atmospheric specific subject; El Niño-Southern Oscillation (ENSO)
Atmospheric composition and structure, 1:136–140
absolute zero temperature, atom movement and, 1:139
aerosols, suspended particulates and, 1:137–138
atmospheric pressure and, 1:155–157
carbon dioxide concentration and, 1:136–137
chlorofluorocarbons (CFCs) and, 1:138
density of the atmosphere and, 1:138
gaseous composition of the atmosphere and, 1:136–138
homosphere vs. heterosphere “shell” and, 1:140
ionosphere layer and, 1:140
jet contrails and, 1:137, 1:148
mesopause region and, 1:140
mesosphere thermal layer and, 1:139–140
nitrogen, oxygen, and argon gases concentration and, 1:136
oxygen concentration vs. altitude levels and, 1:138
ozone concentrations and, 1:138, 1:139
roads affecting, 2:952
stratopause boundary and, 1:139
stratosphere thermal layer and, 1:139
temperature definition, stratosphere thermal layer and, 1:139
thermal structure of atmosphere and, 1:138–140
thermosphere thermal layer and, 1:140
trace gasses composition and, 1:137
tropopause boundary and, 1:139
troposphere thermal layer and, 1:139, 1:157
water vapor and, 1:137
See also Atmospheric specific subject
Atmospheric energy transfer, 1:140–143
air mass characteristics and, 1:62–65
baroclinic systems and, 1:142
convective boundary layer (CBL) and, 1:141
Coriolis force and, 2:586–587
deep moisture convection (DMC) and, 1:141
El Niño-Southern Oscillation (ENSO) and, 2:889
extratropical cyclones and, 1:142, 2:650–654
frictional torque as tangential stress and, 1:143
global angular momentum (Earth’s axis rotation) source of,
1:140–141, 1:142–143
greenhouse gases of water vapor and, 1:141
Hadley cells and, 3:1395–1397
heat and temperature and, 1:141–142
heat energy from sun source of and, 1:140–141
latent heat and, 4:1761–1762
lower planetary boundary layer (PBL) and, 1:141
Madden-Julian oscillation (MJO) 60-day cycle and, 1:143
moist deep convection and, 1:142
mountains vs. frictional torque and, 1:142–143
ozone levels and, 1:141
Pacific frictional torque and, 1:143
positive vs. negative mountain torque and, 1:143
Rossby wave trains and, 1:143
torque, 1:142
Type A vs. Type B cyclones and, 1:142
urbanization effects and, 1:141
Wien’s law and, 1:141
See also Atmospheric specific subject; El Niño-Southern Oscillation (ENSO)
Atmospheric moisture, 1:143–149
air mass characteristics and, 1:62–65
atmospheric rivers and, 1:146
changes in, 1:148–149
characteristics of, 1:144–146
climatology and, 1:148
cloud attributes and, 1:147
clouds and, 1:144, 1:476–480
cloud types and cloud structure measures and, 1:147–148
condensed (liquid) and sublimated (ice) water in clouds and, 1:143
direct observation vs. remote sensing and, 1:146–147
diurnal temperature range (DTR) and, 1:144, 1:148
dry line of Central U.S. and, 1:146
El Niño and La Niña events and, 1:148
GPS remote sensing measurement of, 1:160
greenhouse gas-induced “global warming” and, 1:148
Hadley cells and, 1:3195–1397
hot towers, Hadley cell and, 1:146
humidity and, 1:145, 3:1485–1486
hydroclimatology and, 1:473
incoming solar radiation vs. earth-emitted long wave radiation and, 1:144
interannual variations in, 1:148
Intertropical Convergence Zone (ITCZ) and, 1:146, 1:148, 6:2832
latent heat and, 4:1761–1762
long-wave (cloud) image of Australian sector and, 1:145 (fig.) measures of, 1:144–145
moisture transport (qV, advection of moisture by vector wind) and, 1:146
monitoring of, 1:146–148
planetary boundary layer (PBL) location of, 1:144
slantwise convection and, 1:146
spatial variations in, 1:148
Special Sensor Microwave/Imager (SSM/I) climatologies and, 1:147, 1:148
static stability measures and, 1:145–146
temperature-evaporation-humidity feedback and, 1:145
tropical-extra-tropical cloud bands (TECBs, moisture bursts) and, 1:146
tropical rainfall measuring mission (TRMM) climatologies and, 1:148, 1:160
vertical air motions and, 1:146
“warm pool” of highest sea-surface temperatures and, 1:145
water vapor and, 1:143–144
water vapor spatial variations and, 1:146
See also Atmospheric circulation; Atmospheric specific subject; El Niño-Southern Oscillation (ENSO)
Atmospheric particulates across scales, 1:149–151
aerodynamic diameter feature of, 1:149–150
anthropogenic PM effect on cloud development and, 1:150
anthropogenic vs. natural sources of, 1:149
characteristics of, 1:150 (table)
components of, 1:149
course to ultrafine size continuum of, 1:150, 1:153–154
human health affected by, 1:150–151, 1:154
particulate matter (PM) and, 1:149
secondary particles and, 1:150
size fractions categorization of, 1:149–150
solar and terrestrial radiation and, 5:2346–2349
See also Atmospheric pollution; Atmospheric specific subject
Atmospheric pollution, 1:151–155
air filtration and, 3:1115
air quality indices of, 1:151
atmospheric particulates and, 1:149–151
carbon monoxide pollutant, 1:151–152
cities and, 2:942
clean source of sulfur dioxide and, 1:153
cosmic ray effect on cloud development and, 1:150
criteria air pollutants and, 1:151
dispersion and dilution and, 1:154
fine particulate matter pollutant, 1:153–154
greenhouse gases and, 1:152
human health affected by, 1:154
manufacturing and, 2:945
mobile monitoring of, 1:154
monitoring of, 1:154
National Ambient Air Quality Standards and, 2:984
oxides of nitrogen pollutant, 1:152
ozone secondary pollutant, 1:152–153
personal monitors of, 1:154
pollution control technology’s waste products and, 2:945
primary vs. secondary classification of, 1:151
reduction of, 1:154
sulfur dioxide pollutant, 1:153
sunlight component of ozone and, 1:153
temperature inversions and smog, Mexico City, 1:152 (photo), 1:154
urban area factor in, 1:151, 1:152, 1:153
volatile organic compounds pollutants, 1:153
volcanic activity, carbon cycle and, 1:328
See also Acid rain; Atmospheric particulates across scales; Atmospheric specific subject
Atmospheric pressure, 1:155–157
adiabatic temperature changes and, 1:15–17
air mass characteristics and, 1:62–63
barometer measurement instrument and, 1:155
definitions, 1:155
density measure and, 1:155
dynamic processes changes and, 1:156
extratropical cyclones and, 2:650–654
force, Newton’s second law and, 1:155
gravitation acceleration and, 1:155
Hadley cells and, 3:1395–1397
imbalance in mass and/or heat across space and, 1:155–156
inches measurement unit of, 1:155
International System (SI) measurement units of, 1:155
inverse barometer effect and, 1:497
mass of the atmosphere, Pascal’s law and, 1:155
pressure change and, 1:156
pressure gradient force (PGF) and, 1:156
pressure gradients and, 1:155–156
quasi-geostrophic (QG) theory and, 1:156
temperature, mass, volume changes and, 1:156
upper-level disturbances and, 1:156
vertical pressure profile and, 1:156–157
See also Atmospheric specific subject
Atmospheric remote sensing, 1:157–161
active vs. passive instruments and, 1:158, 1:159
advanced very high resolution radiometer, channels of, 1:159, 1:160 (table)
Committee on Earth Observation Satellites and, 1:160
definitions of, 1:157
Doppler radar active system and, 1:158, 1:159
electromagnetic spectrum and, 1:158, 1:158 (fig.)
electromagnetic spectrum and, 1:158 (fig.)
future trends in, 1:161
gyrocompassing or geostationary spacecraft orbits and, 1:159
Global Precipitation Measurement Mission, 1:160
GOES-R and NPOESS next generation operational satellites and, 1:160
ground-based systems of, 1:161
history of space-borne atmospheric remote sensing, 1:159–160
infrared radiometers, pyranometers and, 1:158
Moderate Resolution Imaging Spectroradiometer (MODIS)
multispectral sensor and, 1:158, 2:252, 2:974, 3:1542,
4:1738, 4:1740, 4:1960
NASA’s Tropical Rainfall Measuring Mission (TRMM) and,
1:159, 1:160
next generation operational satellites and, 1:160
Nimbus Series, microwave remote sensing and, 1:159–160
numerical weather prediction (NWP) models and, 1:160
physical parameters or variables measured by, 1:157–158
polar-orbiting satellites and, 1:159
resolution characteristic of, 1:158
Satellite Meteorology (Vander Haar and Kiddier), 1:159–160
space-borne systems of, 1:160
technology advances in, 1:160–161
TRIOS I and, 1:159
wind profilers and, 1:160
See also Atmospheric specific subject: Biophysical remote sensing
Atmospheric variations in energy, 1:161–165
adiabatic processes and, 1:162
Atlantic Multi-decadal Oscillation (AMO) and, 1:165
atmospheric mass factor in, 1:161
backscattering (reflection) of radiation and, 1:161–162
Coriolis force and, 2:586–587
coronosphere of the sun and, 1:163
Dalton Minimum and, 1:163
differential heating and, 2:740–742
Earth’s upper and lower atmosphere and, 1:161
El Niño, La Niña and, 1:164
extratropical cyclones and, 2:650–654
Great Pacific Climatic Shift and, 1:164
Maunder Minimum period and, 1:163
Modern Maximum period and, 1:163
numerical models and, 1:162
ocean temperature measurements and, 1:164
Pacific and Atlantic Ocean oscillations and, 1:163–165
Pacific Decadal Oscillation (PDO) and, 1:164
solar constant concept and, 1:162, 1:163
solar energy and, 1:161–163
solar energy variations and, 1:162–163
urban vs. rural climate stations measure of, 1:164
volcanic eruptions and, 1:163
See also Atmospheric specific subject: El Niño-Southern Oscillation (ENSO)
Atoll, 1:165–169
atoll environments and social issues and, 1:167–168
Bikini Atoll, 1:166, 1:167
climate change and, 1:168
Reginald Daly’s glacial control theory of, 1:166
Darwin’s subsidence origin theory and, 1:166, 1:167 (fig.), 2:585
definition, explanation of, 1:165
Eniwetok Atoll, 1:166
formation of, 1:166–167, 1:167–168 (figs.), 2:583
geomorphic features of, 2:585, 2:585 (fig.)
Kwajalein Atoll, 1:167–168
low islands and, 3:1635–1638, 3:1636 (photo), 3:1637 (photo)
Marshall Islands atolls, 1:166, 1:166 (photo), 3:1637 (photo)
Midway Atoll, U.S. territory, 2:583
Mururoa and Fangataufa atolls, French Polynesia, 1:167–168
nuclear testing on, 1:167–168, 2:956
Edward Purdy’s karst control theory of, 1:166–167, 1:167 (fig.)
AU. See African Union (AU)
Augelli, John P., 2:567
Auletta, Ken, 6:2998
Australia
ANZUS treaty and, 1:505
APEC membership of, 1:121
Australian monsoon and, 4:1941
bird species richness in, 1:262 (fig.)
birthrates in, 2:708
British colonization of, 1:515, 3:1222
cadastral systems, land ownership and, 1:315
Cape Bauer, South Australia, 4:1717 (photo)
chenier ridge, Princess Charlotte Bay, 1:491 (photo)
Closer Economic Relations (CER) Free Trade Agreement (FTA) and, 1:121
coil in, 1:485
coastal erosion and deposition in, 1:491–492, 1:491 (photo)
colonial migrations of, 1500–1914, 3:1542, 3:1543 (fig.)
Captain James Cook’s exploration of, 2:576
critical human geography in, 2:618, 2:620
deposit refund systems in, 2:742
drought prone region, 2:787
drug substitution programs in, 2:799
dry climates in, 1:429, 1:430 (fig.)
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
ecotourism certification in, 2:873
El Niño-Southern Oscillation (ENSO) and, 2:887, 2:888
indigenous environmental knowledge, resource
management and, 3:1565
energy feed-in tariffs (FIT) in, 2:901
environmental management legislation in, 2:969
environmental history studies in, 2:929
environmental privatization in, 4:2009
European rabbit introduced in, 2:1048, 2:1049 (photo)
foreign aid flow from, 3:1152
GIS pioneering in, 3:1283
green building programs in, 3:1368, 3:1371
greenhouse gas emissions of, 5:2220
groundwater usage in, 3:1386, 3:1387
herbicide use in, 1:1421
housing policy in, 1:1448
hunting and gathering tribes in, 3:1492
incubator zones in, 3:1552
indigenous and community conserved areas in, 3:1561
Indo-European languages in, 4:1749, 4:1750 (fig.)
installed capacity for electricity production forecast, 2010,
3:1268 (fig.)
Kyoto Protocol of 1997, GHG emissions and, 1:463
Lake Eyre regional basin lowpoint in, 1:114
land degradation estimates in, 4:1680 (table)
long-wave cloud image of, 1:145 (fig.)
lower birth rates in, 4:1981
Melbourne’s air quality measurement and, 1:69
midlatitude deciduous forest in, 1:224
midlatitude grasslands in, 1:228
monsoons in, 2:741
morphine-rich narcotics produced in, 2:797 (table)
national drought policy of, 2:793
New South Wales GHG Reduction Scheme,
carbon markets, 1:331 (table)
Oyster Bay, 1:492 (photo)
political map of, 6:3157
poppy thebaine production in, 2:796
postmodernism in, 2:619
potential water availability in, 2007, 2050, 6:3059 (fig.)
prehistoric exploration of, 2:1050
rabbit population in, 3:1474
Aviation and geography, 1:179–182
Airbus A380 and, 1:179–180
aircraft technology factor and, 1:179–180
airline network development and, 1:179
environment affected by, 1:179, 1:182
hub-and-spoke network example and,
1:180, 1:180 (fig.), 4:2017
impact of, 1:179
low-cost carriers (LCCs) and, 1:181
point-to-point services example and, 1:181 (fig.)
secondary airports and, 1:181
Singapore and Sydney and, 1:180
urban and regional development patterns and, 1:179
Wizz Air network and, 1:181–182, 1:181 (fig.)

Azerbaijan
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of,
2:536 (table)
economically active females in, 3:1190 (table)
GUAM Organization for Democracy and Economic
Development co-founded by, 2:538
HIV/AIDS in, 3:1438

Azores, 2:1051
Bachelard, Gaston, 4:1769
Bacon, Francis, 2:893, 4:1928
Baghdad, 1:402
Bagnold, R. A., 2:801, 4:1896–1897
Bahamas, 1:512
Bahrain, 3:1190 (table)
Baldwin, Richard, 2:781
Bale, John, 5:2680
Balkan states, 2:1038
Baltimore, Maryland
CO₂ emissions in, 3:1377
fruit and vegetable canning industry in, 4:1821
Bangladesh
cholera in, 1:402
clothing exports from, 6:2186 (fig.)
deficient calorie consumption in, 3:1487
ecological footprint and biocapacity
of, 2:827 (table)
economically active females in, 3:1190 (table)
marine aquaculture in, 4:1854 (fig.)
monsoon season floods and, 3:1135
textile exports from, 6:2816 (fig.)
water supply contamination and, 3:1387
Baran, Paul, 2:712
Barber, Benjamin, 1:94
Barlow, Philip, 5:2407
Barnes, Trevor, 4:1897
Barrier islands, 1:183–185
barrier reefs (coral reefs) and, 2:583
Bora Bora, French Polynesia (barrier reef) and, 2:583
formation theories of, 1:183, 1:185, 2:583
island overstepping and, 1:183
long wave vs. mixed vs. short wave barriers and, 1:183
physical characteristics of, 1:183
small islands and, 3:1634–1637
washover fans, Santa Rosa Island, northwest
Florida, 1:183, 1:184 (photo)
wave-dominated barrier island, Santa Rosa Island, northwest
Florida, 1:184 (photo)
Barrow, Christopher, 2:1003
Barrows, Harlan, 1:185–186
evironmental determinism and, 1:185
graphy as human ecology views of, 1:185, 2:894, 2:895, 2:896–897
Richard Hartshorne influenced by, 3:1402
ory vs. historical geography and, 1:185
Ellen Churchill Semple and, 1:185
ater resources conservation work of, 1:185
Barthes, Roland, 5:2270
Bartlett, Richard, 3:1572
Bash, Jeffrey, 2:993–994
Basi and range toponography, 1:186
crustal extension causes of, 1:186
diastrophic processes formation of, 1:186
aulting and, 3:1083–1088
geographic locations of, 1:186
graben rock and horst block rock structures and, 1:186, 2:604
half-grabens tilted fault blocks and, 1:186
Bassett, Karl, 3:2631
Batty, Michael, 1:187
cities as fractals theorization of, 2:561
ity systems work of, 1:187
complex systems theory work of, 2:560
complex systems work of, 2:560
GIScience contributions of, 1:187
Baudrillard, J., 2:574
Bash, Jeffrey, 2:993–994
Basin and range toponography, 1:186

crustal extension causes of, 1:186
diastrophic processes formation of, 1:186
aulting and, 3:1083–1088
geographic locations of, 1:186
graben rock and horst block rock structures and, 1:186, 2:604
half-grabens tilted fault blocks and, 1:186
Bassett, Karl, 3:2631
Batty, Michael, 1:187
cities as fractals theorization of, 2:561
ity systems work of, 1:187
complex systems theory work of, 2:560
complex systems work of, 2:560
GIScience contributions of, 1:187
Baudrillard, J., 2:574
Bayesian statistics in spatial analysis, 1:187–189
Bayesian kriging, spatial interpolation and, 5:2648
Bayesian maximal entropy (BME) to study nature
systems and, 1:187
cellular automata used in, 1:370
core knowledge basis of, 1:188
scientific applications of, 1:188
software applications of, 1:188
spatial autocorrelation and, 5:2607–2608
spatial coordinate systems of, 1:188
stochastics theory and epistematics principles
fusion and, 1:187
Beakhurst, Grahame, 5:2212
Beasley, Charles, 5:2252, 5:2253
Bebington, Anthony, 3:1557
Beck, Ulrich, 2:837, 5:2515
Begg, Robert, 4:2109
Behaim, Martin, 3:1461, 4:2179
Behavioral geography, 1:189–190
assumptions of, 1:189–190

cognitive mapping (Tolman) and, 1:189, 4:1881
constructivism learning theory and, 1:189

contributions of, 1:190


criticism of, 1:190

Environmental Perception and Behavioral Geography (EPBG)
Group of AMG and, 2:978

eyday life geographies and, 2:1042–1045

eplanation of, 1:189

graphies of emotion and, 2:891–892

hierarchy of spatial human development and, 1:189
human spatial decisions and problem solving and, 1:189, 1:190
mental maps and, 4:1881–1883
methods of, 1:190
mixed methods used in, 1:190
nonvisual geographies and, 4:2042
resulting data formats of, 1:190
theoretical basis of, 1:189–190
understanding processes focus of, 1:190
Beijing, China
Hou Renzhi historical research on, 3:1443
ral migrant worker, urban waste management in, 5:2497 (photo)
Belarus
Collective Security Treaty Organization (CSTO)
membership of, 2:536

Commonwealth of Independent States (CIS) membership of,

2:536, 2:536 (table)
conomically active females in, 3:1190 (table)

european bison extinction in, 2:1071
Belgium
AGILE membership of, 1:124 (table)
cal energy source in, 3:1382

colonial empire of, 1:509, 1:509 (fig.)

economically active females in, 3:1190 (table)

European Union (EU) membership of, 2:1035

first textile factories in, 3:1583

gully erosion in, 3:1393

particulate matter pollution in, 1:151

Belize, 4:1854 (fig.)
Bell, Daniel, 5:2262–2263, 6:2843
Bell, Scott, 2:615
Bell, Thomas L., 4:1969
Belyea, Barbara, 3:1563
Bengal
British colonization of, 1:514
Chinese exploration of, 2:1054

Great Bengal Famine of 1843 and, 3:1084
Benin, 3:1190 (table)
Benjamin, Walter, 2:573–574
class-based analysis of representations and consumption
and, 4:1862
how to read urban spaces and, 5:2298
literature geographies and, 4:1788, 5:2298
ordinariness views of, 2:1043
Bennett, Hugh, 5:2585
Bennetworth, Paul, 1:482
Bensin, Basil, 1:54
Bentham, Jeremy, 4:2116, 5:2272
Bentley, Ian, 4:2168
Berger, P., 5:2297
Bering land bridge, 1:213
Berkeley, George, 2:893
Berkeley School, 1:191–192

California School name and, 1:191
characteristics of study and, 1:191
critiques and decline of, 1:192
cultural geography, architecture and, 1:106, 1:191, 1:192, 4:1967
diffusion, cultural geography and, 2:745, 2:746
environmental determinism vs., 1:191
fieldwork study methods used by, 1:191

folk culture and geography and, 3:1142–1144, 4:1967
holistic view of culture and, 3:1458
human culture impact on landscapes focus of, 1:191, 3:1458
isolation of school factor and, 1:191
key people, dissertations of, 1:192

music and sound studies of, 4:1967

origins of, 1:191
See also Berkeley School: noted scholars
Berkeley School: noted scholars
Luc Anselin, 1:80–81
Harold Brookfield, 3:1458
James Parsons, 4:2120–2121
global biotic plant regions and, 1:208
human impacts of distributions and, 1:213
invasion and succession and, 3:1627
biome: boreal forest, 1:210
issues and themes of, 1:208
jump dispersal and, 1:213
landscape and wildlife conservation and, 4:1696–1698
law of the minimum (Liebig) and, 1:209
mapping biotic regions and, 1:209
micro vs. macro evolution and, 1:209
new species from geographic isolation and, 1:210
organism-environment relationship focus of, 1:210
plate tectonics and, 5:2195–2199
reproductive isolation and, 1:211
science of taxonomy and, 1:208
spatial distributions of organisms and, 1:210–211
species ecological niches and, 1:210–211
timeline of 1600–1850: age of reason, 1:208–209
timeline of 1850–1900: evolution by natural selection, 1:209
timeline of 1900–1950: continental drift
and ecology, 1:209–210
timeline of 1950–present: ecological and historical
theories, 1:210
vegetation development theories (Howles and Clements)
and, 1:209–210, 4:2180
vegetation dynamics focus of, 1:208
vicariance biogeography (Croizat) and, 1:210
vicariant event boundaries and, 1:211
Wallace’s Line boundary area and, 1:209, 1:234
zoogeography and, 1:209
See also Biogeography: noted individuals
Biogeography: noted individuals
Luc Anselin, 1:80–81
Comte de Buffon, 1:208
Frederic Clements, 1:209–210, 4:2180
Henry Cowles, 1:209, 4:2180
Leon Croizat, 1:210
Charles Darwin, 1:209
Johann Reinhold Forster, 1:208
Henry Gleason, 1:210
Alexander von Humboldt, 1:208–209, 3:1463, 5:2447
Justus Liebig, 1:209
Carl Linnaeus, 1:208
R. H. MacArthur, 1:210
Ernst Mayr, 1:210
Christen Raunkiaer, 1:210
Philip Ludley Scater, 1:209
Arthur Tansley, 1:210
Alfred Russel Wallace, 1:209
Alfred Wegener, 1:209
Robert Harding Whittaker, 1:210
E. O. Wilson, 1:210
Biome: boreal forest, 1:214–217
as biodiversity conversation resource, 1:215
broad-leaved deciduous trees in, 1:215
carbon cycle and, 1:214, 1:215
coniferous tree species in, 1:214
commercial timber harvest disturbance in, 1:217
coniferous tree species in, 1:215
cultural significance of, 1:217
dead trees and, 1:216
disease development projects disturbances in, 1:217
fire effects and, 3:1156–1159
forest fragmentation and, 3:1159–1163
forest land use and, 3:1163–1165
geographic boundary definitions of, 1:214
high northern latitudes location of, 1:214
Holocene warm period and, 1:459
indigenous cultures of, 1:217
insect infestation disturbance in, 1:217
large and small herbivorous species of, 1:215
natural and human-caused disturbances in, 1:216–217
Northern Ontario, Canada, 1:216 (photo)
peat fires, peat mining disturbances and, 1:216–217
peatlands formation and, 1:215
permafrost distribution and, 1:215
prey species of, 1:215–216
severe midlatitude climate and, 1:442
vegetative form boundary definitions of, 1:214–215
warming trends, vegetation shifts and, 1:214
wildland fires disturbances and, 1:216
See also Periglacial environments
Biome: desert, 1:218–223
arid deserts, features of, 1:218, 1:220–221
arid deserts, flora and fauna of, 1:220–221
arid deserts, location of, 1:221
arid deserts, overgrazing in, 1:220 (photo)
arid deserts, springbok of Kalahari Desert, 1:221 (photo)
adaptability measure, calculation and, 1:218
categorization of, 1:218
description of, 1:218
dry climate and, 1:428–435
hyperarid deserts, features of, 1:218, 1:221–223
hyperarid deserts, flora and fauna of, 1:222, 1:222 (photo)
hyperarid deserts, location of, 1:222
hyperarid deserts, sand dunes, 1:223 (photo)
semi-arid deserts, features of, 1:218–219
semi-arid deserts, flora and fauna of, 1:219
semi-arid deserts, location of, 1:219–220
semi-arid deserts, wildlife of East Africa, 1:219 (photo)
See also Dunes; Environmental management: drylands
Biome: midlatitude deciduous forest, 1:223–226
alfisols vs. ultisols soil variations in, 1:224–225
climate variations in, 1:224
disturbances in, 1:226
disturbances of, 1:223–224
human-induced disturbances and, 1:226
insect disturbances and, 1:226
leaf loss and leafing out timing and, 1:225
light variations in, 1:225
mild midlatitude climate and, 1:435–439
mountain ranges and glaciers factors affecting, 1:224
old-growth forest, primary forest rarity and, 1:226
passenger pigeon extinction and, 1:224
productivity diversity in, 1:225
second-growth forest and, 1:226
severe midlatitude climate and, 1:440–441
shade tolerance variations in, 1:225
structure and composition of, 1:223–224
tree associations in, 1:224
tropical deciduous forest
old-growth forest, primary forest rarity and, 1:226
passenger pigeon extinction and, 1:224
productivity diversity in, 1:225
second-growth forest and, 1:226
severe midlatitude climate and, 1:440–441
white-tailed deer prevalence in, 1:224
See also Periglacial environments
Biome: midlatitude grassland, 1:227–230
animal use of, 1:229
crop species of, 1:227
domesticated grain crops and, 1:229
domesticated grain crops and, 1:227
domesticated grain crops and, 1:227
geographic locations of, 1:227
glossary of, 1:227
glossary of, 1:227
grass seed dispersal mechanisms and, 1:227
grass species of, 1:227–229, 1:228 (fig.)
human interactions and maintenance and, 1:229
nutrient rich soil and, 1:229
overgrazing damage and, 1:229
photosynthetic grass types and, 1:227, 1:228 (fig.)
See also Biome: midlatitude grassland: grasses
Biome: midlatitude grassland: grasses
Andropogoneae, 1:228
Andropogon gerardii, 1:227
Arundinaria, 1:229
Aveneae, 1:228
Chloridoideae, 1:227, 1:228
Nassella, 1:229
Paniceae, 1:228
Pbragmites, 1:229
Piptochaetium, 1:229
Poa pratensis, 1:227
Puccinellia nutaliana, 1:227
Spartina, 1:229
Spinifex, 1:228–229
Stipa, 1:229
Stipeae, 1:228, 1:229
Ticiteae, 1:228
Biome: tropical deciduous forest, 1:230–233
Adansonia (baobob), Western Madagascar, 1:231, 1:232 (photo), 1:239
bush fallow farming practiced in, 1:301–302
in East Africa, 1:232 (fig.)
evergreen to deciduous forests transition and, 1:230
fauna diversity in, 1:231–232
features of, 1:230
forest degradation and, 3:1156–1159
forest fragmentation and, 3:1159–1163
forest land use and, 3:1163–1165
fuel wood and charcoal sources and, 1:232
geographic locations of, 1:230
mammal population densities in, 1:232
midlatitude deciduous forest vs., 1:223
road construction factor in, 1:232
seasonally wet and dry or monsoon climates and, 1:230
seasonal rainfall patterns of, 1:230–231
semi-evergreen forest, Tina River, Kenya, 1:233 (photo)
soil conditions in, 1:231
tree species composition of, 1:230–231
tropical rain forest vs., 1:230
tropical savanna vs., 1:230
tropical scrub similarities to, 1:245
valuable timber harvesting and, 1:232
See also Biome: midlatitude grassland: grasses
Biome: tropical rain forest, 1:234–239
biodiversity hotspots in, 1:200, 1:200 (fig.)
biogeographical patterns of diversity in, 1:234–235
broad-leaved evergreen trees and, 1:235
cloud forests and, 1:237, 1:238 (photo), 1:239 (photo)
community plant types and, 1:237
competition for light, nutrients, and reproduction in, 1:235–236
day lengths of, 1:234
decomposition and chemical weathering in, 1:236
deforestation rates and, 1:238, 4:1683–1684
ecolgical structure, function, and dynamics of, 1:235–237
extractive reserves and, 2:1072–1073
faunal diversity in, 1:236
forest degradation and, 3:1156–1159
forest land use and, 3:1163–1165
geographic locations of, 1:234
heath forests, Kerangus in Sabah, Malaysia, 1:237, 1:237 (photo)
human interactions with, 1:237–238
interdependencies among animals in, 1:236
montane cloud forests, Eastern Arc mountains, 1:238 (photo)
montane cloud forests, Mt. Kinabalu, Sabah, Malaysia, 1:239 (photo)
monthly precipitation of, 1:234
oldest, most weathered landscapes in the world and, 1:236
plant adaptations in, 1:235–236, 1:235 (photo), 1:236 (photo)
structural layers of, 1:235
tall emergent trees in, 1:235 (photo)
temperature conditions of, 1:234
tropical deciduous forest vs., 1:230
woody plant groups and, 1:235
Biome: tropical savanna, 1:239–243
acacia-dominated savanna on black-cotton soils, Kenya, 1:241 (photo)
agricultural and pastoral populations conflict and, 1:243
biogeographical patterns of diversity in, 1:239
bush fallow farming practiced in, 1:301–302
climatic conditions in, 1:239–240
disturbance ecology and derived savannas. 1:241–243
ecological adaptations of, 1:240–241
fire factor and, 1:242
geographical location of, 1:239
gerenuk browning, arid bush savanna and, 1:242 (photo)
grasses and woody plants mixture in, 1:239, 1:240–241
grazing and browsing by animals and, 1:241
large animal diversity in, 1:242
Masai Mara, Kenya, 1:240 (photo), 1:243 (photo)
plant adaptations in, 1:240–241
rainfall seasonality of, 1:240
savanna and, 1:239
soil conditions in, 1:241
tropical to subtropical wet-dry climate of, 1:239–240
 tropical deciduous forest and tropical scrub overlap with, 1:239
tropical deciduous forest vs., 1:240
 tropical scrub similarities to, 1:244, 1:245
Biome: tropical scrub, 1:244–246
annual precipitation gradient of, 1:244
evolutionary convergence and, 1:244
fire and, 1:244
geographic locations of, 1:244
herbivore disturbances and, 1:245
human interaction disturbances and, 1:245
multi-stemmed woody plants of, 1:244
soil characteristics of, 1:244
thorn woodland plants of, 1:244
tropical deciduous forest similarities to, 1:245
tropical savanna similarities to, 1:244, 1:245
vulnerable species protection needs and, 1:245–246
wind disturbances and, 1:245
woody plant invasion in, 1:245
Biome: tundra, 1:246–251
Arctic geographical definition and, 1:247
climate changes in, 1:247
geographic locations of, 1:247
Low vs. High Arctic tundra and, 1:249
mixed and coniferous forests of, 1:247
mixed vegetation types and, 1:249, 1:250 (photo)
North American vs. Eurasian continent variations and, 1:247, 1:248 (table)
peat depths and, 1:249
polar semideserts, 1:249
polar semideserts and, 1:249
shrub tundras, 1:247–248
soil formation and characteristics of, 1:249–251
soil podzolization soil formation process and, 1:250
subzones within, 1:247
tundra and, 1:249
tundra definition and, 1:246
tussock and sedge-dwarf shrub tundras, 1:248–249
wet tundras, 1:249
Zackenberg valley, northeastern Greenland, 1:250 (photo)
See also Periglacial environments; Permafrost
Biophysical remote sensing, 1:251–254
advances in and applications of, 1:254
atmospheric remote sensing and, 1:157–161
canopy reflective indices of, 1:254
electromagnetic radiations interpretation and, 1:251
enhanced vegetation index of, 1:254
Fire Weather index of, 1:254
individual green vegetation factor in, 1:253
leaf area index (LAI) technology of, 1:254
MODIS Terra Image of Greece and, 1:252 (photo)
nighttime vs. daytime images and, 1:252–253
physical quality of life measures of, 1:254
plant canopy productivity information
importance and, 1:251
predictive abilities of, 1:251
remote sensing definition and, 1:251
soil moisture electromagnetic radiation factor and, 1:253
topography factor in, 1:252–253
vegetation, spectrally different classifications of, 1:253–254
warm-and-cool patterns displayed by, 1:251
weather behavior patterns displayed by, 1:252
wind patterns displayed by, 1:251–252
Bioregionalism, 1:255
criticism of, 1:255
definition of, 1:255
ecosheds and, 2:857
human-ecological relations framework of, 1:255
interdisciplinary nature of, 1:255
normative characteristic of, 1:255
permaculture and, 4:2152–2153
sustainability development and, 1:255
themes of, 1:255
Biosphere reserves, 1:256–257
biogeochemical cycles and, 1:204–208
cities and, 2:942–943
core, buffer, and transition zones of, 1:256
core development strategies in developing
countries and, 1:256
environmental protection function of, 1:236
financial support issues of, 1:257
functions demonstrated by, 1:256
humans and natural landscapes connections and, 1:257
Our Common Future (World Commission on Environment
and Development) and, 1:256, 6:2737
parks and reserves and, 4:2117–2120
periodic review by UNESCO and, 1:256–257
scientific research and education function of, 1:256, 1:257
Seville Strategy of 1995 (UNESCO) and, 1:256
socio-ecological systems focus of, 1:257
sustainable resource use function of, 1:256, 1:257
UNESCO creation and recognition of, 1:256
watersheds or landscape-level features basis of, 1:256
Biota and climate, 1:257–264
altitudinal gradient factor and, 1:262
biodiversity and, 1:197–201
biota’s influence on climate and, 1:263–264
biotic environment and, 1:257
bird species, Australia, and, 1:262 (photo)
boreal forest biome and, 1:214–217
carbon sinks, plants and, 1:264
climate as cause vs. constraint on diversity issue, 1:262
climate opportunity vs. threat and, 1:258
climate-plant relationships and, 1:259–260
clima’s influence on biota and, 1:258–263
climatic envelope modeling, 1:259
climograph and, 1:259, 1:259 (fig.)
conservation biogeography and, 1:264
current and future research directions in, 1:265
definitions, 1:257
depth gradient of oceans factor and, 1:262–263
evolution, organisms adapting to climate and, 1:258–259
historical biogeography and, 1:258
latitude diversity gradient and, 1:198–200, 1:260, 1:260 (fig.)
macroecology field and, 1:260
ocean salinity and Earth’s surface temperature constants and,
1:263–264
phenology of plants, climate change and, 1:263
photosynthesis process and, 1:258, 1:259, 1:263
Plectrohyla exquisita frog, Cusuco National Park, Honduras,
1:261 (photo)
spatial patterns of species richness and, 1:262
species dispersal factor and, 1:263
species richness and, 1:260–263, 1:260 (fig.), 1:262 (fig.)
species traits factors and, 1:263
sun’s angle of incidence factor and, 1:263
temperature and ambient conditions and, 1:258, 1:259 (fig.)
tropical montane rain forest, Cusuco National Park, Honduras,
1:261 (photo)
tundra biome and, 1:246–250
See also Biota and soils; Biota and topography;
Biota migration and dispersal
Biota and soils, 1:264–270
animal bioturbations’ subprocesses and, 1:267–269,
1:268 (fig.), 1:274
biota role in soil formation and it biomantle, 1:267–269
computer animation and, 1:269
tfive factors soil formation model and, 1:265–266
gatekeeper soil documents and, 1:263–266
1993 Soil Survey Manual and, 1:265–266
1999 Soil Taxonomy and, 1:265–266
organisms (numbers of) in soil and, 1:267
research trends in, 1:264
rooted plants environments and, 1:266
slough mud and, 1:264–265
soil biomantle, 1:265
soil definitions and, 1:265–266
soil forming underwater concept and, 1:265
soil paradigms and, 1:265
thicknesses and whole soil biomantles and, 1:269
two-layered biomantle and, 1:268 (fig.)
universal soil definition and, 1:266–267
See also Biota and climate; Biota and topography; Biota
migration and dispersal
Biota and topography, 1:270–276
alluvial bar of River Allier, France, and, 1:272 (photo)
bearer dam, Alaska, 1:274, 1:274 (photo)
below-ground burrowing animals and, 1:274
Biota migration and dispersal, biogeography and, 1:270
biogeomorphology and, 1:270, 1:271–272
bioturbation and, 1:267–269, 1:268 (fig.), 1:274
buildings concentrations and, 1:275, 1:275 (photo)
control of topography by microorganisms, insects, and animals, 1:273–274
control of topography since Precambrian era and, 1:273
control of topography through human activities at a global scale, 1:275–276
crayfishes activity and, 1:274
deforestation of Mediterranean catchments and, 1:275
earthworm activity and, 1:274
exogenetic weather agents topographic component, 1:271
global warming, climate change and, 1:276
landform materials topographic component and, 1:271
large mammals and, 1:274
life as an evolving force concept and, 1:272
Manhattan from Empire State Building, New York City, 1:275 (photo)
photosynthesis process and, 1:273
plant control of topography on continents and, 1:273
sedimentary and biochemical cycles and, 1:273
tectonics topographic component and, 1:271
topography: definition by substrate cohesion and physicochemical agents and, 1:270–271
topography: significant control through biota and, 1:271–272
trees’ topography modification and, 1:273
See also Biota and climate; Biota and soils;
Biota migration and dispersal
Biota migration and dispersal, 1:276–278
biodiversity and, 1:197–201
bird migrations and, 1:276–277
breeding experience of dispersing individual and, 1:277
definitions, 1:276
dispersal process stages and, 1:277
 genetic control and environmental variation factors in, 1:277–278
habitat variability and, 1:277
invasion and succession and, 3:1627
mate or mating cues as triggers of, 1:277
seasonal cues as triggers of, 1:277
See also Biota and climate; Biota and soils; Biota and topography
Biotechnology and ecological risk, 1:278–279
agricultural biotechnology and, 1:33–34
applications of, 1:278
ecological risk and, 1:279
Farm-Scale Evaluations (U.K.) and, 1:279
genetically modified organisms (GMOs) and, 1:278–279, 3:1197–1199
geography and holism and, 1:279
GMO crops, ecological risk of, 1:279
GMO crops, first and second generation and, 1:278
herbicide tolerant (HT) “super weeds” and, 1:279
plant “gene escape” issue and, 1:279
recombinant DNA vs. 1:278
risk assessment vs. risk analysis” and, 1:278
selective plant breeding example of, 1:278
“super fish,” 1:278
terminology, 1:278
Biotechnology industry, 1:280–282
agricultural biotechnology and, 1:33–34
definitions, 1:280
district clustering of, 1:280–281, 1:281 (fig.)
federal research funds and, 1:280
government involvement in, 1:280
industry statistics and, 1:280
national science policies and, 1:280
pharmaceutical firms and, 1:280
research universities and scientists importance to, 1:281
U.S. biotechnology centers and, 1:281 (fig.)
venture capital importance in, 1:280
See also Agricultural biotechnology
Biruni, 1:282–284, 1:282 (image)
astronomical work of, 1:282
chorography and physical geography work of, 1:283, 3:1461
early education of, 1:282
empirical science, experimental and comparative methods of, 1:282
mathematical geography work of, 1:283
publications of, 1:282–283
theory of solar motion work of, 1:282
Bivand, Roger, 5:2637
Black, James Wallace, 4:2176
Black Sea, 1:487–488
Blaikie, Piers, 1:284–285
comparative environmental policy work of, 1:284
India, Nepal, and Himalayas work of, 1:284
political ecology (PE) work of, 1:284, 5:2213
publications of, 1:284
Blaut, James, 1:285–286
academic life of, 1:285
colonialism work of, 1:285, 4:1862
Eurocentrism work of, 1:285, 2:1030, 4:1862
multi-disciplinary work of, 1:285
publications of, 1:285
social justice work of, 1:285
spatial cognition of children work of, 1:285
Blindness and geography, 1:286–288
acoustic production of space and, 1:286
Reginald Golledge’s work in, 1:286, 1:287 (photo)
humanistic geography and, 1:286
navigation aids for visually impaired and, 1:286–287
navigation system for visually impaired, 1:287 (photo)
nonvisual space negotiation and, 1:286
policy implications, 1:286
social experience of visually impaired in public spaces, 1:286
spatial competence achievement and, 1:286
Bliss, L. C., 1:249
Bloch, Marc, 3:1090
Bloom, George, 3:1449
Bloomley, Nicholas, 4:1764
Blumer, Herbert, 3:1625
Blunt, Alison, 5:2325
Boas, Franz, 5:2323
Body, geography of, 1:288–291
behavioral geography and, 1:288
blindness and geography and, 1:286–287
Judith Butler’s feminist geographies work and, 1:289
disability geographies and, 2:757–759
embodied geography and, 1:289
empirical knowledge and, 1:290
ethnomet hodological account and, 1:289
face-to-face interaction rituals and, 1:289
feminist accounts and, 1:289
Michel Foucault’s work and, 1:289
humanistic geography and, 1:288
knowledge production, situated knowledge and, 1:290
Marxist geography and, 1:288
methodology after performative turn and, 1:290
mind-body dualism and, 1:288
nonrepresentational theory and, 1:290
“Othering” of the body and, 1:288
performative turn of, 1:289–290
poststructuralist account and, 1:289
power and knowledge relationship and, 1:289
time-geography and, 1:288
traditional geographical view and, 1:288
tropical deciduous forest in, 1:230
tropical scrub in, 1:230
Tijuana, Mexico, U.S. border
superimposition of borders, ethnic societies and, 1:292
structuralism
high-tech economic geography and, 2:509, 1:722–724, 2:309
megapolis element of, 3:1355–1356
structuralism and cultural hegemony, 1:211, 2:602
structural theory and, 1:205, 2:92
structuralization
interaction and passage between political regions and, 1:291, 1:292
La Paz Agreement (U.S. and Mexico) and, 1:291
multispectral image of U.S.-Mexico border, California, 4:1955 (photo)
superimposition of borders, ethnic societies and, 1:292
Tijuana, Mexico, U.S. border, 1:291 (photo)
See also Borders and boundaries
Borders and boundaries, 1:291–292
common concerns of bordering populations and, 1:291
cross-border cooperation and, 2:630–631
deforestation in, 2:679
economic integration and, 1:291
economic integration and, 2:630–631
economically active females in, 3:1190 (table)
environmental privatization in, 4:2009
Heavily Indebted Poor Countries initiative and, 2:690
income ratio relative to slum population in, 2006, 5:2644 (fig.)
Internet access in, 2:749
silver trade and, 1:511
tropical deciduous forest in, 1:230
tropical scrub in, 1:245
water privatization in, 5:2317
Bondi, Liz, 2:892
Booth, Charles, 5:2565–2566
Borderlands, 1:291–292
Bordieu, Pierre, 2:1043
Boserup, Ester, 1:49
agroforestry practices and, 1:562
Conditions of Agricultural Growth written by, 1:36
world and regional population factors and, 5:2238
Bosnia-Herzegovina
AGILE membership of, 1:124 (table)
cultural annihilation in, 3:1200
economically active females in, 3:1190 (table)
Hajji Alija Mosque, Počitelj, 5:2406 (photo)
hate groups in, 3:1407
human rights violations in, 3:1480
Boston, Massachusetts
“Big Dig” infrastructure construction in, 3:1595
central business district of, 1:379
deterritorialization and reterritorialization and, 3:1598, 5:2435, 5:2436
megapolis element of, 3:1355–1356
musical instrument industry in, 4:1821
rail hub in, 5:2358
Botswana
economically active females in, 3:1190 (table)
David Livingstone exploration of, 2:1057
Boughassi, Carmina, 1:294–295
advanced chemical techniques developed by, 1:243
Antarctica travels of, 1:242–243
paleogeographies studied by, 1:243
penguin seasonal migration patterns work of, 1:294
Bourdieu, Pierre
built environment work of, 1:298–299
classed capitals and classed habitus concepts and, 1:421–422
classing of spaces and subjectivities work of, 1:421, 4:1786
self-reflexivity qualitative method and, 5:2325
structuring and, 3:1278
Bowman, Isaiah, 1:295–296
American liberal internationalism and, 1:295
Council of Foreign Relations co-founded by, 1:295, 3:1465
economic integration and, 5:2222
5:2222, 5:2307
Johns Hopkins and, 1:296, 3:1465
Latin America and the Andes focus of, 1:295, 3:1465
Paris Peace Conference and, 1:295, 5:2307
political geography of natural resources and, 5:2222
settlement geography views of, 5:2336
United Nations work of, 1:296
Derwent Whittlesey and, 6:3097–3098
Boyden, Stephen, 3:1458
Boyle, Ray, 3:1283
Bracken, L. J., 3:1512
Braudel, Fernand, 1:779, 3:1090, 4:2070
Brazil
agricultural landownership distribution in (2003), 4:1949 (figs.)
agroforestry in, 1:57
automobile industry in, 1:169
biofuels produced in, 1:202
Gilberto Câmara, GIScience and remote sensing work of, 1:319
China-Brazil Earth Resources Satellites and, 1:319
Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)
deforestation in, 1:319, 2:696, 2:698
drought prone region in, 2:787
ecological footprint and biocapacity of, 2:827 (table)
Built environment, 1:298–300
GHG emissions of, 3:1375–1376
government regulation of, 1:298
grounded capital and, 5:2639–2640
historic preservation and, 3:1435
Hong Kong example of, 1:299 (photo)
interdisciplinary element of, 1:298
landscape architecture history and, 4:1699
soiety and culture reflected by, 1:298–300
spatial fix and, 5:2639–2640
Bulgaria
COMECON membership of, 2:593 (table)
economically active females in, 3:1190 (table)
European Union (EU) membership of, 2:1035
international outsourcing between Western Europe and, 4:1209 (fig.)
Bullard, Robert, 2:986
Bunge, William, 1:300–301
Brian Berry and, 1:192
children’s health and survival focus of, 1:300
countermapping by, 2:595, 3:1645
Detroit Geographical Expedition urban fieldwork of, 1:300,
4:1862, 5:2350
early years of, 1:300
Fitzgerald written by, 1:118, 1:300
mapping never-before-shown variables, 1:300, 2:595
Nuclear War Atlas written by, 1:300
as quantitative and scientific geographer, 1:300, 3:1466
radical geography and, 1:300, 3:1466, 3:1645, 5:2350
regional geography and literature work of, 1:118, 1:300, 5:2238
Bunsen, Robert, 1:1542
Burgess, Ernest, 1:386, 1:387–388, 1:387 (fig.), 3:1112,
3:1449, 4:1728, 5:2323
Burkina Faso
economically active females in, 3:1190 (table)
poverty rates in, 5:2274
Burma
British colonization of, 1:515, 1:516
colonization of, 1:516
drug culture in, 2:799
nation-state after colonialism in, 1:517
opium and heroin production in, 2:797
Burundi
economically active females in, 3:1190 (table)
undernourishment in, 3:1487
Bush, Vannevar, 6:2740–2741
Bush fallow farming, 1:301–302
agricultural goals of, 1:301
criticism of, 1:301–302
crop diversity and, 1:301
as ecologically sound agroforestry, 1:302
geographic locations of practice, 1:301
land rotation between different uses and, 1:301
shifting cultivation and, 1:301
soil nutrients replenished by, 1:302
swidden/slash-and-burn cultivation and, 1:301–302, 2:696
tropical forest biodiversity threatened by, 1:301–302
varieties of methods of, 1:301
Business cycles and geography, 1:302–305
business services element in, 1:304
capitalism instability and, 1:302
communication technology element in, 1:303
“creative destruction,” 1:303
factors affecting location of firms and, 3:1077–1080
Industrial Revolution and, 1:303, 3:1581–1586
information technology and, 1:303
innovation geographies and, 3:1397–1599
Kondratieff waves and, 1:302, 1:303–304
Simon Kuznets’ work in, 1:303
regulation theory and, 5:2399–2402
Joseph Schumpeter’s work in, 1:303
spatial division of labor and, 1:304
Spatial Divisions of Labor (Massey) and, 1:304
uneven development in space and, 1:304
See also Crisis (economic); Kondratieff waves, business cycles
Business geography, 1:305–306
in academia, 1:305–306
business decisions enhanced by, 1:305
business models for geographic information systems and, 1:306–308
Certified Commercial Investment Manager academic program and, 1:305
cost-benefit analysis used in, 2:592–593
distance-decay retail consumer demand interactions and, 1:305
e-commerce and, 2:844–846
factors affecting location of firms and, 3:1077–1080
future of, 1:306
godemographics and, 3:1215–1217
geographic management systems technology and, 1:305
geospatial technologies and, 1:305
location analysis methods and, 1:305
qualitative elements of, 1:305
real estate geographies and, 5:2367–2369
spatial management objectives element of, 1:305
spatial tracking of products and, 1:305
undergraduate degree program model in, 1:306
Business models for geographic information systems (GIS), 1:306–308
applications of, 1:306–307
business strategy and, 1:308
cost-benefit analysis used in, 2:592–593
databases element of, 1:308
decision support systems (DSSs) and, 1:307
distributed computing and, 2:774–776
Enterprise GIS, 2:911–913
Enterprise Resource Planning (ERP) system and, 1:307
GIS-IT business alignment model and, 1:308
management models of, 1:308
managing spatial data and, 1:308
models of, examples, 1:307
spatial decision support system (SDSS) and, 1:307
Web and mobile spatial applications of, 1:307
Butler, Judith, 1:289, 3:1192, 5:1529, 4:2042
Buttimer, Anne, 1:308–309
academic career of, 1:308
genres de vie life worlds, 1:309, 3:1476
Torsten Hagerstrand’s collaboration with, 3:1398
phenomenology views of, 4:2167
philosophy of geography views of, 1:309
professional positions held by, 1:308–309
qualitative methods and, 5:2324
recentering the human subject views of, 2:1046
research themes of, 1:309
social and humanist geography work of, 1:308–309, 2:1046,
3:1476, 4:1786, 4:2167
social justice work of, 1:309
sustainable development work of, 1:308–309
time-space rhythms and, 6:2836
Values in Geography written by, 4:2167
Butzer, Karl, 2:633
agriculture impact on, 2:938, 2:939
atmosphere, 1:326 (table), 1:328
atmosphere, hydrosphere, lithosphere and biota linked by, 1:325–326
biologic pump concept and, 1:328
biota and, 1:326
boreal forest biome and, 1:214, 1:215
carbon building blocks of life and, 1:206
carbon pools in modern Earth, 1:326 (table)
forest land use and, 3:1164
fossil fuels, climate instability and, 1:206, 2:601
global level of spatial scale and, 2:863–864
global oxygen cycle and, 1:205–206
greenhouse effect and, 1:326, 1:327
human emissions factor in, 1:206, 2:601
hydrologic cycle and, 1:205–206
land use and cover change impact on, 4:1736
lithosphere, 1:326–327, 1:326 (table)
major fluxes in, 1:326, 1:327 (table)
major fluxes in production and, 2:945
nitrogen cycle and, 4:2028–2029
oceans and, 1:206, 1:327–328
oil fields and, 2:947
peat and, 4:2142–2143
permafrost degradation and, 4:2156
photosynthesis and, 1:326, 1:327 (table)
respiration and, 1:206
rock weathering and, 1:325, 1:326–327
sustainable forestry and, 6:2759
Urey reaction and, 1:327
Venus, Earth, and Mars, carbon in atmospheres of, 1:326
volcanic activity and, 1:327, 1:328
See also Carbonation; Greenhouse gases (GHGs)
Carbon trading and carbon offsets, 1:329–335
allowance-based vs. project-based markets and, 1:330
cap* on total emissions and, 1:330
carbon markets, trading volume and value, 1:329, 1:332 (table)
carbon markets and emissions trading, critiques of, 1:332, 1:334–335
carbon offsets growth projections, 1:333 (fig.)
carbon tax issue and, 1:334–335
carbon trading under International Climate Regime and, 1:330, 1:332, 1:333 (fig.)
Clean Air Act (CAA, U.S.) and, 1:330
climate policy and, 1:462–464
current carbon markets and, 1:330, 1:332
definitions, 1:329
environmental markets for, 4:2009
European Union’s Emissions Trading Scheme and, 1:330, 1:331 (table), 1:334
grandfathering of allowances issue and, 1:334
greenhouse gas emissions and, 1:329, 1:330, 1:334
Kyoto Protocol and, 1:330, 1:332, 1:333 (fig.), 2:900, 4:1857
luxury vs. survival emissions issue and, 1:334
optimal pollution level concept and, 1:329–330
privatization of “atmospheric sink” issue and, 1:332, 1:334
social and political contexts, 1:334
social costs of economic activity and, 1:329–330
theoretical foundations of carbon trading and, 1:329–330
voluntary markets and, 1:330
See also Climate policy; Greenhouse gases (GHGs)
Carcinogens, 1:335–337
cancer cluster investigations and, 1:336
cancer geography and, 1:320–324
definitions, 1:335
immigrant studies and, 1:335–336
lists of, 1:335
reliable data in studies of, 1:336
Cardoso, Fernando, 2:713
Caribbean islands
adults and children living with HIV in 2007 in, 3:1437 (fig.)
British Empire colonies in, 1:514
coca cultivation in, 2:797
Cold War and, 1:504
colonial powers in, 1:512
HIV/AIDS in, 3:1438
land inequalities in, 4:1693
military expenditures in, 4:1899 (table)
neoliberalist policies in, 4:2012
plantations in, 5:2192
political map of, 6:3162
population growth of, 5:2233 (fig.)
poverty rates in, 5:2275
slave trade in, 1:511–512
tropical deciduous forest in, 1:230
tropical rain forest of, 1:234
undernourishment in, 3:1488, 3:1488 (table)
Carlowitz, Hans Carl von, 6:2737
Carney, Judith, 3:1100
Carpenter, Steve, 5:2439
Carrying capacity, 1:337
British colonialism, African populations and, 1:337
definition of, 1:337
human populations and, 1:337, 5:2238–2239
laboratory experiments, 1:337
living organisms and natural systems and, 1:337
tourism industry, 2:855
Pierre-François Verhulst’s logistic equation and, 1:337
Carson, Rachel
conservation efforts of, 2:570
endangered marine environment and, 4:2068
environmental ethics work of, 2:925, 6:2743
Silent Spring written by, 2:831, 2:934–935, 2:980–981, 4:2158, 6:2743
sustainable agriculture and, 6:2743
Cartier, Jacques, 4:2179
Cartograms, 1:338–339
area estimation difficulty in, 1:339
continuous vs. noncontiguous cartograms, 1:338–339
explanation of, 1:338
linear or distance cartograms, 1:338
themetic variable distribution factor in, 1:339
Waldo Tobler, computer program production of, 1:338
2004 presidential election cartogram map, 2:880, 2:880 (fig.)
value-by-area cartogram, 1:338, 1:338 (fig.)
Cartography, 1:339–345
Age of Exploration maps, 1:342
ancient and indigenous civilization maps and, 1:341
animated maps, 1:344
art component of, 1:339
cartograms and, 1:338–339
cartographer definition and, 1:339
cartographic ethics and, 1:344
cartographic or mapmaking process and, 1:342–343
categories of maps and map uses and, 1:339–340
choropleth map, 1:343
cognition and perception skills in, 1:339, 1:343
color in map design and, 1:516–522
countermapping and, 2:595–596
data representation or symbolism and, 1:343
decision-making process assistance and, 1:340
definition of, 1:339
digital maps and GPS technology and, 1:344
dot maps and, 2:787–790
dynamic and interactive displays and, 2:804–808
Earth’s circumference estimation and, 1:341
electronic atlases and, 2:884
equivalent vs. conformal vs. equidistant map projection and, 1:342
flow maps and, 3:1138–1139
goadesy and, 3:1217–1219
Geographia (Ptolemy) and, 1:341
geographic change over time and, 1:340
geometric measures and, 3:1240–1241
geovisualization and, 1:344
Good’s Interrupted Homolosine projection and, 3:1351, 31351 (fig.)
graduated or proportional symbol map, 1:343
Greek and Roman Empire maps and, 1:341–342
How Maps Work (MacEachren) and, 4:1811
indigenous cartographies and, 3:1561–564
interactive maps, 1:344
isopleth maps and, 3:1638–1639
latitude and longitude coordinate system and, 1:342
Look of Maps (Robinson) and, 1:343
map generalization and, 4:1835–1841
map scale, generalization, coordinate systems, and map projections and, 1:342
Middle Ages maps, 1:341–342
modern cartography and, 1:344
multivariate mapping and, 4:1963–1967
navigation or wayfinding purposes of, 1:339
Ortelius’s Map of Palestine and the Holy Lands, 1:341 (fig.)
Peutinger Table, Roman road network map, 1:341
privacy issues and, 1:344
reference map classification, 1:340, 1:340 (fig.)
Renaisance maps, 1:342
representations of space and, 5:2432–2433
resources management and, 1:340
science component of, 1:339
social, cultural, and ethical aspects of, 1:344
statistical maps, 1:340
technology advances in, 1:343–344
thematic map classification, 1:340, 1:340 (fig.)
3D and virtual reality map displays, 1:344
T-O maps, 1:341–342, 1:349
trap streets and, 6:2877
trends or patterns display and, 1:340
university programs of, 1:342
user feedback maps and, 1:343
visual variables and, 1:343
Web-based maps and, 1:344, 1:359
Western cartography history and, 1:340–342
See also Cartography: noted individuals; Cartography, history of; Environmental mapping; Map design; Map projections; Map visualization; Political maps; United States: maps

World maps
Cartography: noted individuals
al-Idrisi’s world map, 1:66–67, 1:350, 1:351 (fig.), 3:1461
Balbi and Guerry, 1:335
Chimborazo, 1:335
Dud Dudley, 1:355
Eratothenes, 1:341
Edmond Halley, 1:355, 1:357 (fig.)
Brian Harley, 3:1401–1402
Jodocus Hondius, 1:342
Alexander von Humboldt, 1:355
Gerardus Mercator, 1:342, 1:350, 1:353 (fig.), 3:1461, 4:1883–1885
Mark Monmonier, 4:1938–1938
Ortelius, 4:2104–2106
Abraham Ortelius, 1:341 (fig.), 1:342, 1:350
Prince Henry the Navigator, 1:342
Claudius Ptolemy, 1:341, 1:347, 1:348 (fig.), 1:350, 5:2300, 5:2387
Erwin Raisz, 5:2364–2365
Arthur Robinson, 1:343, 4:1844, 4:1845 (fig.), 5:2364
John Snow, 1:355
Bradford Washburn, 1:356 (fig.)
Edward Wright, 1:350, 1:353 (fig.)

Cartography, history of, 1:345–364
Anaximander’s work and, 1:74–75
base map of, satellite image, Ukraine, 1:360, 1:360 (fig.)
Book of Roger (al-Idrisi) and, 1:350
cadastral systems and, 1:311–318
celestial map, 1:346, 1:346 (fig.)
climatic, biotic, and sociocultural environment mapping and, 1:355
cognitive maps, 1:346
Christopher Columbus and, 1:74–75, 4:2179
community infrastructure organization function and, 1:346
contour lines and, 1:350, 1:356 (fig.)
cosmological maps, 1:346–347
cuneiform wring on clay tablets, 1:346, 1:347 (fig.)
cyberspace mapping concept and, 2:540
Digital Chart of the World and, 1:362
digital databases and, 1:362
digital elevation model (DEM) base and, 1:350
dual functions of maps and, 1:345–346
engraving and printing, painting reproduction, 1:359, 1:360 (fig.)
environmental management function of, 1:346, 1:350, 1:359
environmental sustainability function and, 1:362, 1:364
Eratosthenes and, 2:1010–1011
GIS in environmental management and, 1:364
Good’s Interrupted Homolosine projection and, 3:1351, 3:1351 (fig.)
GPS mapping systems and, 1:362
graphic design and communication and, 1:362, 1:363 (fig.)
hachures technique and, 1:354, 1:354 (fig.)
Brian Harley and, 3:1401–1402
Hipparchus and, 3:1428
indigenous cartographies and, 3:1561–564
Islamic geographers and, 1:350
isobaths lines and, 1:354, 1:355 (fig.)
map visualization and, 1:350
Mediterranean Sea navigation and, 1:350
Mercator projection map, 1:342, 1:350, 1:353 (fig.), 4:1843, 4:1843 (fig.), 4:1883–1885, 6:3168
in 19th and 20th centuries, 1:357, 1:359, 1:362
Ordnance Survey map, 1:354, 1:354 (fig.)
Ortelius and, 4:2104–2106
portolan chart, Mediterranean and North Atlantic navigation, 1:350, 1:352 (fig.)
portolan charts and, 5:2251–2252
printing, commercialization, and democratization of maps and, 1:330
Erwin Raisz and, 5:2364–2365
symbolization of data and map design and, 1:359, 1:362, 1:362 (fig.), 1:363 (fig.)
terrain elevation measurement methods and, 1:354, 1:355 (fig.)
textbook development and, 1:359
Theatrum Orbis Terrarum (Ortelius) and, 1:350
timeline of prehistoric and ancient origins, 1:346–347
timeline of medieval and Renaissance cartography, 1:347, 1:350
timeline of national topographic mapping, 1:350, 1:353–354
(figs.), 1:354, 1:362
timeline of thematic maps, 1:342, 1:354–357
timeline of 21st century, 1:362, 1:364
T-in-O maps, 1:341–342, 1:347, 1:349 (fig.), 3:1461, 6:2845 (fig.)
tint screens, “graphic middle ground” symbols, 1:363 (fig.)
topographic mapping, Mount Everest, 1:356 (fig.)
in the 21st century, 1:362, 1:364
U.S. Census decennial maps, 1:358 (fig.)
wayfinding function of, 1:345
Web-based mapping services and, 1:344, 1:359
World Geodetic System, 1:362
See also Cartography; Map projections
Case, Robbie, 1:391
Casey, Edward, 2:892, 4:2168
Caspian Sea, 1:115
Castells, Manuel, 1:364–366
books written by, 1:365–366
cross-cultural theory of urban social change and, 1:365
empirical research of, 1:365–366
global socioeconomic transformations work of, 1:364–365
informal economy studied by, 3:1591
information technology and, 1:365, 5:2670
Henri Lefebvre and, 4:1769
Marxist theory work of, 1:365, 1:366, 5:2670, 5:2706–2707, 5:2707 (table)
space of flows and, 5:2600–2601, 5:2670
talents and interests of, 1:364–365
technology as force of social change views of, 1:365
urban politics, planning, and policy work of, 1:365
Urban Question written by, 4:1769
Castoradios, Cornelius, 4:2144
Caucasus Mountains, avalanche, 1:177 (photo)
Caverns, 1:366–368
carbonation and, 1:325
Carlsbad Caverns and, 1:368
Cave of Crystals, Chihuahua, Mexico, 1:368
host rock materials and, 1:366–367
hydrogen sulfide gas process and, 1:368
karst topography and, 4:1649–1654
locations and sizes of, 1:368
Mammoth Cave limestone cavern, Kentucky, 1:367, 1:367 (photo)
solution type caverns, 1:366–367
speleogenesis process and, 1:367–368
speleotherms and, 1:368
water tables and, 1:367
Caves. See Caverns
CBA. See Cost-benefit analysis (CBA)
CBC. See Cross-border cooperation (CBC)
CBNRM. See Community-based natural resource management (CBNRM)
Cellular automata (CA), 1:368–371
agent-based models, 1:29
complexity theory and, 2:559–561
complex systems models and, 2:566–567
definition and explanation of, 1:368
geoautomata examples of, 3:1215
geoautomata applications of, 1:370
geoautomata and, 1:370
g eoautomata and, 4:1738
g eoautomata and, 5:473
geometrically fixed neighborhoods viewed by, 1:29
GIS and, 1:370, 3:1313
history and development of, 1:369
land use and cover change models and, 4:1738
land use change over time, 1:371 (fig.)
mathematical formulism of, 1:369–370
model calibration and validation procedures in, 1:370
MOLAND (Monitoring Land Cover/Use Dynamics) project in
Europe and, 3:1313
neighborhoods types used in procedures of,
1:369, 1:369 (fig.)
transition rules element in, 1:369–370, 3:1215
Census, 1:371–373
American Community Survey (ACS) and,
1:372, 1:373 (table)
Census 2000 and, 1:372
Census 2010 and, 1:372
census tracts and, 1:374, 2:669 (fig.)
data security and, 1:372
Decennial Census of Population and Housing (U.S. Census
Bureau) and, 1:371–373
definition of, 1:371
economic census and, 1:372
federal funds distribution and, 1:373
g eographic databases and GIS software and, 1:372
population density by census tract and block group, Guilford
County, North Carolina, 2:669 (fig.)
preparations for, 1:372
survey vs., 1:371
technology advances and, 1:372
Topologically Integrated Geographic Encoding and Referencing–automated mapping database and, 1:372
Census tracts, 1:374
changes in tract geography and, 1:374
demographic changes tracking and, 1:374
development and growth of, 1:374
g eography of disease mapping and, 2:772
neighborhoods concept and, 4:1998
redictions of (1960, 2010) and, 1:374
See also Census
Center for Earth System Research Analysis (CESAR), San Diego
State University, 1:24 (photo)
Centers of domestication, 1:374–378
Amazon basin, 1:377, 1:377 (photo)
animal domestication and, 1:376
crop domestication areas and, 1:374–375, 1:375 (photo)
cultural landscapes concept (Sauer) and, 1:376, 3:1465
dog as oldest domesticated animal and, 1:376
domestication of animals and, 2:781–783
domestication of plants and, 2:784–786
explanation of, 1:374
Fertile Crescent crops and animals, 1:375, 1:376
in situ and adjacent domestication of camu camu trees,
1:377, 1:377 (photo)
natural fires and, 1:376
natural mutations and, 1:376
predomestication cultivation and, 1:375–376
seed dispersal mechanisms and, 1:376
village-based agricultural economies and, 1:375
Central Africa
Bantu or Niger-Kordofanian languages in, 4:1751
malaria in, 4:1816
interational sociology and, 3:1104
interviewing and, 3:1625–1626
Los Angeles School vs., 1:389, 4:1803
multiple nuclei model of urban growth (Harris and Ullman) and,
1:389, 1:389 (fig.)
origins of, 1:386
participant observation methodology and, 4:2121–2122
racial residential segregation studies of, 5:2344
sector model of urban growth (Hoyt) and,
1:388–389, 1:388 (fig.)
sense of community absent in cities and, 1:387
social Darwinism and, 5:2562
social ecology and, 2:607
socially disorganized neighborhoods studied and, 2:607
spatial turn and, 5:2669
urban population density issue and, 5:2238
urban social structure models and, 1:387–389
urban spatial structure models of, 6:2985 (fig.)
zone of transition and, 1:388, 1:388 (fig.)
See also Chicago School: noted individuals
Chicago School: noted individuals
Ernest Burgess, 1:386, 1:387–388, 1:387 (fig.)
Chauncy Harris, 1:389, 1:389 (fig.)
Homer Hoyt, 1:388–399, 1:388 (fig.)
Roderick McKenzie, 1:386, 5:2562
George Herbert Mead, 3:1625
Robert Park, 1:386
Frederick Tönnies, 1:387
Edward Ullman, 1:389, 1:389 (fig.), 5:2329
Louis Wirth, 1:387, 4:1936
Chile, Gordon, 2:1029
Childhood spatial and environmental learning, 1:390–392
Jerome Bruner’s cognitive growth theory and, 1:391
cartographic-scale spaces challenge and, 1:390
challenges in teaching young children and, 1:390
cognitive learning in early and middle childhood and, 1:390–391
cognitive resources and, 1:391
developmental and learning theories and, 1:390–391
graphic learning from immediate and visible and, 1:390
Jean Piaget’s developmental learning theory and, 1:391
spatial primitives concept and, 1:391
See also Children, geography of
Children, geography of, 1:392–394
academic journals of, 1:394
children as active agents concept and, 1:392
Children’s Experience of Place (Hart) and, 1:392
early research in, 1:392
multidisciplinary foundation of, 1:392
summary of research on, 1:393 (table), 1:394
See also Childhood spatial and environmental learning;
Education, geographies of
Chile
basin and range topography in, 1:186
Cold War and, 1:504, 1:505
cooper mine underground processing facility, 4:1912 (photo)
economically active females in, 3:1190 (table)
El Niño-Southern Oscillation (ENSO) and, 2:887, 2:889
El Tatio geothermal area in, 3:1273
environmental privatization in, 4:2009
fjords in, 3:1121
forest plantations in, 5:2195
glaciers in, 3:1332
human rights violations in, 3:1480
inequalities in resource access and, 4:1996
marine aquaculture in, 4:1854, 4:1854 (fig.)
neoliberal economic policies in, 2:1066, 4:2023
neoliberalist policies in, 4:2012
as newly industrializing country, 4:2023
San Rafael Glacier in, 3:1328
social movements research in, 1:365
squatter settlements in, 5:2684
water management in, 4:1996
China
AAG specialty groups focus on, 1:122
acid rain in, 1:7
APEC membership of, 1:121
aquaculture in, 1:102–103
automobile industry in, 1:169, 1:170
biomass for energy production, Guangdong Province, 5:2454, 5:2455 (fig.)
Boxer Rebellion in, 1:515
British trade balance, opium and, 1:515
built environment of, 1:299
camel domesticated in, 2:783
China-Brazil Earth Resources Satellites, 1:319
Clean Development Mechanism (CDM), carbon offsets
and, 1:333 (fig.)
climate change action plans in, 2:902
clothing exports from, 6:2186 (fig.)
coal production in, 1:483–484, 1:485 (fig.), 2:902
CO₂ emissions in, 3:1377, 3:1454
Cold War and, 1:505
collectivized farming in, 2:543
colonialism resisted by, 1:514–515
colonial migrations of, 1500–1914, 3:1543
Cultural Revolution in, 2:543
desert biome in, 1:218
desertification in Dunhuang, Gansu province, 2:716 (photo)
domino theory and, 3:1224
Dong Zhi winter solstice celebration in, 5:2598
drought in, 2:791
dry climate in, Flaming Mountain, Xinjiang, 1:428 (photo)
drought losses in, 4:1984
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
economic restructuring in, 5:2460
ecotourism in, 2:870
electronic waste pollution in, 1:502
ethnocentrism in history of, 2:1027
export-oriented industrialization (EOI) in, 2:1064
fertility levels in, 2:709
foreign aid from, 3:1153
foreign direct investment by, 1:130, 3:1155
foreign direct investment in, 4:2022
forest plantations in, 5:2195
gated communities in, 3:1181
GDP of, 3:1382, 3:1383 (fig.), 4:2022–2023
girls’ education inequalities, Gansu, 5:2642 (fig.)
GIS pioneering in, 3:1283
Great American Exchange and, 3:1362
Great Leap Forward in, 2:542, 2:543
green building programs in, 3:1369
greenhouse gas emissions of, 1:462, 1:463, 1:464, 2:902
groundwater usage in, 3:1386, 3:1387
historical climate records in, 1:456
HIV/AIDS in, 3:1438, 3:1439
Hou Renzhi, modern study of geography in, 3:1443–1444
human rights violations in, 3:1480
humid continental climate of, 1:440
hydroelectric power in, 3:1507, 3:1509, 3:1510
See also China
Ibn Battuta exploration of, 2:1054, 3:1519, 4:2179
IMF voting rights of, 3:1617
import substitution industrialization in, 3:1551
incubator zones in, 3:1552
industrialized agriculture in, 1:44
industrialization in, 2:542, 3:1580, 3:1583, 4:2020
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Internet access limitations in, 2:750
Internet content regulated in, 2:64
Japanese colonization in, 1:514
Japanese electronics industry in, 4:861
karst topography, Li River, Guilin, 4:1630 (photo)
Kyoto Protocol of 1997, greenhouse gas emissions and, 1:463
land inequality in, 4:1693
land use and cover change in, 4:1736
Mandarin language in, 4:1751, 4:1753
 Maoist version of Marxism in, 4:1861
marine aquaculture in, 4:1853, 4:1854 (fig.)
metropolitan development in, 1:299
military expenditures in, 4:1898, 4:1899 (table)
 Mongols preindustrial agriculture in, 1:48
multinational corporations investment in, 5:2220
nationalization in, 2:542
new bridge construction, Guizhou Province (2006), 5:2489 (photo)
as newly industrializing country, 2:4022–2023, 4:2022 (fig.)
nuclear power in, 2:902
oil imports of, 4:2073
oil production in, 4:2099
opium and heroin production in, 2:796–797
Opium Wars and, 1:515
particulate matter pollution in, 1:151
Marco Polo’s exploration of, 2:1053
population growth in, 5:2241
prairie restoration in, 5:2279
remittance flows to, 5:2412
rice paddy cultivation in, 1:48
Roman exploration of, 2:1051
rural migrant worker, Beijing, 5:2497 (photo)
satellite dishes illegal in, 2:750
search for new route to, 2:1054
Shenzhen Special Economic Zone (SEZ) in, 2:1067
Silk road and, 2:1053
silkworm domestication in, 2:783
silver trade and, 1:512
 Special Economic Zones in, 4:2022 (fig.)
strike-slip faults in, 3:1087
Taiping Rebellion and, 1:515
as technology diffusion center, 2:746
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
Three Gorges Dam controversy and, 2:542
topographic mapping in, 1:350
total factor productivity (TFP) of, 6:2780 (table)
transnational corporations in, 3:1154
Typhoon Nina (1975), flash flood, Banqiao Reservoir, 3:1125
undernourishment in, 3:1487
urbanization in, 2:543
U.S. industry moving to, 2:700
waste management in, 5:2372
wind and solar energy in, 2:902
Yellow River flash flood (2008) in, 3:1124
Chinooks /tochins, 1:394–395
environmental consequences of, 1:394
Chomsky, Noam, 3:196, 3:211
Chorley, Richard, 4:103–404
Chorley, Richard, 4:103–404
Chorley, Richard, 4:103–404
Chorley, Richard, 4:103–404
Chorley, Richard, 4:103–404
Chorology, 1:404–405
Anneals School and, 3:1465
areal differentiation and, 1:404, 3:1465
*Geographia Generalis* (Varenius) and, 1:404, 5:2387
graphy and topography vs., 1:404
_ Geography* (Ptolemy) and, 1:404
Geography* (Strabo) and, 1:404, 3:1460
Localities School and, 1:405
positivism replacement of, 1:405
specific vs. general geography (Varenius) and, 1:404
use values of places work (Ritter) and, 1:404

Chorology: notable individuals
Richard Hartshorne, 1:405, 3:1465–1466
Immanuel Kant, 1:404
Alfred Kettner, 1:404
Ptolemy, 1:404, 5:2300, 5:2387
Karl Ritter, 1:404
Fred Schaefer, 1:405, 3:1466
Varenius, 1:404, 4:2179, 5:2387
Paul Vidal de la Blache, 1:404, 3:1465

Choropleth maps, 1:406–408
cartograms and, 1:338–339
classed map of U.S. population density, 1:406, 1:406 (fig.)
daisyometric maps and, 2:669–671
data classification and, 1:407
graphy of disease mapping and, 2:772
interactive change of color technique and, 2:806 (fig.), 2:808
as most common map, 1:406
multivariate mapping, U.S. murder rates and families in poverty and, 4:1965, 4:1965 (photo)
Natural Breaks classification method used by, 1:407
normalization, 1:406
representation, 1:406
sequential, divergent, or qualitative symbolization used in, 1:407–408, 1:408 (fig.)
symbolization and, 1:407–408
2004 presidential election, 2:879 (fig.)
unclassed map of U.S. population density, 1:406, 1:407 (fig.)
U.S. population density by state and, 1:406 (fig.)
as value-by-area or value-by-population maps, 1:406
Chouinard, Vera, 2:619

Chrisman, Nicholas, 1:408–409
“Cartographic Data Structures” co-authored by, 1:408
_Exploring Geographic Information Systems* written by, 1:408
GEODE, research funding and, 1:408
GIS development work of, 1:408
role of time in geographic information and measurement theory and, 1:408

Christaller, Walter, 1:409–410
_Central Places in Southern Germany* written by, 1:380, 4:1798
community sizes, 1:409
decision making on settlement growth and contraction and, 1:410
_Economics of Location* (Losch) and, 1:410
hexagon-shaped trade areas and, 1:409, 4:1798, 4:1805
hierarchy of places nearing spatial equilibrium and, 1:409, 4:1798, 4:1805
highway development plans and, 1:410, 4:1798
internalizing externalities within hierarchy of administrative zones and, 1:409
location theory and, 3:1628
August Losch and, 1:410, 3:1628
Nazi party membership and service of, 1:410

Atsuyuki Okabe and, 4:2077
spatial interdependence between places and, 1:409–410
Christopherson, Robert, 1:452
dunes work of, 2:801 (fig.), 2:802 (fig.)
Church, Richard, 4:1793
Churchill, Ellen, anthropogeography work of, 1:93
Cicero, 5:2572

Circuits of capital, 1:410–412
capitalist value circulation process and, 1:410–411
circuit of culture and, 1:412
commodity-capital circuit, 1:411, 1:411 (fig.), 1:412
commodity chains and, 1:524
Euromarkets and, 2:1030–1032
geographic applications of, 1:412
Karl Marx and, 1:410
Doreen Massey’s spatial divisions of labor and, 1:412, 4:1866–1867
money-capital circuit, 1:410–411, 1:411 (fig.)
productive-capital circuit, 1:411, 1:411 (fig.)
spatial and temporal interruptions of, 1:411 (fig.)
See also Crisis (economic)
CIS. See *Commonwealth of Independent States* (CIS)
Citizen’s Clearinghouse for Hazardous Waste
Citizen’s Clearinghouse for Hazardous Waste
Citizen’s Clearinghouse for Hazardous Waste
Citizen’s Clearinghouse for Hazardous Waste

Civil society, 1:414–416
cosmopolitanism and, 2:590–592
cultural and ethnic diversity of societies and, 1:413
definitions, 1:412–413
excluded and marginalized groups and, 1:412–413
geographical definition variations and, 1:412
geography and citizenship intersections and, 1:412
global and cross-cultural perspective on, 1:413–414
immigration and, 3:1542–1545
multicultural citizenship and, 4:143
neoliberal global capitalism and, 1:413
political power organization element in, 1:413
regional free trade and, 1:413
rights and responsibilities with a society and, 1:412–413
social and economic justice and, 1:413–414
spatial unevenness of wealth and, 1:413–414
transnational environmental issues and, 1:413

CIS. See *Commonwealth of Independent States* (CIS)

Citizen’s Clearinghouse for Hazardous Waste

Clag, Andrew, 1:416–417
academic career of, 1:416
beneficial examples of, 1:415–416
citizenship and, 1:412–414
communication technology advances and, 1:414
critics of, 1:415
definitions, 1:414
governance and, 3:1357–1359
grassroots organizations and, 1:414
nationalism and, 4:1978–1981
nongovernmental organizations (NGOs) and, 1:414
World Social Forum and, 1:414–415

CLAG. See *Conference of Latin Americanist Geographers* (CLAG)

Clark, Andrew, 1:416–417
academic career of, 1:416
beneficial examples of, 1:415–416
citizenship and, 1:412–414
communication technology advances and, 1:414
critics of, 1:415
definitions, 1:414
governance and, 3:1357–1359
grassroots organizations and, 1:414
nationalism and, 4:1978–1981
nongovernmental organizations (NGOs) and, 1:414
World Social Forum and, 1:414–415

Clark, Andy, 4:1882
Clark, Colin, 5:2240, 5:2263
Clark, Gordon, 3:1118
Clark, William, 6:2741
Clark, William, 1:417–418

criticism of, 1:418
human ecology work of, 3:1459
immigration studies of, 1:418
mobility and migration studied by, 1:417–418
National Academy of Science service of, 1:417
school districts and residential segregation work of, 1:418
Clark, William (Lewis and Clark expedition), 4:1773–1777
Clarke, John Innes, 1:2351
Clark, William (Lewis and Clark expedition), 4:126
examples of,

distributed GIS and,
spatial segregation and,

Species-being of humans and, 1:420
urban ecology work of, 4:2962

Climate: midlatitude, mild, 1:435–439
climate change and, 1:438–439
continental interior weather conditions, 1:436
diversity within, 1:435–436
droughts, 1:438
eventual cyclones and, 2:650–654
flooding, 1:437–438
humid summer weather in, 1:436
large scale weather and climate features of, 1:435, 1:437–438
latitude/climate variability and, 1:436
marine and continental locations of, 1:436–437
midlatitude grassland biome and, 1:227–230
nor’easter systems and, 1:436
rainfall in, 1:436

storm systems and, 1:436

tornadoes and, 1:437
vegetation, Warwick, New York, 1:438 (photo)
weather and climate in, 1:435

Client-server architecture, 1:426–428

distributed GIS and, 1:427–428
Enterprise GIS, 2:911–913
examples of, 1:426
exploration of, 1:426
generational examples of, 1:426
GIS software and, 1:426
Open Geospatial Consortium standards and, 1:426

stateless versus stateful, 1:427

synchronous versus asynchronous, 1:427

thin versus thick clients and, 1:426–427

virtual globes applications and, 1:426

See also Client-server architecture: examples

Client-server architecture: examples
Arc GIS Desktop, 1:426
ENVI, 1:426
Google Earth, 1:426
Google Maps, 1:426
Microsoft Virtual Earth, 1:426
NASA World Wind, 1:426
Quantum GIS, 1:426
Web Coverage Service (WCS), 1:426
Web Feature Service (WFS), 1:426
Web Map Service (WMS), 1:426

Climate: dry, 1:428–435

air subsidence in general circulation factors in,

1:430, 1:430 (fig.)
aridity index classification of, 1:433
aridity versus drought and, 1:429
basin and range topography and, 1:186–187
classifications of dry climates and, 1:432–433
definition of, 1:428–429
desert biome and, 1:218–223
diurnal surface temperature, Northern Sahara desert, 1:434 (fig.)
early civilizations and, 1:428

factors contributing to, 1:430–431
Flaming Mountain, Xinjiang, China, 1:428 (photo)
global distribution of world deserts and, 1:430 (fig.)
hyperarid climates and, 1:428, 1:433
indices of, 1:432–433
locations of, 1:429–432
Sahara, North Africa and, 1:429

semiarid climates, humidity provinces and, 1:432, 1:433
solar radiation element of, 1:433
temperature element of, 1:433–435
vertical temperature and moisture profile and,

1:431–432, 1:431 (fig.)

See also Environmental management: drylands

Climate: midlatitude, mild, 1:435–439
climate change and, 1:438–439
continental interior weather conditions, 1:436
diversity within, 1:435–436
droughts, 1:438
eventual cyclones and, 2:650–654
flooding, 1:437–438
humid summer weather in, 1:436
large scale weather and climate features of, 1:435, 1:437–438
latitude/climate variability and, 1:436
marine and continental locations of, 1:436–437
midlatitude grassland biome and, 1:227–230

nor’easter systems and, 1:436

rainfall in, 1:436
storm systems and, 1:436

storm systems and, 1:436

tornadoes and, 1:437
vegetation, Warwick, New York, 1:438 (photo)
weather and climate in, 1:435

See also Climate: midlatitude, severe

Climate: midlatitude, severe, 1:439–442
animals living in, 1:441, 1:442
biome diversity in, 1:440
boreal forest or taiga biome located in, 1:442
deciduous tree cycle and, 1:440
Climate: tropical humid, 1:452–455
extratropical cyclones and, 2:650–654
fires in, 1:440–441
four seasons in, 1:441
grasslands of, 1:440–441
human settlement in, 1:442
humid continental, 1:439–441
Köppen map of humid continental and subarctic (microthermal) climates, 1:439, 1:440 (fig.)
Köppen symbols of, 1:441
locations of, 1:439, 1:440 (fig.)
microthermal climate type and, 1:439
midlatitude grassland biome and, 1:227–230
Murmansk, Russia in, 1:442
permafrost subsoil characteristic of, 1:441–442
precipitation in, 1:441
soil varieties in, 1:441, 1:442
subarctic, 1:441–442
thunderstorms and, 6:2832
tundra biome and, 1:246–250
See also Climate: midlatitude, mild
Climate: mountain, 1:443–449
altitude factor in, 1:443
anabatic flow of air, 1:447
climate change and variability and, 1:448–449
clouds, 1:446, 1:447 (photo)
continuity factor in, 1:443
El Niño/Southern Oscillation and, 1:448
environmental lapse rate factor in, 1:444
environmental processes exaggeration in, 1:443
Fisher Peak, North Cascades National Park, Washington, 1:444
foehn wind, 1:447–448
internal disturbances factor in, 1:449
katabatic flow of air, 1:447, 4:2149
latitude factor in, 1:443
mean annual temperatures, North Cascades, Washington, 1:445 (fig.)
 microclimates and, 1:448
mini-rain-shadow zones and, 1:444
Mt. St. Helens, 1:447 (photo)
 orographic effect and, 1:444
 precipitation and clouds factors in, 1:446, 1:448
rain-shadow effect and, 1:444
solar radiation factor in, 1:444–445
temperature factor in, 1:445–446, 1:445 (fig.), 1:448–449
 temperature inversions and, 1:444
wind factor in, 1:446–447
Climate: polar, 1:449–452
albedo coefficient and, 1:449
Antarctica, 1:451
Antarctic Convergence zone and, 1:451
Arctic, 1:449–450
causes of, 1:449
climatic changes and, 1:451–452
cyclones, polar cyclones, and anticyclones and, 1:451
glacial mountains of Spitsbergen, Norway, and, 1:450 (photo)
locations of, 1:449
maritime vs. continental polar climates and, 1:450
See also Ice; Periglacial environments; Permafrost
Climate: tropical humid, 1:452–455
atmospheric lifting mechanisms, 1:453
causal factors of, 1:452–453
characteristics and classification of, 1:453
Christopherson's climate categories and, 1:452
deforestation in, 2:696
devastation of, 1:452
extensiveness of, 1:452
forest layers in, 1:455
humidity and, 3:1485–1486
intertropical convergence zone (ITCZ) and, 1:132, 1:453–454, 4:1940, 6:2832
maritime equatorial (mE) air masses of, 1:453–454
monsoons and, 4:1940–1945
orographic atmospheric lifting process and, 1:453
precipitation in, 1:453–454
subcategories of, 1:453
temperatures in, 1:453
tropical forest, Sachatamia, Ecuador, 1:454 (photo)
tropical monsoon climate, 1:454–455, 2:741
tropical rain forest biome and, 1:234–239
tropical rain forest climate, 1:453–454, 1:454 (photo)
tropical savanna climate, 1:455
Tropics of Cancer and Capricorn boundaries of, 1:452
Climate change, 1:455–461
on atolls, 1:168
Beaufort wind scale measure and, 1:456
biota and climate and, 1:257–264
climatic relics and, 1:467–471
climatology and, 1:475
as coupled human and natural system, 2:601–602
Dansgaard-Oeschger Oscillations and, 1:457–458
ecological and carbon footprints and, 2:570–571
ecoregions and, 2:855–856
ecosystems and, 2:867
El Niño-Southern Oscillation (ENSO) and, 2:886–890
environmental refugees and, 2:989–991
fossil fuel burning and deforestation factors in, 1:328
geological record and, 1:457–459
geophysical, biological, and chemical proxy variables and, 1:456–457
glacial/interglacial cycles and, 1:457–459, 1:458 (fig.)
greenhouse gases increase and, 1:461
Heinrich events and, 1:457–458
historical records timescale of, 1:456
Holocene (postglacial period) and, 1:459, 1:470
Ice Age records and, 1:457
instrumental records of, 1:456
land use and cover change impact on, 4:1736
La Niña and, 4:1754–1757
Little Ice Age and, 1:459, 3:1333, 3:1335
Maunder Minimum sunspot activity and, 1:459
mountain glaciers affected by, 3:1328–1333
natural hazards and risk analysis and, 4:1985
past millennium and, 1:459–461, 1:460 (fig.)
permafrost affected by, 4:2154–2157
in polar climate, 1:451–452
Poles, North and South and, 5:2203–2209
precipitation measurement and, 1:456
proxy records of, 1:456–457
satellite climate recording and, 1:456
sea surface temperature measures issue and, 1:456
solar and terrestrial radiation and, 5:2346–2349
solar output factor in, 1:459
symptoms and effects of, 6:2770–2773
temperature scales and, 1:456
temperature variance in surface air temperature in Northern Hemisphere and, 1:460 (fig.)
volcanic activity, carbon cycle and, 1:328
volcanic eruptions factor in, 1:461
Vostok time series and ice volume and, 1:458 (fig.)
wind speed at sea measures and, 1:456
See also Adaptation to climate change; Albedo; Anthropogenic climate change; Biota and climate; Global environmental changes; Social and economic impacts of climate change

Climate types,

See also

Strahler classification system and,

precipitation measures and,

climate classification and,

Montreal Protocol (1987) and,

empirical classification approach and,

mild, midlatitude climate and,

Köppen climate classification system and,

data and statistics,

climate controls and factors,

Joint Implementation (JI) and,

climate zone shifts or single climatic variable changes and,

Köppen-Geiger climate classification

Climate policy, 1:462–465

assigned amount units concept and,

1:463
carbon dioxide emissions and,

1:462
carbon trading and carbon offsets and,

1:329–335
chlorofluorocarbons phase out and,

1:462
Clean Development Mechanism (CDM) and,

1:463
climatology and,

1:475
common but differentiated responsibility principle and,

1:462
Copenhagen international climate change summit and,

1:463
Intergovernmental Panel on Climate Change (IPCC) and,

1:462,

5:2204, 5:2552, 5:2554 (fig.)
Joint Implementation (JI) and,

1:463
Kyoto Protocol of 1997 and,

1:83, 1:330, 1:332, 1:333 (fig.),


4:1857, 5:2244
land use, land use change, and forestry (LULUCF) activities and,

1:463
Montreal Protocol (1987) and,

1:400–401, 1:462, 3:1336,

3:1374, 5:2244, 6:2763
national policies and compliance and,

1:463–464
ozone layer and,

1:462
post-Kyoto period and,

1:464
UN Framework Convention on Climate Change (UNFCCC) and,

1:9, 1:462, 2:945, 3:1374, 5:2220, 5:2244,

6:2748–2749
United Nations Environment Programme (UNEP) and,

1:462
Climate types, 1:465–469

applied classification approach and,

1:466
atmospheric energy variations and,

1:161–165
biota and climate and,

1:257–264
climate classification and,

1:466–467
climate controls and factors,

1:466
climate definitions and,

1:465
data and statistics,

1:463–466
ecoregions and,

2:855–856
ecotones and,

2:865–869
empirical classification approach and,

1:466
genetic classification approach and,

1:466
Grosswetter genetic classification approach and,

1:467
Köppen climate classification system and,

1:465, 1:467–469
mild, midlatitude climate and,

1:435–349
precipitation measures and,

1:465–466
seasonal patterns and,

1:465
Strahler classification system and,

1:467
temperature measures and,

1:465
Thornthwaite classification system, 1:467
See also

Atmospheric energy transfer; Biota and climate;

Climate: specific climate; Köppen-Geiger climate classification

Climate relict, 1:469–471

American pika faunal example, 1:470–471
climate zone shifts or single climatic variable changes and,

1:469–470
European strawberry tree floral example and,

1:470
faunal climatic relics,

1:470
floral climatic relics,

1:470
future climatic relics, 1:470–471
global climate changes and,

1:469
Holocene climate changes and,

1:459, 1:470
Joshua tree floral example and,

1:470
marine fauna relict and,

1:470
musk ox faunal example and,

1:470
Norwegian mugwort floral example and,

1:470
staghorn coral faunal example and,

1:470
Climatology, 1:471–476

atmospheric energy variations and,

1:161–165
biota and climate and,

1:257–264
climate change and,

1:475
climate models and,

1:474
climatology resources and,

1:473–475
Coriolis force and,

2:586–587
data sources for,

1:474–475, 1:671
definition of,

1:671
dendrochronology and,

2:711
differential heating and,

2:740–742
geospatial techniques and,

1:473–474, 1:671
geostatistics and,

1:474
health and medical climatology,

1:473
hydroclimatology,

1:473
interdisciplinary characteristic of,

1:671
microclimatology,

1:472
oceanic circulation and,

4:2058–2064
paleoclimatology,

1:471–472
physical climatology,

1:472
as physical geography subdiscipline,

1:671
proxy data sources and,

1:472
subdisciplinary studies within,

1:671
synoptic and dynamic climatology,

1:472–473
C. Warren Thornthwaite and,

6:2821–2822
See also

Atmospheric specific subject; Biota and climate; Climate types; Köppen-Geiger climate classification

Closer Economic Relations (CER) Free Trade Agreement (FTA), 1:121

Clouds, 1:476–480

adiabatic temperature changes and,

1:15–17
aerosol-cloud-precipitation interactions and,

1:479–480
aerosol indirect effects and,

1:479–480
altitude classification of,

1:476
atmospheric perturbations and,

1:149–151
Bergeron-Findeisen mechanism and,

1:478–479
classification (WMO) of,

1:476, 1:477 (photo), 1:478
cloud condensation nuclei (CCN) and,

1:478
cloud-seeding experiments and,

1:478
dissolution and development of,

1:478–479
global climate influenced by,

1:476, 1:479–480
global cloud climatologies development and,

1:479
global radiation balance function of,

1:476, 1:479
Hallet-Mossop ice multiplication process and,

1:478
homogeneous nucleation, freezing of liquid droplets and,

1:478
hydrometeors and,

1:476
hydrometeor composition classification of,

1:478
Intergovernmental Panel on Climate Change and,

1:480
International Cloud Atlas (WMO) and,

1:476
International Satellite Cloud Climatology Project and,

1:478
marine fauna relict and,

1:470
mothur cloud origin and,

1:476
precipitation distinguished from,

1:479
riming ice-phase particle growth process and,

1:479
second direct, cloud lifetime, or Albrecht effect and,

1:479
solute effect (Raoult’s law) and,

1:478
terminal fall velocity of,

1:476
Coal, 1:480–482
  competitive advantage and, 2:558–559
  competitive diamond concept (Porter) and, 1:481, 1:481 (fig.)
  creative destruction concept (Porter) and, 1:481
definition of, 1:480
economic localization and increasing returns and, 1:481
  external industrial economies’ factors and, 1:480
  human and economic geography and, 1:480
  importance of local context and, 1:481
  industrial districts and, 1:480, 2:851–852
  industrial to knowledge-based economy shift and, 1:482
  Michel Porter’s work and, 1:482
  new industrial districts and, 1:482
  Porter’s competitive diamond and, 1:481–482, 1:481 (fig.)
  Michel Porter’s work and, 1:481–482, 1:482 (fig.)
  R&D geographies and, 5:2435–2436
temporality of, 1:482

Coal, 1:483–486
  in China, 1:483–484, 1:485 (fig.)
  Coal fields and Rank coverage and, 1:485 (fig.)
  coalification degree classifications of, 1:483
  emissions issue of, 1:483, 1:485–486
  future trends, 1:485–486
  global reserves of, 2:903 (fig.), 2:906 (fig.)
  in other countries, 1:485
  strip mining and, 5:2701–2702
  in the U.S., 1:483, 1:484 (fig.)

Coastal dead zones, 1:486–488
  bacteria in benthic zone and, 1:486
  in Gulf of Mexico, 1:207, 1:486, 1:487 (photo), 1:488, 1:502, 2:939
  hypoxic conditions in, 1:486, 1:502
  inorganic fertilizers and, 1:488
  nitrogen cycle and, 4:2029
  phytoplankton role in, 1:486, 1:487 (photo), 1:502
  seasonal physical factors of, 1:486–487
  storms or hurricanes and, 1:486

Coastal erosion and deposition, 1:488–496
  barrier islands and, 1:183–185
  beach rotation and, 1:491
  Bruun rule and, 1:494, 1:495 (fig.), 1:496
  chemical effects factor in, 1:493–494
  chenier ridge, Princess Charlotte Bay, Northern Australia, 1:491 (photo)
  coastal deposition, 1:489–490
  coastal erosion, 1:489, 1:490 (photo)
  as coastal hazard, 1:498
  as coastal hazard, 1:498
  as coastal hazard, 1:498
  coastal morphodynamics and, 1:488
  coral reefs and, 2:581–584
  definitions, 1:488
  deltas and, 2:702–705
  dunes factor in, 1:492, 1:499
  erosion from nor’easter, Outer Banks, North Carolina, 1:300
  factors affecting, 1:488
  floodplains and, 3:1128–1133
  human interference factor in, 1:493 (photo), 1:494
  longshore currents and, 1:491
  longshore transport and, 1:491–492
  overstepping and, 1:496

Oyster Bay, Australia, 1:492 (photo)
  progradation, transgression (deposition) and, 1:489–490
  prograding, eroding, and stationary coast categories and, 1:488
  reefs, tombolos, and biota factors in, 1:492–493, 1:492 (photo)
  retrograding, encroaching, or receding coasts and, 1:489
  rollover and, 1:496
  sea-level change factor in, 1:494, 1:496
  sea wall collapse, French coast, 1:493 (photo)
  shoreface responses to sea-level rise and, 1:495 (fig.)
  shoreline monitoring and predictions, 1:496
  tidal currents factor in, 1:492
  Twelve Apostles, Australia and, 1:489, 1:489 (photo)
  wave climate factor in, 1:490–492

Coastal hazards, 1:496–500
  climate change and, 1:499–400
  coastal hazard zone and, 1:498–499
  coastal property assets and, 1:497
  defenses against, 1:498–499
deltas and, 2:704
dunes defense against, 1:499
erosion, 1:498
  erosion, Outer Banks, North Carolina, 1:499 (photo)
  explanation of, 1:492–493
  flooding, 1:497–498
  Intergovernmental Panel on Climate Change and, 1:500
  inverse barometer effect and, 1:497
  mean sea level and, 1:497
  oil spills and, 4:2073–2076
  rip currents and, 1:498
  run-up caused by waves and, 1:498
  set-up of waves and, 1:498
  storm surge and, 1:497
  swash of waves and, 1:498
  tide and, 1:497–498

See also Hurricanes, physical geography of;
  Hurricanes, risk and hazard

Coastal zone and marine pollution, 1:500–504
  atmospheric carbon dioxide concentrations and, 1:501
  climate-induced sea level changes and, 1:500–501
  coastal dead zones and, 1:486–488, 1:502, 2:939
  coastal zone definition and, 1:500
economic attributes of coastal zone and, 1:500
  electronic waste and, 1:502
  excessive nutrients, 1:502
  future issues and challenges, 1:503–504
  global biogeochemical cycles and, 1:501
  heavy metals, 1:501–502
  human interaction disturbances and, 1:500
  marine aquaculture and, 4:1853–1855
  marine litter, 1:502–503, 1:503 (photo)
  Minamata disease, mercury poisoning and, 1:501–502
  nonpoint sources of pollution and, 4:2039–2040
  ocean acidification and, 1:501
  oil fields and, 2:946–948
  oil pollution, 1:503
  oil spills and, 4:2073–2076
  persistent organic pollutants (POPs), 1:501
  physical attributes of coastal zone and, 1:500
  population attributes of coastal zone and, 1:500
  radioactive substances, 1:503
  sewage, 1:501
  Cockburn, Alex, 5:2212
  Coode, Edgar, 2:6711
  Cognitive mapping, 1:189, 5:2609–2610
  Cohen, Saul, 3:1250
Cold War, geography of, 1:504–505
American geographical imagination and, 3:1223–1224
Committee on the Present Danger (CPD) and, 3:1251
containment and domino theory principles of, 1:504–505
democracy vs. communism and, 1:504
domino theory and, 1:505, 2:787, 3:1224
geopolitics and, 2:611, 3:1250–1252
global divisions of power and, 1:504
international criminal court and, 3:1606
Henry Kissinger and, 3:1251
Sir Halford Mackinder’s Heartland model and, 4:1813
nationalist movements during, 2:691–692
NATO and, 4:2047
new Cold War potential and, 4:2048
North Atlantic Treaty Organization and, 1:505
nuclear annihilation fear and, 3:1224
nuclear weapons and, 4:2052
political geography and, 5:2222–2223
See also Commonwealth of Independent States (CIS)
Collaborative GIS, 1:506–508
applications of, 1:507, 1:507 (fig.)
collaborative process component in, 1:507
components of, 1:506–507, 1:506 (fig.)
definition of, 1:506
gecollaboration and, 3:1209–1211
geospatial databases role in, 1:507
GIS and GISScience collaborative link and, 1:507
GIS design and, 3:1290–1293
GIS technology and, 1:506
humanistic GIScience and, 3:1474–1478
planning and decision-making tasks applications of, 1:506
user interfaces component of, 1:507
Web server element in, 1:507
See also GIS specific subject
Collins, Harry, 5:2518

Colombia
Cerrejón coal mine in, 4:2086
Conference of Latin Americanist Geographers held in, 2:568
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
glaciers in, 3:1332
human rights atrocities in, 3:1481
illicit drug cultivation in, 2:797
indigenous and community conserved areas in, 3:1561
market-based land reform in, 4:1695
“narcoterrorism” and, 2:798
tropical scrub in, 1:245

Colonialism, 1:508–518
Africa, 1:512–513
African political geography and, 1:512
Arab world, 1:513–514
James Blair’s work and, 1:285–286
British imperial geographical imagination and, 3:1221–1222
capitalist economy factor in, 1:511
Christian missionaries and, 1:517
colonial dependence and, 2:713
colonial empires prior to 1914 and, 1:513 (fig.)
community-based natural resource management and, 2:550
cultural and ideological processes and, 1:517
decolonization and, 1:509
disease and, 1:516
drug discoveries and, 2:795
East Asia, 1:514–515
economic, political, and cultural impact of, 1:508, 1:516
education systems and, 1:517
effects of, 1:516–517
end of, 1:517
environmental resources and, 5:2447–2448
European Age of Exploration and, 1:508
European conquest factors and, 1:509–511
European definitions of humanity and, 5:2340
European racial thought and, 5:2339–2340
European shipbuilding and ocean navigation skills and, 1:510
Europe changed by, 1:508
famine and, 1:516
fighting against, 1:508
forestlands administration and, 2:552
genocide and, 1:516
impacts of, 1:508
imperialism and, 3:1545–1548
independence movements and, 1:517
Industrial Revolution era of, 1:509
inequalities in colonized societies and, 1:516
land reform after, 4:1492–1692
Latin America, 1:511–512
mercantilist trade policies and, 1:508
mining settlements and, 4:1911
nation-states after, 1:517
neo-colonialism and, 4:2002–2005
North America, 1:512
Oceania, 1:515–516
ocean navigation factor in, 1:510
Orientalism and, 4:2101–2104
plantations and, 5:2192
polarized spaces and, 1:516
preindustrial mercantile era of, 1:508
ship-based empires and, 1:510
silver flows, 16th to 18th centuries and, 1:513 (fig.)
silver trade and, 1:511–512
slave trade and, 1:512, 1:516
smallpox disease and, 1:511
South Asia, 1:514
southeast Asia, 1:515
Spanish encomienda land grant system and, 1:512
telegraph technology and, 1:1221–1222
temporal and spatial unevenness of, 1:508–509, 1:509 (fig.)
even landscapes and commodity export-dependent economies and, 4:1692
water supply issues and, 5:2316–2317
“white man’s burden” and, 2:1021, 2:1027
world development and world systems theories and, 1:508
See also Decolonization; Neocolonialism; Race and empire

Colorado
cardboard recycling, Englewood, 5:2374
Colorado National Monument, 5:2483 (photo)
gated community in, 3:1182 (photo)
hazardous waste and garbage mixture in Lowry Landfill, 4:1685 (photo)
sedimentary layers, Artist’s Point, Colorado National Monument, 5:2521 (photo)
solar hot water system, Adams County Detention Facility, Denver, 5:2595 (photo)
Steamboat Springs geothermal area in, 3:1273

Color in map design, 1:518–520
color associations and, 1:519–520, 1:519 (fig.)
color connotations and, 1:518–519
color interactions and, 1:520
definitions in, 1:518
functions of, 1:518
hardiness zones in U.S. example of, 1:519 (fig.)
INDEX 3209

hue differences in color and, I:518
light source and, I:520
map conventions and, I:520
psychological reactions of viewers and, I:519
saturation of color in, I:518
See also Map design

Columbus, Christopher, I:520–522
explorations of, I:521, 3:1461, 4:2179
financing obtained by, I:511
historical legacy of, I:521
legal claims and battles, I:521
maps and charts of, I:521
Ptolemy's influence on, I:520, 5:2300
resources of, I:520
sense of geography, religion and, I:521

COMECON. See Council for Mutual Economic Assistance (COMECON)

Commodity chains, I:522–525
actor-network theory and, I:524
alternatives to GCC approach and, I:524
buyer-driven commodity chains and, I:523
capitalism geographies and, I:524–525
captive value chains and, I:523–524
circuits of capital and, I:410–412
circuits of culture and, I:524
“cultural turn” in human geography and, I:522
definition of, I:522
ethical consumption practices and, I:525
factors in, I:523
Gary Gereffi's work and, I:522–524
global commodity chain (GCC) and, I:522
governance structures and, I:522–523
hierarchy value chains and, I:524
industrial upgrading decisions and, I:524
input-output structure dimension of, I:522
interfirm linkages element of, I:522
labor unions application of, I:524–525
market governance and, I:523
modular value chains and, I:523
outsourcing and, 4:2108–2110
producer-driven chains and, I:523
production and consumption analysis using, I:522
relational value chains and, I:523
revised typology of governance and, I:523–524
territoriality dimension of, I:522
vertical relationships focus and, I:522
Commoner, Barry, 2:570
Common pool resources (CPRs), I:525–528
benefits and costs of, I:525
definition of, I:525
ecological economics and, 2:820–824
environmental entitlements and, 2:921–925
environmental services and, 2:1000–1002
examples of, I:525
free rider problem of, I:525
fugitive resources and, I:526, I:527 (fig.)
geographical typology of, I:526, I:528
geography and, I:526
humans and spatial environment interaction and, I:526
migratory resources and, I:526, I:527 (fig.)
open-access resource and, I:526, I:527 (fig.)
Elinor Ostrom's work in, I:525, I:529
research examples of, I:526
scale and space issues in, I:526
spatial adjustment for river basin conflict resolution
example of, I:527 (fig.)
tragedy of open-access resources (Ostrom) and, I:525–526, I:529
Tragedy of the Commons thesis (Hardin) and, I:525–526
user incentives, I:525
See also Common property resource management;
Commons, tragedy of the

Common property resource management, I:528–532
common/community property rights and, I:529–530
common property resources (CPRs) and, I:528
community-based natural resource management and, 2:549–551
community forestry and, 2:551–553
conditions for success of, I:530, I:531 (table)
CPRs examples and, I:528
explanation of, I:528
free rider problem and, I:529, I:528
global common resources issues and, I:530–531
governmentality and conservation and, 3:1359–1360
indigenous water management and, 3:1573–1576
open-access property rights and, I:529, I:530
Elinor Ostrom's work, I:529
principles of difficulty or exclusion and subtractability,
I:528–529, I:530
private property rights and, I:529, I:530
property rights systems for governing CPRs and, I:529–530
state or government property rights and, I:529
tragedy of open access and, I:529
tragedy of open-access resources (Ostrom) and, I:529
Tragedy of the Commons (Hardin) and, I:529
See also Common pool resources (CPRs); Commons, tragedy of the; Distribution of resource access; Governance

Commons, tragedy of the, I:532–535
common pool resources (CPRs) and, I:525–528
commons or common pool resources definition and, I:532
communal property solution to, I:534
critiques, I:534–535
current research, I:535
desertification resulting from, 2:716
destruction of the commons and, I:525–526
developing world examples of, I:532–533, I:533 (photo)
distribution of resource access and, 2:779
examples of, I:532–533, I:533 (photo)
excludability and subtractability issues and, I:532
fisheries example of, I:532
forests, pasture, grazing land examples of, I:532–533
free-rider issue in, I:532
global warming example of, I:533
groundwater resources and, 3:1388
Garrett Hardin's thesis of, I:525–526, I:532
influence and, I:534
natural resources management policies and, I:529, I:532
nomadic herding and, 4:2032
Elinor Ostrom's work in, I:525, I:534
overpopulation and pollution examples of, I:533
pollution of the commons and, I:533
socialism or privatization as solutions to, I:533–535
social justice perspective on, I:535
solution, I:533–534
sustainable fisheries and, 6:2755
See also Common pool resources (CPRs); Common property resource management

Commonwealth of Independent States (CIS), 2:536–537
CIS Joint Armed Forces High Command and, 2:536
Collective Security Treaty Organization (CSTO) and, 2:536–537
Communications geography, 2:537–542
Ronald Abler’s contributions to, 1:1–2
background, 2:538–539
closed-circuit television systems in cities and, 2:541
cultural geography issues and, 2:538
current and future trends in, 2:541
cyberspace and virtual space and, 2:539–540, 2:646–648
economic changes issues in, 2:540–541
geographical patterns of economic activity and, 2:851
graphy element in, 2:539
Habermas’s public sphere concept and, 2:541
ICTs and social impacts of, 2:540
ICTs and space relationship focus of, 2:537–538
ICTs surveillance and self-surveillance and, 2:541
interdisciplinary nature of, 2:538
media, geopolitics/political geography issues in, 2:541
network accessibility issues and, 2:539
popular geopolitics and, 2:541
research areas of, 2:537–538
spatial barriers elimination and, 2:539
spatial science and modeling theme of, 2:539
timeline of fiber optic networks and 24/7 communication technologies, 2:539
timeline of geography of ICT networks research, 2:538–539
timeline of humanist, Marxist, and behavioral geography approaches, 2:538
timeline of Internet, digitization, computer communication technologies and, 2:538
timeline of political and economic goal facilitation, 2:538–539
timeline of social issues and changes, fulfilling human potential fulfillment, 2:538
timeline of space representations research, 2:538
timeline of transportation geography and spatial analysis, 2:538
transportation geography and, 2:539
urban structures issues and, 2:539

Communism and geography, 2:542–545
architecture, ideology, and public space and, 2:543–544
collectivization and, 2:542–543
communist cities and, 2:543–544
Council for Mutual Economic Assistance and, 2:593–595
Five Year Plans (Soviet Union) and, 2:542
Great Leap Forward (China) and, 2:542, 2:543
housing and, 2:544
impact and influence of, 2:542
industrialization and, 2:542
Moscow, May Day celebrations and, 2:544, 2:544 (photo)
public space in communist countries, 2:543–544, 2:544 (photo)
renaming of places after heroes and, 2:543
Community-based conservation, 2:545–547
activities associated with, 2:545–546
benefits of, 2:545
community garden planning, Echo Park area of Los Angeles, California, 2:548 (photo)
concepts related to, 2:544
ecosystem management and, 2:545
efficacy and appropriateness criticisms of, 2:546–547
evaluating success of, 2:546
indigenous and community conserved areas, 3:1557–1561
indigenous environmental knowledge and, 3:1354–1567
multistakeholder participation and, 4:1956–1959
skill levels issue and, 2:547
See also Community-based environmental planning (CBEP);
Community-based natural resource management (CBNRM)

Community-based environmental planning (CBEP), 2:547–549
advantages of, 2:548
applications of, 2:549
capacity of communities issue and, 2:548
communicative action (Habermas) and, 2:548
community participation element in, 2:548
definition of, 2:547
democratic effects of, 2:548
indigenous knowledge vs. technical skills and, 2:548
limitations and criticism of, 2:548–549
outcomes and legitimacy of, 2:548
participatory planning and, 4:2126–2129
place-based environmental management element of, 2:547–548
scale of environmental issues and, 2:548–549
Seeing Like a State (Scott) and, 2:548
top-down planning approach vs., 2:548
See also Community-based conservation; Community-based natural resource management (CBNRM);
Environmental planning

Community-based natural resource management (CBNRM), 2:549–551
adaptive harvest management and, 2:551
bioregionalist promise concept (Paehlke) and, 2:551
colonialism ad, 2:550
community forestry and, 2:551–553
community forestry example of, 2:550
defining characteristics of, 2:550
ecosystem-based river basin management and, 3:1620
environmental entitlements and, 2:549–551
feedback effect concept (McCay and Jentoff) and, 2:551
flow resources focus of, 2:549–551
local ownership or access and use rights feature of, 2:549–550
open-access resources and, 2:550
as a practice, 2:549–550
as a process, 2:550
securing management authority and, 2:550
sense of place and belonging and, 2:551
sustainable management benefit of, 2:550–551
See also Community-based conservation; Community-based environmental planning (CBEP)

Community forestry, 2:551–553
building local capacities in, 2:552
capacity building and, 2:552
central issues in, 2:552–553
community-based natural resource management and, 2:549–551
definition of, 2:551–552
enabling participation issue in, 2:552–553
goal of, 2:552
indigenous forestry and, 3:1569–1570
participation and building community capacities in, 2:552
participatory research and, 2:552
See also Social forestry
Commuting, 2:553–555

Commute definition and, 2:553

Commuting paradox concept and, 2:554

Commuting and, 2:553

Compact City or Polycentricity Policy (Europe) and, 2:555
costs of, 2:554
disutility features of, 2:554
from exurbs, 2:1075
gender differences in, 3:1096–1097
geographic dispersal of economic activities and, 2:554
GIS in transportation and, 3:1311–1312
Susan Hanson’s work in, 3:1400–1401
long distance and excess commuting and, 2:554
New Urbanism movement (U.S.), 2:555
physiological and psychological impacts of, 2:554–555
positive utility features of, 2:555
research objectives, 2:553
separation of work from residence place and, 2:554
urban sprawl and suburban development and, 2:554

Comoros

Comparative advantage, 2:556–558

absolute advantage and, 2:556
capitalism’s success attributed to, 2:556
division of labor and, 2:780–781
economic geography implications of, 2:556–557
factor-price equalization and, 2:557
free trade and, 2:556
Heckscher-Ohlin multi-factor approach to trade theory and, 2:557, 5:2395
large vs. small markets and, 2:556–557
location quotients and, 4:1796–1797
newly industrializing countries and, 4:2021
production factors in, 2:557
regions, cities, or countries specialized production or export and, 2:556
Ricardo’s two-country, two-product theory of, 2:556–557, 2:557 (table)
transportation element of, 2:557

Competitive advantage, 2:558–559

comparative advantage and, 2:556–558
demand conditions of, 2:559
determining factors of, 2:558
dynamic and changing nature of, 2:558
factor conditions or production factors of, 2:559
high value-added goods and, 2:558
nation’s attributes to increase, 2:538–539
networks access factor in, 2:559
productivity growth element in, 2:558
social creation of innovation focus of, 2:558
state support factor in, 2:559

Complexity theory, 2:559–561

algorithmic, deterministic, and aggregate complexities (Manson) and, 2:560
cellular automata and, 1:368–371
chaos theory and, 2:560
cities as fractals theory (Batty) and, 2:561
complex adaptive systems explained by, 2:559
complex systems models and, 2:561–567
conceptualizing space, time, and space-time (Massey) and, 2:560, 4:1866–1867
contributors to, 2:560
definitions of, 2:559–560
dispersed and decentralized control of, 2:560
distributed artificial intelligence foundation of, 2:560
ecotones and, 2:867
emergence phenomenon and, 2:560
equilibrium element in, 2:560
evolutionary economic geography and, 2:668
general systems theory (GST) and, 2:560
geographic applications of, 2:560
intra-disciplinary nature (O’Sullivan) of, 2:560
landscape ecology and, 2:867
land use and land cover change application of, 2:561
multiagent systems tool of, 2:560–561
physical geography and human geography commonalities (Massey) and, 2:560
positive feedback loops in, 2:560
segregation experiments (Schelling) using, 2:560
spatial behavior research (Batty) and, 2:561
tools of, 2:560–561
urban systems research (Batty) and, 2:560
See also Complexity theory: noted individuals

Complexity theory: noted individuals

Michael Barry, 2:560
Nicholas Chisholm, 2:560
John Holland, 2:560
David Livingston, 2:560
Steven Manson, 2:560
Doreen Massey, 2:560, 4:1866–1867
David O’Sullivan, 2:560
Dawn Parker, 2:561
Jonathon Raper, 2:560
Thomas Schelling, 2:560
Ludwig von Bertallanfy, 2:560

Complex systems models, 2:561–567

from analysis to synthesis of, 2:561–562
applications of, 2:563–567
“butterfly effect,” chaos theory and, 2:563
cellular automata and, 1:368–371, 2:567
complex adaptive systems (CAS) and, 2:561
complexity theory and, 2:559–561
computer simulations use of, 2:567
continuous models in, 2:563, 2:564 (fig.)
continuous space-and-time models of, 2:565–566
coupled map lattices vs. cellular automata models and, 2:566–567
discrete space-and-time models of, 2:566–567
discrete temporal models of, 2:563, 2:565, 2:565 (fig.)
emergent properties feature of, 2:562
examples of, 2:562
explanation of, 2:561
feedback processes in, 2:562
global chaotic stability concept and, 2:565
industrial ecology and, 3:1577–1579
Kolmogorov (K-) or Kolmogorov complexity and, 2:562
Lyapunov exponents feature of, 2:562
mathematical models in, 2:563–567
Moore neighborhood of coupled map lattices and, 2:566–567
nonlinearity processes element of, 2:562
Jonathan Phillips’s work in, 2:562
Von Neumann neighborhood of coupled map lattices and, 2:566
See also Agent-based models (ABMs)

Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA), 4:1808
Comte, Auguste, 4:1800

Conditions of Agricultural Growth (Boserup), 1:36


Conference of Latin Americanist Geographers (CLAG), 2:567–568

John P. Augelli and, 2:567
Arch C. Gerlach and, 2:567
governing structure of, 2:568
Preston James and, 2:567
Latin American Specialty Group of, 2:567
meetings of, 2:568
printed and electronic publications of, 2:568
specialty groups of, 2:567
working committees of, 2:567

Conflation, 2:568–569
data fusion and, 2:568
definition of, 2:568
map-to-map vs. map-to-image vs. image-to-map
conflation and, 2:569
match-and-merge conflation strategy and, 2:568–569
spatial data conflation software and, 2:569
USGS/Census map conflation system and, 2:568–569

Congo River, tropical rain forest of, 1:453, 1:454

Connell, Robert,

Conservation, 2:569–571
civilian conservation corps and, 2:570
definitions, 2:569
ecological and carbon footprints and, 2:570–571
Everglades restoration and, 2:1038–1039
fossil fuel use and greenhouse gas emission issues and, 2:570
global wildlife conservation and biodiversity and, 2:570
keystone species and, 4:1653–1658
landscape and wildlife conservation and, 4:1696–1698
national parks and, 2:569–570
National Park Service and, 2:570
neo-Malthusianism and, 2:570
parks and reserves and, 4:2117–2120
population growth issues and, 2:570
soil conservation service and, 2:570
sustainable development and, 2:570
U.S. environmental protection agency and, 2:570
U.S. movement of, 2:569–570
whole earth ecosystem and, 2:570
See also Conservation: noted individuals; Conservation zoning

Conservation: noted individuals, 2:570
Rachel Carson, 2:570, 4:2158
Barry Commoner, 2:570
Paul Ehrlich, 2:570
Barry Goldwater, 2:570
George Perkins Marsh, 2:569, 4:1858–1859, 4:2180
Clifford Pinchot, 2:570
Franklin D. Roosevelt, 2:570
Theodore Roosevelt, 2:569–570
Henry David Thoreau, 2:569

Conservation International, 2:871

Conservation zoning, 2:571–572
bounded zones with rules and, 2:571
definition and explanation of, 2:571
ocean conservation zoning and, 2:572
political features of, 2:572
rural conservation zoning and, 2:571–572
spatial planning strategy of, 2:571
sustainable communities and, 2:571
urban planning and, 2:571
See also Conservation

Constructivist learning theory
behavioral geography and, 1:189
heterogeneous constructivism (Demeritt), critical GIS and, 2:614
social construction of space and, 5:2297

Consumption, geographies of, 2:572–576
Walter Benjamin’s work, 2:573–574
central place theory and, 2:575
class, gender, ethnicity, and power factors of, 2:573
commodities as distillations of signs (Benjamin) and, 2:573–574
commodities as embodiments of social relations
(Marxism) and, 2:573
commodity chains and, 1:522–525
commodity fetishism concept and, 2:573
consumption as a social process and, 2:574
definitions, 2:572
economic landscapes and, 2:575
geographies of food and, 3:1144–1146
geography of tourism and, 2:575
global economy and, 2:575
humanistic geography and, 2:574–575
impact of, 2:572
Keynesian demand management and, 2:572
Mall of America, Bloomington, Minnesota, and,
2:574 (photo), 2:575
Marxist interpretation of, 2:573
mass production and, 2:572
neoclassical economics and, 2:572–573
postmodernist consumption analysis and, 2:574
principles of, 2:574–575
production relationship to, 2:572
recycling of municipal solid waste and, 5:2372–2375
symbolic value of commodities and, 2:574
theoretical perspectives on, 2:572–574
world economy changes and, 2:572
See also Agrofoods; Food, geography of

Convention on Biological Diversity (CBD)
biodiversity definition of, 6:2748

Conventional Migratory Species, 3:1604

Cook, Captain James, 2:576–577
Alaska and Hawaiian islands explored by, 2:576
Antarctic explored by, 2:576
Cook Islands explored by, 2:576
Earth’s resources studied by, 5:2447
New Zealand and Australia explorations of, 2:576
Northwest Passage sought by, 2:576
Pacific Ocean travels of, 2:575, 3:1461
St. Lawrence River mapped by, 2:576

Cook, lan, 1:524

Cooke, Philip, 4:1791

Coordinate geometry, 2:577–579
cartesian coordinate system used in, 2:577
distortion issues and, 2:578
goecentric coordinate system, 2:578–579, 2:578 (fig.)
geometric measures and, 3:1240–1241
projecting objects from 3D model to 2D map and, 2:578
scale and distance unit implications of 3D model coordinate system and, 2:577, 2:577 (fig.)
3D modeling software and, 2:577
See also Coordinate systems; Coordinate transformations

Coordinate systems, 2:579–580
absolute methods of specifying location and, 2:579
coordinate geometry and, 2:577–579
curvature of the earth issue and, 2:579
Earth Centered, Earth Fixed X, Y, Z system (ECEF) system, 2:579
geocoding and, 3:1208–1209
green geometry and, 3:1239–1240
local plane coordinate systems, 2:579
longitude, latitude, and altitude examples of, 2:579
map projections and, 2:579, 4:1841–1849
Military Grid Reference System (MGRS), 2:580
national grid systems, 2:579–580
participatory mapping and, 4:2124–2125
projection parameters and, 2:579
surveyors and engineers use of, 2:579
Universal Transverse Mercator (UTM) system of, 2:580
See also Coordinate geometry; Coordinate transformations;
Earth’s coordinate grid
Coordinate transformations, 2:580–581
affine transformation and, 2:581
categories of, 2:580–581
definitions, 2:580–581
global debate on future of, 2:585
geometric correction and, 3:1239–1240
GLScience applications of, 2:580
local models and, 2:581
map projections and, 2:581
polynomial models in, 2:581
See also Coordinate geometry; Coordinate systems
Cope, Meghan, 2:615
Copernicus, 1:116
Coral reef, 2:581–584
atolls, 2:583
barrier reefs, 2:583
biodiversity conservation and, 3:1635
climates and, 2:583
Coron Island, coral island seascape, Tagbanwa people, the Philippines, 3:1360 (photo)
fauna harvesting for aquarists and, 2:583
formation of, 2:583
fringing reefs, 2:583
geographic locations of, 2:581–582
hard vs. soft corals and, 2:583
high islands and atoll structures and, 3:1635–1638, 3:1636 (photo), 3:1637 (photo)
in Mariana Islands, Guam, 2:582 (photo)
protein richnes of, 2:582
as resource at risk, 2:582–583
species richness and biodiversity of, 2:582
tourism economy and, 2:582–583
volcanoes and, 2:583
See also Coral reef geomorphology
Coral reef geomorphology, 2:584–586
beginnings of, 2:584–585
explanation of, 2:584
geomorphic features of, 2:584, 2:585 (fig.)
global debate on future of, 2:586
intrarreef-platform scale of, 2:586
landforms and, 2:584
plate tectonics and, 2:586
reelf sedimentary landforms vs., 2:584, 2:585 (fig.)
short-term geological and long-term geological timescales and, 2:584
space and timescale of relevance to, 2:585–586
Corbridge, Stuart, 3:1220, 3:1420
Coriolis force, 2:586–587
atmospheric circulation and, 1:132, 1:133, 2:586–587
Coriolis effect and, 2:587
Coriolis parameter definition and, 2:587
Earth’s rotation element in, 2:586, 3:1395
El Niño-Southern Oscillation (ENSO) and, 2:888
equator and, 2:1008
as a fictitious force, 2:587
hurricanes and, 1:134
magnitude of, 2:587
Northern vs. Southern Hemisphere and, 2:586
ocean circulation and, 2:586–587
oceanic circulation and, 4:2058–2064
Cornish, Vaughan, 4:2175
Corporate voluntary environmental initiatives and
self-regulation, 2:587–589
advocates vs. critics of, 2:589
catalyst factors in, 2:589
categories of, 2:588
eo-eficiencies and, 2:587, 2:588–589
eo-labeling and accreditation programs and, 2:588
explanation of, 2:587
global benefits of, 2:588–589
Global Reporting Initiative (GRI) and, 2:588
government regulation vs., 2:587
International Organization for Standardization and, 2:588
liability issues and, 2:588
market-based environmental incentives vs., 2:587
perceived obligation motivations and, 2:588
product stewardship programs and, 2:588
Responsible Care program (chemical industry) and, 2:587–588
Cosgrove, Denis, 2:589–590
art and geography, 1:118
class and nature, 1:425
“crisis of representation,” 2:589, 2:590
cultural landscape studies of, 2:590, 4:1863
geographic imagination and knowledge representation work of, 2:589, 3:1221, 5:2432
iconography and, 2:590
landscape depiction and mapping focus of, 2:589, 2:590, 5:2432, 6:2810–2811
Marxist geography, 4:1863
“One-World, Whole-Earth” Apollo space mission and, 4:2175
“spatial turn” and, 5:2668
symbolic landscapes and, 2:590, 4:1863
vision and geography, 2:590, 6:3025
Cosmopolitanism, 2:590–592
anti-nationalism and antipatriotism of, 2:591
Bahá’í faith and, 2:591
as a ethical, moral, and political philosophy, 2:590
feminism and, 2:591
globalization and, 2:591
Hierocles’s circle model and, 2:591
humanitarian interventions and, 2:591–592
meanings associated with, 2:590
moral universalism and, 2:590
neoliberalism and, 2:591
origins of, 2:590–591
postpositivism and, 2:591
Renaissance and Enlightenment thinkers and, 2:591
shared humanity and, 2:590
Costanza, Robert, 6:3022
Costa Rica
bird species in, 1:199
Conference of Latin Americanist Geographers held in, 2:568
Costa Rican National Grid coordinate system, 2:579–580
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
ecotourism certification in, 2:873
ecotourism in, 2:870
greenhouse gas emissions and, 1:463
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
sea turtle conservation, as common resource in, 1:526
trading blocs and, 3:1550
Cost-benefit analysis (CBA), 2:592–593
criticism of, 2:593
definition and applications of, 2:592
ex ante, vs. ex post, vs. in medias res uses of, 2:592
net present value provided by, 2:592
steps in process of, 2:592–593
Cote d’Ivoire, 3:1190 (table)
Council for Mutual Economic Assistance (COMECON), 2:593–595
barter process in, 2:594
bilateral trade and, 2:594
dissolution of, 2:594
governing structure of, 2:593–594
independence from Soviet Union and, 2:594
limitations of, 2:594
membership of, 2:593 (table)
multilateral trade and, 2:594
price-setting markets absence in, 2:594
Solidarity movement (Poland) and, 2:594
Soviet Union and, 2:593–594
Countermapping, 2:595–596
cartographic forms of, 2:595
focus areas of, 2:595
indigenous cartography and, 2:595
public participation GIS (PPGIS) and, 2:595
social injustice focus of, 2:595–596, 3:1645
Counterurbanization, 2:596–597
deconcentration from urban to rural areas and, 2:596
definition of, 2:596
in France, 2:596
industrial to postindustrial society shift and, 2:596–597
suburbanization vs., 2:596
Coupe, Patty, 4:1882
Coupled human and animal systems (CHAS), 2:597–599
as an analytical concept, globalization and, 2:598
animal geographies and, 1:75–79
characteristics of, 2:597, 2:598 (fig.)
coupled human and natural system (CHANS) and, 2:598 (fig.)
Domestication of animals, 1:75–79
human/animal integral interdependent system and, 2:597–598
multidisciplinary nature of, 2:598
nomadic pastoralism and, 2:597
spatial and temporal movement elements in, 2:598
Coupled human and natural systems (CHANS), 2:599–604
biophysical and socioeconomic sphere linkages and, 2:600
carbon dioxide levels and, 2:601–602
characteristics of, 2:598 (fig.), 2:599, 2:600–601
climate change as, 2:601–602
coupled human and animal systems (CHAS) and, 2:598 (fig.)
cross-scale measurement difficulties and, 2:600
distance relationships and, 2:600
environmental determinism and, 2:599
future directions and challenges of, 2:603
gains from, 2:603
hazards research and, 2:599
human-environment relations research and, 2:599–600
land use and cover change (LUC) and, 2:602
linkages across spheres and nonlinear changes over time examples and, 2:602
long-term impacts, legacy effects and, 2:601
methods and tools used in, 2:602
modeling approaches to, 2:602
natural hazards and, 2:600–601
nonlinear systems and behavior and, 2:601
positive and negative feedback loops elements of, 2:600, 2:602
reciprocal effects element of, 2:600
research areas and, 2:599–600
research funding and, 2:599
scale element of, 2:600
scale mismatches over time and, 2:601
synergistic and cumulative effects of local processes and, 2:600
systems approach to, 2:602–603
theoretical framework of, 2:602–603
timeline of 1960s–1980s,
theory of adaptive change and, 2:603
uniqueness and time over space and, 2:600–601
Cousteau, Jacques, 4:2168
Cowles, Henry, 2:604
Cranberry Glades Botanical Area, West Virginia, 2:606
Cranz, Galen, 2:575
Creamer, N., 1:54
Creed, Clara, 2:1043–1044
Creep, 2:604–605
aseismic creep, 2:604, 2:605
definition of, 2:604
downhill creep, 2:604–605
expansion and contraction cycles and, 2:604
mass wasting and, 4:1868–1871
rock-mass creep, or deep creep and, 2:604
sagging or settlement, grabens, and antislope scarps from
snow on slopes effects and, 2:605
soil creep effects and, 2:605
types of, 2:604
Cresswell, Tim, 3:1419
Crime, geography of, 2:605–609
approaches and issues in, 2:606
Cartographic School of Criminology and, 2:606–607
Chicago School of social ecology and, 2:607
crime school vs. consensus school of criminal law and, 2:606
criminal law as cause of crime and, 2:606
criminal law base metric of, 2:606
environmental criminology and, 2:608
fear geographies and, 3:1088
geographical profiling and, 2:608
GIS technology and, 2:608
history, 2:606–607
International Criminal Court (ICC) and, 3:1605–1608
location quotients, spatial variation of crime and, 2:606
mobility of offenders factor in, 2:607
National Crime Victimization Surveys data and, 2:606
poverty and illiteracy factors and, 2:607
police report data and, 2:606
self-report data and, 2:606
social disorganization factor in, 2:607
spatial variation of crime across urban areas research and, 2:606–607
violence crime vs. crime against property and, 2:606
See also Law, geography of
Crisis (economic), 2:609–610
capitalist crisis in production and, 2:609–610
Critical GIS, 2:610
flexible accumulation and, 2:610
Fordism crisis and, 2:610
genetics of uneven development concept and, 2:610
Limits to Capital (Harvey) and, 2:609–610, 4:1862, 5:2350–2351
mainstream economics, localized system and, 2:609
Marxist crisis theories and, 2:609–610
over accumulation theory of crisis and, 2:609, 2:610
recurring economic crises and, 2:609
spatial fixes limitations and, 2:610
Critical geopolitics, 2:610–613
“axis of evil” (G. W. Bush) and, 2:612
cognitive elements vs. affective elements and, 2:613
critical human geography and, 2:705–706
economic environmental security and, 2:998–1000
Eurocentrism and, 2:1028–130
exploration of, 2:610
feminist critiques of, 2:613
formal geopolitics, 2:611–612
future trends in, 2:612–613
genocide geographies and, 3:1200
goal of, 2:610
heartland/rimland model of, 2:611–612, 4:1812
Nazi aggression justification and, 2:611
nonrepresentational theory and, 2:612–613
oceans and, 4:2069
origins of, 2:611
popular geopolitics, 2:612
power and knowledge elements in, 2:611, 5:2224
practical geopolitics, 2:612
World War II Axis powers and, 2:612
See also Critical geopolitics: noted individuals; Geopolitics

Critical geopolitics: noted individuals
John Agnew, 1:32–33
Michel Foucault, 2:611
Henry Kissinger, 2:611
Henri Lefebvre, 2:611, 4:1768–1770, 4:2043
Halford Mackinder, 2:611, 4:1812–1813
Nicholas Spykman, 2:611

Critical GIS, 2:613–616
applications of, 2:615
breast cancer and environmental links research using, 2:615
epistemology and, 2:614
external vs. internal critique of, 2:614
feelings and emotions in GIS analysis and, 2:615
feminism and, 2:615
GIS researchers and social critics collaboration and, 2:614
goal and agenda of, 2:613–614
heterogeneous constructivism (Demeritt) and, 2:614
human geographers and GIScientists conflict origin of, 2:614
neighborhood mapping project using, 2:615
ontology, essence of being and, 2:614–615
public participation GIS (PPGIS) and, 2:615–616
qualitative methods incorporated into, 2:615
social networking and Web 2.0 applications and, 2:615
See also Critical GIS: noted individuals; GIScience

Critical GIS: noted individuals
Scott Bell, 2:615
Meghan Cope, 2:615
David Demeritt, 2:614
Sarah Elwood, 2:615
Rina Ghose, 2:616
Piotr Jankowski, 2:616
LaDonna Knigge, 2:616

Mei-Po Kwan, 2:615, 4:1674
Sara McLaflerty, 2:615
Timothy Nyerges, 2:616
John Pickles, 4:2182–2813
M. Reed, 2:615

Critical human geography, 2:616–621
actor-network theory and, 1:8
Antipode (Wisner and Peet, eds.) and, 1:73, 2:618, 4:2144, 5:2350
Cincinnati Mini-Conference in Critical Geography and, 2:619
Condition of the Working Class in England in 1844 (Engels) and, 2:617
Critical Geography Forum online (U.K.) and, 2:620
critical studies of nature and, 2:623–624
democracy and, 2:705–706
disabled activists and, 2:619
emancipatory politics, progressive social change and, 2:616
ethics and geography and, 2:1013–1016
existentialist geographies and, 2:1046–107
extreme geography and, 2:1073–1074
feminist geography and, 2:618
“The Geography of Women: An Historical Introduction” essay (Hayford) and, 2:618
historical geographies of knowledge production facet of, 2:616
hybrid geographies and, 3:1502–1504
Institute of British Geographers and, 2:619–620
International Conference of Critical Geography, 2:620
International Critical Geography Group and, 2:619–620
journals of, 2:617
justice/injustice geographies and, 3:1643–1645
Marxism and, 2:618–619
medical geographies and, 4:1878
Nordic Symposium on Critical Geography and, 2:618, 2:619
“One Not Excluding Half the Human in Human Geography” essay (Monk and Hanson), 2:618
postmodernism and, 2:619
radical geographers and, 2:618, 2:619
Royal Dutch Shell and, 2:619–620
Royal Geographical Society and, 2:619–620
sexuality geographies and, 5:2538–2540
socialism and, 5:2571
Social Justice and the City (Harvey) and, 2:618, 3:1405, 4:1862, 5:2350, 5:2442
theoretical foundations of, 2:616
See also Critical human geography: noted individuals;

Humanistic geography
Critical human geography: noted individuals
Vera Chouinard, 2:619
Michael Dear, 2:619
Pierre George, 2:617
Anthony Giddens, 3:1277–1278
Ali Grant, 2:619
Derek Gregory, 3:1380–1381, 4:1787
Susan Hanson, 2:618
Brian Harley, 3:1401–1402
David Harvey, 2:618, 3:1404–1406, 4:1862, 5:2350, 5:2442
Alison Hayford, 2:618
Anatole Kopp, 2:617
Peter Kropotkin, 2:617, 5:2211
Yves Lacoste, 2:617
Henri Lefebvre, 2:617
Karl Marx, 2:617
Linda McDowell, 2:618
Janice Monk, 2:618
Gunnar Olsson, 4:2077–2078
Critical studies of nature, 2:621–625
actor-network theory and, 2:623–624
biological ecofeminism and, 2:623
class and nature and, 1:423–425
constructing nature and, 2:621–622
critical race theory and, 5:2338
deep-green, deep-ecology philosophies and, 2:624
denaturalizing gender and socializing nature in, 2:622–623
ecosystemic approach to nature and, 2:625
environmental determinism and, 2:621
environmental discourse and, 2:918–921
environmental justice and, 2:625
feminist geographical research and, 2:622–623
gender and nature and, 3:1194–1197
geography definitions and, 2:621
hybrid geographies research and, 2:624
Marxism and, 2:624–625
nature definitions and views on, 2:621
political ecology and, 2:622
politizing nature and denaturalizing hazards and, 2:622
post-humanism, interspecies connections and, 2:623–624
urbanization of nature and, 2:625
Croatia
bluefin tuna farm, mid Adriatic, 4:2066 (photo)
economically active females in, 3:1190 (table)
Croke, J., 3:1512
Cronon, William, 4:1995, 5:2339
Crop genetic diversity, 2:625–627
crop breeding programs decrease of, 2:626
definition of, 2:625–626
domestication bottleneck process and, 2:626
domestication of plants and, 2:784–786
gene banks and, 2:626
genetic erosion concept and, 2:626
genetic resource conservation programs and, 2:626–627
Germplasm Enhancement for Maize project and, 2:626 (photo)
hybridization of plants and, 3:1504–1506
International Treaty on Plant Genetic Resources for Food
and Agriculture (ITPGRFA) and, 2:626
measurement methods of, 2:626
toxic levels of, 2:626
Crop rotation, 2:627–630
agrochemical use and, 2:627
alternative crop rotation and, 2:628 (photo)
cropping pattern changes and, 2:629–630
crop properties and rotation benefits of, 2:628, 2:628 (fig.)
in developing world, 2:627
fallow farming and, 2:627
mixed farming and, 4:1914–1917
pest control by using, 2:628
social, economic, and environmental factors in, 2:627
weed control by using, 2:629
Cross-border cooperation (CBC), 2:630–631
borderlands and, 1:291–292
cross-border spatial integration and, 2:630
economic, cultural, and political benefits of, 2:630
European Union integration process and, 2:630
Euroregions and, 2:630, 2:631 (fig.)
goal to transcend barrier function of borders and, 2:630
multilevel governance networks and, 2:630
See also Borders and boundaries
Cruikshank, George, 3:1363
Crump, J., 2:1075
Cuba
Cold War and, 1:505
domino theory and, 3:1224
domestication bottleneck process and, 2:626
denaturalizing gender and socializing nature in, 2:622–623
domestication of plants and, 2:625
economic, cultural, and political benefits of, 2:630
European Union integration process and, 2:630
Grotius, Hugo, 4:2065
historical development of, 2:632–633
human adaptation to and of environment focus of,
2:632, 2:895–896
human agency issue and, 2:632
human ecology and, 2:633, 2:895–896
indigenous agriculture and, 3:1536
issues addressed by, 2:632
journals specializing in, 2:633
land use and cover change field and, 2:633
local food and subsistence systems focus of, 2:633
mixed methods used in, 2:632
Nietschmann’s work in, 2:632
oceans and, 4:2065
political ecology and, 2:632–633, 5:2211, 5:2212
postmodernism, poststructuralism and, 2:632
quantitative methods and, 2:632
Santo’s work in, 2:632
Spanish colony of, 1:512
sustainable agriculture success in, 6:2744
Cultural ecology, 2:631–634
current trends in, 2:633–634
Denevan’s work in, 2:632
discourse analysis, critical theory used in, 2:632
empirical feedback element in, 2:632
energy and human ecology and, 2:895–896
genes and, 2:632
Grotius, Hugo, 4:2065
historical development of, 2:632–633
humans and and environment focus of, 2:632, 2:895–896
human agency issue and, 2:632
human ecology and, 2:633, 2:895–896
human rights atrocities in, 3:1481
human agency issue and, 2:632
indigenous agriculture and, 3:1536
issues addressed by, 2:632
journals specializing in, 2:633
land use and cover change field and, 2:633
local food and subsistence systems focus of, 2:633
mixed methods used in, 2:632
Nietschmann’s work in, 2:632
oceans and, 4:2065
political ecology and, 2:632–633, 5:2211, 5:2212
postmodernism, poststructuralism and, 2:632
quantitative methods and, 2:632
Santo’s work in, 2:632
Spanish colony of, 1:512
sustainable agriculture success in, 6:2744
Cultural geography, 2:634–640
Berkeley School and, 1:191, 1:192
cultural approaches within, 2:637–639
cultural hearth areas and, 3:1142
cultural turn and, 2:644–646
culture as a thing vs. as a process and, 2:634–635
culture definitions and, 2:634–635
current status of, 2:639
dominant approaches within, 2:637
Enlightenment and, 2:910–911
folk culture and, 3:1142–1144
folk and popular culture and, 2:637, 3:1142
French Annales School of history and, 1:79–80
gender and, 3:1238–1230
glocalization and, 3:1347
humanistic approaches within, 2:637, 3:1476–1477
Jerusalem’s Walling Wall and, 2:638 (photo)
landscape interpretation and, 2:635–636
morphology concept (Sauer) and, 2:636
Cultural landscape, 2:640–644
behavioralist approach to study of, 2:642
Berkeley School and, 2:653–636, 2:641–642
Bodie State Historic Park, California, and, 4:1705
deeper meanings of, 2:642
early development of, 2:640–642
environmental determinism and, 2:641–642
geomancy and, 3:1238–1230
human modification of Earth’s surface focus of, 2:640
landscape, landscapes, and landchaft terms and, 2:640, 2:641
landscape architecture and, 4:1698–1701
landscape as something that is lived concept and, 2:642
landscape design and, 4:1705
landscape interpretation and, 4:1713–1715
landscape morphology and, 2:640, 2:641, 2:643 (fig.)
landscape quality assessment and, 4:1715–1718
meanings embedded in, 2:643–644
mental mapping study approach and, 2:642–643
origins of, 2:640
palimpsest concept and, 4:2111–2112
Park Guell, Barcelona, Spain, and, 2:641 (photo)
“reading” the landscape and, 2:642, 2:643
religious geographies and, 5:2405–2409
research approaches to, 2:642–644
sense of place and, 2:642
sequent occupance and, 5:2534–2535
symbolism element in, 2:643
time element in, 2:643
UNESCO definition of, 4:1705
vernacular landscape concept (Jackson) and, 2:642

See also Architecture and geography; Art and geography;
Cultural landscape: noted individuals

Cultural landscape: noted individuals
Denis Cosgrove, 2:589–590, 5:2432
J. B. Jackson, 2:642
Fred Kniffen, 2:642
Peirce Lewis, 4:1772–1773

Otto Schlüter, 2:640, 2:641
Paul Vidal de la Blache, 2:640, 2:641, 3:1465, 5:2387
Wilbur Zelinsky, 2:642

Cultural turn, 2:644–646
Denis Cosgrove’s work and, 2:589–590, 5:2432
criticism of, 2:850
culture and embeddedness terms in, 2:849
cyborg ecologies and, 2:649
definition of, 2:644
ecological imaginaries and, 2:829
eyevery day geographies and, 2:1045
feminist methodologies origins and, 3:1098
gendered character of labor markets (Massey) and, 2:852,
4:1866–1867
government of enterprise and, 2:850
inequalities and injustices and, 2:645
interdisciplinarity of cultural studies and, 2:645
issues addressed and, 2:645–646, 3:1429
issues of, 3:1404
knowledge and meaning making enmeshed within power
practices and, 2:645
knowledge produces the world concept, impact of, 2:644–645
music and sound geographies and, 4:1967–1968
“new” geographies, 2:645
objective knowledge impossibility and, 2:645
origins of, 2:645
place and politics of representation and, 6:2810
poststructuralism and, 2:645, 2:849–850
space and sexuality issues and, 6:2810
Curacao, Dutch colony of, 1:512
Cutter, Susan, 2:963

Cyberspace, 2:646–648
Advanced Research Projects Agency of U.S. Department of
Defense and, 2:646
Atlas of Cyberspace and, 2:540, 2:646
digital convergence of different media and, 2:646–647
digital divide and, 2:647, 2:748–753
e-commerce and, 2:844–846
history and dimensions of, 2:646–648
hybrid nature of, 2:647
illegal activities and, 2:648
Internet domain names growth and, 2:647, 2:647 (fig.)
Internet vs., 2:646
mapping cyberspace concept and, 2:540
material infrastructures element of, 2:647
as mirror of society, 2:648
social networks in, 2:648
“surface Web” vs. “deep Web” and, 2:648
TCP-IP (transfer control protocol, Internet protocol) element of, 2:646
virtual world, 2:647
World Wide Web creation and, 2:646
See also Communications geography

Cyborg ecologies, 2:649, 2:649–650
actor-network theory and, 2:649
“A Cyborg Manifesto” (Caraway) and, 2:649
cultural turn, return to the material and, 2:649
definition, explanation of, 2:649
discourse in constituting the world and, 2:649
Hybrid Geographies (Whatmore) and, 2:649–650
nature, culture, animals and human, object and subject
boundaries and, 2:649
as a political metaphor, 2:649
purification and mediation modernity processes and, 2:649
relational character of the world element of, 2:649–650

INDEX 3217
science studies scholars and, 2:649  
Simians, Cyber, and Women (Caraway) and, 2:649  
synthetic and organic interconnections and, 2:649  
We Have Never Been Modern (Latour), 2:649  
See also Cyborg ecologies: noted individuals  
Cyborg ecologies: noted individuals  
Gilles Deleuze, 2:649  
Felix Guattari, 2:649  
Donna Haraway, 2:649  
Bruno Latour, 2:649, 3:1503  
Sarah Whatmore, 2:649–650, 3:1503  

Cyclones: extratropical, 2:650–654  
-atmospheric circulation and energy transfer patterns of, 2:650  
-Bergen school of meteorology and, 2:650–651  
-comma-cloud shape of, north-central United States, south-central Canada, 2:651 (image)  
-extratropical cyclogenesis, 2:652–653  
-incipient frontal wave and, 2:652, 2:652 (fig.)  
-life cycle evolution of, 2:652 (figs.)  
-mature occlusion and, 2:653, 2:654 (fig.)  
-mature open wave and, 2:652–653, 2:653 (fig.), 2:654 (fig.)  
-midlatitude weather patterns of, 2:650  
-Norwegian Cyclone Model of, 2:652  
-polar front theory (PFT), 2:650–652  
-Rosby-wave configuration and, 2:652  
-stacked low, low-pressure profile rearrangement and, 2:653  
-stationary front and, 2:652, 2:652 (fig.)  
-tropical cyclones and, 2:651–652  
-weather events associated with, 2:650  

Cyclones: occluded, 2:654–661  
-case study, timeline of, 2:657, 2:658 (fig.)  
-case study, total precipitation distribution, 2:659, 2:659 (fig.)  
-case study, distribution of shorter-period precipitation amounts, 2:659–661, 2:660 (fig.)  
-explanation of, 2:654  
-frontal development from maturity to occlusion and, 2:655–657, 2:656 (fig.)  
-jet streams and surface weather interaction and, 2:654–655  
-middle latitude weather changes and, 2:654  
-Rosby waves and, 2:654–655  
-upper airflow and surface extratropical cyclone formation and, 2:653 (fig.)  
-Westerlies and, 2:654  

Cyprus  
cats domestication in, 2:783  
economically active females in, 3:1190 (table)  
-European Union (EU) membership of, 2:1035  

Czechoslovakia  
-Cold War and, 1:504  
collapse of, 4:1978  
-COMECON membership of, 2:593 (table)  
-conservation and environmental education movement in, 2:1032  
economically active females in, 3:1190 (table)  
-industrialization in, 2:542  

Czech Republic  
-acid rain in, 1:7  
-AGILE membership of, 1:124 (table)  
-automobile industry in, 1:171  
-green roof of superstore, Prague, 6:2993 (photo)  

Dacey, Michael, 1:192, 3:1466  
Daguerré, Louis Jacques Mandé, 4:2175  
Dahmann, N., 4:1804  
Dalby, Simon, 3:1252  
Daly, Herman, 2:835, 2:896, 5:2446, 6:2749  
Daly, Reginald, 1:166  
Dangermond, Jack, 2:663–664  
ArcGIS developed by, 2:663  
-Environmental Systems Research Institute (ESRI)  
-co-founded by, 2:663  
-spatial analysis methods work of, 2:663–664  
Daniels, Stephen, 1:118, 1:425, 2:590  
Darby, Henry Clifford, 2:664–665  
Doomsday Book written by, 2:664  
-historical geography work of, 2:664  
-vertical approach preferred by, 2:664  
-medieval England focus of, 2:664  
Darwin, Charles  
-atoll subsidence origin theory of, 1:166, 2:585  
-Earth's resources studied by, 5:2447  
-earthworms observed by, 1:274  
-evolution by natural selection work of, 1:209, 2:916  
-Galapagos Islands archipelagoes, adaptive radiation and, 1:106  
-hybridization views of, 3:1504–1505  
-Origin of Species written by, 1:209, 4:2179–2180  
Darwinism and geography, 2:665–668  
collective knowledge and, 2:666  
-competition and survival of the species and, 2:666  
-complexity theory and, 2:668  
-Darwinian view of evolution and, 2:665  
-William Morris Davis's cycle of life work and, 2:666  
-economic landscapes as layers of accumulation and, 2:666  
-environmental determinism in geography and, 2:667, 3:1429  
environmental economics and, 2:668  
evolution as change through time and, 2:665, 2:666, 4:2179–2180  
-geographic impact of, 2:665  
-historicism and, 3:1434  
-island biogeography and, 3:1635  
-Peter Kropotkin's work and, 2:667–668, 5:2211  
-Lamarckian evolutionary theory and, 2:666, 2:667, 3:1464  
-Pierre-Simon Laplace's probability work and, 2:667  
-layering geological metaphor and, 2:666  
-Marxist economic geography and, 2:666  
-natural selection and struggle for existence issue and, 2:667–668  
-organic life and the environment relationship (Ratzel) and, 2:665, 2:666–667  
-organism analogy and, 2:666–667  
-organization and ecology, 2:666–667  
-part-whole dilemma and, 2:666–667  
-random nature of original variations work of, 2:665–666  
-recent developments, 2:668  
-Social Darwinism and, 3:1464  
-Herbert Spencer and, 3:1434, 3:1464  

Dasymetric maps, 2:669–671  
-choropleth mapping origins of, 2:669  
-population density by census tract and block group, Guilford County, North Carolina, 2:668, 2:669 (fig.)  
-population density using dasymetric mapping, Guilford County, North Carolina, 2:668, 2:670 (fig.)  
-treatment of boundaries of political units and, 2:669  
J. K. Wright's work in, 2:670  

Database management systems (DBMS)  
-benefits of, 2:671  
-business models for GIC, 1:308  
-client-server architecture and, 1:426–428  
-Edgar Codd's relational database work and, 2:671  
-conflation and, 2:568–569  
-Jack Dangermond's work in, 2:663–664  
-data editing and, 2:880–881  

data indexing and, 2:682–684
definition and history of database models and, 2:671
environmental mapping, 2:974–976
error propagation and, 2:1011–1012
ESRI ARC/INFO coverage format and, 2:674
ESRI shapefile format and, 2:674, 2:685 (fig.)
foreign key element of, 2:672, 2:673 (fig.)
geodatabase format and, 2:674
geography applications of, 2:674
GIS data formats and, 2:671, 2:674
metadata and, 4:1885
network vs. hierarchical model of, 2:671
normalization database design process and, 2:672
object-relational model of, 2:671
one-to-one, one-to-many, many-to-many relationships and,
2:672, 2:673 (fig.)
primary key identifier element of, 2:672
query language and methods in, 2:672–674,
2:684–685, 2:685 (fig.)
referential integrity and, 2:672
relational database management systems and, 2:671–674
relational database structure and design and, 2:671–672
research application of, 2:671
SELECT command in, 2:672–673
spatial databases and, 2:671, 2:674
standard structured query language (SQL) and, 2:671,
2:672–673, 2:676, 2:684–685
structure and design of relational databases and, 2:671–672,
2:672 (fig.)
See also GIS software; GIS specific subject
Database versioning
branching and versioning in the set approach and,
2:676, 2:676 (fig.)
goals of set concept in, 2:676
hierarchical structure and, 2:675
integrity of data and, 2:675
merging of sets and, 2:675
parallel lineage tree with active versions at tips,
2:676, 2:676 (fig.)
Data classification schemes, 2:677–679
assigning data elements to a class and, 2:677
choropleth maps and, 1:406–408
equal interval classification, 2:677 (fig.), 2:678
error propagation and, 2:1011–1012
interquartile range classification, 2:678, 2:678 (fig.)
natural breaks classification, 2:677 (fig.), 2:678
standard deviation classification, 2:678–679, 2:678 (fig.)
supervised classification and, 5:2725
Data compression methods, 2:679–680
error propagation and, 2:1011–1012
GIS and geospatial information applications of, 2:680
JPEG3000 and MPEG4 and, 2:679
“lossy” vs. “lossless” compression methods and, 2:679
problems solved by, 2:679
variable resolution compression method and, 2:680
vector quantization (VQ) lossy data compression method and,
2:679–680
See also Data format conversion
Data editing, 2:680–681
accuracy assessment and, 2:680–681
data error examples and, 2:680
data format conversion and, 2:681–682
definition of, 2:680
delta value element in, 2:681
error magnitude evaluation and, 2:680–681
error propagation and, 2:1011–1012
imputation procedures used in, 2:681
spatial vs. aspatial data and, 2:680
Data format conversion, 2:681–682
error propagation and, 2:1011–1012
examples of, 2:681
geographic information systems (GIS) use of, 2:681–682
Geospatial Data Abstraction Library (GDAL) and, 2:682
GIS software programs and, 2:682
lossless vs. lossy conversion and, 2:681
transformational languages and, 2:682
vector data to raster representation conversion
(lossy) and, 2:681–682
See also Data compression methods
Data indexing, 2:682–684
B-tree nontrivial data index and, 2:683, 2:683 (fig.)
functions of, 2:682
goal of, 2:682
grid indexing and, 2:683
Antonin Guttman and, 2:683
minimum bounding rectangles (MBRs) or bounding
boxes and, 2:684
nonspatial data indexing, 2:682–683
quad trees and, 2:684
R-tree and R*–tree data structure and, 2:683–684
spatial data indexing, 2:682, 2:683–684
Data querying in GIS, 2:684–685
Canadian Geographic Information System (CAGIS), 2:674
connecting with other database management systems and, 2:684
data duplication prevention and, 2:684
Dual Independent Map Encoding (DIME), U.S. Census Bureau
and, 2:674
ESRI shapefile format and, 2:674, 2:685 (fig.)
GIS data formats and, 2:674
join and link functions and, 2:684
key fields and, 2:684
relational database practices and, 2:684
spatial queries in, 2:685
standard structured query language (SQL) and, 2:671,
2:672–673, 2:676, 2:684–685
See also Database management systems (DBMS); GIS software;
GIS specific subject
Datums, 2:685–686
Earth shapes and, 2:686
equator and prime meridian as zero points and, 2:686
equatorial datums and, 2:685
examples of, 2:686
functions of, 2:685
network of monuments and, 2:686
vertical, horizontal, and complete datums, 2:685–686
David, Paul, 4:2133
da Vinci, Leonardo, 3:1245
Davis, John, 4:2179
Davis, Mike, 2:688, 4:1803
Davis, William Morris, 2:686–687
Isaiah Bowman influenced by, 1:295
criticism of, 3:1246
cycle of erosion developed by, 1:191, 3:1246, 4:2180, 5:2534
cycle of life views of, 2:666, 3:1245, 3:1279
gemographic cycle (geographical cycle) created by, 2:686–687,
3:1241–1242, 3:1246, 4:2180
Grove Karl Gilbert and, 3:1279
impact of, 2:687
morphogenetic terms of, 2:687
nature-society views of, 4:1989
Walther Penck and, 4:2145
physical geography work of, 3:1463
RGS award of, 5:2487
Dawson, George, 5:2448
Day, Richard, 1:74
Deacon, Robert, 5:1458
Dawson, George, 2:458
Decolonization, 2:691–692
Cold War and, 2:691–692
disintegration of large European empires and, 2:691
guerrilla conflicts and, 2:692
imperialism and, 3:1545–1548
India's peaceful independence and, 2:692
political, economic, and ideological changes of, 2:692
white superiority, racism challenged by, 2:692
world systems theory and, 2:691
Deep ecology movements, 2:692–695
bioregionalism, 1:255
cultural geography, situationism and landscape
aesthetics and, 2:694
deep green design and development and, 3:1372–1373
ecofeminism and, 2:817–820
ecological justice and, 2:831
ecological self-realization process and, 2:693, 2:695
environmental ethics and, 2:925–927
fellow travelers and, 2:695
Gaia organic wholeness, Earth systems science and, 2:693, 2:695
Gaia theory and, 3:1175–1178
impact of, 2:692–693
levels of questioning and articulation of, 2:693, 2:694 (table)
nature and self are one theme of, 2:692–693
political platform of, 2:693–695, 2:694 (table)
“shallow ecology” vs., 2:692
“think like a mountain” concept (Seed) and, 2:692
See also Deep ecology movements: noted individuals; European
green movements
Deep ecology movements: noted individuals
Joseph Beuys, 2:695
Mahatma Gandhi, 2:693
Stephan Harding, 2:695
James Lovelock, 2:695
Joanna Macy, 2:695
Arne Naess, 2:692–693, 2:694
John Seed, 2:693
George Sessions, 2:693
Baruch Spinoza, 2:693
Defoe, Daniel, 4:1787
Deforestation, 2:695–699
agroforestry and, 1:60–62
biological integrity of tropical ecosystems and, 2:699
carbon dioxide in atmosphere changes and, 1:328
causes of, 2:697–698
carbon emissions and, 2:697
commercial logging and, 2:698
ecosystem decay and, 2:858–862
explanatory framework of, 2:696–697
forest fragmentation and, 3:1159–1163
forest land use and, 3:1163–1165
fuelwood harvesting and, 2:698
impacts of, 2:698–699, 3:1334, 3:1335
industrialized farming and, 2:698
land change science (LCS) and, 2:696, 2:697
land degradation from, 4:1683–1684
from land use and cover change, in Sabah, Malaysia,
4:1737 (photo)
logging and slash-and-burn agriculture and, 2:697 (photo)
Mediterranean catchments, 1:275
midlatitude deciduous forest biome and, 1:223–226
small-scale farming and, 2:697–698
socioeconomic, technological, and ecological
conditions and, 2:698
species extinctions and, 2:699
statistics, 2:696
tropical deciduous forest biome and, 1:230–233
tropical rain forest biome and, 1:234–239
See also Forest degradation
De Geer, Gerard, clay-varve glacial dating method of, 1:82
Deindustrialization, 2:700–702
automobile industry and, 2:700
brownfields and, 1:296–298
explanation of, 2:700
industrialization vs., 2:700
labor force decline and, 2:700, 2:701 (fig.)
Manufacturing Belt, Rust Belt and, 2:701–702, 4:1823–1824
production processes shift and, 2:700–701
steel industry and, 2:700–701
textile industry and, 2:700
Deinstitutionalization, Doreen Massey’s work in, 4:1866–1867
Del Mar, California, 1:21 (photo)
Delta, 2:702–705
estuaries and, 2:703–704
fans, 2:703
geographic locations of, 2:715–716
human vs. biophysical causes of, 2:715, 2:716–717
Sahelian grasslands south of Sahara Desert and, 2:717–718,
2:792, 2:989
soil degradation in dryland areas and, 2:715–716
tragedy of the commons and, 2:716
UN conferences on, 2:718–719, 2:972–973, 3:1335
U.S. Dust Bowl and, 2:717
world-wide pervasiveness of, 2:717
See also Dunes

Desert varnish, 2:719–722
arid topography and, 1:112–113
Death Valley, California, 2:719, 2:722 (photo)
Tanzhuo Liu’s work and, 2:719–710
polygenetic formation model of, 2:719, 2:721 (photo)
rock coating categories and, 2:720 (table)
rock varnish and, 2:719
varnish microlaminations (VMLs) tool and, 2:719–720,
2:722 (photo)
Deskahel of Cayuga people, 3:1553

Deterritorialization and reterritorialization, 2:722–724
borderlands and, 1:291–292
borders and boundaries, 1:293–294
capitalism, power, and identity elements of, 2:722–723
Cold War and, 2:723, 2:724
cultural and social issues and, 2:723
Gilles Deleuze and, 2:722
globalization and, 2:723
globalized network flows and, 2:724, 3:1339–1340, 3:1341
Felix Guattari and, 2:722
nation-state changes and, 2:723, 2:724
political economy changes and, 2:723
reterritorialization processes and, 2:723–724
social life and territorial moorings relationship and, 2:722
spatial dimensions of capital accumulation and, 2:722
spatial reconfiguration and rebordering of social relations and, 2:724
territorial organization of power and, 2:722

Detroit, Michigan
automobile industry in, 1:169, 1:171, 1:172
Dotty Wotty House in, 1:119 (photo)
electronic music festival in, 6:2858 (photo), 6:2859 (photo)
Heidelberg Project and “Detroit. Demolition. Disneyland.”
in, 1:120
OJ (Obstruction of Justice) House and
The Oval Room and, 1:120 (photo)

Developing world, 2:724–729
African Union (AU) and, 1:25
carbon emissions issues and, 1:334
civil society and, 1:414–416
coastal zone and marine pollution and, 1:501
CO2 emissions, GHGs and, 3:1337
commodity chains in industrial decision-making and, 1:524
crop rotation methods in, 2:627
debt crisis and, 2:688–689
definition, 2:724
dependency theory and, 2:712–714
disease, drought, and distance to world markets factors and,
2:725, 2:725 (fig.)
diseases in, 2:726–727
drought and, 2:727–728, 2:793
drugs and, 2:795–996
early industrial societies in, 2:709
ecotourism industry in, 2:870
electronic waste and, 1:502
emerging markets and, 2:890–891
emigration in, 4:1893–1894
fertility rates decline in, 4:2015
food geographies and, 3:1145
foreign aid to, 3:1151–1153
foreign direct investment in, 3:1155–1156
forestland management in, 2:552
government and economic development and, 2:725
greenhouse gas emissions, Kyoto Protocol and, 1:463
Green Revolution and, 2:939
homelessness in, 3:1442
housing policy in, 3:1447
Human Development Index and, 2:725 (fig.), 5:2573
import substitution industrialism in, 2:1063, 3:1549–1551
informal economy and, 3:1590–1592
landlocked status and, 2:726
land reform in, 4:1692–1696
land tenure issues and, 1:316, 1:317
malaria and, 2:726–727
marine aquaculture in, 4:1854, 4:1854 (fig.)
mobilization theory and, 4:1931–1935
nation-states after colonialism in, 1:517
natural hazards and disasters and, 2:726
neocolonialism and, 4:2002–2005
new international division of labor and, 4:2019–2021
nongovernmental organizations (NGOs) and, 1:414–416
opium and heroin production in, 2:796–797
participatory learning and action used in, 4:2123
participatory rural appraisal used in, 4:2130
peasants and peasantry and, 4:2137–2142
plant diseases and pests factors and, 2:727
population growth and poverty relationship and, 2:726
population pyramid for, 5:2250 (fig.)
public water services in, 5:2316–2317
remittances and, 5:2411–2414
rural-urban migration in, 5:2495–2496
soil fertility factor and, 2:728
structural development programs in, 2:1065, 5:2703–2704
swathfoot labor in, 2:575
tragedy of the commons examples in, 1:532–533
transnational corporations and, 4:2004
Tropic of Cancer relevance to, 2:725–726
urbanization of hunger and, 3:1489
urban migration in, 5:2232
urban storm water management in, 6:2992, 6:2992 (photo)
water management issues in, 1:338
women’s lives in, 3:1097
World Development Report 1992 (World Bank) and, 2:1004
See also Development theory

Development theory, 2:729–733
capitalism evolution theories and, 2:729
central places theory and, 2:730
classical political economists and, 2:729
critiques of, 2:732–733
demographic transition and, 2:707–710
dependency theory and, 2:712–714, 2:732
developing countries modernization and, 2:730
East Asian “tigers” and, 2:731
economic multipliers theory and, 2:730
export-led development and, 2:1063–1066
eventalities and, 2:1068–1069
foreign aid and, 3:1151–1153
growth and modernization theories and, 2:730
historical idealism and, 2:729
historical materialism and, 2:729
Development theory: noted individuals


Robert Bates, 2:731
Brian Berry, 2:730
Lawrence Brown, 2:730
Walter Christaller, 2:730
Ronald Coase, 2:731, 4:1857
Eveey Domar, 2:730
Michel Foucault, 2:732
André Gunder Frank, 2:732
Peter Gould, 2:730
Antonio Gramsci, 2:732, 5:2230
Törsten Hagerstrand, 2:730
Roy Harrod, 2:730
Friedrich Hayek, 2:730, 2:781, 4:2011
Friedrich Hegel, 2:729
Albert Hirschman, 2:730
John Maynard Keynes, 2:730
Simon Kuznets, 2:730
Arthur Lewis, 2:730
Thomas Robert Malthus, 2:729, 4:1819–1820
Karl Marx, 2:729
John Stuart Mill, 2:729
Akin Mobogunje, 2:730
Gunnar Myrdal, 2:730
Douglas North, 2:731
Richard Peet, 4:2144
François Perroux, 2:730
Michael Polanyi, 2:729
Raúl Prebisch, 2:732
David Ricardo, 2:729
Everett Rogers, 2:730
Walter Rostow, 2:730
Adam Smith, 2:729
Robert Solow, 2:730
Robert Swan, 2:730
Thorstein Veblen, 2:729
Immanuel Wallerstein, 2:732
Max Weber, 2:729, 4:1931–1932
Georg Wilhelm, 2:729
Oliver Williamson, 2:731
Dewsbury, J. D., 4:2042

Diamond, Jared, 2:734
biological diversity studies of, 2:734, 4:1697, 5:2216, 5:2545, 5:2548
 Collapse written by, 2:734, 2:930
evolutionary determinism views of, 2:917
 Guns, Germs, and Steel written by, 1:509, 2:734, 2:917, 2:930, 5:2216
human geography studies of, 2:734, 2:917, 5:2216
New Guinea studies of, 2:734
power and wealth distribution work of, 2:917, 5:2216

Diaspora, 2:734–735
academic themes of, 2:735
cultural loss and, 2:735
development and resettlement themes and, 2:735
hybrid and personal identities formation and, 2:735
meanings of, 2:734–735
policy-making and, 2:735
transnationalism theme and, 2:735

Diotrophism, 2:736–737
basin and range topography and, 1:186–187
epeirogeny and, 2:736
eustasy and, 2:737
igneous processes and, 2:737
isostasy and, 2:736–737
mountain building orogenesis and, 2:736
orogenesis types and, 2:736
tectonic processes study and, 2:736
types of, 2:736

Diaz, Robert J., 1:488
Dibiase, David, 4:1826
Dicken, Peter, 2:850
Dickens, Charles, 6:2879 (image)
Diderot, Denis, 4:1928

Difference, geographies of, 2:737–740
as analytical concept, 2:737–738
blindness and geography and, 1:286–287
class, gender, race, and sexuality differences and, 2:738
fluid features of, 2:739
gender example of, 2:738–739
genderization and, 2:738
goal and, 2:737–738
geographies of exclusion and, 2:738
geographies of indeterminacy and, 2:739
hybridity and, 2:739–740
identity assertion and, 2:739
identity geographies and, 3:1527–1531
masculinity geographies, 2:738
measure of separation concept and, 2:737
multiple identities and, 2:739
Other/Otherness and, 4:2106–2107
power element in, 2:739
quantitative vs. qualitative approaches to, 2:738
relational difference element of, 2:739
theoretical and methodological approaches to, 2:738–740
whiteness, 2:738

Differential heating, 2:740–742
daily and seasonal insulation variations and, 2:741
energy transfer processes and, 2:740
evaporation over water vs. land and, 2:741
temperature and precipitation patterns and, 2:741

Differential vulnerabilities to hazards, 2:742–745
coping with hazards and, 2:742, 2:743 (photo)
Digital divide, 2:742
drought risk and hazard and, 2:790–794
environmental justice and, 2:744
examples of, 2:742
fossil fuels risks and, 2:743–744
Hurricane Katrina example of, 2:743, 4:1985–1986
immediate vs. creeping hazards and, 2:742
less wealthy vs. wealthy societies and, 2:742–744
natural vs. technological hazards and, 2:744
Tsunami of 2004, Indian Ocean example of, 2:743
women, children, elderly, and disabled at risk and, 2:744
See also Disaster prediction and warning; Disaster preparedness; Environmental justice

Diffusion, 2:745–748
in the automobile industry, 2:747
British railroad technology to India example of, 2:747
British textile technology to U.S. example of, 2:747
capitalist development and, 2:746
China as innovation center and, 2:746
Eurocentric vs. other-centric diffusion, 2:746
evolutionary perspective on, 2:745
global economy rhythms and, 2:746
innovation vs., 2:747
Japanese Datsun automobile from Germany example of, 2:747
China as innovation center and, 2:746
culture circles of diffusion theory and, 2:745
Eurocentric vs. other-centric diffusion, 2:746
evolutionary perspective on, 2:745
global economy rhythms and, 2:746
innovation vs., 2:747

Digitizing, 2:756–757
cadastral mapping and, 2:757
digital representation or digital image product of, 2:753
digitizing cursor tool of, 2:757
digitizing error and, 2:1012
digitizing tablet tool of, 2:756–757
GIS application editing tools used with, 2:757
GIS applications of, 2:756
process of, 2:757
Dinosaur extinction, 1:15

Disability, geography of, 2:757–759
biomedical models of disability and, 2:757
"cause" of disability, 2:757
chronic illnesses as disability and, 2:758
disability definitions and, 2:757
mental illness and learning disabilities and, 2:758
nature of research in, 2:757
participatory processes in research issue and, 2:759
research power dynamics and, 2:759
research topics of, 2:758
social models of disability and, 2:757–758
sociospatial experiences of disability and, 2:757
wheelchair tennis and, 2:758 (photo)
See also Blindness and geography

Disaster prediction and warning, 2:759–763
interpretations of warnings and, 2:760
lead time in prediction factor and, 2:760
myths and exaggerations, interpretation influenced by, 2:762
natural hazards and risk analysis and, 4:1983–1989
natural vs. technological disaster types and, 2:759
notification types and goals in, 2:761
participants in the communication process in, 2:761
study of, 3:2424–2428
“Reverse 911” notifications and, 2:761
social stratification factor and, 2:761
three-dimensional numerical studied of tornadoes and, 2:760
tsunami early warning buoy and, 2:760 (photo)
warning communication process and, 2:761–762
Warning Decision Support System (WDSS) and, 2:760
weather Web sites and, 2:762
See also Disaster preparedness; Natural hazards and risk analysis

Disaster preparedness, 2:763–766
Bhopal, India, chemical disaster and, 1:194–195
Disease, geography of, 2:764, 2:765
disaster, 2:763, 2:765
disaster mitigation Act of 2000 and, 2:763
disaster response and, 2:763
emergency management perspective on, 2:763–764
emergency management phases and, 2:764 (fig.)
Federal Emergency Management Agency (FEMA) and, 2:763
flooding Control Acts and, 2:763
general mode of risk communication and, 2:767
hazards and disaster research and, 2:765–766
individual preparedness and, 2:764, 2:765
National Flood Insurance Program and, 2:763, 2:764
natural hazards and risk analysis and, 4:1983–1989
Natural Hazards Research and Applications
Information Center and, 2:763
natural vs. willful hazards and, 2:765
psychological and attitudinal factors in, 2:765
response and recovery elements in, 2:764
risk, vulnerability, and resilience factors in, 2:763
situation, and cognitive factors in, 2:765
socioeconomic status factor in, 2:765
Gilbert White, floodplain management and, 2:763
See also Disaster prediction and warning: Natural hazards and risk analysis
Discourse and geography, 2:766–769
discourses shape our conception of the world and, 2:766
discourse theory application to geography, 2:767–769
discursive aggregation principle of, 2:767
environmental discourse and, 3:1454
everyday life geographies and, 2:1042–1045
Michel Foucault's work in, 2:766, 2:767, 2:769
geographic concept of scale example and, 2:768
geographic space, rules of discursive construction and, 2:768
government of poverty discourse example and, 2:768–769
human dimensions of global environmental change and, 3:1454
language and geographic analysis and, 4:1754
objects are discursive constructs concept and, 2:766
Orientalism and, 4:2101–2104
Other/Otherness and, 4:2106–2107
poverty maps, 2:768–769
power, knowledge, and truth relationship with, 2:767
selection principle of, 2:767
social institutions' role in, 2:766–767
space definition and, 2:768
See also Environmental discourse; Literature, geography and Disease, geography of, 2:769–774
cancer, 1:320–324
cholera, 1:401–403
current methods used in, 2:772–773
developing world, 2:726–727
developments in, 2:771–772
disease mapping (Snow) and, 2:770
diagnostic codes of health data and, 2:771
GIS development and, 2:771
Peter Haggett's work in, 3:1399–1400
health and medical climatology and, 1:473
Health Insurance Portability and Accountability Act (HIPAA) and, 2:771–772
historical foundations of, 2:770
HIV infection, global, 2:770 (fig.)
incoherences, 2:771
Kriging geostatistical technique and, 2:772
malaria, 4:1816–1819
mapping methods and, 2:772
Markov Chain Monte Carlo statistics and, 2:772–773
Minamata disease, mercury poisoning, 1:501–502
modifiable areal unit problem of mapping and, 2:772
physical environment quality factor in, 2:770
population density factor and, 2:771
public health applications and, 2:769–770
qualitative research methods and, 2:773
SaTScan cluster detection statistic and, 2:772
John Snow's work in, 2:770
social and economic conditions, population demographic factors and, 2:771
spatial autocorrelation spatial analysis method and, 2:773
spatial distribution and spread patterns of disease and, 2:769
spatial patterning causes and, 2:770–771
statistical analysis methods and, 2:772–773
susceptible-infected-recovered (SIR) simulation model and, 2:773
See also Carcinogens; Drugs, geography of;
HIV/AIDS, geography of
Disease, land use and cover change impact on, 4:1736–1737
Distance decay, 2:774–776
definition of, 2:774
examples of, 2:774, 2:775 (fig.)
human geography application of, 2:774
Edward Jarvis's work in, 2:775–776
migration and spatial interaction studies (Ravenstein) and, 2:775–776
Newton's fundamental law of attraction, 2:774
principle of least action (Moreau de Maupertuis) and, 2:774
spatial-temporal analysis element of, 2:774
Tobler's first law of geography of, 2:774
Distributed computing, 2:776–778
distributed component object servers and, 2:778
distributed database and file servers and, 2:777–778
generic database servers and, 2:777
geographic information systems (GIS) development and, 2:776–777
goal of, 2:777
Internet GIS and, 3:1620–11623
open and interoperable environments and protocols and languages used in, 2:777
operating frameworks of, 2:777
stand-alone file servers and, 2:777
Distribution of resource access, 2:778–780
common resources access and, 2:779
definition of, 2:778–779
ecological economics and, 2:820–824
human-resource relationship focus of, 2:778–779
land cover dynamics and, 2:779
power relations in societies and among locations and, 2:779–780
technology advances and, 2:779
tragedy of the commons (Hardin) and, 2:779
See also Commons, tragedy of the; Resource tenure
Distribution of resources access
mining geographies and, 4:1911–1913
“resource curse” hypothesis and, 4:1913, 5:2217, 5:2693
Division of labor, 2:780–781
benefits of, 2:780
circuits of capital and, 1:410–412
communication technology and, 2:781
comparative advantage and, 2:556–558
gendered division of labor and, 3:1195, 3:1196, 3:1439
geographical division of labor dimensions, 2:780–781
increasing returns concept and, 2:780
individuals and societies interdependence and, 2:781
individuals vs. firm vs. others located elsewhere levels of, 2:780
Adam Smith and, 2:780
transportation technology and, 2:781
wealth and economic development and, 2:780
See also New international division of labor
Doctors Without Borders, 1:96
Dodge, Martin, 2:646
Dodge, Stanley, 5:2534
Dokuchaev, V. V., 4:2180
Domestication centers. See Centers of domestication
Domestication of animals, 2:781–784
centers of domestication and, 1:374–378
cultural ecological change process and, 2:782
diffusion element in, 2:782
dogs, 2:783
eyear geographers’ writing, 2:782
gazelle, 2:783
historic waves of, 2:783
Neolithic Revolution, 2:781
newer domestications and, 2:783
Old and New World domestications and, 2:783
reindeer, Mongolia, 2:782 (photo)
role of ritual and religion in, 2:782
sheep, goats, pig, cattle, chickens, cats, 2:783
wild populations divergences and, 2:782–783
See also Domestication of plants
Domestication of plants, 2:784–786
climate conditions factor in, 2:785–786
crop diversity and, 2:786
dispersal of agriculture and the Columbian Exchange in, 2:786
domestication, definition and, 2:784
domestication syndrome and, 2:784
factors in process of, 2:784
genetic and evolutionary process of, 2:784
geographic centers of, 1:374–378, 2:784–785, 2:785 (fig.), 2:786
human role in, 2:784
origin and evolution of agriculture and, 2:784
results of, 2:784
themes in study of, 2:784
timing of, 2:785–786
See also Crop genetic diversity; Domestication of animals
Dominican Republic
Conference of Latin Americanist Geographers held in, 2:568
economically active females in, 3:1190 (table)
HIV/AIDS in, 3:1438
Domino theory, 2:786–787
Cold War and, 1:505, 2:787
communism containment and, 2:787
First, Second, and Third World geopolitical world model and, 2:786–787
origins of concept and, 2:787
Domosh, Mona, 2:590, 3:1431
Dorpalen, Andreas, 3:1250
Dos Santos, Theotonio, 2:713
Dot density maps, 2:787–790
aggregated data and, 2:788, 2:789 (fig.)
geographic pattern representation and, 2:787–788
one-to-many design considerations in, 2:788–790
one-to-one vs. one-to-many dot maps and, 2:788
Dougenik, James, 1:408
Douglass, Andrew, 2:710
Dove, Michael, 6:2741
Dowd, Charles, 5:2363
Downing, Andrew Jackson, 4:1699
Downs, Anthony, 5:2214
Drake, Sir Francis, 4:2179
Drought risk and hazard, 2:790–794
agricultural drought, 2:791
Arkansas (U.S.) lake example and, 2:788 (photo)
climate causes of, 2:792
climate change and, 2:794
in developing world, 2:727–728
drought prone regions of the world and, 2:787
drylands environmental management and, 2:971–973
El-Niño-Southern Oscillation (ENSO) and, 2:792, 2:793
hydrological drought, 2:791
indices of, 2:792
Intergovernmental Panel on Climate Change and, 2:793
mega-droughts and, 2:792
meteorological drought, 2:791
monitoring networks and, 2:792
National Drought Mitigation Center drought monitor, 2:787–788, 2:792
ocean-atmosphere variabilities factor in, 2:792
Pacific and Atlantic tropical ocean-atmosphere circulation prediction and, 2:793
participatory research on human agency and, 2:793
planning for, 2:793
political ecology research on, 2:793
prediction, monitoring, and mitigation in, 2:792–793
pyrogeography and, 5:2319–2322
remote sensing monitoring of, 2:792
social construction of, 2:793
socioeconomic and policy choice factors in, 2:787
socioeconomic drought, 2:791
tree ring evidence of, 2:792
types of, 2:790–792
vulnerability and, 2:793
Drugs, geography of, 2:794–800
addiction, health problems, and treatment, 2:799
alcohol and, 2:795
coca cultivation and, 2:797
colonialism and, 2:795
designer drugs and, 2:799
developing world and, 2:796–798
ethnobotanists research and, 2:795
GIS tools used in, 2:800
global production of licit raw narcotics, 2003–2008 and, 2:797 (table)
harm reduction policies and, 2:799
historical drug geographies and, 2:795–796
HIV/AIDS and, 2:799
indigenous identities and cultural practices and, 2:795
International Opium Commission, Shanghai (1909) and, 2:796
marijuana decriminalization and, 2:798
“narco-terrorism” and, 2:798
narcotic production since UN regulation and, 2:796
opium licit and illicit uses and, 2:795–796
opium poppies, Northern Tasmania, Australia, 2:798 (photo)
overview of, 2:794
“poppy straw process” and, 2:796
rebellious youth cultures and, 2:799
spatial approaches to analysis and policing in, 2:799–800
synthetic drugs and, 2:798–799
traditional drug practices and, 2:795
UN regulation and, 2:796
Dry adiabatic lapse (DALR) rate, 1:15–16
DTM. See Digital terrain model (DTM)
Dubai, as hub port, 5:2234
Duncan, Jim, 4:1777
Dunes, 2:800–803
R. A. Bagnold’s dune building work, 2:801
barchans dune type, 2:801–802
barrier islands and, 1:183–185
coastal dunes, 2:803
coastal erosion and deposition and, 1:492
conceptual model of coastal dune ecology, 2:564 (fig.)
cross section of, 2:801 (fig.)
dome, star, and reversing dune types, 2:802
factors and variations in, 2:800–801
internal structure of, 2:801
linear or longitudinal dune type, 2:802
lunette dune type, 2:802
morphology classification of, 2:801
paleodune type, 2:802
parabolic dune type, 2:802
sand seas or erg dune types, 2:802
star dunes, Namibia Desert, southwest Africa, 2:803 (photo)
star dune type, 2:802
transverse dune type, 2:802
types of, 2:802 (fig.)
Dunning, John, 3:1154
Durand, Loyal, 5:2536, 5:2537
Durkheim, Émile
classic social theory of, 3:1277
modernity and commodification relationship and, 4:1936
social sciences vs. natural sciences and, 5:2513
Dust storm, satellite image of, 1:20 (photo)
Dutton, Geoff, 1:408
Dynamic and interactive displays, 2:804–808
animated display and, 2:804
animated maps and, 2:804
brushing technique and, 2:805 (fig.), 2:808
cellular automata and, 1:368–371
computer animation and, 2:804
data manipulation and, 2:807 (fig.), 2:808
definitions, 2:804
dynamic filtering technique and, 2:806 (fig.), 2:808
fly-through displays and, 2:804
functions of, 2:808
interactive change of color technique and, 2:806 (fig.)
interactive maps and globes and, 2:804
location-based services (LBSs) and, 4:1794–1796
thematic maps and, 2:804
Web-based interactive displays and, 2:804
Dynamic climatology, 1:472–473
Eager, Bill, 5:2373
Earle, Carville, 2:809–810
American past and present studied by, 2:809
capitalist crises focus of, 2:809
historical geography work of, 2:809–810
publications of, 2:809–810
Earle, Sylvia, 4:2068
Earthquakes, 2:810–815
bracketed duration measure of, 2:811
in Calabria, Southern Italy, 1783–1785, 2:812
collisional plate margins and, 2:810
creep and, 2:604–605
deceleration determination and, 2:811
faulting and, 3:1085–1088
frequencies of seismic waves measure of, 2:811
Gujarat earthquake (2001) and, 4:1986
in Haiti, 2010, 2:815
human effects from, 2:813–814
hypocentral depth measure of, 2:810–811
in Kobe, Japan, 1995, 2:814
landslides resulting from, 2:811–812
in Loma Prieta, California, October 17, 1989, 2:812 (fig.), 4:1722 (photo)
magnitude as surrogate measure of strong motion and, 2:810
measuring of, 2:811
mechanisms of, 2:810–811
in Mexico City, 1985, 2:811
“hot spots” of intraplate seismicity and, 2:810
physical effects of, 2:811–813
postearthquake relief efforts, 2:814–815
real-time earthquakes, Google view of, 3:1355 (fig.)
Richter scale and, 2:810
search and rescue factors in, 2:814
seismic measures, 2:811
seismicity distribution and, 2:810
seismic performance of structures and, 2:814
seismic resistance of building materials and, 2:814
seismic wave types and, 2:810
subduction zones and, 2:810
transverse zones and, 2:810
“hot spots” of intraplate seismicity and, 2:814
physical effects of, 2:811–813
tsunamis, seismic sea waves and, 2:812–813
in 2003, 2:813 (fig.)
See also Plate tectonics
Earth’s coordinate grid, 2:815–816
coordinate geometry and, 2:577–579
coordinate transformations and, 2:580–581
datums and, 2:685–686
equator and, 2:1008–1009
great circle and, 3:1217–1219
geographic databases and, 2:816
geometric measures and, 3:1240–1241
local and regional coordinate systems and, 2:815–816
map distortions and, 2:816
Gerardus Mercator’s projection map and, 2:815, 3:1461, 4:1843, 4:1843 (fig.), 4:1883–1885, 6:3168
Plate Carrée map projection and, 2:815, 4:1844, 4:1846 (fig.)
Plate tectonics
Ptolemy’s longitude and latitude lines and, 2:815, 5:2300
Royal Observatory, Greenwich, England, as zero origin for longitude, 2:815
See also Coordinate geometry; Coordinate systems;
Coordinate transformations
Earth Summit. See United Nations Conference on
Environment and Development (UNCED)
East Africa
British Empire colonies in, 1:509, 1:514
coastal zone and marine pollution and, 1:501
HIV/AIDS origins in, 3:1437
land inequalities in, 4:1693
Masai preindustrial agriculture in, 1:48
normal faults in, 3:1086
tropical deciduous forest in, 1:230, 1:231, 1:232
tropical humid climate in, 1:453
tropical rain forest of, 1:234
tropical savanna climate in, 1:455
tropical savanna in, 1:239, 1:241, 1:242, 1:243
East Asia
adults and children living with HIV in 2007 in, 3:1437 (fig.)
colonization of, 1:514–515
cross-border cooperation and, 2:630
developed countries in, 2:725 (fig.)
domesticated dogs from, 2:783
economic development success in, 3:1152
electronics manufacturing in, 2:885–886
export-oriented “tigers” in, 2:731
feng shui and, 3:1238–1239
foreign aid to, 3:1152
geomantic applied arts in, 3:1238
government and industry links in, 3:1581
hydropower in, 3:1507
industrialization in, 3:1583
land reform in, 4:1693
military expenditures in, 4:1899 (table)
newly industrializing countries in, 4:2021, 4:2022 (fig.)
people living in extreme poverty and, 3:1082 (table)
poverty rates in, 5:2274
prehistoric exploration of, 2:1050
sewage entering coastal zones of, 1:501
U.S. industry moving to, 2:700
wind-and-water geomancy variant and, 3:1238
See also specific countries of
Eastern Europe, political map of, 6:3161
Eastman, Ronald, 2:815–816
GIS, remote sensing, and cartography fields of, 2:815–816
Idrisi and Cartalinx software developed by, 2:815
land use planning and environmental and biodiversity
modeling work of, 2:815
Ecofeminism, 2:817–820
Chipko environmental movement (Indian Himalaya) and,
criticism of, 3:1195
deep ecology movements and, 2:692–695
differences among women and, 2:819
ecological feminism and feminist political ecology from, 2:817,
2:818–820
environmental ethics and, 2:926
essentialism and, 2:817, 2:831
feminist environmentalist geographies and, 3:1092–1094
feminist historical materialists and, 3:1195
Gaia theory and, 2:819, 3:1175–1178
gendered division of labor and, 3:1195
gender-nature relations and, 3:1195
global women’s movement and, 2:819
historical materialism and women’s knowledge in, 2:819–820
mutual inferiorization and, 2:831
patriarchy, 2:817–819, 3:1195
social ecofeminists and, 3:1195
spirituality and, 2:817, 2:818, 2:819
Staying Alive (Shiva) and, 2:818–819
traditional ecological knowledge and, 2:819
Woman and Nature (Griffin) and, 2:817
women of color and, 2:819
women’s connections to nature and, 2:817, 2:818, 2:831
See also Deep Ecology; Ecofeminism: noted individuals; Feminist
specific subject; Gender and nature
Ecofeminism: noted individuals
Bina Agarwal, 2:819–820
Susan Griffin, 2:817
James Lovelock, 2:819
Carolyn Merchant, 2:818, 2:819
Sherry Ortner, 2:817
Val Plumwood, 2:831
Vandana Shiva, 2:818–819
Ecological economics, 2:820–824
carbon trading and carbon offsets and, 1:329–335
command-and-control regulations and, 2:822
economy as subset of the environment and, 2:821
ecosystem goods and services and, 2:820
efficient resource allocation and, 2:822–823
empirical applications and testing of, 2:896
energy and human economics and, 2:896
“Energy Return on Investment” (EROI) and, 2:896
Entropy Law and the Economic Process
(georgesu-rogens) and, 2:896
environment and economy relationship theme in, 2:821
equitable resource distribution in, 2:823
future issues, 2:823
growth-based and steady-state economies and, 2:896
growth vs. development: themes and policies in, 2:822–823
multidisciplinary characteristic of, 2:820–821
natural resources, as capital and, 2:820–822
open-access resources and, 2:821
optimal scale of the economy and, 2:822
Pigouvian taxes per pollution unit and, 2:822
population density and, 5:2238
positive or negative externalities, 2:821–822
sustainability, 2:821–822
temporal distribution of resources and, 2:823
Ecological fallacy, 2:824–825
textual fallacies and, 2:824
cross-level fallacy and, 2:824
cross-sectional and longitudinal fallacies and, 2:824
errors arising from ecological inference and, 2:824
individualistic fallacy and, 2:824
Modifiable Areal Unit Problem and, 2:824
William Robinson’s work in, 2:824
selective fallacy and, 2:824
stereotyping or geographic profiling examples of, 2:824
universal fallacy and, 2:824
Ecological footprint, 2:825–828
biocapacity concept and, 2:825
carbon footprint and, 2:570–571
conservation and, 2:570
definition of, 2:826–828
ecological deficits and, 2:825
ecological footprint analysis method and, 2:825–826
ecological footprints and biocapacities for selected countries,
2005, 2:827 (fig.)
ecological modernization and, 2:832–834
ecological overshoot and, 2:825
ecological resource accounting and, 2:825
environmental planning and, 2:982
Global Footprint Network measurement of, 2:825, 2:828
humanity’s ecological footprint, 1961–2005 and,
2:825–826, 2:826 (fig.)
mass flow balance, 2:825
sustainability requirements and, 2:825, 2:828
war, 2:956
Ecological imaginaries, 2:828–830
“cultural turn” and “green turn” and, 2:829
explanation of, 2:827
ideologies and conceptions of nature and society and, 2:827
livability and sustainability examples of, 2:829
origins of, 2:829
representational and material spatial strategies and, 2:829
urban theories and, 2:829
uses of, 2:829–830
utopian or dystopian themes and, 2:829–830
See also Environmental imaginaries
Ecological justice, 2:830–832
animal geographies and, 2:831–832
Animal Liberation (Singer) and, 2:831
animal rights (Singer) and, 2:831
deeDeep ecology movements and, 2:692–695, 2:831
definitions of, 2:830
ecofeminism (Plumwood) and, 2:831
environmental ethics and, 2:925–927
environmental justice and, 2:959
equal rights of nature doctrine (Naess) and, 2:831
geographers’ contributions to, 2:831–832
human’s moral obligations to other species and, 2:830
instrumental grounds of, 2:830
justice to nature and, 2:830
legal rights for nature (Stone) and, 2:830
“moral considerability” and, 2:830
moral grounds of, 2:830
political ecology and, 2:832
religiouis grounds of, 2:830
Silent Spring (Carson) and, 2:831
See also Ecological justice: noted individuals;
Environmental justice
Ecological justice: noted individuals
Bruce Braun, 2:831
Rachel Carson, 2:830
Luc Ferry, rights of nature, 2:831
Brendan Gleeson, 2:830
Aldo Leopold, 2:830
Nicholas Low, 2:830
Roderick Nash, rights of nature, 2:831
Arne Naess, deep ecology, 2:831
Val Plumwood, ecofeminism, 2:831
Peter Singer, animal rights, 2:831
Christopher Stone, legal rights for nature, 2:831
Sarah Whatmore, 2:831, 2:832
Jennifer Wolch, 2:831
Ecological mapping, 2:832–834
boundaries determination issue and, 2:833
climates in ecosystem differentiation and, 2:833–834
coregions and, 2:855–856
empirical boundary determination methods and, 2:833
geographic approach to study and delineate ecosystems and, 2:833
hierarchal schemes of ecosystem units and, 2:833
knowledge of processes to determine landscapes
concept and, 2:833
land management and planning applications of, 2:832
levels of, 2:832
macroclimate factors and, 2:834
mesoscale of climate factors and, 2:834
microscale of climate factors and, 2:834
sites, landscape mosaic, and coregions perception
levels of, 2:833
spatial hierarchy approach to, 2:833
Ecological modernization, 2:835–838
capitalism critiques and, 2:836
criticism of, 2:835
diverse environmental values and, 2:835
empirical testing of through policy processes and, 2:837
globalization and, 2:835
goals of, 2:835
harmful effects of, 2:835
institutional and cultural dynamics of, 2:836–837
neoliberalism emergence and, 2:836
origins and development of, 2:836–837
positive-sum solutions to zero sum problems and, 2:835
reflexive ecological modernization (Hajer and Beck), 2:837
sustainable development and, 2:835
techno-corporatist form (Hajer) of, 2:836, 2:837
theory of, 2:836–837
See also Ecological modernization: noted individuals
Ecological modernization: noted individuals
Ulrich Beck, 2:837
Maarten Hajer, 2:836–837
Joseph Huber, 2:836
Martin Janicke, 2:836–837
Arthur Mol, 2:836
Gert Spaargaren, 2:836
Ecological regimes, 2:838–840
definition of, 2:839
empirical analysis of, 2:839–840, 2:839 (fig.), 2:840 (fig.)
isintegration of social and physical structures and, 2:838–839
nature and culture coevolution and, 2:838
regulation, 2:838–839
See also Ecological regimes: noted individuals
Ecological regimes: noted individuals
Marina Fisher-Kowalski, 2:839
Christoph Gerg, 2:838
Rolf Peter Sieferle, 2:839
Ecological risk analysis (ERA), 2:840–843
analysis or modeling vs. valuation and, 2:841
as different complex problems analysis, 2:840–841
environmental planning and, 2:841–842
environmental risk and, 2:840–841
as impact analysis method, 2:840–841
land use change application of, 2:841–842
Multicriteria Landscape Assessment and
Optimization tool and, 2:842
sectoral approaches using, 2:841
Soil and Water Assessment Tool and, 2:842
sustainability impacts assessment tools and, 2:843
systems behavior assessed by, 2:840
tools and GIS applications for, 2:842–843
utility value analysis methods compared with, 2:842
Ecological Society of America, 1:34
Ecological zones, 2:843–844
definition of, 2:843–844
coregions and, 2:855–856
cotonenes and, 2:865–869
cotopo, biome, and niche landscape ecology
concepts and, 2:844
factors in, 2:844
regional scale of, 2:844
E-commerce and geography, 2:844–846
business-to-business sales and, 2:845
business-to-consumer sales and, 2:845
centralizing force of, 2:845–846
definition of, 2:844
small- and medium-sized enterprises use of, 2:845–846
tangible and intangible goods and, 2:844
tangible products transportation and, 2:845
Economic base analysis, 2:846–848
aggregation sensitivity of, 2:847
assignment export identification method and, 2:847
cross-hauling assumption in, 2:847
definition of, 2:844
demand-driven theory nature of, 2:846
economic impact analysis use of, 2:846
input-output models and, 3:1599–1601
limitations of, 2:847
location quotient export identification method and, 2:847
location quotients and, 4:1796–1797
minimum-requirements approach in, 2:847
regional economic growth theory and, 2:846
surveys of local businesses export identification method and, 2:847

Economic geography, 2:848–853
agglomeration economies and, 1:31–32
capitalist accumulation and crisis issues (Harvey) and, 2:849, 3:1467
central place theory and, 2:575
circuits of capital and, 1:410–412
commodity chains and, 1:522–525
comparative advantage and, 2:556–558
competitive advantage and, 2:558–559
core areas of, 2:850–852
“cultural turn” and, 2:849–850
development theory and, 2:729–733
division of labor and, 2:780–781
economic base analysis and, 2:846–848
economies of scale and, 2:853–854
economies of scope and, 2:854–855
environmental impacts of economic activity and, 2:851
Euromarkets and, 2:1030–1032
factors affecting location of firms and, 3:1077–1080
finance geographies and, 3:1115–1118
firms and finance and, 2:850–851
Fordism and, 3:1148–1151
frameworks of, 2:848
French regulation theory and, 2:849
gendered character of labor markets (Massey) and, 2:852, 4:1866–1867
geographies of consumption and, 2:572–575
geography of enterprise and, 2:850
geography of tourism and, 2:575
globalization and neoliberalism in, 2:850
Global Shift (Dicken) and, 2:850
Handbook of Commercial Geography (Chisholm) and, 2:848
high-tech and creative economies and, 2:851–852
history of, 2:848–850
incubator zones and, 3:1551–1553
Industrial and Commercial Geography (J. R. Smith) and, 2:848
industrial capitalism issues and, 2:849
industrial districts and, 2:851–852
industrial restructuring issues (Massey) and, 2:849, 4:1790–1791, 4:1866–1867
Industrial Revolution and, 3:1581–1586
information and communications technologies (ICTs) and, 2:540
information societies, 2:540
innovation geographies and, 3:1597–1599
Internet and role of place in, 2:540
knowledge spillover and, 4:1663–1664
labor and work and, 2:852
Manufacturing Belt and, 4:1820–1824
money geographies and, 4:1936–1938
natural resources studies and, 2:851
nature and environment in, 2:851
Nature of Geography (Hartshorne) and, 2:849, 3:1403, 5:2387, 5:2433
neoliberal post-Fordism and, 5:2400–2401
oceans and, 4:2067–2068
outsourcing and, 4:2108–2110
path dependence theory and, 4:2133–2135
post-Fordism transformation and, 2:849
quantitative revolution in, 2:849
radical geography and, 2:849
regional approach to, 2:848–849
regulation theory and, 5:2399–2402
service industries and, 2:540
transportation and communication in, 2:851
transportation geography and, 6:2875
typological regional classification scheme (C. F. Jones) and, 2:849

See also Business cycles and geography; Business geography;
Business models for geographic information systems (GIS);
Economic geography: noted individuals; Globalization

Economic geography: noted individuals
George Chisholm, 2:848, 2:850, 2:851, 4:1990
Peter Dicken, 2:850
Richard Florida, 2:851
Masahisa Fujita, 5:2395
Richard Hartshorne, 2:849, 4:1801, 5:2387–2388, 5:2433
David Harvey, 2:849, 2:851, 3:1467, 4:1862, 5:2350, 5:2442
Clarence Fielden Jones, 2:849
Paul Krugman, 5:2395
Lionel Lyde, 2:848
J. Russell Smith, 2:848, 2:850, 2:851
Neil Smith, 2:851, 5:2351, 5:2551–2552
Anthony Venable, 5:2395
Ray Whibeyck, 2:848–849

Economics. See Agglomeration economies

Economies of scale, 2:853–854
definition of, 2:853
economies of scale and, 2:853–854
economies of scope and, 2:854–855
governmental policy and, 2:855
long-run average costs and, 2:853, 2:854 (fig.)
oligopolistic market structures and, 2:854–855

Economies of scope, 2:854–855
byproducts production and, 2:855
combinations of output focus of, 2:854
definition of, 2:854
economies of scale is, 2:854
economies of scale and, 2:854–855
economies of scope and, 2:854–855
Ecoregions, 2:855–856
bioregionalism and, 1:255
boundaries determination issue and, 2:855
climate types and, 2:853–856
cocoastal zones or ecological zones and, 2:855
ecological mapping and, 2:832–834
ecological zones and, 2:834–844
ecosheds and, 2:857
ecosystems and, 2:855
ecosystems of different climates and, 2:855
ecotonians and, 2:865–869
landforms variations and, 2:856
macroclimatic units and, 2:855
macroscale ecosystems patterns and, 2:855
natural ecoregions of the earth and, 2:855, 2:856 (fig.)
subzones or provinces of, 2:855–856
vegetation features and, 2:856

Ecoshed, 2:857
community watershed rehabilitation management and, 2:857
definition of, 2:857
ecology and watershed terms and, 2:857
Gail Feenstra’s work, 2:857
foodshed and, 2:857
Ecofarming, 2:855–862
ecosystem, 2:858–862
Amazon rain forest, 2:858
area factor and, 2:860–861
Biological Dynamics of Forest Fragments Project and, 2:858, 2:859, 2:859 (photo), 2:860
edge effects factors and, 2:858–860, 2:859 (photo), 2:860 (fig.), 2:867, 3:1161
extinction rates and, 2:861
immigration-to-extinction ratio and, 2:861
island biogeographic theory and, 2:861
isolation and, 2:861–862
Thomas Lovejoy and, 2:862, 2:859, 2:861
plants and animals affected by, 2:859–860
reproductive success of species and, 2:861
species-area relationship and, 2:861–862
species’ individual responses factor in, 2:861–862

Ecotone, 2:862–865
biodiversity and, 1:197–201
biome and ecological zone and, 2:862
community-based conservation and, 2:545–547
definition of, 2:862
ecological mapping and, 2:832–834
ecological zones and, 2:834–844
ecoregions and, 2:855–856
ecosystems and, 2:857
ecosystem decay and, 2:858–862
ectotones and, 2:865–869
function categories of, 2:862–863
global level of spatial scale and, 2:863–864
human actions and, 2:864
intermediate level of spatial scale and, 2:863
keystone species and, 4:1655–1658
local level of spatial scale and, 2:863
management strategies of, 2:545, 2:864
Millennium Ecosystem Assessment and, 2:862, 2:864
passive support to active component transition in, 2:862–863
resilience, resistance, stability, and persistence of, 2:863

Ecotone, 2:865–869
alpine tree line (forest-tundra) ecotone, Glacier National Park, Montana, 2:865 (photo)
complexity theory and, 2:867
crendulated, advancing tree line (forest-tundra) ecotone, Glacier National Park, Montana, 2:866 (photo)
definition of, 2:865
ecological zones and, 2:834–844
edge effect and, 2:858–860, 2:859 (photo), 2:860 (fig.), 2:867, 4:1669
global climate change and, 2:867
krumhholz, 4:1669 (photo)
landscape ecology and, 2:867
lower tree line (forest-grassland) ecotone, Yellowstone National Park, Wyoming, 2:868 (photo)
meadow-forest ecotone, Cranberry Glades Botanical Area, West Virginia, 2:868 (photo)
research issues, 2:866
scale dependent structural characteristics and dynamics of, 2:866
technology advances and, 2:869
upper and lower tree line ecotones, Rocky Mountain National Park, Colorado, 2:868 (photo)
water-riparian and riparian desert scrub ecotones, Grand Canyon, Arizona, 2:868 (photo)

Ecotourism, 2:869–874
advocacy and watchdog groups of, 2:872
certification of, 2:872–873
continuum of, 2:871 (fig.)
criteria of, 2:869–870
criticisms of, 2:872, 2:873
definition issues and, 2:869
environmental impacts of tourism and, 2:953–955
examples of, 2:871–872
forms of, 2:870, 2:870 (fig.)
future of, 2:873
“greenwashing” and ecotourism and, 2:871, 2:871 (fig.)
International Ecotourism Society and, 2:869
mainstreaming detriments of, 2:871
origins of, 2:870
practice of, 2:870–872
promoters of, 2:871
successful models of, 2:871–872
sustainable development concept and, 2:870, 2:873
Sustainable Tourism Stewardship Council (Rainforest Alliance) and, 2:873

Ecuador
agrobiodiversity in, 1:50
as center of crop domestication, 1:376
early-morning smog, Quito, 4:2172 (photo)
economically active females in, 3:1190 (table)
ecotourism in, 2:870
Alexander von Humboldt’s travels in, 3:1482
indigenous agriculture in, 3:1557
marine aquaculture in, 2:854 (fig.)
OPEC membership of, 3:2099, 4:2100 (fig.)
poverty rates in, 5:2274
tropical rain forest, Sachatamia, 1:454 (photo)
tropical rain forest of, 1:234

Education, geographies of, 2:874–876
challenges and issues of, 2:875
city-school relationship and, 2:874
disciplines, space, and civil society interactions and, 2:874
diversity of, 2:876
diversity and, 2:876
diversity of, 2:876
diversity of, 2:876
diversity of, 2:876
diversity of, 2:876
educational spaces’ multiple purposes and meanings, 2:874
geographic education vs., 2:874
institutional discrimination practices and, 2:874
knowledge and, 4:1659–1663
lifelong learning process and, 2:874
Pedagogy of the Oppressed (Freire) and, 2:875
as political consensus agencies, 2:875
rural schools and, 2:874
schools definition and, 2:874
topics of, 2:874

Egypt
British colonialism of, 1:514
community organization maps in, 1:346
cosmological maps and, 1:346–347
demographic footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
French colonialism of, 1:514
“gift of the Nile” (Herodotus), 3:1422
Elderly, geography and the, 2:877–878
  aging population trends and, 2:877
  changing location and migration patterns of, 2:877
  emergent environments and enduring policy dilemmas of, 2:878
  geographic concentrations of elderly and, 2:877
  independence and age-in-place desires of, 2:878
  Older Americans Act (U.S.) and, 2:878
  participant observation research methodology (Rowles) and, 4:2122
  service provision and care provisions for, 2:878
  space and place experiences of, 2:877–878

Electoral geography, 2:879–884
  aggregate nature of electoral data and, 2:883
  liberal-representative democracy and, 2:702
  micro or precinct level electoral data and, 2:883
  “neighborhood effect” and, 2:879, 2:883
  place-based studies of, 2:883
  political geography and, 5:2223
  political parties evolution and, 2:880–881
  redistricting and, 2:881, 5:2375–2377
  roll-call analysis of, 2:881–882, 2:882 (fig.)
  scale in application of, 2:882–883
  spatial dynamics of political life and, 2:879, 2:882–883
  spatial patterns of votes focus of, 2:879
  traditional uses of, 2:879–881
  2004 presidential election choropleth map and, 2:880, 2:880 (fig.)
  2004 presidential election choropleth map and, 2:879, 2:879 (fig.)
  U.S. political cultural regions and, 2:880
  world-systems perspective on, 2:881
  **See also** Electoral geography: noted individuals

Electoral geography: noted individuals
  John Agnew, 2:883
  Daniel Elazar, 2:880
  R. J. Johnston, 4:1643
  André Siegried, 2:879, 5:2223
  Peter Taylor, 2:881

Electronic atlases, 2:884
  benefits of, 2:884
  definition of, 2:884
  interactive capabilities of, 2:884
  Internet access to, 2:884
  media mapping and, 4:1951–1953
  visualization of geostatistical data and, 2:884

Electronics industry, geography of, 2:885–886
  core and boundaries of, 2:885
  definition of, 2:885
  division of labor in, 2:885
  economic development potential from, 2:885–886
  flexible production and, 3:1126–1127
  Japan and, 2:885
  Japanese electronics manufacturing and, 2:885–886
  R&D functions of, 2:885
  regional development relative to, 2:885
  routine production functions of, 2:885

Electronics industry, geography of: lead firms
  Apple, 2:885
  Bell Labs, 2:885
  Hewlett-Packard, 2:885
  Intel, 2:885
  Sony, 2:885
  Western Electronics, 2:885
  Elkin, S. L., 4:1746–1747
  Elliot, Robert, 2:992
  Ellwood, Sarah, 2:615

El Niño-Southern Oscillation (ENSO), 2:886–890
  Atlantic hurricanes and, 1:165
  atmospheric moisture and, 1:148
  beach rotation and, 1:491
  cholera and, 1:402
  Coriolis force and, 2:888
  drought and, 2:792
  global impacts of, 2:886, 2:888–889, 2:889 (images), 3:1336
  global weather and, 2:887
  Hadley Cell Circulation and, 2:887–888
  history of, 2:887
  Humboldt Current and, 2:887
  Inter-Tropical Convergence Zone (ITCA) and, 2:888, 2:889
  long-term changes in, 2:889–890
  mean sea level changes and, 1:497
  midlatitude, mild climate and, 1:435–436
  mountain climate and, 1:448
  oceanic and atmospheric phenomenon of, 2:886, 3:1336
  Pacific Decadal Oscillation (PDO) and, 1:164
  phases of, 2:886–887
  physics of, 2:887–888, 2:889 (images)
  South Asian monsoon and, 4:1943–1944
  synoptic and dynamic climatology and, 1:473
  teleconnections atmospheric linkages and, 2:886,
  2:889–890, 6:2790
  volcanic eruptions and, 1:163
  Walker Cell Circulation and, 2:888, 2:889
  Gilbert Walker’s contributions to, 2:887
  water surface and subsurface temperatures and, 2:888

El Salvador
  Cold War and, 1:504
  earthquakes in, 2:814
  economically active females in, 3:1190 (table)
  human rights violations in, 3:1480
  installed capacity for electricity production forecast, 2010,
  3:1268 (fig.)

Emanuel, Kerry, 3:1495

Emerging markets, 2:890–891
  Antoine van Agmela, 2:890
  closed-end vs. open-end country funds and, 2:891
  financial instruments used in, 2:891
  identification criteria of, 2:890
  International Finance Corporation (IFC) and, 2:890
  international securities issuance by, 2:890
  net equity flows of, 2:890–891
  newly industrializing countries and, 4:2021–2024
  World Bank and, 2:890

Emotions, geography and, 2:891–892
  cultural geography and, 2:639
  fear geographies and, 3:1088–1089
feminist geographers, dualisms and, 2:892
financial markets and, 2:892
intangibility of emotions and, 2:891–892
political geographies and, 2:892
sense of place and, 2:892
“writing of the world” and, 2:892
Empiricism, 2:893–894
abstraction and causation limitations of, 2:849–850
British Enlightenment origins of, 2:893
derivation of word and, 2:893
empirical work vs., 2:894
fact-opinion dichotomy and, 2:849
Richard Hartshorne work and, 2:893, 3:1402–1403,
inductive logic and, 2:893
logical positivism and, 2:893
top-down vs. bottom-up models and, 2:898
See also Energy and human ecology
Energy and human ecology, 2:894–897
biofuels production and, 1:201–204
Chicago School of Urban Sociologists and, 2:894
critique of, 2:896–897
cultural ecology and, 2:895–896
ecological economics and, 2:896
ecological flows of energy and matter and, 2:895
energetic efficiencies of energy sources and, 2:896
ergy as ecological concept, 2:894–895
energy flows measurement and, 2:895–896
energy models and, 2:897–899
Energy Return on Investment (EROI), 2:896, 2:897
entropy concept and, 2:895
Entropy Law and the Economic Process (Georgescu-Roegen) and, 2:896
entropy law of thermodynamics and, 2:896
gardening practices, Maring people of New Guinea research example of, 2:895–896
growth as human ecology (Barrows) and, 2:894
Holistic energy approach of, 2:894, 2:897
human ecological approach to energy and, 2:895–896
laws of thermodynamics and, 2:895
nuclear energy and, 4:2050–2052
photosynthesis process and, 2:895
systems ecology approach (Odum) and, 2:894–895
See also Energy and human ecology: noted individuals;
Energy policy
Energy and human ecology: noted individuals
Harlan Barrows, 2:894, 2:895, 2:896–897
Cutler Cleveland, 2:896
Herman Daly, 2:896
Nicholas Georgescu-Roegen, 2:896
Howard Odum, 2:894–895
Roy Rappaport, 2:895–896
Gilbert White, 2:894
Energy models, 2:897–899
differences in, 2:898
ergy return on investment (ER0I) and, 2:896
energy system characterized by, 2:897
energy system components and, 2:897
frameworks of, 2:898
functions of, 2:897–898
geographic perspective of, 2:898
GIS spatial analyses modeling, 2:898–899
input-output (IO) models, 2:898
optimization-based models, 2:898
partial equilibrium models, 2:898
regional econometric models, 2:898
results interpretation differences in, 2:898
second-generation model, 2:898
simulation models, 2:898
spatial perspective and, 2:898–899
system dynamics models, 2:898
top-down vs. bottom-up models and, 2:898
See also Energy and human ecology
Energy policy, 2:899–902
access to resources issue and, 2:899
biofuels production and, 1:201–204, 2:900, 2:901
carbon dioxide capture and geologic storage and, 2:900
cost and economic impact issues and, 2:899
domestic fossil fuel supply and, 2:899, 2:900, 2:901
environmental and energy security issues and, 2:901
environmental damage and global climate change issues and, 2:899
environmental law and, 2:965–967
future, 2:902
GHG emissions and, 2:900
greenhouse gas emissions (U.S.) and, 2:900
hydroelectric power and, 3:1506–1512
Kyoto Protocol and, 2:900
natural gas, 2:901
neoliberal energy policy and, 2:900, 2:901
nuclear power, 2:899, 2:901
OPEC oil embargo and, 2:899–900
Organization of the Petroleum Exporting Countries (OPEC) and,
2:900–901
other countries and, 2:901–902
renewable energy and, 2:900–901
strategy of maximum extraction and, 2:901
Three Mile Island nuclear accident and, 2:899
U.S. policy and, 2:899–901
wind and solar energy and, 2:900
See also Energy policy: U.S. policies; Petroleum
Energy policy: U.S. policies
Atoms for Peace program, 2:899
Clean Air Act (1970), 2:899, 2:900
Corporate Average Fuel Economy (CAFE) standards, 2:900
Energy Policy and Conservation Act (1975), 2:901
Federal Energy Regulatory commission (FERC), 2:900
Federal Water Power Act (1920), 2:899
Nuclear Waste Policy Act, 2:901
North American Electric Reliability Council, 2:899
North American Electric Reliability Council, 2:899
Public Utility Holding Company Act (1935), 2:899
renewable portfolio standards (RPS) and, 2:901
U.S. Department of Energy formation, 2:900
Energy resources, 2:903–910
biofuels production and, 1:201–204
biomass energy, 2:907
ecological economics and, 2:820–824
end use efficiency and conservation as, 2:908–909
energy models and, 2:897–899
fossil fuels, 2:904–907
geo thermal energy, 3:1265–1270
global coal reserve by country, 2:906 (fig.)
global gas reserve by country, 2:905 (fig.)
global reserves of energy sources by type, 2:903 (fig.)
global reserves of oil by country, 2:904 (fig.)
global uranium reserves by country, 2:909 (fig.)
hydroelectric power and, 3:1506–1512
hydropower, 2:907–908
nonrenewable resources and, 4:2039–2041
nuclear energy and, 4:2050–2052
Organization of the Petroleum Exporting Countries (OPEC) and, 4:2097–2100
renewable energy sources, 2:908
uranium and nuclear power, 2:908
See also Energy and human ecology; Energy policy; Petroleum
Engels, Friedrich, 2:544 (photo)
Condition of the Working Class in England in 1844
written by, 2:617
Karl Marx and, 4:1859
England. See Britain; United Kingdom
Enitrea, 3:1190 (table)

Enlightenment, 2:910–911
centrality of space and, 2:910
critical reason, progress, utility, and order emphasized by, 2:910, 2:911
definitions, 2:910
as a discourse and process, 2:910
as a geographical phenomenon, 2:910
geography as tool to understand and explain the world and, 2:910–911
nation word origins and, 4:1971–1972
plural usage of, 2:910
potential of the world and, 2:911
universal human rights concept and, 3:1480

Enterprise GIS, 2:911–913
explanation of, 2:911
IT infrastructure of an organization and, 2:911
organizational issues of, 2:912–913
overview of an example of, 2:913, 2:913 (fig.)
requirements of, 2:911–912
technical issues of, 2:912
three-tier client-server architecture and, 2:912 (fig.)

Environmental certification, 2:914–916
accountability issue, 2:915
Agenda 21 (UN), global sustainable development action plan, 2:914
definition of, 2:914
forest certification example of, 2:914–915
Forest Stewardship Council, 2:915
future market developments, 2:915
global reach and local specificity of, 2:915
International Federation of Organic Agriculture Movements (IFOAM), 2:914
ISO 14001 Standard for Environmental Management Systems (organic agriculture), 2:914
management system vs. performance standards and, 2:914
National Standard on Sustainable Forest Management (Canada), 2:915
organic agriculture standards and, 2:914, 4:2094–2096
origins of, 2:914–915
process of, 2:914
product vs. process standards and, 2:914
Programme for Endorsement of Forest Certification, 2:915
Rainforest Alliance certification scheme, 2:914
Sustainable Forestry Initiative, 2:915
UK Woodlands Assurance Scheme, 2:915
See also Fair trade and environmental certification

Environmental determinism, 2:916–918
as an ancient belief, 2:916
anthropogeography and, 1:93
Berkeley School and, 1:191–192
cause-and-effect relationships and, 2:917
chorology and, 1:404–405
critical factors in society and, 3:1428–1429
connections between people and place and, 2:1020, 5:2338
critical studies of nature and, 2:621
criticisms, 2:917, 3:1464–1465
cultural landscape (Sauer) and, 2:641–642
environment holds sway over humanity and, 2:916
Eurocentrism and, 3:1434
evolutionary theory and, 2:916–917, 3:1464
Guns, Germs, and Steel (Diamond) and, 2:734, 2:917, 5:2216
hierarchy of competing races focus of, 3:1464
Lamarckian evolutionary theory and, 2:667, 3:1464
nation building and, 4:1972
neo-environmental determinism and, 2:917
oceans ignored by, 4:2065
Orientalism and, 4:2102–2103
social Darwinism and, 2:1014
See also Environmental determinism: noted individuals;

Race and empire
Environmental determinism: noted individuals
Aristotle, 2:916
Harlan Barrows, 1:185
James Blaut’s critique of, 1:285
Jared Diamond, 2:734, 2:917
Lucien Febvre, 3:1090
Hippocrates, 2:916
Immanuel Kant, 4:1648
Montesquieu, 2:916
Plato, 2:916
Frederich Ratzel, 2:916, 3:1464, 5:2246
Herbert Spencer, 2:916, 3:1464
George Tatham’s criticism of, 2:917
Griffith Taylor, 3:1464, 6:2777
Frederick Jackson Turner, 2:667

Environmental discourse, 2:918–921
conceptual underpinnings of, 2:918–919
critical insights of, 2:918
deconstruction process and, 2:921
difference making in, 2:920–921
discursive strategies and, 2:920
environmental knowledge and, 2:919
material outcomes and effects of, 2:919–920
normalizing power and, 2:920–921
objects of, 2:919
operation of, 2:919–920
power of, 2:920–921

Environmental entitlements, 2:921–925
applications of, 2:923–924
community-based natural resource management (CBNRM) and, 2:921–922, 2:923–924

criticisms and prospects, 2:924
definition of, 2:923

economic entitlements to, 2:922–923

equity as rights and resources social actors have and, 2:923

entitlement mapping and, 2:922

environmental resources linked to, 2:921

environmental services and, 2:1000–1002

institutional perspectives on, 2:923

“new” ecologies, 2:922

people and natural resources link and, 2:922

people-environment interactions structure and, 2:923

reconceptualizing CBNRM approaches and, 2:922

supply-driven to demand- and access-driven perspectives on well-being and, 2:922

sustainable development in developing countries and, 2:921

See also Environmental entitlements: noted individuals;

Environmental rights

Environmental entitlements: noted individuals

Melissa Leach, 2:921, 2:922–923

Robin Mearns, 2:921, 2:922–923

Ian Scoones, 2:921, 2:922–923

Amartya Sen, 2:921, 2:922, 2:924

Environmental ethics, 2:925–927

anthropocentric arguments, 2:926

biocentrists and, 2:926

bioregionalism and, 1:255

Clean Air Act (1970), 2:925

Clean Water Act (1972), 2:925

deep ecology movements and, 2:692–695

Earth Day and, 2:925

ecofeminism and, 2:926

ecological justice and, 2:830–832

ecological modernization and, 2:832–834

Endangered species Act (1973) and, 2:925

Green Revolution environmental activism and, 2:925

holistic, ecological approach of, 2:926

human behavior and environmental and ecological crises focus of, 2:925

intrinsic value concept and, 2:926

National Environmental Policy Act (1970) and, 2:925

origins of, 2:925

social ethics and, 2:925, 2:926

speciesism and, 2:926

See also Environmental ethics: noted individuals

Environmental ethics: noted individuals

J. Baird Callicott, 2:925

Rachel Carson, 2:925

Garrett Hardin, 2:925

Aldo Leopold, 2:926

Tom Regan, 2:926

Peter Singer, 2:926

Lynn White, 2:925

Environmental history, 2:927–932

tagroecology (Worster) and, 2:929

American Society for Environmental History and, 2:929

colonialism’s effects and, 2:928, 2:931

definition of, 2:927

development of, 2:927–930

ecological footprint and, 2:825–828, 2:931

ecological history and, 2:929

ecological interpretation of history (Leopold) and, 2:929

ecological restoration projects and, 2:932

ecology and geography origins of, 2:929

ecosystem concept (Tansley), 2:929

environmental movement and, 2:929

european environmental sustainability issue and, 2:927, 2:931

European Society for Environmental History, 2:929

eamples and applications of, 2:931–932

framework of, 2:928 (fig.)

Guns, Germs and Steel (Diamond) and, 2:930, 5:2216

holistic approach to study of, 2:929, 2:930


Industrial Revolution and, 2:928

International Consortium of Environmental History Organization and, 2:929

landscape ecology (Troll) and, 2:929

as landscape management and planning tool, 2:931–932

term-long quantitative data shortage limitation of, 2:930–931

Man and Nature (Marsh) and, 2:928, 2:991, 4:2180

maps and spatial representations of change and, 2:931

methods used in, 2:930–931

narrative synthesis methods used in, 2:930

overgeneralization caution and, 2:932

qualitative and quantitative methods used in, 2:930, 2:931

spatial studies of, 2:930

themes in study of, 2:927, 2:930

theory of plant succession (Clements) and, 2:929, 4:2180

Walden (Thoreau) and, 2:928

See also Environmental history: noted individuals

Environmental history: noted individuals

Frederic Clement, 2:929

Alfred Crosby, 2:930

Jared Diamond, 2:930, 5:2216

Aldo Leopold, 2:929

Charles Mann, 2:930

George Perkins Marsh, 2:928, 4:2180, 5:2584

Pierre Poivre, 2:928


Arthur Tansley, 2:929

Henry David Thoreau, 2:928

Carl Troll, 2:929, 4:1714

Alexander von Humboldt, 2:928

Eugen Warming, 2:929

Environmental imaginaries, 2:932–934

business spatial imaginaries and, 2:933

ty and transformation and, 2:933

creativity factor in, 2:933

explanation of, 2:933

globalization as spatial imaginary and, 2:933

global North application of, 2:933

class, race and gender factors in, 2:933

genital component of, 2:933

role of place in, 2:933

spatial and social imaginaries and, 2:932–933

See also Ecological imaginaries

Environmental impact assessment (EIA), 2:934–937

beyond the project and, 2:936

cost-effectiveness issue and, 2:937

definition of, 2:934

ecological risk analysis (ERA) and, 2:840–843

enduring concerns, 2:936–937

environmental impact statements (EISs) and, 2:935, 2:958–959

environmental movement of 1960s and, 2:934

environmental studies vs., 2:934

federal policies, laws and, 2:935

follow-up and monitoring of projects and, 2:937

See also Environmental impact assessment (EIA)
Environmental impacts of agriculture, 2:937–940
agricultural intensification and, 1:35–36
agricultural revolution and, 2:938
biotechnology and ecological risk and, 1:278–279
coastal dead zones and, 1:486–488, 2:939
forest clearance: ecosystem and atmospheric impacts of, 2:938
Green Revolution and modern farming in, 2:939
Green Revolution controversy and, 1:35, 1:50
herbicides use and, 3:1420–1421
impact areas and, 2:937–938
nitrogen and phosphorus cycles and, 2:939
pesticides and nutrient loading and, 2:939
water supplies and, 2:938–939
See also Agricultural intensification

Environmental impacts of cities, 2:940–944
Anthropocene Epoch concept and, 2:942
anthroposphere and, 2:943
atmosphere and, 2:942
biosphere and, 2:942–943
built environment and, 1:299
city’s metabolism and, 2:940, 2:941
Earth systems affected by, 2:941–943
ecological footprint of, 2:940, 2:941
environmental degradation from, 2:940
factors of, 2:941
future options, 2:943
geography issues and, 2:943–944
geosphere and, 2:941–942
green building and, 3:1367–1369
history of, 2:941
hydrosphere and, 2:942
Industrial Revolution and Green Revolution and, 2:941
landfills and, 4:1684–1686
Los Angeles, California, example of, 2:940–941
megacities and global cities and, 2:940
solid wastes and, 2:941–942

Environmental impacts of manufacturing, 2:944–946
brownfields and, 1:296–298
chlorinated hydrocarbons (CHCs) and, 1:396–400
coal use effects and, 2:944
electricity and smokeless fuels and, 2:944
energy and, 2:944–945
geography of impacts and, 2:944, 2:945–946
Kyoto Protocol and, 2:945
local, continental, and global impacts and, 2:945–946
manufacturing definition and, 2:944
materials and, 2:945
motorized machinery and division of labor elements of, 2:944
“nuisance” pollution and, 2:945
theorizing environmental protection and, 2:946
UN Economic Commission for Europe Convention on
Long-Range Transboundary Air Pollution and, 2:945
water and, 2:945

Environmental impacts of oil fields, 2:946–948
catastrophic events and, 2:947
direct vs. indirect impacts and, 2:946
ecocide, 2:953
environmental impacts of pipelines and, 2:948–951
GHG emissions and, 2:947
Kuwaiti oil well fires and, 2:955, 2:956 (photo)
onshore and offshore development impacts and, 2:946–947
in situ vs. ex situ remediation of, 2:951

Environmental impacts of pipelines, 2:948–951
above and beneath surface effects and, 2:949 (fig.)
different types of pipelines and, 2:948
ground penetrating radar leak detection and, 2:949
leak detection and, 2:949–951, 2:950 (fig.)
mapping and remediation, 2:951
pipeline integrity monitoring and, 2:949
remote sensing leak detection and, 2:949, 2:950
transported substances variations and, 2:948

Environmental impacts of roads, 2:951–953
atmospheric systems affected by, 2:952
hydropheric processes affected by, 2:951–952
living systems and, 2:951, 2:952
natural processes affected by, 2:952
nonliving systems and, 2:951–952
road construction impacts and, 2:951
road ecology and, 2:952
roads, definition, 2:951
traffic function of roads and, 2:951

Environmental impacts of tourism, 2:953–955
carrying capacity concept and, 2:955
cumulative nature of, 2:953
direct effects of, 2:953–954
ecotourism and sustainable tourism and, 2:955
environment at the core of, 2:953
indirect effects of, 2:954
induced effects of, 2:954
litter in Namib-Naukluft Park, Namibia, Africa, 2:954 (photo)
local, regional, and global scales of, 2:954–955
quantification issue and, 2:955
time and scale impacts of, 2:953
tourism definition and, 2:953
type and intensity of, 2:953
See also Ecotourism

Environmental impacts of war, 2:955–957
eocide, 2:955
ecological footprint of war and, 2:956
Environmental Modification Convention and, 2:957
guerrilla warfare ecosystem impact and, 2:957
Kuwaiti oil well fires example of, 2:955, 2:956 (photo)
NATO bombing of Pancevo, Serbia, example of, 2:953
policy prioritization issues and, 2:956–957

Environmental impact statement (EIS), 2:958–959
environmental impact assessment (EIA) and, 2:934–937, 2:958–959
National Environmental Policy Act (NEPA, 1970) and, 2:958, 2:966, 4:1716
origins of, 2:958
scoping process of, 2:936, 2:958
UN Conference on Environment and Development and, 2:938
World Commission on Environment and Development and, 2:938, 2:958, 6:2737
Environmental justice, 2:959–965
adaptive capacities and local resiliencies and, 2:964
alternative environmentalism and, 2:960
Basel Action Network (BAN) and, 3:1610
Bhopal, India, chemical disaster and, 1:194–195, 4:2158
brownfields and, 1:296–298
changing methodologies of, 2:963–964
class, race, and gender and, 1:425
class and nature and, 1:423–425
Climate Action Network (CAN) and, 3:1610
Clean Air Act (1990) and, 2:960
climate justice and, 2:987
compensatory equity concept and, 2:962
definition of, 2:985
demand distribution concept and, 2:962
differential enforcement of environmental laws and, 2:962
differential vulnerability and, 2:742–744
ecological justice and, 2:830–832, 2:959
environmental racism and, 2:959, 2:985–989
equitable distribution concept and, 2:962
ethnicity and nature and, 2:1021–1022
geographer’s contributions to, 2:960–962
hazardous waste landfills and communities of color and, 2:960, 2:961 (photo)
Hurricane Katrina, differential vulnerabilities and, 2:964, 4:1983–1986
institutional discrimination, 2:962
intentional targeting and, 2:962
international environmental movements and, 3:1608–1612
landfill in Warren County, North Carolina, 2:960, 2:961
(photo), 2:986
landfills and, 4:1684–1686
Love Canal and, 4:1806–1808
market-based distribution of equity and, 2:962
market mechanisms and, 2:962
methods and measurement issues and, 2:963–964
minority groups’ exposure to environmental hazards focus of, 2:959–960
National Environmental Justice Advisory Council and, 2:960
new analysis techniques and, 2:964
organizations in support of, 2:960
PCBs and, 5:2226
pesticide research and, 4:2158
public participation ineffectiveness and, 2:963
quantitative and qualitative analysis methods used in, 2:963–964
Rainforest Action Network (RAN) and, 3:1610
regional racial formations and, 2:963
research, 2:959, 2:964
scale affects and, 2:964
sociodemographic change and, 2:963
successful campaigns, 2:960
vulnerability and choice mechanisms and, 2:962
waste incineration and, 6:3048–3049
“white flight” and, 1:420, 2:962, 2:986
white privilege and, 2:962
See also Environmental rights
Environmental law, 2:965–967
Clean Water Act, 2:925, 2:966, 5:2476
criminalization in, 2:966–967
description of, 2:965
environmental impact statements (EIS) and, 2:966
Federal Water Pollution Control Act, 2:966
hazardous wastes laws and, 2:966
international law, 2:967
National Ambient Air Quality Standards and, 2:966
natural resources use legislation and, 2:966
pollution control laws and, 2:966
Resource Conservation and Recovery Act and, 2:966
division of, 2:963–966
Superfund site legislation and, 2:966, 4:1808, 4:1857
tort law and, 2:965
toxic substance legislation and, 2:966
Trail Smelter Case, sulfur dioxide pollution and, 2:967
U.S. common law, 2:965
U.S. federal law, 2:965–966
wetlands and endangered species legislation and, 2:966
Environmental management, 2:967–970
biosphere reserves and, 1:236–267
collaborative GIS application and, 1:507 (fig.)
community-based natural resource management and, 2:549–551
connectivity and relationships with, 2:969–970
“cultural flow” water management approach, 2:970
Ronald Eastman’s work in, 2:815–816
ecological mapping and, 2:832–834
environmental planning vs., 2:981
environmental restoration and, 2:991–994
Eurocentric science and, 2:968, 2:970
Everglades restoration example of, 2:1038–1042
governmentality and conservation and, 3:1359–1360
Great Whale River Hydro-Electric Project, Quebec, Canada, example of, 2:969–970
human-environment relations focus of, 2:967–969
indigenous perspectives on, 2:969
issues of, 2:968–969
local geographic context importance in, 2:968–969
maps and, 1:346, 1:350, 1:359
George Perkins Marsh and, 4:1858–1859, 4:2180, 5:2584
natural sciences as means of classification and, 2:967–968
nomadic herding and, 4:2032
people, place, and species interrelationships and, 2:967–968, 2:969
scientific perspective on, 2:968
Western natural science and, 2:968
See also Common pool resources (CPRs); Common property resource management; Commons, tragedy of the; Conservation; Corporate voluntary environmental initiatives and self-regulation; Environmental impact assessment (EIA); Environmental impact statement (EIS); GIS in environmental management; Governance
Environmental management: drylands, 2:971–973
challenges in, 2:971–972
diversity-based management and, 2:973
diversified livelihoods of communities and, 2:971
dryland farmer strategies and, 2:971–972
drylands ecological diversity and, 2:971
institutional dimensions of, 2:972–973
Maasai women of Kenya, local water harvesting, 2:972 (photo)
mobility, flexibility, and opportunism elements in, 2:971
pastoralism management strategies and, 2:971
resource access issues and, 2:973

INDEX 3237
silvopastoralism, 2:971
soil management strategies and, 2:972
Environmental mapping, 2:973–976
components of, 2:974 (fig.)
definition of, 2:973
examples of, 2:976
multidisciplinary features of, 2:973
stage 1: problem definition, 2:974
stage 2: data acquisition, 2:974–975
stage 3: preprocessing, 2:975
stage 4: data storage/archiving, 2:975
stage 5: analysis, 2:976
stage 6: visualization, 2:976
stages in process of, 2:975 (fig.)

Environmental perception, 2:977–980
behavior affected by, 2:979
behavioral geography and, 1:189–190
cognition and, 2:977
definition of, 2:977
Landscape Perception and Behavioral Geography (EPBG) Group of AMG and, 2:978
landscape quality assessment and, 4:1715–1718
local vs. large-scale perceptions and, 2:979
mental maps and, 2:978, 2:979
multidisciplinary feature of, 2:978
perspective variable in, 2:978
range of space that can be perceived and, 2:977
research, 2:977–978
risk and fear in the landscape perceptions and, 2:979
senses used in, 2:977
spatial cognition, 2:977
spatial decision making and, 2:979
spatial visualization and, 2:978
universe of geography study and, 2:977

Environmental planning, 2:980–983
accreditation process and, 2:981
brownfields and, 1:296–298
conservation movement phase of, 2:980
current issues in, 2:981–982
definition of, 2:980
ecological footprint reduction theme in, 2:982
ecological risk analysis (ERA) and, 2:840–843
ecosystem-approach to, 2:981–982
environmental management vs., 2:981
environmental restoration and, 2:991–994
human environmental impacts and, 2:980
Internet-based spatial analysis tools and, 2:981
professional urban planning and, 2:981
public consultation process and, 2:981
public health movement phase of, 2:980–981
public participatory GIS tools and, 2:981
smart growth, 2:982; 5:2240
spatial analysis from remote sensing and GIS and, 2:982
sustainability vs., 2:982–983
See also Community-based environmental planning (CBEP);
Regional environmental planning

Environmental protection, 2:983–985
benefits and costs of, 2:984
chlorinated hydrocarbons (CHCs) and, 1:396–400
definitions, 2:983
environmental goods and services depletion issue and, 2:983
human-environment interaction and, 2:983, 2:984
international organizations in support of, 2:984
oceans and, 4:2067–2068
scale of problems factor in, 2:984
See also Environmental Protection Agency (EPA)
Environmental Protection Agency (EPA)
Acid Rain Control Program of, 4:1857
agricultural biotechnology regulated by, 1:34
biotechnology research funds and, 1:280
chlorinated hydrocarbons regulated by, 1:397
conservation and, 2:570
emissions trading systems and, 4:1857
pesticides regulated by, 4:2158

Environmental racism, 2:985–989
causal ordering studies and, 2:986
climatic justice and, 2:987
definition of, 2:985
Dumping in Dixie (Bullard) and, 2:986
empirical evidence of, 2:986
environmental justice and, 2:959–965, 2:985
Environmental Justice Strategic Plan of EPA and, 2:987
environmental policy and, 2:986
ethnicity and nature and, 2:1021–1022
executive orders, 2:987
First People of Color Leadership Summit (1991) and, 2:985
GIS tool in study of, 2:986
green activists and, 2:985, 2:988
Gulf Coast Tenants Union and, 2:985
hazardous waste landfill locations and, 2:986–987
Hurricane Katrina and, 2:987
indigenous rights and international human rights and, 2:988
institutional discrimination and racism and, 2:985–986, 2:987
international agreements and, 2:988
lead exposure and, 2:986
networks and organizations, 2:988
not-in-my-backyard (NIMBY) campaigns and, 2:986–987
“Precautionary Principle” and, 2:988
racial entitlement motivation and, 2:985
remedies for, 2:987–988
Southwest Organizing Project and, 2:985
state policies and, 2:987
structured disadvantaged, 2:985–986
Title VI of Civil Rights Act of 1964 and, 2:987–988
toxic tort claims and, 2:988
Toxic Wastes and Race at Twenty (Bullard) and, 2:986
Toxic Wastes and Race in the United States report (GAO) and, 2:986
toxins in fish and, 2:986
“white flight” and, 1:420, 2:962, 2:986
See also Environmental justice

Environmental refugees, 2:989–991
climatic change element and, 2:989
“climate refugees,” 2:990
definition of, 2:989–990
legal status and, 2:989–990
maximalist vs. minimalist perspectives on, 2:990
migration linked to deteriorating environmental conditions and, 2:989
numbers of, 2:989
political refugees vs., 2:989
politics of, 2:990–991

Environmental restoration, 2:991–994
active vs. passive forms of, 2:993
definitions, 2:991
Everglades restoration example of, 2:1038–1042
Florida Everglades ecosystem restoration project and, 2:992
forest restoration and, 3:166–1168
historical roots of, 2:991–992
Environment and development, 2:992–994
landscape quality assessment and, 4:1715–1718
Man and Nature (Marsh) and, 2:928, 4:2180
George Perkins Marsh and, 2:928, 2:991–992, 4:2180, 5:2584
physical landscape elements focus of, 2:991
rat eradication from Rat Island, Alaskan Aleutian
Island Chain and, 2:992
success assessment and, 2:993–994
Environmental rights, 2:994–998
clean water rights case sample of, 2:995–997, 2:996 (table), 2:997 (fig.)
environmental entitlements and, 2:921–925
environmental services and, 2:994
hierarchical structure power characteristics and, 2:995
international watershed management and, 3:1618–1620
systems, characteristics, and environmental justice in, 2:995–997
Environmental security, 2:998–1000
“The Coming Anarchy” (Kaplan) and, 2:999
definitions, 2:998
Environmental Change and Acute Conflict Project, University of
Toronto, 2:998
environmental services and, 2:1000–1002
natural resources in peace negotiations and, 2:999
Our Common Future (World Commission on Environment and
Development) and, 2:998, 6:2737
policy debates, 2:998
research programs, 2:998–999
resource abundance and violence issues and, 2:999
Worldwatch Institute and, 2:998
Environmental services, 2:1000–1002
bee pollination, 2:1000
ecosystem services and functions and, 2:1000, 2:1001 (table)
evolution of inquiry in, 2:1001
indigenous and community conserved areas (ICCAs) and,
3:1557–1561
market vs. nonmarket damages from loss of, 2:1000–1001
Millennium Ecosystem Assessment project (UN) and, 2:1001
storm protection by costal wetlands, 2:1001
vegetation erosion control services, 2:1000
See also Environmental rights
Environmental Systems Research Institute (ESRI), 1:340 (figs.),
2:663, 2:674, 2:685, 2:685 (fig.), 2:876, 3:1230, 3:1258,
Environment and development, 2:1002–1006
conflict over meanings and, 2:1006
critical objectives for, 2:1004
economic policy-making integration with environmental
considerations and, 2:1002
environmental security and, 2:998–1000
Everglades restoration and, 2:1038–1042
extractive reserves and, 2:1072–1073
gender and environmental hazards and, 3:1186–1188
institutional origins of, 2:1002–1003
international cooperation challenges and, 2:1006
Johannesburg Declaration on Sustainable
Development and, 2:1005
Johannesburg Plan of Implementation for Sustainable
Development and, 2:1005
making sense of, 2:1005–1006
optimism and warning, 2:1002
slow pace of change and, 2:1006
Symposium on Patterns of Resource Use, Environment and
Development Strategies and, 2:1003
UN Conference on Environment and Development and,
2:1004–1005
UN Conference on the Human Environment and,
2:1003, 6:2747
World Commission on, 2:1003–1004
World Conservation Strategy and, 2:1003
World Development Report (World Bank) and, 2:1004
World Summit on Sustainable Development (WSSD), 2:1005,
6:2738, 6:2750, 6:2907
See also Developing world; Environmental history; United
Nations Conference on Environment and Development
(UNCED)
Epistemology, 2:1007–1008
belief we call knowledge and, 2:1007
death penalty example and, 2:1007
defensible propositions and, 2:1007
definition of, 2:1007
demonstrable propositions and, 2:1007
dispute over defensible propositions and, 2:1007
geography and, 2:1007–1008
logical positivism and, 2:1007–1008
ontology and, 4:2081–2083
ontology definition and, 2:1007
postmodern epistemology and, 5:2267–2268
post-positivist epistemology and, 2:1008
preferred propositions and, 2:1007
realism and, 5:2369–2371
rules of knowledge formation and, 2:1007
subjective expressions of individual taste and, 2:1007
EPZ. See Export processing zones (EPZ)
Equator, 2:1008–1009
celestial, astronomic, galactic, geomagnetic equators and, 2:1008
Coriolis force and, 2:1008
datums and, 2:1009
definition of, 2:1008
Earth’s circumference measurement and, 2:1010
equinoxes and, 2:1009–1010
groetic equator and, 2:1008
multicontextual meanings of, 2:1008–1009
Polaris, zero latitude location and, 2:1008
Environment and development, 2:1002–1006
conflict over meanings and, 2:1006
critical objectives for, 2:1004
economic policy-making integration with environmental
considerations and, 2:1002
environmental security and, 2:998–1000
Everglades restoration and, 2:1038–1042
extractive reserves and, 2:1072–1073
gender and environmental hazards and, 3:1186–1188
institutional origins of, 2:1002–1003
international cooperation challenges and, 2:1006
Johannesburg Declaration on Sustainable
Development and, 2:1005
Johannesburg Plan of Implementation for Sustainable
Development and, 2:1005
making sense of, 2:1005–1006
optimism and warning, 2:1002
slow pace of change and, 2:1006
Symposium on Patterns of Resource Use, Environment and
Development Strategies and, 2:1003
UN Conference on Environment and Development and,
2:1004–1005
Eritrea
locusts infestation in, 2:727
undernourishment in, 3:1487
Error propagation, 2:1011–1012
attribute error, 2:1011–1012
calculation error, 2:1011
computational error, 2:1012
doctrine of, 2:1011
critique of, 2:1012
digitizing error, 2:1012
measurement error, 2:1011, 2:1012
origin of error, relative importance of, 2:1011–1912
INDEX
Ethnicity and nature, 2:1019–1022
anticolonial nationalism and, 2:1020
communities and specific landscape links and, 2:1019
connections between people and place and, 2:1020

environmental determinism and, 2:1020
environmental racism and environmental justice and, 2:1021–1022
essentialized identities concept and, 2:1019–1020
ethnic cleansing and, 2:1020
Israel and Palestine examples of, 2:1020
nationalism and nature and, 2:1020
noble savage, 2:1020–1021
strategic essentialism, 2:1021
“white man’s burden,” 2:1021
race and empire and, 5:2335–2337
See also Environmental justice; Ethnicity; Ethnic segregation

Ethnic segregation, 2:1022–1026
African Americans in United States, 2:1024, 2:1025–1026 (figs.), 2:1026
causes of, 2:1022–1023
William Clark’s work, 1:417–418
definition of, 2:1022
dissimilarity index measure of, 2:1023
ethnic enclave vs. ghetto paradigms and, 2:1024
ethnic social solidarity and, 2:1023
gated communities and, 3:1181–1183
ghettos and, 3:1275–1277
home loan restrictions and zoning laws and, 2:1023
housing discrimination cause of, 2:1023
inequality geographies and, 3:1589
local and geographic scales of, 2:1022
meaning of, 2:1023–1026
measurement of, 2:1023
Native Americans and Japanese Americans examples of, 2:1023
positive and negative implications of, 2:1023–1024
relining and blockbusting restrictions and, 2:1023
self-segregation and, 2:1023
socioeconomic status factors and, 2:1023
See also Ethnicity; Ethnicity and nature;
Racial segregation; Segregation and geography

Ethnocentrism, 2:1027
definition of, 2:1027
ethnic cleansing and, 2:1027
ethnocide and genocide and, 2:1027
European colonialism and, 2:1027
geographical imagination and, 3:1221–1225
Holocaust and, 2:1027
manifest destiny (U.S.) and, 2:1027
nationalism and, 4:1978–1981
“white man’s burden,” 2:1027
See also Ethnicity; Eurocentrism

Ethnomethodology, 1:289
Eurasia
polar semidesert in, 1:249
shrub tundra of, 1:248
tundra of, 1:247
tundra vegetation in, 1:248 (table)

Eurocentrism, 2:1028–1030
James Blaut’s work and, 1:285–286
colonialism and, 2:1029
ccontra-Eurocentrist movement and, 2:1029
critical race theory and, 5:2338
criticism of, 2:1030
definition of, 2:1028–1029
environmental determinism and, 3:1434
environmental management and, 2:968, 2:970
European economic and sociopolitical power and, 2:1029
Europe/Asia continental division and, 2:1028
geographical imagination and, 3:1221–1225, 3:1429

Ethnicity and nature, 2:1019–1020
alternative traditions of, 2:1014
animals and nature issue and, 2:1015
challenges of, 2:1015–1016
definitions, 2:1013
empirical objection issue and, 2:1015
environmental ethics and, 2:925–927
ethnic definition and, 2:1013
intangible vs. tangible dimension issue and, 2:1014
internal and external domains of, 2:1014–1015
logical positivism and, 2:1013
moral geographies examples and, 2:1013–1014
political and academic life and, 2:1013
practical reasoning and, 2:1014
social change and, 2:1013
truth and trust moral values and, 2:1014
well-being and, 2:1013

Ethiopia
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
Ethiopian Women’s Organization, 4:1
installed capacity for electricity production forecast, 2010,
3:1268 (fig.)
Italian colony of, 1:509
Kushitic language in, 4:1749
locusts infestation in, 2:727
soil erosion in, 5:2585

Ethnicity, 2:1016–1019
assimilation and, 2:1017
citizenship and, 1:413–414
definition issues and, 2:1016, 2:1019
dominant groups role and, 2:1017
Eastern spiritualism and, 2:1017
ethnic groups as marginalized minorities and, 2:1017
ethnocentrism and, 2:1027
external attributes and, 2:1016–1017
genocide geographies and, 3:1199–1202
genre of differences and, 2:737–740
immigrants’ experiences and, 2:1017–1018
individual characteristics and, 2:1016
race, physical attributes and, 2:1017
race, social construction of, 2:1017
race and empire and, 5:2335–2337
role of race and, 2:1017–1018
role of space and place and, 2:1018–1019
situational and dynamic nature of, 2:1016
as a social construction, 2:1016
spatial distribution of ethnic groups and, 2:1018–1019
symbolic ethnicity and, 2:1017
See also Ethnicity and nature; Ethnic segregation;
Ethnocentrism; Race and racism; Racial segregation

Ethnicity and nature, 2:1019–1022
anticolonial nationalism and, 2:1020
connections between people and place and, 2:1020
European Union (EU) membership and, 2:1036 (fig.)
Wizz air point-to-point airline services, 1:181–182, 1:181 (fig.)

European green movements, 2:1032–1034
criticism of, 2:1034
diversity in, 2:1034
environmentalism and, 2:1032
“environmentalisms of the poor” and, 2:1034
German Green Party and, 2:1032, 2:1033–1034
Greenpeace and, 1:96, 3:1612
international environmental movements and, 3:1608–1612
Marxist/Left politics and, 2:1032
New Left activism and, 2:1032
organizational and political forms of, 2:1032

See also Colonialism; Eurocentrism; European Union (EU)

Europe: maps

European green movements; European Union (EU); specific nation

Europe: maps
European Union (EU) membership and, 2:1036 (fig.)
Exotic species, 2:1048–1050
biodiversity and, 3:1337
dispersal prevention strategies and, 2:1049
European rabbit introduction in Australia and, 2:1048, 2:1049 (photo)
extinctions and, 2:1069–1072
forest fragmentation and, 3:1163
forest restoration and, 3:1168
global environmental change and, 3:1337
Great American Exchange and, 2:1055
human movement factor in, 2:1048
invasion and succession and, 3:1627
native species and ecosystems, 2:1048–1049
repeated introductions of, 2:1048
species vs. habitat-focused treatments of, 2:1049

Exploration, 2:1050–1059
Africa, 2:1051, 1057
ancient history and, 2:1051
Arab explorers, 2:1053–1054
Arctic and Antarctic, 2:1055
astrolobe invention, 2:1054
Chinese discoveries and, 2:1054
circumnavigation of the globe and, 2:1055
division between humans and nature and, 2:1055, 2:1056 (fig.)
Enlightenment and, 2:1055
European age of discovery and, 2:1054–1055
historical map of the Old World, as Ptolemy knew it, 2:1056 (fig.)
imaginary geographies and, 2:1055
indigenous people’s rights violated by, 2:1050
Islam and, 2:1053–1054
Lewis and Clark expedition and, 4:1773–1777
magnetic compass and, 2:1054
Mediterranean Sea by Greeks, 2:1051
Mediterranean Sea by Phoenicians, 2:1051
Mediterranean Sea by Romans, 2:1051
New World discovery, impact of, 2:1055
Norse discovery of America issue and, 2:1051
for Northwest and Northeast Passages, 2:1055, 2:1057
prehistoric exploration and, 2:1050–1051
reasons for exploration and, 2:1050
scientific exploration (Cook) and, 2:1055
sternpost rudder invention and, 2:1054
Viking explorers, 2:1051–1053
Vineland map, 15th-century from 13th-century original, 2:1051, 2:1052 (fig.), 2:1053
women explorers, 2:1057–1058
See also Colonialism; Exploration: noted explorers

Exploration: noted explorers
Alexander the Great, 2:1051
Roald Amundsen, 2:1055, 2:1057
William Baffin, 2:1055
Richard Francis Burton, 2:1057
John Cabot, 2:1054, 2:1055
Cheng Ho, 2:1054
Christopher Columbus, 1:520–521, 3:1461, 4:2179
Captain James Cook, 2:1057, 2:1055, 3:1461
Alexandra David-Néel, 2:1057
Bartolomeu Dias, 2:1054, 3:1461
Isabelle Eberhardt, 2:1057
Eratosthenes of Cyrene, 2:1051
Vasco da Gama, 2:1054, 3:1178–1179
Sir Walter William Herbert, 2:1055
Henry Hudson, 2:1055
Alexander von Humboldt, 3:1482–1485
Ibn Battuta, 2:1054, 3:1519–1520, 4:2179
Mary Henrietta Kingsley, 2:1057
David Livingstone, 2:1057
Simon Lucas, 2:1057
Ferdinand Magellan, 3:1461, 4:1813–1815, 4:2179
Adolf Erik Nordenskjöld, 2:1055
William Edward Parry, 2:1055, 2:1057
Robert Edwin Peary, 2:1055
Ida Pfeiffer, 2:1057, 2:1058 (fig.)
Marco Polo, 2:1053, 2:1053 (fig.), 3:1461
Pytheas, 2:1051
John Ross, 2:1055
Robert Scott, 2:1055
John Flannig Speke, 2:1057
Amerigo Vespucci, 2:1054, 6:3041

Exploratory spatial data analysis (ESDA), 2:1059–1063
confirmatory analysis step in, 2:1059
descriptive statistical methods and, 2:1061
detecting local clusters and, 2:1061
distance view based on geostatistics and, 2:1061
evidence collection step in, 2:1059
exploratory data analysis (EDA) and, 2:1059
future directions of, 2:1061–1062
Geographical Analysis Machine (GAM) and, 2:1061
geospatial analytics (GA) research field and, 2:1062
GIscience tool of, 2:1059
global spatial autocorrelation and, 2:1060–1061
inferential statistical cluster detection methods and, 2:1061
Kulldorff’s spatial scan statistic and, 2:1061
lattice vs. geostatistical spatial association and, 2:1060
LISA map and, 2:1060–1061
machine-learning and data-mining computational methods and, 2:1062
Moran scatter plots and, 2:1060–1061, 2:1061 (fig.)
nearneighborhood view of spatial autocorrelation and, 2:1060
SaTScan and, 2:1061, 2:1062 (fig.)
scan statistical method and, 2:1061
spatial association and, 2:1060
spatial autocorrelation and, 2:1059–1061, 5:2607–2608
spatial data and, 2:1059–1061
“spatial smooth” vs. “spatial rough” data and, 2:1060
Tobler’s First Law of Geography and, 2:1059, 4:1648
J. W. Tukey’s work in, 2:1057
variogram autocorrelation visualization tool and, 2:1061
visualization of high-risk clusters of cervical cancer in U.S. and, 2:1062 (fig.)
visualization of spatial distribution and, 2:1060

Export-led development, 2:1063–1066
comparative vs. competitive advantage, 2:1063
decaying terms of trade and, 2:1065
definition of, 2:1063
economic base analysis and, 2:846–848
export-oriented industrialization (EOI) and, 2:1063, 2:1064–1065
foreign direct investment (FDI) and, 3:1153–1156
global free trade model of, 2:1065
Heckscher-Ohlin model and, 2:1065, 5:2395
import substitution industrialism, 2:1064, 3:1549–1551
models and theories on, 2:1063–1065
new international division of labor and, 4:2019–2020
newly industrializing countries and, 4:2021–2024
outcomes, 2:1065–1066
Richard Peet’s views, 2:1063
role of the state, 2:1063
“strong” vs. “weak” development and, 2:1063
structural adjustment programs and, 2:1065–1066
structuralism perspective on, 2:1064
sustainable development and poststructuralism and, 2:1063

Export processing zones (EPZ), 2:1066–1068
competition in, 2:1067–1068
critiques, 2:1067–1068
definition of, 2:1066
developmental trend in, 2:1068
economic gain objective of, 2:1067
export-led development and, 2:1063–1066
foreign investment concentration in, 2:1067
history and developmental functions of, 2:1067
industrial production process division and, 2:1067
labor and, 2:1068
Labor, international division of, 4:2019–2020
policies of, 2:1066
Shenzhen Special Economic Zone (SEZ) and, 2:1067
structural adjustment and, 2:1065
transnational corporations and, 2:1067, 2:1068

Externalities, 2:1068–1069
definition of, 2:1068–1069
gerographers’ study of, 2:1069
knowledge spillover and, 4:1663–1664, 5:2395
network externalities and, 2:1069
positive and negative results of, 2:1069

Extinctions, 2:1069–1072
anthropogenic climate change and, 2:1070, 3:1337
biodiversity and, 1:197–201, 3:1337
climatic relics and, 1:467–471
definition of, 2:1069
ecological and cultural place of the species and, 2:1070–1071
enclosed spaces, global connections and, 2:1071
European bison in Belarus, 2:1071
from hybridizations, 3:1505
functional extinction and, 2:1070
geographic distribution of, 2:1070
Gyps vultures in India, 2:1070, 2:1070 (photo)
human/nonhuman entanglements in place and, 2:1069, 2:1070
interrupted spaces and, 2:1071, 3:1335
island species and, 3:1635
keystone species, 2:1070
rates of, 2:1069–1070
spectacled flying fox in Australia, 2:1070–1071
2005 Millennium Ecosystem Assessment and, 2:1070

Extractive reserves, 2:1072–1073
Brazilian Amazon and, 2:1072
definition of, 2:1072
economic and conservation viability issues and, 2:1072
enforcement issues and, 2:1072
land tenure model and, 2:1072
Chico Mendes and, 2:1072
origins of, 2:1072
rubber tappers movement (Amazon), 2:1072–1073
social justice and, 2:1072
Extreme geography, 2:1073–1074
definition of, 2:1073–1074
Globebead! Journal of Extreme Geography and, 2:1074
Nikolas H. “N4k” Huffman and, 2:1074
hyperradical postmodern attitudes of, 2:1074
proponents of, 2:1074

Exurbs, 2:1074–1076
characteristics of, 2:1074
counterurbanization and, 2:596–597
critics of, 2:1074
decentralization of employment factor of, 2:1075
definition of, 2:1074
economic factors and, 2:1075
Exurbanites (Spectorsky) and, 2:1075
low-density character of, 2:1075
rising housing costs factor of, 2:1075
rural ideal, rural landscape focus of, 2:1075
settlement patterns classification and, 2:1075
statistics, 2:1074–1075
stereotypical vision of, 2:1074
U.S. Census Bureau study of, 2:1074–1075
viability of, 2:1075–1076
voting patterns of, 2:1075
Eyles, John, 2:1042

Facebook, 2:648, 3:1478

Factors affecting location of firms, 3:1077–1080
capital contexts and, 3:1079
capital intensification in different industries and, 3:1080
corporate decision making and, 3:1080
corporate division of labor and, 3:1080
fixed vs. liquid capital and, 3:1079
Infosys Technologies, Mysore, India and, 3:1078
innovation geographies and, 3:1597–1599
investment capital and, 3:1079
labor factor, 3:1077–1078
labor process political factors and, 3:1078
land availability and cost and, 3:1078–1079
management factor, 3:1080
managing move to suburban locations and, 3:1079
R&D technical skills and, 3:1080
relative productivity of labor and, 3:1078
securing capital and, 3:1079–1080
skilled labor markets and, 3:1078
transportation costs and, 3:1079
unionization of labor and, 3:1078
Faroe Islands, cancer incidence and mortality in, 1:322 (fig.), 1:323 (fig.)

Fair trade and environmental certification, 3:1080–1082
accountability focus of, 3:1080
certification logos and, 3:1080
definition of, 3:1080
examples of, 3:1080–1081
Fair Trade-certified products and, 3:1081
networks of, 3:1080
organic products and, 3:1081
social activist organizations and, 3:1081
statistics, 3:1081
See also Corporate voluntary environmental initiatives and self-regulation; Environmental certification

Faller, Enzo, 2:713
INDEX 3245

Famine, geography of, 3:1082–1085
boom famines, Great Bengal Famine of 1843 and, 3:1084
definition and meaning of, 3:1082–1083
entitlement theory (Sen) of, 3:1084
famine-prone regions, world-wide, 3:1083 (fig.)
gender differences in, 3:1097
gender inequalities and, 3:1084
geography and, 3:1248
GIS early warning systems for, 3:1301
Great American Exchange and, 3:1362
health, welfare provision, and community access
contexts of, 3:1084
Malthusian population principle, and, 3:1082–1083, 4:1819–1820
new mappings of, 3:1085
in Niger, 2005, 4:1986
people living in extreme poverty and, 3:1082 (table)
political functions of, 3:1084
Poverty and Famines (Sen) and, 3:1084
technical or managerial approach to, 3:1084
See also Hunger

Fanon, Franz, 2:1047, 3:1528
FAO. See Food and Agriculture Organization (FAO)
Farish, Matthew, 4:1897

Faulting, 3:1085–1088
definition of, 3:1085
dip-slip faults, 3:1086–1087
earthquakes and, 3:1085
extension, compression, and lateral shear movement
types and, 3:1085
fault line scarp and, 3:1088
fault plane motion and orientation and, 3:1085–1086
fault scarps, 3:1088
folding and, 3:1140–1142
footwall and, 3:1086, 3:1086 (fig.)
hanging wall and, 3:1086, 3:1086 (fig.)
normal fault, 3:1086, 3:1086 (fig.)
normal fault, Basin and Range Province, Utah and
Nevada and, 3:1086
oblique slip and, 3:1086
reverse fault, 3:1086–1087, 3:1087 (fig.)
San Andreas Fault in California and, 3:1087
strike-slip faults, 3:1087–1088, 3:1087 (fig.)
thrust fault, 3:1087, 3:1087 (fig.)
transform faults, 3:1087–1088

FDI. See Foreign direct investment (FDI)

Fear, geographies of, 3:1088–1089
affective and emotional geographies and, 3:1089
earliest studies of, 3:1088
effects of crime and, 3:1088
fear definition and, 3:1088
fearful label and, 3:1088
feminist geographers and, 3:1088
genocide geographies and, 3:1199–1202
globalized terrorism fear and, 3:1089
hope, geographies of, 3:1089
landscape and crime studies and, 3:1088
media role in, 3:1089
movement patterns of, 3:1089
race and globalized fear, 3:1089
structural vulnerability and insecurity and, 3:1088
urban development, fortified city and, 3:1088–1089

Featherstone, David, 5:2574–2575

Febvre, Lucien, 3:1090
Annales School and, 1:79–80, 3:1090
Marc Bloch and, 3:1090
Fernand Braudel and, 3:1090
criticism of, 3:1090
Henry Clifford Darby influenced by, 2:664
environmental possibility and, 3:1465
human-environment relationship work of, 3:1090
La terre en Pivilation humaine written by, 1:80, 3:1090
la tradition vidalienn en, 1:80
regional monograph technique of, 3:1090
Paul Vidal de la Blache and, 3:1090, 3:1465

Federated States of Micronesia (FSM)
biodiversity conservation and, 3:1635
as biodiversity conservation “hot spot,” 3:1635
Chuuk Lagoon from satellite imagery, Chuuk
State, 3:1635 (photo)
coping with hazards and, 2:743 (photo)
deposit refund systems in, 2:742
high island of Tonowas, Chuuk State, 3:1635 (photo)
indigenous water management and, 3:1573
Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)

Feenstra, Gail, 2:857

Fellmann, Jerome, 3:1274

Feminist environmentalism, 3:1090–1092
Chipko movement and, 1:395–396
community activism and, 3:1091
criticism of, 3:1091
Françoise d’Eaubonne and, 3:1091
domination of nonhuman nature and, 3:1090–1091
ecofeminism and, 2:817–820, 3:1091
patriarchal practices, gender power differentials and, 3:1092
sexism within environmental movement, 3:1091
suffrage and abolition movements and, 3:1091
women as “moral mothers” and, 3:1091
Women’s Pentagon Action and, 3:1091
See also Feminist specific subject; Gender and nature

Feminist environmentalist geographies, 3:1092–1094
gender and environmental hazards and, 3:1186–1188
genдерed landscapes and identities in, 3:1094
genendered power relations in participatory decision-making
and, 3:1094
genendered relations of global development and
environments, 3:1093–1094
masculinity and, 3:1094
See also Feminist environmentalist geographies: noted
feminists; Feminist specific subject

Feminist environmentalist geographies: noted feminists
Jody Emel, 3:1093
Cathy Nesmith, 3:1092
Sarah Radcliffe, 3:1092
Gillian Rose, 3:1094, 3:1468, 5:2484–2485
Joni Seager, 3:1092–1093

Feminist geographies, 3:1095–1098
body, geographies of, 1:289
capitalism and, 1:419
citizenship and, 1:414
Committee on the Status of Women in
Geography and, 3:1234
critical geopolitics criticized by, 2:613
critical GIS and, 2:615
critical human geography and, 2:618
deconstructionism and, 5:2271
dual-systems vs. single-systems model of, 4:2136
EuroFEM and, 2:1045
eyeveryday life and, 2:1042, 2:1043–1044, 2:1045
female labor force, “glass ceiling” concept and, 3:1096
feminist epistemologies and, 1:290, 3:1097
feminist methodologies and, 3:1097
feminist politics and, 3:1095–1096
feminization of poverty and, 3:1097
gay and lesbian geographies and, 3:1184
gender and geography and, 3:1188–1194
gender and space intersection and, 3:1096
gender differences in commuting and, 3:1096–1097
gendered division of labor and, 3:1195, 3:1196, 3:1439
gendered geographical knowledge and, 3:1097–1098
gendered language and, 4:1754
“gender gap” in voting patterns and, 3:1097
gendering and feminism in, 3:1096–1097
geography of emotions and, 2:892
“The Geography of Women: An Historical Introduction” essay (Hayford), 2:618
historical geography and, 3:1431
home and family life, 3:1439
identity formation and, 3:1530
masculine geographies and, 2:1043–1044, 4:1865–1866
“On Not Excluding Half the Human in Human Geography” essay (Monk and Hanson), 2:618
panopticicon and, 4:2116–2117
patriarchal geographies and, 3:1096, 4:2135–2136
“pink-collar ghettos,” 1:419
postcolonial feminists and, 3:1096, 5:2261
postmodern feminists and, 3:1096
qualitative methods and, 3:1097
radical geography and, 5:2351
researcher bias and, 3:1431
resistance geographies and, 5:2442
social construction of gender and, 1:289, 3:1431
social geography and, 5:2367–2368
space and place and, 3:1431, 3:1530, 4:1644
women in the developing world and, 3:1097
See also Ecofeminism, 2:817–820; Feminist geographies: noted feminists; Feminist specific subject; Gender and nature
Feminist geographies: noted feminists
Susan B. Anthony, 3:1095
Judith Butler, 1:289
Nancy Chodorow, 3:1095–1096
Simone de Beauvoir, 3:1095
Sarah Elwood, 2:615
Betty Friedan, 3:1095
Clara Greed, 2:1043–1044
Nicki Gregson, 1:230
Susan Hanson, 2:618, 3:1400–1401
Donna Haraway, 3:1097
Sandra Harding, 3:1097
Alison Hayford, 2:618
bell hooks, 3:1095
Mei-Po Kwan, 2:615, 4:1674
Audrey Lorde, 3:1095
Doreen Massey, 4:1866–1867
Linda McDowell, 3:1097, 3:1400, 3:1468, 4:2136
Sara McCafferty, 2:615
Janice Monk, 2:618
Elizabeth Cady Stanton, 3:1095
Feminist methodologies, 3:1098–1100
cultural turn origins of, 3:1098
definition of, 3:1098
feminist institutional ethnography (D. E. Smith) and, 2:1043
feminist methodologies and, 3:1097
gendered spaces and places focus of, 3:1098
intersectionality, and transversalism and, 3:1099
Orientalism and, 4:2104
participatory action research and, 3:1099
power relationships theme in, 3:1097, 3:1098, 3:1099, 3:1530
qualitative, quantitative, and mixed methodologies and, 3:1097, 3:1099
reflexivity in knowledge production and, 3:1099
researcher role and, 3:1098, 3:1099
Gillian Rose and, 5:2484–2485
situationedness of knowledge production and, 3:1099
Dorothy E. Smith and, 2:1043
See also Feminist specific subject
Feminist political ecology, 3:1100–1102
anarchism and geography and, 1:73, 1:74
culture, race, and gender issues and, 3:1101
culture and place emphasis in, 3:1101
DAWN (Development Alternatives for Women of a New Era), 3:1102
distribution of resource access and, 2:779–780
ecofeminism and, 2:817–820
ecological justice and, 2:830–832
gender and development focus of, 3:1100
gender and nature and, 3:1195–1196
gendered and racialized landscape formations and, 3:1101
gendered division of labor, 1:419, 3:195
gendered land and resource tenure systems and, 3:1101
gendered power relations and, 3:1101
gendered resources distribution and, 3:1101
International Working Group on Women and the Politics of Place and, 3:1101
maldevelopment (Shiva) and, 3:1101
multidisciplinary features of, 3:1100–1101
policy and advocacy framework of, 3:1102
sustainable development focus of, 3:1100, 3:1101
urban and rural environmental and social justice issues and, 3:1100, 3:1101
See also Feminist political ecology: noted contributors; Feminist specific subject
Feminist political ecology: noted contributors
Judith Carney, 3:1100
A. Escobar, 3:1101
Donna Haraway, 3:1100
Wendy Harcourt, 3:1101
Betsy Hartmann, 3:1100
Heidi Hartmann, 4:2136
Cindy Katz, 3:1100
Carolyn Merchant, 3:1100
Jan Momsen, 3:1100
Val Plumwood, 3:1100
Marianne Schmink, 3:1100
Joni Seager, 3:1100
Vandana Shiva, 3:1101
Juanita Sundberg, 3:1101
Sylvia Walby, 4:2136
Feng shui, 3:1238–1239
Ferrel, William, 1:132
Fertile Crescent
animal domestication in, 1:376
animal domestication in, 1:376
crops domestication in, 1:375
Fertility rate, 3:1102–1103
age-specific fertility rate (ASFR) and, 3:1103
crude birth rate (CBR) and, 3:1102
definition of, 3:1102
in demographic transition stages, 2:708–710
general fertility rate (GFR) and, 3:1102
population pyramid and, 5:2249–2250
total fertility rate (TFR) and, 3:1103
Field, Richard, 1:261 (photos)
Fieldwork in human geography, 3:1103–1105
Chicago School of urban sociology and geography and, 3:1103–1104
clarity element in, 3:1104
communication, trust, and timing elements of, 3:1104
credibility, transferability, dependability, and confirmability elements in, 3:1104–1005
decline in, 3:1103
evaluation of, 3:1104–1105
formal training opportunities decline in, 3:1103
future of, 3:1105
geraphical experience of the elderly example of, 3:1104
inner city as a frontier outpost work (Ley) and, 3:1104, 3:1476
interactionist sociology and, 3:1104
interviewing and, 3:1625–1627
life in the ghetto fieldwork (Wirth), 3:1103
power relationships between researcher and observed and, 3:1104
qualitative methodologies and, 3:1105
in teaching geography, 3:1105
triangulation process and, 3:1104–1105
See also Fieldwork in human geography: noted geographers
Fieldwork in human geography: noted geographers
D. Gilbertson, 3:1105
C. Hunt, 3:1105
Jennifer Hyndman, 3:1104
M. Kent, 3:1105
David Ley, 3:1104, 3:1476
Graham Rowles, 3:1104
Carl Sauer, 3:1103, 3:1465
Louis Wirth, 3:1103
Wilbur Zelinsky, 3:1103
Fieldwork in physical geography, 3:1105–1110
advanced field seminars and, 3:1107–1108
aerial photograph and satellite imagery skills and, 3:1108
criticism of, 3:1106
data sources of, 3:1106
field camp research programs and, 3:1108
field courses and, 3:1107
field safety and security in, 3:1109
field trips and, 3:1107
GIScience mapping tools and, 3:1105
instruction methods in, 3:1106–1109
“life before science” adage and, 3:1109
map reading skills and, 3:1108
media and, 3:1109–1110
multidisciplinary topics in, 3:1107
personal and cultural sensitivity skills in, 3:1107
prior training and classroom work links to, 3:1107
procedures of, 3:1106
specialized nature of data in, 3:1106–1107
student objectives in, 3:1108–1109
techniques of, 3:1106
themes of, 3:1108
Fietelson, Eran, 1:526
Fiji
British colonization of, 1:514
economically active females in, 3:1190 (table)
Film and geography, 3:1110–1111
affective nature of film and, 3:1111
author-text-reader (A-T-R model) and, 3:1110–1111
crisis of representation and, 3:1110
cultural texts produced from, 3:1110
film as modern-day cartography concept and, 3:1111
naturalized assumptions issue and, 3:1110
photography and, 4:2176–2178
realism through representation issue and, 3:1110
reality effect produced by, 3:1110
socially mediated treatment of meaning and, 3:1111
See also Film and geography: noted individuals
Film and geography: noted individuals
Roger Manvell, 3:1110
Eugen Wirth, 3:1110
J. K. Wright, 3:1110
Filtering, 3:1111–1114
Chicago School of urban studies and, 1:388, 3:1114
definition of, 3:1111
downward socioeconomic status shift of residents and, 3:1112
gentrification vs., 3:1112
housing policies and, 3:1112
housing policies research and, 3:1114
ladders metaphors use and, 3:1111–1112
laissez-faire politics and, 3:1112, 3:1114
Laws of Migration (Ravenstein) and, 3:1113
model of sectoral land use patterns (Hoyt) and, 3:1112
model of urban concentric zones (Burgess) and, 3:1112
neighborhood life cycles and, 3:1112
push factor of immigrants and, 3:1112
residential mobility patterns and, 3:1111–1112
spatial dimension of, 3:1112
substandard housing end product of, 3:1112
vacancy chains and, 3:1113–1114, 3:1113 (fig.)
See also Filtering; noted scholars
Filtering: noted scholars
Ernest Burgess, 3:1112
Homer Hoyt, 3:1112
Richard Ratcliff, 3:1114
Ernst George Ravenstein, 3:1113
Filtration, 3:1114–1115
air filtration, 3:1115
definition of, 3:1114
granular-medium water filtration, 3:1115
purposes of, 3:1114–1115
reverse osmosis and, 3:1115
water filtration, 3:1115
surface membrane water filtration, 3:1115
water filtration, 3:1115
Finance, geography of, 3:1115–1118
autonomous research field of, 3:1115
central-place theory and, 3:1116, 3:1117
comparative institutionalism and, 3:1117–1118
cultures of company business strategy and, 2:850–851
disciplinary perspectives on, 3:1116–1118
Economic Backwardness in Historical Perspective (Gershenkron) and, 3:1117
emerging markets and, 2:890–891
Euromarkets and, 2:1030–1032
financial-center literature and, 3:1117
financial division of labor and, 3:1116
formation of financial centers (Kindleberger) and, 3:1116
gaining synthesis in, 3:1118
geography of enterprise and, 2:850–851
global city indices and, 3:1117
international financial centers and, 2:851
International Monetary Fund (IMF) and, 3:1615–1618
metropolitan service economies and, 3:1117
money geographies and, 4:1936–1938
multimethod, multitheoretical, and multidisciplinary approach to, 3:1118
offshore finance and, 4:2071–2073
origins of, 3:1116
performativity and, 3:1116
policy interventions and, 3:1117
relational geography and, 3:1117
rise in financial markets challenges and, 3:1115–1116
social studies of finance and, 3:1117
space, place, and money relationships and, 2:850–851
“space shrinking” property of money and, 3:1116
spatial distribution of financial value production and, 3:1116
telecommunications technology and, 62785–2786
transnational developments and, 3:1117–1118
See also Finance, geography of: noted individuals
Finance, geography of: noted individuals
Gordon Clark, 3:1118
Alexander Gershenkron, 3:1117
Charles Kindleberger, 3:1116
Donald MacKenzie, 3:1116–1117
Saskia Sassen, 3:1117
Peter Taylor, 3:1117
Dariusz Wojcik, 3:1118
Finland
acid rain in, 1:7
AGILE membership of, 1:124 (table)
cancer incidence and mortality in, 1:322 (fig.), 1:323 (fig.)
carbon or climate change taxes in, 4:1857
critical human geography in, 2:620
economically active females in, 3:1190 (table)
European Union (EU) membership of, 2:1035
Lapps preindustrial agriculture in, 1:48
next generation nuclear reactors in, 4:2051
Ural Altaic or Finno-Ugric languages in, 4:1751 (fig.)
Fischhendler, Italy, 1:526
Fisher, Peter, 3:1118–1119
G Science work of, 3:1118–1119
International Journal of Geographic Information Science (IJGIS) and, 3:1118–1119
publications of, 3:1119
societal impacts of geographic technologies work of, 3:1119
uncertainty models work of, 3:1119
Fisher-Kowalski, Mariana, 2:839
Fish farming, 3:1119–1121
aquaculture and, 1:102–104
Atlantic salmon in Norway example of, 3:1119–1120
Blue Revolution and, 2:1120
culture as a cultivation process and, 2:1120
culture of, 3:1120–1121
culture, meanings of, 2:1120–1121
cultivating and domestication processes and, 2:1120
global wild fisheries decline and, 2:1120
international economic development and, 2:1120
marine aquaculture and, 4:1853–1855
water trading permit systems and, 4:1857
Raymond Williams and, 2:1120
Fjords, 3:1121–1123
characteristics of, 3:1121
erosion rates and, 3:1121
erosive powers of outlet glaciers and, 3:1121
irregular longitudinal profile of, 3:1122, 3:1123 (fig.)
linear nature of, 3:1122
locations of, 3:1121
overdeepened trough landform of, 3:1122–1123
preglacial landscape factor and, 3:1121–1122
rock mass strength factor and, 3:1121
Sognefjorden fjord, Norway, 3:1121, 3:1122 (photo), 3:1123 (fig.)
Flash floods, 3:1123–1125
canyon flash flood, 3:1124
dam and levee failures and, 3:1124–1125
deaths from, 3:1125
definition of, 3:1123
ice dams and, 3:1124
impermeable surfaces factor in, 3:1549
infrastructural failures and, 3:1124
in Iowa, 3:1124 (photo)
Storm Events database and, 3:1125
urbanization contributing factor to, 3:1123
See also Flash floods: examples
Flash floods: examples
Big Thompson River flood (1976), Colorado, 3:1124
Hurricane Katrina storm surge, levee failures, 3:1125
Typhoon Nina (1975), Banqiao Reservoir, China, 3:1125
Yellow River (2008), China, 3:1124
Fleure, Herbert, 3:1458
Flexible production, 3:1125–1127
agglomeration economies and, 1:32
core competencies focus and, 3:1126
customization of output and, 3:1127
definition of, 3:1125–1126
deindustrialization and, 2:701–702
Fordism economies of scale and, 3:1126
Fordism vs., 3:1148–1151
increased subcontracting and, 3:1126
in industrial districts, 3:1576–1577
industrialization and, 3:1580–1581
information technologies use in, 3:1126–1127
just-in-time inventory systems and, 3:1126
Los Angeles School of urban economy and, 4:1803–1805
microelectronics revolution and, 3:1126
noneconomic factors and, 3:1127
post-Fordism and, 3:1125–1126
productivity increase and, 3:1126
quality control in, 3:1127
vertical disintegration and, 3:1126
Flint, Colin, 4:1897
Flocculation, 3:1127–1128
aggregates vs. flocs and, 3:1127
cohesion mechanism needed for, 3:1128
collision mechanism needed for, 3:1127–1128
composite particle and, 3:1127
definition of, 3:1127
floc density and, 3:1128
floc settling velocity and, 3:1128
flocs units and, 3:1127
secondary particle size analysis and, 3:1128
terms related to, 3:1127
water quality and, 3:1127
Floodplain, 3:1128–1133
Amazon River, 3:1129 (photo)
backwater modeling and, 3:1131
base level and climate changes and, 3:1128
crop cultivation on, 3:1132
cycle of land use on, 3:1132–1133, 3:1132 (fig.)
definition and description of, 3:1128
delineation methods of, 3:1131–1132
development of, 3:1128–1130
features of, 3:1130 (fig.)
flash floods and, 3:1123–1125
hydrographs of, 3:1131, 3:1132 (fig.)
hydrological floodplains, 3:1130
landforms of, 3:1128
Nile River and Mississippi River floodplain land use and,
3:1130 (photo)
tectonic deformation and, 3:1128, 3:1129 (photos), 3:1133 (fig.)
topographic floodplains, 3:1130, 3:1131 (fig.)
types of, 3:1130–1131
uses of, 3:1132–1133
water flow and sediment transport over, 3:1131
White Volta River, Ghana, 3:1129 (photo)
Leopold Wolman’s model of, 3:1128, 3:1130
See also Rivers
Floods, 3:1133–1137
antecedent environmental condition factors and, 3:1134
in arid regions, 3:1135
causal mechanisms of, 3:1133, 3:1134–1135
coastal flooding measurement and, 3:1136
discharge measurement and, 3:1135
drainage basin factors in, 3:1134, 3:1134 (fig.)
extensive vs. intensive events and, 3:1136
flashy vs. sluggish streams and, 3:1134, 3:1135 (fig.)
flood depths measures and, 3:1135–1136
flood recession agriculture and, 3:1134
flow velocity measures and, 3:1136
forecasting and warning systems and, 3:1137
frequency component of, 3:1136
geomorphology of shorelines and, 3:1135
human intervention in drainage basins and, 3:1136
magnitude and severity of, 3:1135–1136
mitigation of, 3:1136–1137
in mountainous areas, 3:1135
nonstructural mitigation of, 3:1137
positive outcomes from, 3:1133–1134
precipitation and, 3:1134
relocation from, 3:1137
shoreline environments and, 3:1135
storm surge height and, 3:1136
stream cross-section and floodplain and, 3:1134 (fig.)
structural mitigation of, 3:1136–1137
In United States, 2008, 3:1134–1135
See also Floodplain; Floods: examples; Rivers
Floods: examples
  Big Thompson, Colorado (1976), 3:1135, 3:1136
  California-Arizona border (2008), 3:1135
  Hurricane Ike, Texas, 3:1136
  Hurricane Katrina, 3:1135
  Mississippi River at St. Louis (1993), 3:1135
Florida
  barrier islands in, 1:184 (photos)
  Celebration, Osceola County, new urbanism, 4:2025 (photo)
  Florida Everglades ecosystem restoration project, 2:992
  Hurricane Katrina and, 3:1493
  hurricane risk in, 3:1500
  hurricanes in, 3:1501
  Kennedy Space Center Launch Complex in, 4:1975 (photo)
  land cover in Leon County, 4:1709 (fig.), 4:1710 (table)
  sea and lake breeze fronts in, 3:1335
  Seaside, Walton County, resort town, new urbanism, 4:2025 (photo)
  Spanish colonialism in, 1:512
  stagnant coral faunal relict and, 1:470
  tropical humid climate in, 1:453
See also Everglades restoration
Florida, Richard, 1:119–120, 2:851, 5:2263
Flow, 3:1138
floods and, 3:1133–1137
fluids in motion, 3:1138
liminar flow, 3:1138
Reynolds number (Re) dimensional parameter of, 3:1138
rising cigarette smoke example of, 3:1138
turbulent flow, 3:1138
See also Flow maps
Flow maps, 3:1138–1140
  computer-generated flow map (Tobler) of California migration
  (1995–2000) and, 3:1139, 3:1139 (fig.)
  dynamic maps and, 3:1138
  economic geography and, 3:1139
  Flow Mapper software (Tobler) and, 3:1139 (fig.)
  flow mapping software (Phan) and, 3:1139, 3:1139 (fig.)
  kriskogram and, 3:1139, 3:1140 (fig.)
  Minard’s 1864 flow map and, 3:1138, 3:1139 (fig.)
  movement of phenomena between locations depicted by, 3:1138
  origins of, 3:1138
  quantitative data of, 3:1138
  types of, 3:1138
See also Flow
Flow maps: noted individuals
  Yongwan Chun, 3:1139, 3:1140 (fig.)
  Henry Drury Harness, 3:1138
  Doantam Phan, 3:1139
  Waldo Tobler, 3:1139
  Ningchuan Xiao, 3:1139, 3:1140 (fig.)
Folding, 3:1140–1142
antcline vs. syncline features of, 3:1141
antiforms vs. synforms features of, 3:1141
approaches to studies of, 3:1141
axial surface feature of, 3:1141
bending folds and, 3:1142
causes of, 3:1142
chevron folds and, 3:1141
conditions prevalent in, 3:1140–1141
definition of, 3:1140
descriptive terminology of form classification categories of, 3:1141
face and vergence features of, 3:1141
faulting and, 3:1085–1088
fold nappes feature of, 3:1141
fold tightness and, 3:1141
gentle vs. isoclinal folds and, 3:1141
hinge zone or fold nose feature of, 3:1141
monocline vs. structural bench features of, 3:1141
overturned vs. recumbent fold and, 3:1141
parallel, competent, or concentric folds and, 3:1141
passive folding and, 3:1142
plunge inclination of, 3:1141
ptymatic folds and, 3:1141
similar folds and, 3:1141
structural basin and, 3:1141
symmetrical vs. asymmetrical fold and, 3:1141
upright vs. inclined fold features of, 3:1141
Folk culture and geography, 3:1142–1144
  Berkeley School of cultural geography and, 3:1142
  cultural geography and, 3:1142
cultural hearth areas and, 3:1142
definition of, 3:1142
music and sound geographies and, 4:1967–1969
popular culture res., 3:1142
popular geography and, 3:1143
urban culture and, 3:1142
See also Folk culture and geography: noted individuals
Folk culture and geography: noted individuals
Stuart Hall, 3:1142
Allan Pred, 3:1143–1144
Carl Sauer, 3:1142
Johann Gottfried von Herder, 3:1143
Raymond Williams, 3:1142
Food, geography of, 3:1144–1146
agriculture as oldest marker of civilization and, 3:1144
development process role of, 3:1144–1146
ecosheds and, 2:857
famine geographies and, 3:1082–1085
food sovereignty farmers’ movements and, 3:1146
General Agreement on Trade and Tariffs and,
3:1145–1146, 4:2045
genetic engineering and biotechnology and, 3:1145
geophagy and, 3:1248–1249
global food connections and, 3:1146
green revolution technologies and, 3:1145
industrialized food production and, 3:1145
neoliberal globalization and, 3:1146
organic agriculture and, 4:2094–2096
power geographies and, 3:1144
social meanings and environmental practices associated
with, 3:1144–1145
von Thünen geographic model of, 3:1144
See also Agrofoods; Consumption, geographies of; Food and
Agriculture Organization (FAO); Hunger
Food and Agriculture Organization (FAO), 3:1146–1148
aquaculture, 1:102
forests and land use statistics of, 3:1147–1148
geographies of food and, 3:1144–1146
geography studies’ statistics of, 3:1148
governing structure of, 3:1146–1147
history and constitution of, 3:1146–1147
international organizations within, 3:1147
plantation development and, 5:2193
secretariat role in, 3:1147
studies of, 3:1147
sustainable fisheries and, 6:2754
sustainable forestry and, 6:2758
United Nations and, 3:1146, 3:1147, 6:2754
World Forestry Congress and, 3:1147
Foodprint analysis. See Ecological footprint
Foord, Jo, 3:1189
Fordism, 3:1148–1151
centralized production and direct resources control
features of, 3:1149
definition of, 3:1148–1149
deplacement of, 3:1150
economies of scale and high output volumes from, 3:1149
Antonio Gramsci’s views on, 3:1149
greenfield facilities and, 3:1149
Industrial Revolution and, 3:1582, 3:1584
machine-paced production methods and, 3:1149, 3:1150 (fig.)
mass production and mass consumption linked by, 3:1149
modernity, rationality, and efficiency characteristics of, 3:1149
outsourcing and, 4:2108–2110
post-Fordism and, 2:849, 3:1125–1126, 3:1194,
5:2264, 5:2399, 5:2400–2401
production of decentralized parts and, 3:1149
regulation theory and, 5:2399–2402
social theorists and, 3:1149
spatial requirements of, 3:1149
Foreign aid, 3:1151–1153
absorptive capacity of recipient countries and, 3:1153
Britain and U.S. histories of, 3:1151–1152
controversies, 3:1153
definition of, 3:1151
developing world benefits from, 3:1151
East Asian economic development success and, 3:1152
geographies of, 3:1152–1153
history of, 3:1151–1152
measures of, 3:1152
modern international developments in, 3:1152
positive vs. negative effects of, 3:1153
purpose of, 3:1151
study of spatial distributions of, 3:1152
types of, 3:1151
UN Millennium Development Goals and, 3:1152, 5:2220
Foreign direct investment (FDI), 3:1153–1156
acquire controlling interests in established firms and, 3:1153
in China, 4:2022
definition of, 3:1153
John Dunning’s eclectic paradigm of, 3:1154
emerging economies and, 3:1155–1156
establishing new firms overseas and, 3:1153
human capital interactions of, 3:1155
impacts of, 3:1154
importance of, 3:1154–1155
in India, 4:2023
market orientation vs. asset orientation and, 3:1154
NAFTA and, 4:2044
new international division of labor and, 4:2020
newly industrializing countries and, 4:2021
ordinary (common stock) component of, 3:1153
organizational and geographical networks linked by, 3:1153
purposes of, 3:1155
retained earnings component of, 3:1153
theories of, 3:1154
transnational corporations (TNCs) and, 3:1153, 3:1154
Raymond Vernon’s locational product life cycle
concept and, 3:1154
Forest degradation, 3:1156–1159
boreal forest belt zones and, 3:1157–1158
boreal forest conifer species and, 3:1158
closed-crown forest degradation and, 3:1157 (fig.), 3:1158
definition of, 3:1156
from deforestation, 3:1157
ecosystem and atmospheric impacts of, 2:938
ecosystem decay and, 2:858–862
estimating extent of, 3:1156–1157
fire and, 3:1158
forest fragmentation and, 3:1159–1163
human-related activities as cause of, 3:1156
lichen woodland zone and, 3:1157
in Northern Hemisphere, 3:1157–1158
stand disturbances, Eastern Canada, 3:1157 (fig.), 3:1158
tropical deciduous forest biome and, 1:230–233
tropical rain forest biome and, 1:234–239
See also Forest fragmentation; Forest land use;
Forest restoration
forest fragmentation, 3:1159–1163

growth forestry and, 1:60–62

biophysical environment changes and, 3:1161–1163

bird species affected by, 3:1161–1162

boreal forest biome and, 1:214–217

compensatory effects of, 3:1161

connective vegetation structures and, 3:1160

core species populations and, 3:1161

definition of, 3:1159

developed effects of, 3:1161

equilibrium theory of island biogeography and, 3:1159

exotic species invasions and, 3:1163

extractive reserves and, 2:1072–1073

climatic change implications of, 3:1163

midlatitude deciduous forest biome and, 1:223–226

patches and corridors and, 4:2131–2133

depression of, 3:1159

pesticides and, 3:1163

plant and animal species adaptation and, 3:1159

planted seed dispersal and survival affected by, 3:1159–1161,

3:1161 (fig.), 3:1162 (fig.)

population dynamics changes and, 3:1159–1161

reforestation and, 3:1159

sea of human land use around and, 3:1161

selective tree cutting and, 3:1163

“single large or several small” (SLOSS) nature preserves debate and, 3:1161

tropical forest biome and, 1:230–233

in the tropics, 3:1159

See also Deforestation; Forest degradation; Forest land use;

Forest restoration

Forest land use, 3:1163–1166

agricultural and urban areas transition of, 3:1165

agroforestry and, 1:60–62

boreal forest biome and, 1:214–217

carbon cycle and, 3:1164

carbon sinks and, 3:1164

cellular automata used in, 1:370, 1:371 (fig.)

climate systems and, 3:1164

deforestation process of forest transition and, 3:1165

degradation process of forest transition and, 3:1165

degree of disturbance and, 3:1164

environmental services and, 3:1164

forest definition and, 3:1163

forest density measurement and, 3:1165

forest fair trade certification and, 3:1081

forest plantations and seminatural forests and, 3:1164

forest spatial coverage changes and, 3:1165

Forest Stewardship Council and, 3:1081

forest types and spatial distribution in, 3:1164

global net deforestation and, 3:1165

indigenous forest dwellers and, 3:1164

indirect divers of forest change and, 3:1165

midlatitude deciduous forest biome and, 1:223–226

modified natural forests and, 3:1164

nontimber products use and, 3:1164

primary forests and, 3:1164

proximate causes. underlying processes of forest change and, 3:1165

reforestation process of forest transition and, 3:1165

regeneration process of forest transition and, 3:1165

slash pine plantation, Georgia (U.S.), 6:2835 (photo)

subsistence economies and, 3:1164

tropical, temperate, and boreal forest types and, 3:1163, 3:1164

tropical deciduous forest biome and, 1:230–233

water cycles and, 3:1164

See also Food and Agriculture Organization (FAO); Forest degradation; Forest fragmentation; Forest restoration;

Timber plantations

Forest restoration, 3:1166–1168

boreal forest biome and, 1:214–217

conservation of species and, 3:1166

ecollogous restoration definition and, 3:1166

ecosystem productivity and, 3:1166

endangered species support and, 3:1168

exotic species removal, 3:1168

forest degradation and, 3:1156–1159

forest landscape restoration (FLR) and, 3:1168

goals and purposes of, 3:1166

Gus Pearson Natural Area, Flagstaff, Arizona, and, 3:1167 (photo)

implementation of, 3:1166–1167

key elements of, 3:1167

landscape-scale, geographic perspective in, 3:1168

midlatitude deciduous forest biome and, 1:223–226

multiple-scale systems with place-based approach integration and, 3:1168

Redwood National Park, California, example of, 3:1167–1168

tropical deciduous forest biome and, 1:230–233

watershed-scale restoration and, 3:1167–1168

See also Food and Agriculture Organization (FAO); Forest degradation; Forest fragmentation; Forest land use

Formosa, 1:514

Fossey, Edwin, 4:1873

Foster, George, 4:2137

Fotheringham, A. Stewart, 3:1168–1169

gigographically weighted regression (GWR) co-developed by, 3:1169, 3:1226

geographic information science research of, 3:1168–1169

journals edited by, 3:1169

quantitative geography work of, 3:1169

spatial interaction modeling work of, 3:1169

spatial statistics research of, 3:1169, 5:2395–2396

Strategic Research in Advanced Geotechnologies group led by, 3:1169

Foucault, Michel

analytics of government work of, 3:1359

biopolitics work of, 5:239

critical geopolitics work of, 2:611

Discipline and Punishment written by, 4:2116


discourse theory work of, 2:766, 2:767, 2:769, 4:1754, 4:2102, 5:2326

gender geographies and, 3:1192

governmentality and conservation and, 3:1359

History of Sexuality written by, 3:1528

Madness and Civilization written by, 5:2271

Marxist geography work of, 4:1863

panopticon concept and, 4:2116

Richard Peet influenced by, 4:2144

postmodernism and, 5:2267

poststructuralism, power and knowledge work of, 1:289, 3:1468, 3:2271–2272, 5:2712

Edward Said influenced by, 4:2102

sea as arena for culture formation and, 4:2070

time-space discourse of, 3:1433

Fourier, Charles, 4:1860

France

AGILE membership of, 1:124 (table)
antiglobalization, anticolonialism in, 1:97
Arab countries colonized by, 1:514
automobile industry in, 1:169, 1:171
automobility in, 1:171
biotechnology industry in, 1:280
civic nationalism in, 4:1979
coil energy source in, 3:1582
colonial empire of, 1:509, 1:509 (fig.), 1:512
counterurbanization in, 2:596
cultural nationalism in, 4:1980
cecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
Egypt colonized by, 1:514
European Union (EU) membership of, 2:1035
federalism political model and, 2:1036
Francocentrism of, 2:1030 (table)
GDP of, 3:1382, 3:1383 (fig.)
hate groups in, 3:1407
high-speed trains in, 5:2364
hydroelectricity in, 3:1507
income distribution, percentile of world income, 5:2641 (fig.)
Indochina colonization by, 1:515
industrialization in, 3:1583
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Kyoto Protocol of 1997 and, 1:463
Marxism in, 2:617
military expenditures in, 4:1898, 4:1899 (table)
Minard’s flow map of wine exports from (1864), 3:1139 (fig.)
Minutely network system in, 2:646
morphine-rich narcotics produced in, 2:796, 2:797 (table)
movement against genetically modified organisms in, 3:1610
national boundaries identification and, 4:1972
national geographical society in, 3:1462
nuclear reactors in, 4:2052
pays rural areas, chorology of, 1:404
pollution taxes in, 4:1857
Prestige oil tanker spill and, 4:2076
public urban water systems in, 5:2316
railroads in, 5:2358, 5:2359 (fig.)
Rhones-Alps technology area in, 5:2435
small village settlement, Liausson, 5:2536 (photo)
SPOT multitemporal imaging system of, 4:1959, 4:1960
student dissident movement in, 1:100
total factor productivity (TFP) of, 6:2780 (table)
vegetation on alluvial bar, River Alliet, 1:272 (photo)
See also Paris, France
Francis, Charles, 1:54
Frank, Andrew, 3:1169–1170
dependency theory work of, 2:713
International Conference on Spatial Information Theory established by, 3:1170
journals edited by, 3:1170
National Center for Geographic Information and Analysis co-founded by, 3:1170
ontological aspects of geographic information work of, 3:1170
quantitative reasoning and natural linguistics work of, 3:1170
spatial data analysis and GIScience work of, 3:1169–1170
Frankfurt Institute for Social Research, 2:617, 3:1419
Frankfurt School
culture industry analysis and, 5:2230
Karl Wittfogel and, 2:617
Fraunhofer, Joseph von, 3:1542
Freire, Paulo, 2:875
French Guiana, 1:234
Frey, W., 2:1075
Friedan, Betty, 3:1095
Friedman, Milton, 4:1934, 4:2011
Friedman, Thomas, 3:1224
Friends of the Earth International, 3:1612–1613
Froebisher, Martin, 4:2179
Frontiers, 3:1170–1172
Amazonia’s contemporary frontier and, 3:1171–1172
borderlands and, 1:291–292
boundaries between principalities or states and, 3:1170–1171
decennial censuses and, 3:1170–1171
European vs. American usages of, 3:1170
meaning of, 3:1170
Native Americans and disputed space and, 3:1171
“The Significance of the Frontier in American History” essay (Turner), 3:1171
Fronts, 3:1172–1174
anafront, 3:1173
Bjerknes cyclone model and, 3:1173–1174
Chinook winds and, 3:1172
cold fronts, 3:1173
definition of, 3:1172
dryline and, 3:1172
frontal lift and, 3:1173
greatest temperature changes examples and, 3:1172
instant occlusions and, 3:1174
lift and, 3:1174
mesoscale convective system (MCS) and, 3:1173
“nor’easters” and, 3:1174
occluded fronts, 3:1173–1174
polar lows and, 3:1174
split fronts, 3:1172–1173
stationary fronts, 3:1174
thermal or moisture discontinuity of, 3:1172
warm fronts, 3:1173
zero-order fronts, 3:1172
FSM. See Federated States of Micronesia (FSM)
Fujita, Masahisa, 5:2395
Fullilove, Mindy, 4:2168
Furtado, Celso, 2:713
Gabon, 3:1190 (table)
Gaia theory, 3:1175–1178
atmospheric carbon dioxide climate regulation and, 3:1176
biogeochemical cycles and, 1:204
biogeochemical recycling and, 3:1176
current trends in, 3:1177
Dasyworld mathematical model and, 3:1176
debates, 3:1176–1177
deep ecology and, 2:693, 2:695, 3:1177
Earth as a single living organism theme of, 3:1175–1176
Earth systems science and, 3:1177
ecofeminism and, 3:1177
Gaia organic wholeness, Earth systems science and, 2:693, 2:695
Gaia word origins and, 3:1175
gephysiology, Earth system science and, 3:1175–1176
global temperature evidence of, 3:1175–1176
Goldilocks hypothesis of life on Earth and, 3:1175
humans as planetary disease issue and, 3:1176–1177
James Lovelock’s Gaia hypothesis origin of, 3:1175, 3:1177
Lynn Margulis’s work in, 3:1177
planetary self-regulation by biosphere and, 3:1176
spectrum of Gaian hypotheses and, 3:1177, 3:1177 (table)
theory of ecological succession and, 3:1175
Galapagos Islands
adaptive radiation and, 3:1106
archipelago formation of, 3:1105
Darwin and, 1:106, 4:107
ecotourism and, 2:870
finches evolution and, 1:14–15
mockingbird varieties of, 1:209
Gama, Vasco da, 3:1178–1179
Africa circumnavigated by, 2:1054, 3:1178–1179, 4:1461, 4:2179
spice trade route search of, 3:1178–1179
Gambia, 3:1190 (table)
Game ranching, 3:1179–1181
Jocubus de P. Bothma and, 3:1180
capital requirements of, 3:1180
for-profit type of, 3:1079
Game Ranch Management (Bothma) and, 3:1180
growth of, 3:1179–1180
Wouter van Hoven and, 3:1180
management and profitability of, 3:1180
mathematical modeling research used in, 3:1180
purposes of, 3:1079
scientific management of, 3:1180
South Africa and, 3:1179–1180
wildlife conservation by, 3:1079
Gannett, Henry, 5:2307
Garnier, Jacqueline Beaujeu, 5:2247
Gasset, Oretega y, 2:1046
Gast, John, 3:1223 (fig.)
Gated community, 3:1181–1183
amenities and infrastructures of, 3:1181
cultural, social, economic, and political development factors in, 3:1182–1183
definition of, 3:1181
forms and contexts variations of, 3:1183
impact debate, 3:1181–1182, 3:1182 (photo)
inequality geographies and, 3:1589
lifestyle communities category of, 3:1181
prestige communities category of, 3:1181
retirement communities and, 3:1181
safety element of, 3:1182
security zones category of, 3:1181
social segregation result of, 3:1181
in Sunbelt areas, 4:2002
tax reduction issue of, 3:1181
in urban environments, 3:1181, 3:1589
urban secession issue of, 3:1181
urban services availability in, 3:1182–1183
Gatrell, J, 3:1541
Gaustad, Edwin, 5:2407
Gays and lesbians, geography and/of, 3:1183–1185
feminist geography and, 3:1184
fractured and hybridized subjectivities and, 3:1184
gay spaces, impacts on urban landscapes and, 3:1183
geographies on sexualities and, 3:1184
Mapping Desire (Bell and Vallentine) and, 3:1184
post-Fordist and neoliberal perspectives on, 3:1184
postmodern and poststructural perspectives on, 3:1184
queer geography and, 3:1184
queer theory and, 3:1184
spatial concentration of San Francisco’s gay community and, 3:1183–1184
urban politics and, 3:1183
See also Gays and lesbians, geography and/of: noted scholars; Sexuality, geography and/of
Gays and lesbians, geography and/of: noted scholars
David Bell, 3:1184
Jacquelyn Beyer, 3:1183
Manuel Castells, 3:1183–1184
E. M. Ettore, 3:1183
Bill Ketteringham, 3:1183
Don Lee, 3:1183
Bob McNee, 3:1183
Karen Murphy, 3:1183
Gill Valentine, 3:1184
Barbara Weightman, 3:1183
Gazetteers, 3:1185–1186
content standards for, 3:1185
categories of, 3:1185, 3:1186
Geographic Names Information System (GNIS) digital gazetteer and, 3:1185
geospatial search functions of, 3:1185–1186
information retrieval role of, 3:1185
GDP/GNP. See Gross domestic product/gross national product (GDP/GNP)
Geddes, Patrick, 4:1700, 4:2126, 5:2372
Geertz, Clifford
culture defined by, 2:634
postmodern research methods and, 5:2266
Gehry, Frank, 5:2264
Geiger, Rudolf, 4:1665
Gender and environmental hazards, 3:1186–1188
conceptual level dimensions of, 3:1186
externally driven forces and, 3:1187
gender division of labor and household space and, 3:1187
gender relation changes and, 3:1187–1188
micro politics of household and community power and, 3:1187
social, political, economic, and cultural processes of, 3:1186
social norms and roles of behavior and responsibility and, 3:1186–1187
social production and reproduction roles and, 3:1187
socioeconomic status and age factors and, 3:1187
vulnerability concept and, 3:1186–1187
Gender and geography, 3:1188–1194
capitalism and patriarchy relationship issue and, 3:1189
Committee on the Status of Women in Geography, 3:1234
ethnographic methods and, 3:1193
European colonization, dominant power relations and, 3:1191
feminist criticism of political economy and, 3:1191
future trends in, 3:1193–1194
gender definition an, 3:1198
gendered bodies and, 3:1192
gendered transnational migration and, 3:1192
geography of differences and, 2:737–740
GIScience and, 3:1193
issues concerning, 3:1188
labor market participation and commuting patterns and, 3:1188
Marxist geography and, 3:1188–1189
masculine geographies and, 4:1865–1866
methodology and, 3:1192–1193
origins of, 3:1188
patriarchic geographies and, 4:2135–2136
postcolonial feminism and, 3:1191–1192
postmodern feminism and, 3:1191
poststructural approach to, 3:1191
power relation inequities and, 3:1188, 3:1193
quantitative vs. qualitative methods and, 3:1193
social construction of gender and, 3:1188
social difference and, 3:1189–1191
spatial and social processes and, 3:1193
spatial and social separation of home and waged work theme of, 3:1189
spatial dynamics, social processes, and power relations themes in, 3:1188, 3:1193
spatial patterns of women’s activities focus of, 3:1188
Theorizing Patriarchy (Walby) and, 3:1189
time-space geographies of urban women and, 3:1193
uneven power relations and oppressive patriarchal structures and, 3:1191
urban spatial patterns and, 3:1189
women as domestic servants and sex workers and, 3:1192
women of global South and, 3:1191
See also Feminist specific subject; Gender and geography: noted geographers
Gender and geography: noted geographers
Judith Butler, 3:1192
Jo Foord, 3:1189
Michel Foucault, 3:1192
J. K. Gibson-Graham, 3:1191, 5:2351
Nicky Gregson, 3:1189
Susan Hanson, 3:1189, 3:1400–1401, 3:1468
Mei Po Kwan, 3:1193
Nina Lauri, 3:1193
Doreen Massey, 2:852, 4:1866–1867
Sara McAfferty, 3:1193
Janice Monk, 3:1189
Richa Nagar, 3:1193
Geraldine Pratt, 3:1192
 Gillian Rose, 5:2484–2485
Melissa Wright, 3:1192
Gender and nature, 3:1194–1197
actor-network theory and, 3:1196
class and nature and, 4:423–425
denaturalizing gender, socializing nature and, 2:622–623
ecofeminism and, 2:817–820, 3:1195
environmental justice and, 1:425
feminist environmentalism and, 3:1090–1094
feminist political ecology and, 3:1195–1196
feminized landscape and, 3:1196
gender and environmental hazards, 3:1186–1188
gendered division of labor and, 3:1195
gender in social theory and, 3:1194
global South research focus and, 3:1195–1196
landscape and the masculine gaze and, 3:1196, 4:2043
Marxist theory and, 3:1196
Mr and Mrs Andrews painting (Gainsborough) and, 3:1196
nature vs. culture and, 3:1194
new ontological politics and, 3:1196–1197
production and reproduction spheres and, 3:1195
queer theory and, 3:1196
sex/gender distinction and, 3:1194
social construction of nature and, 3:1196
social ecofeminists and, 3:1195
social vs. biological category of gender and, 3:1194
visual methodologies and, 3:1196
See also Feminist specific subject
Genderen, Pohl, 3:1533
Genderen, Van, 3:1533
Genetically modified organisms (GMOs), 3:1197–1199
animals, 3:1197–1198
benefits of, 3:1197
biotechnology and ecological risk and, 1:278–279
definitions, 3:1197
environmental markets for, 4:2009
food crops and, 3:1198
food labels issue and, 3:1198
human insulin example of, 3:1197
hybridization and, 3:1503–1506
movement against, 3:1609–1610
natural processes vs., 3:1197
neo-Malthusianism and, 4:2016
Network of GMO Free Regions and, 3:1610
organic agriculture and, 4:2094–2095
plants, 3:1198
potential risks of, 3:1197, 3:1198
recombinant bovine growth hormone, milk issues and, 3:1198
terms related to, 3:1197
See also Agricultural biotechnology
Genocide, geographies of, 3:1199–1202
Armenian genocide (1915) and, 3:1201
belonging and identity and, 3:1201
contested postgenocide space and, 3:1202
Convention on the Prevention and Punishment of the Crime of Genocide (UN) and, 3:1199
creation of an imagined “other” and, 3:1201
critical geopolitical element of, 3:1200
destruction of place and erasure of space in, 3:1201–1202
exclusion and fear geographies and, 3:1201
Eyes on Darfur project (Amnesty International), 3:1200, 3:1200 (images)
as field of study, 3:1199
gender, space, and, 3:1202
genocide definition and, 3:1199
Genocide Prevention Mapping Initiative and, 3:1200
GIS and spatial analysis mapping technologies and, 3:1200–1201, 3:1200 (images)
human rights geographies and, 3:1480–1481
International Criminal Court (ICC) and, 3:1605–1608
Jewish Holocaust example of, 3:1199, 3:1202
Khmer Rouge, Cambodia example of, 3:1201–1202
knowledge of places and, 3:1199
mapping technologies and, 3:1200
memorialization and tourism issues and, 3:1202
nationalism, regionalism, sense of place and, 3:1201
Ovaherero, Namibia, genocidal event and, 3:1202
research issues in, 3:1199
sense of place definition and, 3:1201
studies of, 3:1199–1201
terms related to, 3:1199
territory, identity, and power issues of, 3:1199
as transformed space, 3:1201
U.S. Holocaust Memorial Museum and, 3:1200
Gentrification, 3:1203–1208
“back-to-the-city” movement of people and, 3:1204
behavioral perspective on, 3:1203
capital- and occupational-centered class concepts and, 3:1203–1204
as capital investment, 3:1204, 3:1205 (fig.), 3:1206 (table)
as class colonization and displacement, 3:1203–1204
countercultural hippy movement views and, 3:1207
“cultural new class” and, 3:1207
culture and, 3:1207
definitions, 3:1203
devalorization and revalorization processes and, 3:1204, 3:1205 (fig.)
female gentrifiers and, 3:1206
female paid employment and, 3:1206
filtering vs., 3:1112
frontiersmanship, cultural representation of, 3:1207
paced communities and, 3:1181–1183
gentrifiers as developers and, 3:1204
gentrifier types and, 3:1204, 3:1206 (fig.)
law in urban planning policy and, 4:1766
logical positivist spatial science perspective on, 3:1203
managerial and structuralist approaches to, 3:1203
marginal gentrifier and, 3:1204
neoliberalism approach to, 3:1207
new-built construction issue and, 3:1204
performance of reproductive labor issue and, 3:1206
positivist urban models and, 3:1203
postindustrial society and, 5:2263
production-side theory and, 3:1204
production-side vs. consumption-side perspectives on, 3:1203
property investment process and, 3:1204
range of agents involved in, 3:1204
regeneration and, 3:1207
rent-gap concept and, 3:1204, 3:1205 (fig.), 5:2430–2431
reproductive labor and gender in, 3:1206
Neil Smith’s work in, 3:1204, 3:1206 (fig.),
3:1206 (table), 5:2551
social difference and agents of, 3:1205–1206
suburban space aversion and, 3:1207
supergentrification urban centers and, 3:1204
term origins and, 3:1203
value of the term and, 3:1206

Geocoding, 3:1208–1209
applications of, 3:1208
components of, 3:1208
definition of, 3:1208
geodesy and, 3:1217–1219
Geographic Names Information System and, 3:1209
gelibraries and, 3:1234–1235
GEOOnet Names Server (GNS) and, 3:1209
methods of, 3:1208
network data model and, 4:2019
parcel databases and, 3:1208–1209
by place names, 3:1209
by postal code, 3:1209
reverse geocoding and, 3:1209
by street address, 3:1208–1209, 4:2019
U.S. Census TIGER data files and, 3:1208

Geocollaboration, 3:1209–1211
awareness issues and, 3:1210
computer-supported collaborative work (CSCW) and,
3:1209–1210, 3:1210 (fig.)
crisis management example and, 3:1210
definition of, 3:1209
GEOScience and, 3:1209
Google Maps example of, 3:1211, 4:2006
Hurricane Katrina and, 3:1211
mapping “mashups,” 3:1211, 4:178, 5:2305
multidisciplinary nature of, 3:1209
OpenStreetMap project and, 3:1211
organizational geocollaboration and, 3:1210–1211
research perspective of, 3:1210
social mediation research perspectives on, 3:1211
spatial data infrastructures (SDIs) and, 3:1210–1211
time-place matrix of, 3:1210, 3:1210 (fig.)

unique geographic issues in, 3:1210
volunteered geographic information (VGI) and, 3:1211
Web 2.0 technologies and, 3:1211

Geocomputation, 3:1211–1215
as both art and science, 3:1212
classification and clustering algorithms and, 3:1214
computational geometry and, 3:1212
data set size issue in, 3:1212, 3:1213
definition of, 3:1211
disambiguation issue and, 3:1213
Fourier mathematical analysis concept and, 3:1213
GeoComputation conference and, 3:1211, 3:1213
geosy and, 3:1217–1219
geostatistics and, 3:1261–1265
govisualization applications of, 3:1212, 3:1213–1214
GIS analytical operations and, 1:71–72
GIScience applications of, 3:1212
high-performance computing and, 3:1425–1426
linear data arrangement issue and, 3:1213
modeling geographic processes and, 3:1215
Morton ordering disk storage and, 3:1213
multidisciplinary applications of, 3:1215
multidisciplinary feature of, 3:1212
quadtree data structure and, 3:1213
remote sensing applications of, 3:1212
research issues in, 3:1212–1215
spatial analysis applications of, 3:1212
spatial autocorrelation and, 3:1214
spatial optimization methods and, 3:1215
U.S. decennial census and, 3:1214

Geodemographics, 3:1215–1217
academia research in, 3:1217
classification function of, 3:1216
criticisms and future research, 3:1217
data collection and, 3:1216
generalization criticism of, 3:1217
graphic unit of study component of, 3:1216
GIS technology advances and, 3:1216
mapping of classification schemes and, 3:1216
mobility issues of, 3:1217
niche marketing and, 3:1216
private applications of, 3:1216
public applications of, 3:1216–1217
statistical relevance and validity issues of, 3:1217
target group component of, 3:1216
Web-based geodemographics and, 3:1217
where a person lives and lifestyle choices links and, 3:1215

Geodesy, 3:1217–1219
gad and distance, triangulation methods used in, 3:1218
applications of, 3:1218
datums and, 2:685–686
Earth’s shape and size focus of, 3:1217
geocoding and, 3:1208–1209
gioid definition and, 3:1218
gravity and shape link issue in, 3:1218
hierarchical process, 3:1217–1218
International Terrestrial Reference Frame and, 3:1218
long- vs. short-wavelength components of, 3:1218
meanings of, 3:1217
science of map projections and, 3:1218–1219

Geographical ignorance, 3:1219–1220
“Bizarro” cartoon and, 3:1219 (image)
Geographic Literacy Study and, 3:1219
geography education and, 3:1232–1234
high school and university curriculums and, 3:1220
**Geographical imagination**, 3:1221–1225

British imperial outlook on, 3:1221–1222

Cold War fears and American changes in, 3:1223–1224

Denis Cosgrove’s work and, 2:589–590, 3:1221, 5:2432
definition of, 3:1221
domino theory and, 3:1224
“flattening” of the world belief and, 3:1224
globalization and, 3:1338

Derek Gregory’s work and, 3:1221, 3:1380–1381
how people see the world factors and, 3:1221
imagination, social and spatial impacts of, 3:1223
literature geographies and, 4:1785–1788
manifest destiny (U.S.), 3:1222–1223, 3:1223 (fig.)
Native American land loss and relocation and, 3:1223
neoliberalism and, 3:1224
“our” places and “other” places relationships and, 3:1221
social and spatial identity constructions and, 3:1221
telegraph technology and, 3:1221–1222

United States as “great melting pot,” 3:1223

**Geographically weighted regression (GWR)**, 3:1225–1232
applications of, 3:1229–1231, 5:2329
background, 3:1225–1226
bandwidth and scale elements of, 3:1227–1229, 3:1230 (fig.)
bias vs. variance of local parameter estimates and, 3:1229
“borrowing” data and, 3:1229
correlations between two variables search and, 3:1214
definition and explanation of, 3:1225
effective number of parameters (ENP) element in, 3:1229
ESRI’s ArcGIS 9.3 and, 3:1230
A. Stewart Fotheringham’s work in, 3:1169, 3:1226
functions of, 3:1225–1226
geospatial data sets and, 3:1214
geographical weighting function of, 3:1228 (figs.)
geostatistics and, 3:1261–1265
GWR module in R and, 3:1230
GWR 3.0 software and, 3:1230
independent parameter estimates element in, 3:1229
limitations of, 3:1226, 3:1230–1231
multivariate analysis methods and, 4:1961–1962
operationalization of, 3:1226–1227
regression analysis and, 3:1225
SAM ecological software and, 3:1230
social, health, and environmental data applications of, 3:1229–1230
spatial dependency issue and, 3:1226
spatial heterogeneity issue of, 3:1226
spatial weighting function of, 3:1227 (fig.), 3:1230 (fig.), 5:2329
Stata software and, 3:1230
statistical function of, 3:1225
Terraseer’s software and, 3:1230
time series vs. spatial data determined by, 3:1226

**Geographic information systems (GIS)**, 3:1232
applications of, 3:1232
cost-benefit analysis used in, 2:593
decision making support function of, 3:1232
definition of, 3:1232
distributed computing and, 2:774–776
elements of, 3:1232
GIS vs. GIScience and, 3:1285
Michael Goodchild’s work in, 3:1349–1350
landscape interpretation using, 4:1715
media mapping and, 4:1951–1953
medical geographies and, 4:1878
network analysis in, 4:2017–2018
Daniel Sui and, 3:139
surveillance and, 6:2734
users of, 3:1232
Web-based services and, 3:1232

See also Business models for geographic information systems (GIS); GIScience; GIS specific subject; Public participation GIS (PPGIS)

**Geography education**, 3:1232–1234
advanced placement (AP) courses and, 3:1233
Commission on College Geography (AAG) and, 3:1233
Committee on the Status of Women in Geography, 3:1234
in elementary and secondary education, 3:1233
Enhancing Departments and Graduate Education (EDGE) and, 3:1234
federally funded projects and, 3:1234
focus of, 3:1232–1233
geographical ignorance and, 3:1219–1220
Geography Faculty Development Alliance and, 3:1234
Geography for Life (Goals 2000) and, 3:1233
Goals 2000: Educate America Act (1994) and, 3:1233
Guidelines for Geographic Education (AAG and NCGE) and, 3:1233
knowledge geographies and, 4:1659–1663
National Assessment of Educational Progress and, 3:1233
National Center for Geographic Information and Analysis and, 4:1976–1977
National Geographic Society grants and, 3:1233, 4:1977–1978
national reform movement in, 3:1233
Phoenix Project and, 3:1234
in postsecondary education, 3:1233–1234
professional development programs and, 3:1233
research on higher education teaching and learning issues and, 3:1233
state geographic alliances network and, 3:1233
undergraduate, master’s and doctoral degrees in, 3:1234

See also Childhood spatial and environmental learning; Education, geographies of

**Geolibaries, 3:1234–1235**
definition of, 3:1234–1235
geographical information vs. dereference information and, 3:1235
Michael Goodchild and, 3:1234, 3:1235
holdings indexed by location feature of, 3:1235
research challenges of, 3:1235
Geologic Society of America (GSA), 3:1245

**Geologic timescale**, 3:1235–1238
carbon-15 dating method and, 3:1237
geochronology process used in, 3:1237
Earth’s age speculation and, 3:1237
Earth’s magnetic field reversals factor and, 3:1237
hierarchic intervals of, 3:1235, 3:1236 (table), 3:1237
International Commission of Stratigraphy and, 3:1237
law of superposition and, 3:1237
mass extinction events element of, 3:1235
Milankovitch cycles and, 3:1238
orbital tuning process and, 3:1238
paleomagnetism and cyclic stratigraphy interpolation methods and, 3:1237
plate tectonics and, 3:2195–2199
radioactive isotopes dating method and, 3:1237
sedimentary fossils basis of, 3:1235
sediment deposition cyclic patterns and climate change factor in, 3:1237–1238
separate and incompatible versions disputes and, 3:1237

See also Climate change; Geologic timescale; noted geologists
Geomorphology, 3:1238–1239
African “science of sand” variant of, 3:1238
Herbert Chatley's work in, 3:1238
Chinese “wind-and-water” variant of, 3:1238
definition of, 3:1238
East Asian variants of, 3:1238
*feng shui* and, 3:1238–1239
landform divination and, 3:1238–1239
landscape vs. compass *feng shui* schools and, 3:1238

Geometric correction, 3:1239–1240
definition of, 3:1239
image-to-map vs. image-to-image rectification and, 3:1239
intensity (or pixel value) interpolation element in, 3:1239–1240
internal vs. external errors and, 3:1239
methods and procedures in, 3:1239–1240
registration element of process, 3:1239
spatial interpolation element in, 3:1239–1240
systematic vs. nonsystematic sources of, 3:1239

Geometric measures, 3:1240–1241
centroid measures, 3:1240
challenges of, 3:1240
classification issue of, 3:1240
function of, 3:1240
geometric properties categories and, 3:1240
gometry and geography roots of, 3:1240
intensity measures, 3:1240
laws of addition and transitivity and, 3:1240
orientation measures, 3:1240
range measures, 3:1240
shape measures, 3:1240

Geomorphic cycle, 3:1241–1244
climatic geomorphology and, 3:1243
text and objectives of, 3:1241
criticisms regarding, 3:1243–1244
Darwin’s work and, 3:1241
William Morris Davis and, 3:1241–1242, 4:2180
definition of, 3:1241
denudation chronology component of, 3:1242
essential components of, 3:1241–1243
Grove Karl Gilbert’s work and, 3:1279, 4:2180–2181
Grade, concept of, 3:1243
landscape development cycle in, 3:1242
model of landscape development (Davis) and, 3:1241, 4:2180
penepian stage of, 3:1242
river development cycle in, 3:1242
sigmoidal slope profile issue in, 3:1242
slope development cycle in, 3:1242
variables in, 3:1242
youth, maturity, and old age stages of, 3:1242
*See also Geomorphology*

Geomorphology, 3:1244–1248
associations in field of, 3:1245
avalanches and, 1:175–179
barrier islands and, 1:183–185
as basic and applied science, 3:1244
Binghamton Geomorphology Symposium and, 3:1245
carbonation and, 1:325
carbon-14 dating technique and, 3:1245
climatic geomorphology and, 3:1245
coral reef geomorphology and, 2:584–586
cosmogenic isotope dating technique and, 3:1245
dating landforms techniques and, 3:1245–1246
definition of, 3:1244
driving forces in, 3:1245
dunes and, 2:800–803
Earth system science and, 3:1244
field and laboratory methods of, 3:1245
folding and, 3:1140–1142
fundamental concepts of, 3:1246–1248
future trends in, 3:1246–1248
gelogic timescale and, 3:1235–1238
global and local factors in landform development and, 3:1247
gully erosion and, 3:1392–1394
history of, 3:1245–1246
human-induced disturbances and, 3:1247
*To Interpret the Earth* (Schumm), 3:1247
journals of, 3:1245
karst topography and, 4:1649–1654
landform development through catastrophic forces and, 3:1245
landform interpretation factors and, 3:1247
mountain glaciers and, 3:1328–1333
multidisciplinary applications of, 3:1245
optically stimulated luminescence (OSL) dating technique and, 3:1245
physiography and, 3:1245
potassium dating technique and, 3:1245
probabilistic modeling approach to, 3:1245
quaternary geomorphology and, 3:1244
radioisotope dating technique and, 3:1245
reductionist approach to, 3:1244–1245
“relaxation time” after disturbances and, 3:1247
resisting framework concept in, 3:1245
rock weathering and, 5:2477–2484
uniformitarianism and, 3:1245, 4:2179–2180
*See also Geomorphic cycle; Geomorphology: noted individuals*

Geomorphology: noted individuals
Ernst Antevs, 1:81–82
Aristotle, 3:1245
William Buckland, 3:1245
Herbert Louis Büdel, 3:1246
Comte de Buffon, 3:1245
Richard Chorley, 1:403–404, 3:1246
William Morris Davis, 2:686–687, 3:1246, 4:2180
Nicolas Desmarest, 3:1245
Charles Dutton, 3:1245–1246
Grove Karl Gilbert, 3:1279
Herodotus, 3:1245
William Holmes, 3:1245
Roger L. B. Hooke, 3:1247
Robert Horton, 3:1246
James Hutton, 3:1245, 4:2179
Georges-Louis LeClerc, 3:1245
Luna Leopold, 3:1246
Charles Lyell, 3:1245, 4:2180
Walther Penck, 3:1246, 4:2145
Jean Baptiste Perraut, 3:1245
John Phillips, 3:1245
Jonathan Phillips, 3:1247
John Playfair, 3:1245
John Wesley Powell, 3:1245, 5:2276–2277
William Rubey, 3:1246
Horace-Bénédict de Saussure, 3:1245
Stanley Schumm, 3:1246, 3:1247
Adam Sedgwick, 3:1245
Geophagy, 3:1248–1249
“Cachexia Africana,” 3:1249
calabash chalk (Africa), 3:1248–1249
earth eating, 3:1248
famine and, 3:1248
health risks of, 3:1248
nutritional deficiency compensated by, 3:1248
pica and, 3:1248
religious rituals and, 3:1248
Geopolitics, 3:1249–1252
academic manifestations form of, 3:1252
African Union (AU) and, 1:25
biologized international relations and, 3:1464
Cold War and, 1:504–505, 3:1250–1252
Committee on the Present Danger (CPD) and, 3:1251
critical geopolitics and, 3:1251–1252, 5:2224
cultural geopolitics and, 3:1464
domino theory and, 2:786–787
Geographical Pivot of History (Mackinder) and, 3:1464
Geography and Politics in a Divided World (Cohen) ad, 3:1250–1251
geopolitical revival: the Kissinger factor, 3:1251
German prosperity after WWI (Haushofer) and, 3:1249–1250, 3:1464
global capitalism and, 3:1251
imperialism and, 3:1545–1548
land- and sea-based powers relationship and, 3:1249
media power and, 2:541, 3:1252
nations and, 3:1464, 4:1971–1974
NATO and, 4:2046–2048
Nazism, 3:1249
Organization of the Petroleum Exporting Countries (OPEC) and, 4:2097–2100
origins of, 3:1249–1251
peace literature and, 3:1251
political theoretical geographical template form of, 3:1252
popular geopolitics and, 2:541
social Darwinism and, 3:1464
Soviet Union collapse and, 3:1251
world-systems theory and, 3:1251
See also Communism and geography; Political geography
Geopolitics: noted individuals
Zbigniew Brzezinski, 3:1251
Saul Cohen, 3:1250
Simon Dalby, 3:1252
Andreas Dorphalen, 3:1250
Richard Hartshorne, 3:1250
Henry Kissinger, 3:1251
Rudolf Kjellen, 3:1249, 3:1464
Alfred Thayer Mahan, 4:1815–1816
Friedrich Ratzel, 3:1249, 3:1464, 5:2221–2222
Nicholas Spykman, 3:1250
Robert Strausz-Hupe, 3:1250
Gerard Toal, 3:1252
Father Edmund Walsh, 3:1250
Hans Weigert, 3:1250
George, Pierre, 2:617, 5:2247
Georgescu-Roegen, Nicholas, 2:896
Georgia (country)
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)
GUAM Organization for Democracy and Economic Development co-founded by, 2:538
HIV/AIDS in, 3:1438
human rights atrocities in, 3:1481
Georgia (state)
hurricane risk in, 3:1500
slash pine plantation, Georgia (U.S.), 6:2835 (photo)
Geosensor networks (GSNs), 3:1252–1255
applications of, 3:1254
as a distributed spatial database system (DBS), 3:1253
as an environmental microscope, 3:1253
 explanation of, 3:1252–1253
failure-prone nature of, 3:1253
geographical applications of, 3:1254
intelligent data collection and processing and, 3:1253
mobile deployment of, 3:1254
Open GIS Consortium and, 3:1254
research networks established with, 3:1254
for resource-constrained computing environments, 3:1253
reusable sensor platforms and, 3:1254
sensor nodes element of, 3:1252–1253
sensor webs and, 3:1254
spatiotemporal nature of data collection tasks and, 3:1253–1254
technology constraints of, 3:1253
wireless sensor network technology and, 3:1253
Geoslavery, 3:1255–1256
Alzheimer’s disease patients locator use of, 3:1256
child monitoring use of, 3:1256
code of practice for (U.K.), 3:1256
corporate use of, 3:1255–1256
criminal justice system offender management and, 3:1255 (photo)
definition of, 3:1255
panopticon and, 4:2116–2117
personal location devices and, 3:1255, 3:1255 (photo)
socially unacceptable uses of, 3:1256
Geospatial industry, 3:1256–1260
aerial photography and, 3:1257
CAD software tools and, 3:1258
commercial database spatial data and, 3:1258
Jack Dangermond and, 2:663–664
database capabilities within, 3:1258
data distribution modes in, 3:1258
data from functionality separation and, 3:1256–1257
data production sectors of, 3:1257–1258
data production technologies of, 3:1257
GIS software and, 3:1258
GPS technology and, 3:1257
Internet and mobile capabilities in, 3:1258–1259
Internet trends regarding, 3:1257–1258
local, state, federal agencies use of, 3:1257
national-scale transportation data and, 3:1257
Open GIS Consortium (OGC) and, 3:1259, 4:2085
personal digital assistants (PDAs) and, 3:1259
relational data model and, 3:1258
remote sensing technology and, 3:1257
shapefile vector data format and, 3:1258
shapefile vector data format and, 3:1257
See also
Geosensor networks (GSNs), 3:1252–1255
aerial photography and, 3:1257
CAD software tools and, 3:1258
commercial database spatial data and, 3:1258
Jack Dangermond and, 2:663–664
database capabilities within, 3:1258
data distribution modes in, 3:1258
data from functionality separation and, 3:1256–1257
data production sectors of, 3:1257–1258
data production technologies of, 3:1257
GIS software and, 3:1258
GPS technology and, 3:1257
Internet and mobile capabilities in, 3:1258–1259
Internet trends regarding, 3:1257–1258
local, state, federal agencies use of, 3:1257
national-scale transportation data and, 3:1257
Open GIS Consortium (OGC) and, 3:1259, 4:2085
personal digital assistants (PDAs) and, 3:1259
relational data model and, 3:1258
remote sensing technology and, 3:1257
shapefile vector data format and, 3:1258
software, 3:1258–1259
Web-based interactive maps and, 3:1257
Web-based spatial data clearinghouses and, 3:1258
See also Geospatial Semantic Web; Legal aspects of geospatial
information; Privacy and security of geospatial information;
Usability of geospatial information
Geospatial semantic web, 3:1260–1261
client-server architecture and, 1:426–428
definition of, 3:1260
ESRI and MapQuest and, 3:1260
geospatial semantics and, 3:1260
geospatial web and, 3:1260
Open Geospatial Consortium and, 3:1260, 4:2085
OWL (Ontology Web Language) and, 3:1260
RCCS (Regional Connection Calculus) and, 3:1260
RDF (Resource Description Framework) and, 3:1260
semantic web and, 3:1260–1261
spatialization of the Web and, 3:1260
Web scale application challenge of, 3:1260
See also Geospatial industry; Legal aspects of geospatial
information; Privacy and security of geospatial
information; Usability of geospatial information
Geostatistics, 3:1261–1265
applications of, 3:1261
Bayesian statistics in spatial analysis and, 1:187–188
bivariate dependence in, 3:1262
climatology and, 1:474
cokriging and, 3:1265
compete spatial law concept and, 3:1262
covariance function and, 3:1262
definition of, 3:1261
deterministic and probabilistic models of, 3:1261
indicator kriging algorithm and, 3:1265
isotropic vs. anisotropic variogram and, 3:1263
Daniel Krige’s work in, 3:1261–1265
lag and, 3:1262
Georges Matheron’s work in, 3:1261, 3:1263
mining industry origins of, 3:1261
multipoint probability distribution and, 3:1261
point pattern analysis and, 5:2201–2202
random field model of, 3:1262
semivariogram and semivariance and, 3:1262–1263
sequential simulation algorithms, 3:1265
spatial statistics and, 5:2665–2666
spatial variability focus of, 3:1261
stationarity and, 3:1262
strict vs. second-order, vs. intrinsic stationarity and, 3:1262
variable prediction goal of, 3:1261
variogram cloud and, 3:1263
variography and, 3:1262–1263
See also Geostatistics: kriging algorithms
Geostatistics: kriging algorithms
best linear unbiased predictor property and, 3:1263
kriging algorithms used in, 3:1263, 3:1264–1265
kriging limitations and, 3:1265
kriging variance and, 3:1263, 3:1264
kriging weights and, 3:1263–1264
kriging with an external drift technique and, 3:1264–1265
kriging with a trend model and, 3:1264
multi-Gaussian kriging and, 3:1265
normal-scores transformation and, 3:1265
ordinary kriging and, 3:1264
quantifying prediction uncertainty in, 3:1265
simple kriging and, 3:1263–1264
spatial autocorrelation (spatial dependence) and, 3:1263
uncertainty measures in, 3:1264
universal kriging and, 3:1264
Geothermal energy, 3:1265–1270
agricultural applications of, 3:1269
aquaculture applications of, 3:1270
definition of, 3:1265
direct use of geothermal heat and, 3:1269–1270
Earth’s generation of, 3:1266, 3:1266 (fig.)
geothermal field classification and, 3:1269
general history and, 3:1267
general potential, 3:1268–1269, 3:1269 (fig.)
geothermal system and, 3:1266–1267, 3:1266 (fig.)
greenhouse heating and, 3:1269
heat content of Earth’s crust estimation and, 3:1266
heat source, reservoir and fluid elements of, 3:1266, 3:1266 (fig.)
human recovery and use of, 3:1265, 3:1266,
3:1268–1269, 3:1269 (fig.)
installed capacity and energy production of, 3:1267 (fig.)
installed capacity forecast for electricity production,
2010, 3:1268 (fig.)
present use of, 3:1267–1268
radioactive elements decay and, 3:1266, 3:1270
as a renewable energy, 3:1270
space and district heating systems and, 3:1269
space cooling option and, 3:1269
water- vs. vapor-dominated geothermal systems and, 3:1269
See also Geothermal features
Geothermal features, 3:1270–1274
acidic surface water and, 3:1271–1272
definition of, 3:1270
fumarole, Spirit Lake, Kamania County, Washington, 3:1271 (photo)
fumaroles and, 3:1271–1272
geographical distribution of, 3:1273
geyser and, 3:1272–1273
Hawaiian volcanic islands and, 3:1273
high vs. low temperature geothermal areas and, 3:1270–1271
hot springs and, 3:1272
Iceland and, 3:1273
mud pots/mud pools/paint pots and, 3:1272
Pacific Ring of Fire and, 3:1273
radioactive elements decay and, 3:1266, 3:1270
rhylolites geysers and, 3:1272
siliceous sinters and, 3:1272
sinters deposits and, 3:1272
sources of, 3:1270
sulfurous gases (solfatara) and, 3:1271–1272
tectonic plates and, 3:1273
travertines deposits and, 3:1272
volcanoes and, 3:1273
water vapor to gas ratio and, 3:1271
Yellowstone geothermal area and, 3:1273
Yellowstone National Park and, 3:1273
See also Diastrophism
Geovisualization
cartograms and, 1:338–339
cartography and, 1:330
decision support for, 3:1213–1214
decomputation in, 3:1212
demographically weighted regression (GWR) and, 3:1214
demographic decision support and, 3:1214
interactive maps and, 3:1344
Alan MacEachren’s work and, 4:1811–1812
multivariate mapping application and, 4:1963–1966
Donna Peuquet’s work and, 4:2165
uncertainty in geographic data sets and, 3:1214

See also: Cartography; Dynamic and interactive displays; Map visualization; Three-dimensional data models

Gerlach, Arch C., 2:567

Germany

acid rain in, 1:7
agglomeration economies in, 1:32
AGILE membership of, 1:124 (table)
antiglobalization, anticolonialism in, 1:97
atlases and maps produced in, 1:356–357
automobile industry in, 1:169, 1:171
automobility in, 1:172
Baden-Württemberg high-tech region in, 3:1127, 5:2435
biodiesel production in, 1:203
biofuels produced in, 1:203
biotechnology industry in, 1:280

Central Places in Southern Germany (Christaller), 1:380
Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)
coal energy source in, 3:1582
colonial empire of, 1:509, 1:509 (fig.)
COMECON membership of, 2:593 (table)
competitive advantage areas in, 2:558
criminal justice system offender management in, 3:1255 (photo)
cultural nationalism in, 4:1980
das Volk national identity and, 4:1979
deposit refund systems in, 2:742
digital height model and, 2:753
ecological footprint and biocapacity of, 2:827 (table)
ecological modernization theory developed in, 2:836
economically active females in, 3:1190 (table)
ergy feed-in tariffs (FIT) in, 2:901
ergy policies in, 2:902
environmental certification standards in, 2:914
ethnic nationalism and, 4:1979

European Union (EU) membership of, 2:1035
federalism political model and, 2:1036
Frankfurt chemical spill, 1:383 (photo)
 GDP of, 3:1382, 3:1383 (fig.)
German Green Party (Die Grünen), 2:1032, 2:1033–1034
Germanocentrism of, 2:1030 (table)
green design and development in, 3:1371
gully erosion in, 3:1393
hate groups in, 3:1407
high-speed trains in, 5:2364
immigration laws of, 3:1545
industrialization in, 3:1583
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)

Kyoto Protocol of 1997 and, 1:463
military expenditures in, 4:1899 (table)
national geographical society in, 3:1462
nuclear power plant in Lower Saxony, 4:2051 (photo)
particulate matter pollution in, 1:151
population dynamics in, 2:807 (fig.)
regional governance in, 5:2392
“science” of geopolitics in, 3:1249–1250
wind power development in, 2:902

Gershenkron, Alexander, 1:1117

Getis, Arthur, 3:1274–1275
award and honors received by, 3:1274
economic activity patterns analysis work of, 3:1274
William Garrison and, 1:192; 3:1274
geographic education advanced by, 3:1274
publications of, 3:1274

quantitative revolution in geography and, 3:1274
service and leadership roles of, 3:1274
spatial analysis and spatial econometrics work of, 3:1274
spatial statistics work of, 3:1274

Ghettos, 3:1275–1277
capitalist social and economic organization and, 3:1276–1277
classing ideologies regarding, 3:1275–1277
definition controversy regarding, 3:1275
ethnic segregation and, 2:1024
human choice and, 3:1275–1276
liberal and radical perspectives on, 3:1275–1276
neoconservative perspective on, 3:1275
postindustrial economy realities and, 3:1276

Harold Rose and, 3:1275
South Bronx ghetto neighborhood, 3:1276 (photo)
subculture and 3:1275–1276

GHGs. See: Greenhouse gases (GHGs)

Ghose, Rina, 2:616

Gibbs, Lois, 4:1807–1808

Gibson, William, 2:646, 4:1969

Gibson-Graham, J. K., 3:1191, 5:2351

Giddens, Anthony, 3:1277–1279
agency and institutionalized practice and, 3:1278
British “third-way” politics of, 3:1277
Capitalism and Modern Social Theory written by, 3:1277
critical human geography and, 3:1277
distanciation of, 6:2840
duality of social structures and, 3:1278
European social geography and, 3:1277

Derek Gregory and, 3:1380
new regional geography debates and, 3:1277
relative space and, 5:2403
social praxis concept and, 3:1278
social theory and, 3:1277–1278
space as social creation and, 5:2297


Gilbert, Grove Karl, 3:1279–1280
gemorphology work of, 3:1245, 3:1275, 4:2180–2181
time-independent modeling and, 3:1275
U.S. Geological Survey service of, 3:1275

Gilbertson, D., 3:1103

gilder, George, 6:2998

Gilroy, Paul, 4:2070

Giordano, Mark, common pool resources work of, 1:526, 1:527 (fig.)

Giroux, Henry, 2:875

GIS. See Geographic information systems (GIS); GIS specific subject

GIS, environmental model integration and, 3:1280–1281
component-based modeling and, 3:1280
function of, 3:1280
interoperable modeling approach of, 3:1280
meta-information types and, 3:1280
primitive components identification issue and, 3:1280
semantic compatibility issue and, 3:1280
semantic interoperability feature of, 3:1280

See also GIS, specific subject

GIS, history of, 3:1281–1284
automated address matching (U.S. Census Bureau) and, 3:1282
conceptual landscape of, 3:1281

Design With Nature (McHarg) and, 3:1281
DIME (Dual Independent Map Encoding, U.S. Census Bureau) and, 3:1282
engineering contributions to, 3:1284
goedata translation and, 3:1281–1282
government organizations and, 3:1282
Harvard Laboratory for Computer Graphics and, 3:1282, 3:1304
interactive geographic analysis tool and, 3:1283
labor-intensive data digitization factor in, 3:1283
mainstream implementations of, 3:1283–1284
natural resource inventory systems development and, 3:1284
object-based image analysis (OBIA) and, 4:2057–2058
origins of GIS and, 3:1281
pioneering centers in GIS and, 3:1282–1283
raster-based GIS and, 3:1282–1283
remote sensing and, 3:1282–1283
space age technology and computerized information factors in, 3:1281
spatial data overlay mapping methods and, 3:1281
state agencies GIS developments and, 3:1284
technology prerequisites for, 3:1281–1282
virtual Earth geobrowsers and, 3:1284
See also Critical GIS; GIS, history of: noted individuals; GIS, specific subject

GIS, history of: noted individuals
Ray Boyle, 3:1283
Max Egenhofer, 2:876–877
Herman Hollerith, 3:1281
Ian McHarg, 3:1281
Roger Tomlinson, 3:1281, 6:2847

GISScience, 3:1284–1289
Association of Geographic Information Informational for Europe (AGILE) and, 3:1286
brief history of, 3:1285–1286
cellular automata and, 1:368–371
cellular automata and agent-based simulations issues in, 3:1212
client-server architecture and, 1:426–428
GIS with, 1:507
collaborative GIS with, 1:507
transformations in, 2:580
definition of, 3:1284–1285
digitizing and, 2:756–757
education in, 3:1287–1289
feminist geographies and, 3:1193
geocomputation in, 3:1212
GeoVISTA Center, Penn State and, 4:1811
GIScience & Technology Body of Knowledge and, 3:1288–1289
GIS vs. GIScience and, 3:1285
high-performance computing and, 3:1425–1426
Internet GIS and, 3:1620–11623
issues addressed by, 3:1285
map algebra and, 4:1824–1825
media mapping and, 4:1951–1953
mobile GIS and, 4:1918–1921
multidisciplinary foundation of, 3:1285
National Center for Geographic Information and Analysis (NCGIA) and, 3:1286
organizations related to, 3:1286
participatory GIScience and, 5:2305
peer-reviewed journals of, 3:1286
Project Varenius (NCGIA) and, 3:1286
research topics examples in, 3:1287, 3:1288 (table)
scale issues and, 3:1287
spatial data acquisition and integration research and, 3:1287
University Consortium for Geographic Information Science (UCGIS) and, 3:1286

GIScience: noted individuals
Gilberto Camara, 1:319
Nicholas Chrisman, 1:408
Jack Dangermond, 2:663–664
Max Egenhofer, 2:876–877
Peter Fisher, 3:1118–1119
Andrew Frank, 3:1169–1170
Michael Goodchild, 3:1285, 3:1349–1350
Piotr Jankowski, 4:2053–2056
Werner Kuhn, 4:1672–1673
Timothy Nyerges, 4:2053–2056
Daniel Sui, 1:319

GIS design, 3:1290–1293
application domains of, 3:1290
arc-node data model in, 3:1291
definition of process and, 3:1290
Enterprise GIS and, 2:911–913
field-based approach to model selection, 3:1291
gereational relational logical data model in, 3:1292
hardware and software components of, 3:1290
logical data model choices in, 3:1292
object-based approach to model selection, 3:1291
object oriented relational logical data model in, 3:1292
object relational logical data model in, 3:1292
people component of, 3:1290
as powerful research tool, 3:1290
procedure component of, 3:1290
raster data model in, 3:1291
spaghetti data model in, 3:1291
spatial data model selection in, 3:1291–1292
steps in, 3:1290–1292
system implementation in, 3:1292
system requirements component of, 3:1292
system scope definition in, 3:1290–1291
user needs analysis in, 3:1290
vector data model of, 3:1291
See also GIScience; GIS, specific subject

GIS implementation, 3:1293–1294
academic career of, 1:186
accessibility calculations and, 1:5
Advanced Spatial Analysis (Batty) and, 1:187
aerial imagery processed by, 1:21–22
AGILE and, 1:123–126
analytical operations in, 1:71–72
Luc Anselin and, 1:80–81
applied geography field of, 1:102
Marc Armstrong’s work in, 1:117
Michael Batty’s contributions to, 1:187
behavioral geography and, 1:189–190
business geography and, 1:305–306
CAD systems and, 1:318–319
components of, 3:1293
cost-benefit analysis of, 3:1294
econometrics foundation of, 1:80
Enterprise GIS and, 2:911–913
functional specifications development and, 3:1294
geocoding geographies and, 3:1200–1201
GIS analytical operations and, 1:71–72
GIS database design component of, 3:1293
implementation plan development and, 3:1293
Internet GIS and, 3:1620–11623
needs analysis and, 3:1293
Spatial Econometrics (Anselin) and, 1:80
strategic plan development and, 3:1293
system design component of, 3:1293
topographic modeling and, 1:318
user issues in, 3:1294
workflow element of, 3:1294
See also Analytical operations in GIS; Business models for geographic information systems (GIS); GIScience;
GIS specific subject
GIS in archaeology, 3:1294–1296
catchment areas modeling in, 3:1295
cultural resource management (CRM) application and, 3:1295
digital terrain model (DTM) and, 3:1295
evacuation recording and, 3:1296
landscape archaeology application and, 3:1295
movement modeling and, 3:1295
site territories and hierarchies modeling and, 3:1295
spatial relationships foundation of, 3:1294–1295
visibility modeling and, 3:1295–1296
GIS in disaster response, 3:1296–1298
community-focused information dissemination and, 3:1297
criticisms and further development, 3:1297
damage assessment and, 3:1296
decision-making support tool of, 3:1296
damage planning tool of, 3:1296
damage assessment tool of, 3:1296
examples of, 3:1296–1297
preparedness phase of, 3:1297
real-time 3D GIS and, 3:1297
reconstruction and preparedness tool of, 3:1296
reconstruction phase of, 3:1296
recovery and rebuilding phase of, 3:1296, 3:1297
remote sensing in disaster response and, 5:2424–2428
risk mitigation information and, 3:1296
scope assessment phase of, 3:1296
secondary effects assessment phase of, 3:1296
sharing information tool of, 3:1296
technology advances in, 3:1296
user interfaces and training limitations of, 3:1297
See also Remote sensing in disaster response
GIS in environmental management, 3:1298–1300
air and water pollution monitoring and, 3:1299
cartography applications and, 1:364
climatology geospatial techniques and, 1:473–474
daily activities applications of, 3:1298–1299
ecological risk analysis (ERA) and, 2:842–843
damage planning and, 3:1298
environmental decision making and, 3:1298, 3:1299
environmental planning and, 2:975
GIS tools and, 2:981
GIS in health research and health care, 3:1300–1302
cancer studies and, 1:336
cartographic visualization and, 3:1300
critical perspectives in, 3:1301–1302
daily activities applications of, 3:1300–1301
disease geographic information system and, 2:771
infectious disease tracking system and, 3:1300, 3:1301 (fig.)
map and model analysis and, 3:1300
map algebra, 3:1304
soil survey digitization (USDA) and, 3:1303, 3:1303 (photo)
space-time clustering, cancer rates and, 1:321
spatial patterns of health care inequities and, 3:1302
surveillance systems, emergency management and,
3:1300, 3:1301 (fig.)
urban pandemic quarantines and, 3:1300
GIS in land use management, 3:1302–1305
agriculture and landscape GIS applications and, 3:1298–1299
land ownership (cadastral) data and, 3:1303
Land Use and Land Cover (LULC) data sets and, 4:1732
land use (cadastral) data sets and, 4:1732
land use definition and, 3:1302
land use inventory and mapping, 3:1302–1303
land use suitability analysis and, 3:1303–1304
local zoning/land use data and, 4:1732
manual interpretation of aerial photography data
sets and, 4:1732
map algebra, 3:1304
Minnesota Land Management Information System and, 3:1302
National Land Cover Database (NLCD) data sets and, 4:1732
Natural Resources Conservation Service (NRCS) and, 3:1303
New York Land Use and Natural Resources Inventory System and, 3:1302
soil survey digitization (USDA) and, 3:1303, 3:1303 (photo)
terms related to, 3:1303
USGS nationwide inventory of land cover and land use and, 3:1302
Web-based GIS and, 3:1304
GIS in local government, 3:1305–1307
agriculture use of, 3:1306
asset management systems and, 3:1305–1306
computer-aided dispatch (CAD) systems and, 3:1306
department location and staff and, 3:1305
distributed vs. centralized environments and, 3:1305
emergency services and law enforcement and, 3:1306
environmental management and, 3:1306
GIS in public policy and, 3:1307–1311
Health and Human Services use of, 3:1306
jurisdiction size factor in, 3:1305
public facility and infrastructure management and, 3:1305–1306
public information and education and, 3:1306
spatial error and uncertainty issues and, 3:1305
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in public policy and, 3:1307–1311
infection tracking and, 3:1308
spatial error and uncertainty issues and, 3:1306
spatial relationships of biophysical factors application of, 3:1298
GIS in transportation, 3:1311–1312
GIS in utilities, 3:1315–1316
GIS in water management, 3:1316–1318

National Elevation Dataset and National Hydrography Dataset (USGS) and, 3:1317
new generation software and, 3:1318
tasks in, 3:1317
water management categories and, 3:1317
water rights conflict and, 3:1317
watershed and stream network delineation and, 3:1317

GIS software, 3:1318–1321
application examples and, 3:1318
ArcInfo Workstation and Network Analysis, 3:1282, 3:1312
ArcView, 3:1309, 3:1312, 3:1624
Caliper Corporation's TransCAD software, 4:1785
categories of, 3:1320–1321, 3:1321 (fig.)
concepts of, 3:1318–1319
data acquisition element of, 3:1319–1320
definition of, 3:1318
Environmental Systems Research Institute (ESRI) and, 1:340
free and open-source software and, 3:1321
Geographic Resources Analysis Support System (GRASS) and, 4:2085
image processing using, 3:1536, 3:1538
layers to simulate data management tasks and, 3:1319, 3:1319 (fig.)
manufacturers and projects in, 3:1321
MapObjects software, 4:1952
Open Source Geospatial Foundation and, 4:2088–2089
raster representation of a geographic phenomenon and, 3:1318–1319
tasks accomplished by, 3:1320 (fig.)
typical tasks accomplished with, 3:1319–1320
user interface example and, 3:1319 (fig.)
vectorization and, 6:3009–3010
vector representation of a geographic phenomenon and, 3:1319
water management software and, 3:1317
See also GIS software: noted individuals;
Open Source GIS (OGIS)

GIS software: noted individuals;
Gilberto Câmara, 1:319
Jack Dangermond, 2:663–664
Ronald Eastman, 2:815–816

GIS Web services, 3:1321–1323
access geographic data services and, 3:1322
categories of, 3:1321, 3:1322 (fig.)
challenges of, 3:1321
client-server architecture and, 4:426–428
combinational capability of, 3:1322
discovery services and, 3:1321–1322
distributed GIS and, 3:1321
Geography Markup Language (GML) and, 3:1321
Internet GIS and, 3:1620–1623
interoperability specifications and, 3:1321, 3:1322, 3:1623–1625
Kehole Markup Language (KML) and, 3:1321
OGC's Catalogue Services Specification and, 3:1322
Open Geospatial Consortium (OGC) and, 3:1321
orchestration services and, 3:1323
spatial data infrastructure (SDI) and, 3:1321
visualization services and, 3:1323
Web Feature Service (WFS) and Web Coverage Service (WCS) and, 3:1321
WebMap server, 3:1321
Web Processing Service (WPS) and, 3:1322
workflow languages and, 3:1323

GIS in urban planning, 3:1313–1315

aggregation maps and, 1:108–110
cellular automata models and, 3:1313
GIS in local government and, 3:1305–1307
GIS in transportation and, 3:1311–1312
MOLAND (Monitoring Land Cover/Use Dynamics) project in Nigeria and, 3:1313
new urbanism or non-traditional planning and, 3:1313
smart growth principles and, 3:1313, 5:2240
spatial layers and dimensions of cities and, 3:1313
urban fringe watershed of Chicago application of, 3:1313, 3:1314 (fig.)

GIS in water management, 3:1316–1318
digital elevation model (DEM) and, 3:1316–1317
elements in, 3:1316–1317
flood protection practices and, 3:1317
human water usage effectiveness and, 3:1316–1317
HYDR01K digital elevation model (USGS) and, 3:1317–1318
hydrologic analysis and modeling and, 3:1317–1318
monitoring of, 3:1299
Glaciers: continental, 3:1323–1328
ablation, mass loss and, 3:1323
accumulation line and equilibrium line and, 3:1323
Ernst Antevs’s work in, 1:81–82
basal sliding rates and, 3:1326, 3:1326 (fig.)
climate change and, 6:2772
definition of, 3:1325–1326
dry snow zone and, 3:1323
fjords and, 3:1121–1123
glacier word derivation and, 3:1323
glacial global isostatic adjustment process and, 3:1345
Greenland Ice Sheet, 3:1325 (fig.)
sea level affected by, 3:1334–1335
regulation process and, 3:1324
Poles, North and South and, 3:1326
landforms created by, 3:1325
ice streams and, 3:1326
ice shelf and, 3:1324
ice sheets and, 3:1323–1324, 3:1324 (fig.), 3:1325 (fig.)
climate change factor in, 3:1334
moraines and striations and, 3:1327
moulins and, 3:1356
outlet glaciers, 3:1325
past glaciation evidence and, 3:1327
planet’s temperature maintenance and, 3:1323
regulation process and, 3:1326, 3:1326 (fig.)
sea level affected by, 3:1327, 3:1344
sea-level fingerprint of ice melt concept and, 3:1344
sea-level temperature profile of, 3:1326–1327
tidewater glaciers, 3:1325
tidal glaciers, 3:1325
tree line and, 3:1327
West and East Antarctic Ice Sheets, 3:1324 (fig.)
Ernst Antevs’s work in, 3:1324, 3:1325
Sea level affected by, 3:1344
surging glaciers and, 3:1328–1329
water supply and, 3:1331–1332
World Glacier Monitoring Service and, 3:1333

See also Ice

Glacken, Clarence, 4:2167
Glacken, Peter, 6:2737
Glaeser, Edwin, 5:2395
Glass, Judith, 3:1203
Glass, Ruth, 5:2263
Gliessman, Stephen, 1:54

Global environmental change, 3:1334–1338
acid rain and, 3:1336–1337
Anthropocene, new geologic epoch and, 3:1334
atmospheric changes and, 3:1336–1337
biodiversity and, 3:1334, 3:1337
climate change factor in, 3:1334
deforestation and, 2:695–699
habitat fragmentation and, 3:1336
human impacts on Earth and, 3:1334–1335
institutions and local governance and, 3:1334
land cover and land use with, 3:1334–1335
ocean changes from, 3:1336
ozone depletion and, 1:400–401, 3:1336
pesticides and fertilizers and, 3:1334
rate of change increase and, 3:1334
soil degradation during, 3:1335
societal implications of, 3:1337
spatial, temporal, and sociopolitical locales of, 3:1334
urban heat island effect and, 3:1336
urbanization and, 3:1336
water resources and, 3:1335–1336
Younger Dryas Northern Hemisphere cooling (Pleistocene) and, 3:1336

Global Institute for Sustainable Forestry, 1:96

Globalization, 3:1338–1342
antisytemic movements and, 1:99–100
border flows factor and, 3:1339
borderlands’ societies interaction and, 1:292
citizenship and, 1:413–414
cross-border cooperation and, 2:630
definition of, 3:1338
deterritorialization and, 2:722–724, 3:1338, 3:1340–1341
economic modernization and, 2:832–834
economic geography and, 2:830
economic globalization, Euromarket and, 2:1031
globalized networks and, 3:1339–1340, 3:1341
historical context and implications of, 3:1341–1342
human identity and subjectivity and, 3:1341
human rights and, 3:1481
information and communications technologies (ICTs), economic geography and, 2:540
internationalization vs., 3:1340
nation-state borders and, 1:293–294
neoliberal global networks and, 3:1341
neoliberalism and, 2:850
Organisation for Economic Co-operation and Development (OECD) and, 4:2096–2097
popular culture, 5:2229–2230
quantitative transformations and, 3:1341–1342
reterritorialization and, 2:722–724
social status and power accessibility and, 3:1339
socioeconomic transformations of, information technology and, 1:365
sovereignty concept and, 3:1340
space and time compression and, 3:1339
steel industry and, 5:2691–2692
technological change geographies and, 6:2781–2781
transborder activities and, 3:1339
transnationalization and denationalization in, 3:1338, 3:1339–1340
transportation and communications technology and, 3:1339
urban underclass and, 6:2998
See also Antiglobalization; European Union (EU); Glocalization
Global positioning system (GPS), 3:1342–1344
accuracy levels of, 3:1343
atmospheric moisture measured by, 1:160
data production technology of, 3:1257
definition of, 3:1342
differential GPS and, 3:1257
differential GPS (DGPS) and, 3:1343–1344
Federal Aviation Administration Wide Area Augmentation System and, 3:1343
geoslavery and, 3:1255–1256
geospatial industry and, 3:1257
location-based services (LBSs) and, 4:1794–1796
media mapping and, 4:1951–1953
military applications of, 3:1257
Navigation Message bit stream and, 3:1343
origins of, 3:1342
Precise Positioning Service (PPS) of, 3:1343
real-time, code-phase DGPS and, 3:1343–1344
receiver coordinate location and, 3:1257
satellites’ orbits and, 3:1343
Selective Availability degradation feature of, 3:1257
shoreline changes detected by, 1:496
Standard Positioning Service (SPS) of, 3:1343
U.S. Department of Defence (DoD) and, 3:1342
Wide Area Augmentation System (WAAS) and, 3:1257
See also Coordinate systems
Global sea-level rise, 3:1344–1346
anthropogenic climate change and, 1:90, 1:92
anthropogenic factors in, 3:1345
coastal seal-level change measures and, 3:1344–1345
coastal zone and marine pollution and, 1:500–501
El Niño-Southern Oscillation (ENSO) and, 1:497
glacial ice melt and, 1:90, 1:92, 3:1327, 3:1344
global glacial isostatic adjustment process and, 3:1345
greenhouse gas emissions and, 3:1346
Intergovernmental panel on Climate Change (IPCC) predictions and, 3:1346, 5:2204
La Niña and, 1:497
linear trends in mean sea level, 1955–2003, 3:1345 (fig.)
Meltwater Pulse 1A, last deglaciation and, 3:1346
ocean-syphoning effect and, 3:1345
plate tectonics and, 1:494
Poles, North and South and, 5:2203–2209
satellite measurements of, 3:1344
spatial variability in patterns of, 3:1344
static sea-level change and, 3:1344
temporal fluctuations in, 3:1344
volcanic eruptions and, 3:1345
Global South
balance-of-payment crises and state indebtedness in, 4:1694
displaced persons and refugees from, 4:1895
ecofeminism and, 3:1195
feminist political ecology and, 3:1195–1196
income ratio relative to slum population, global
South countries, 5:2644 (fig.)
megacities, global cities grown and, 4:1891
multiple social identities, race and, 3:1189
neoliberalism and, 4:2010–2015
population living on less than $1 per day, 5:2275 (fig.)
postcolonial feminism and, 3:1191
Global warming. See Anthropogenic climate change;
Chlorofluorocarbons (CFCs); Greenhouse gases (GHG);
Stratospheric ozone depletion
Globes. See Cartography; Map projections; Virtual globes
Glocalization, 3:1346–1348
cultural geography and, 3:1347
definition of, 3:1346–1347
financial capital as productive capital and, 3:1347
globalization resistance and, 3:1348
local socioeconomic characteristics and trends and, 3:1347
McDonald’s restaurant in New Delhi example of, 3:1347
(nation-state regulation weakening and, 3:1348
neoliberalism and, 3:1347–1348
spatial hybridity vision and, 3:1347
supranational governance institutions and, 3:1347
GMOs. See Genetically modified organisms (GMOs)
Godwin, William, 4:1819, 4:2015
Goffman, Erving, 1:289
everyday life as staging of drama and, 2:1043
Presentation of Self in Everyday Life written by, 2:1043
Goldwater, Barry, 2:570
Golledge, Reginald, 3:1348–1349
anchor point theory of spatial cognition and, 1:189
behavioral geography and disability geography work of, 3:1349
blindness and geography work of, 3:1349
goodchild, michael, 3:1349–1350
academic career of, 3:1349
geolibrary development work of, 3:1234, 3:1235
GIS analytic operations work of, 3:1345
goodchild, michael, 3:1349
GIS tool functions of, 3:1339
research interests of, 3:1349
service work of, 3:1349
spatial competence” achievement and, 1:286
Good, I. J., 2:1059
Goodchild, Michael, 3:1349–1350
academic career of, 3:1351
American cartographic work of, 3:1350–1351, 3:1351, 5:2364
criticism of, 3:1351–1352
Goode’s Interrupted Homolosine projection and, 3:1351, 3:1351 (fig.), 6:3169
Goode’s World Atlas and, 3:1352
Richard Hartshorne influenced by, 3:1402
Mercator projection criticized by, 3:1351
service work of, 3:1351
Google Earth, 3:1352–1355
application programming interface (API) and, 5:2305
client-server architecture and, 1:426
DEM (digital elevation model) and, 3:1352, 3:1354 (fig.)
development of, 3:1352
environmental planning spatial analysis tools and, 2:981
functions of, 3:1352, 3:1353 (fig.)
GIS tool functions of, 3:1352, 3:1355
Google and, 3:1258
building certification systems flexibility and, 3:1368
costs associated with, 3:1368
criticism of, 3:1369
definitions, 3:1367
dimensions of, 3:1367
energy-efficient measures in, 3:1368 (photo)
global programs of, 3:1368–1369
green collar job movement and, 3:1369
high-performance buildings and, 3:1367
historic preservation and, 3:1435–1436
issues addressed by, 3:1367
Leadership in Energy and Environmental Design (LEED) and, 3:1367, 3:1368–1369
U.S. Green Building Council (USGBC) and, 3:1367
See also Greenbelts; Green design and development
Green design and development, 3:1369–1373
as appropriate technology, 3:1369–1370
autonomy and communality and, 3:1372
bionics, biomimicry, biomimetics and, 3:1372
deep green design and, 3:1372–1373
designers of, 3:1370
design for need movement and, 3:1370
design for the real world (Papanek) and, 3:1372
dweller control over house-building and, 3:1373
ecological modernist perspectives on, 3:1372
environmentally friendly products and, 3:1370–1371
environmental risk and impact dimensions of, 3:1370
government and corporate involvement in, 3:1372
greenbelts and, 3:1363–1367
green capitalism, 3:1370–1372
Intermediate Technology Development Group and, 3:1370
international green developments and, 3:1371
landscape architecture and, 4:1700
light green design and development and, 3:1369–1372
low-carbon design and eco-housing development in, 3:1371–1372
Our Common Future (Brundtland Report) and, 3:1370, 6:2274
self-reliance and communality emphasis of (Kropotkin and Owen) and, 3:1372
Small Is Beautiful (Schumacher) and, 3:1370
smart growth planning and, 3:1371, 3:1372, 5:2240
sustainable communities and, 3:1371
sustainable development and, 3:1370–1371, 3:1372–1373
techniques of, 3:1370–1371
technology advances element in, 3:1370
See also Green belts; Green building; Green design and development: noted individuals
Green design and development: noted individuals
Peter Kropotkin, 3:1372
Arthur Mol, 3:1369
Arne Naess, 3:1369
Robert Owen, 3:1372
Victor Papanek, 3:1372
David Pepper, 3:1372
Ernst Schumacher, 3:1370, 3:1372
Gert Spaargaren, 3:1369
Greene, William, 1:81
Greenhouse gases (GHGs), 3:1373–1380
acid rain, greenhouse gas trading and, 1:7
agricultural contributions to, 2:938, 2:939
alternative fuels and, 3:1375
ancient ice cores study and, 3:1374
anthropogenic climate change and, 1:84–85, 1:86 (fig.)
anthropogenic fossil fuel, energy factors and, 3:1374–1375
atmospheric moisture and, 1:148
atmospheric pollution and, 1:151–155, 1:152
built environment energy demand and, 3:1375–1376
carbon capture, storage, sequestration control strategies and, 3:1377
carbon cycle and, 1:325–329, 2:945
carbon footprint concept and, 2:570–571
carbon markets, carbon trading and, 1:331 (table)
chlorofluorocarbons and, 1:400–401, 2:984
climate change and, 1:461
climate policy and, 1:462–464
coal-generated electricity and, 3:1377–1378
corporate greenhouse, core countries and, 5:2220–2221
CO₂ sources and their control in, 3:1375–1377
developed vs. developing countries comparisons and, 3:1377
energy end-use efficiency control strategy and, 3:1375–1376
F-gases and, 3:1374
functions of, 3:1373
global scale of, 2:984
global sea-level rise and, 3:1346
greenhouse gas trading between nations, Kyoto Protocol and, 3:1374, 4:1857
hydrogen to supplant hydrocarbon fuels and, 3:1377
ice melt and, 3:1524
increase in, climate change adaptation and, 1:9, 1:11
industrial sector and, 3:1376
institutional framework, 3:1374
International Panel on Climate Change and, 3:1374
land use and cover change impact on, 4:1736
low-carbon energy supply control strategy and, 3:1376–1377
low-emission fossil fuel technologies and, 3:1377
manufacturing and, 2:945
mitigation options, 3:1375–1377
Montreal Protocol on Substances that Deplete the Ozone Layer and, 3:1374
naturally occurring vs. anthropogenic GHGs and, 3:1373
nuclear fission, 3:1377
oil fields and, 2:947
ozone-depleting substances and, 3:1374
permafrost degradation and, 4:2156
photochemical smog and, 4:2171–2173
radioactive forcing and climate sensitivity to, 3:1374–1375, 3:1375 (fig.)
regional trends in, 3:1379
tourism industry and, 2:954–955
urban geography of emissions and, 3:1377–1379
U.S. GHG emissions by type and source, 3:1376 (fig.)
water vapor, atmospheric energy transfer and, 1:141
See also Adaptation to climate change; Anthropogenic climate change; Carbon trading and carbon offsets; Climate policy
Greenland
Atlantic Multi-decadal Oscillation and, 1:165
climate change adaptation research in, 1:9
fjords in, 3:1121
glacial/interglacial cycles in, 1:457
Greenland Ice Sheet and, 3:1325 (fig.)
Ice Ages and, 1:457
ice cap of, 3:1336
ice streams in, 3:1326
Jakobshavn Isbrae glacier, west coast and, 5:2205
musk ox faunal relic in, 1:470
polar climate in, 1:449, 1:450
polar semidesert in, 1:249
Gregson, Nicky, 1:96, 3:1612
Green Revolution
agrochemical intensification controversy and, 1:35, 2:939
agrochemical pollution of, 1:52
“blue revolution” (aquaculture) and, and, 1:103–104
greater food availability from, 2:2341
herbicides and pesticides environmental impact and, and, 2:939
indigenous agriculture vs., 3:1555–1556
vast nutrient loading and, 2:939
small farmer agrobiodiversity affected by, 1:50
Gregory, Derek, 3:1380–1382
Colonial Present (written by), 3:1381
Geographical Imagination (written by), 3:1381–1382
geographical imagination work of, 3:1221
humanistic geography focus of, 3:1380
Orientalism views of, 3:1381, 4:1787, 4:2103
postcolonial work of, and, 3:1381
postmodernism and, 3:1380
research areas of, 3:1380
spatial diffusion work of, 3:1380
spatiality of U.S. human rights abuses and, 3:1381
structuring theory and, 5:2710
Western imaginative geographies and, 3:1381
Gregson, Nicky, 1:290, 3:1189
Grenada, Cold War and, 1:504, 1:505
Grey, Lewis, 4:2040, 4:2041
Griffin, Susan, 2:817
Gross domestic product/gross national product (GDP/GNP),
3:1382–1384
definitions, 3:1382
GDP per capita and, 3:1382, 3:1383 (fig.), 3:1384
limitations of, 3:1382, 3:1384
newly industrializing countries and, 4:2021–2024
spatial characteristic of, 3:1382
world’s GDP (2007) and, 3:1382, 3:1383 (fig.)
Grosvener, Gilbert, 3:1463, 4:1977
Grothius, Hugo, 2:4066, 5:2252
Ground reference data (GRD), 3:1384–1385
calibration and validation processes of, 3:1384
continuous data, 3:1384
error and uncertainty in, 3:1384
error propagation and, 2:1011–1012
forms of data and, 3:1384
functions of, 3:1384
geocoding and, 3:1208–1209
ground truth data and, 3:1384
in situ vs. drive-by mapping data collection and, 3:1384
remote sensing products and, 3:1384
thematic data, 3:1384
Groundwater, 3:1385–1390
active vs. deep groundwater and, 3:1386
agrochemical pollution of, 3:1387
anthropogenic pollution sources and, 3:1387–1388
aquifers and aquifer properties and, 3:1386–1386,
3:1387, 3:1389
artesian wells and, 3:1385
carbonation and, 1:325
caverns formation and, 1:366–368, 1:367 (photo)
chlorinated hydrocarbons (CHCs) and, 1:396–400
definition of, 3:1385
drawdown and cone of depression extraction effects of, 3:1385
extraction methods and, 3:1386
flow of, 3:1138
geographical distribution and importance of, 3:1385, 3:1386
groundwater-based agriculture and, 3:1387
groundwater hydrology and, 3:1385–1386
groundwater mining or fossil groundwater extraction and, 3:1387
human-environment interactions involving, 3:1389
human organization, management, and policy, 3:1388–1389
hydrology and, 3:1513–1518
karst topography and, 4:1649–1654
legal frameworks, 3:1389
mathematical modeling approaches to, 3:1386
mechanized pumps extraction method, 3:1386
ocean-aquifer interactions and, 3:1386
pathogenic microorganisms pollution of, 3:1387–1388
physical characteristics of, 3:1385–1386
pollution of, 3:1387–1388
pollution remediation and, 3:1388
qanats extraction method, 3:1386
rural electrification programs and, 3:1387
saline-freshwater interface and, 3:1386
salinity issue and, 3:1388
soil moisture and, 3:1385
sustainable aquifer management and, 3:1389
technology factors and, 3:1388
transboundary aquifers and, 3:1389
use of, 3:1386–1387
water logging condition of, 3:1388
water table and, 3:1385
See also Rivers; Water pollution
Growth machine, 3:1390–1391
American exceptionalism notion and, 3:1390
communities as instruments of profit and, 3:1390
conflicts, 3:1390
document of value-free development and, 3:1390
local business elites as primary actors in, 3:1390
pervasiveness of, 3:1390
urban planning as a “rational science” and, 3:1390
Growth poles, 3:1391–1392
definition of, 1390:1391
disadvantages of, 3:1391
regional development, 3:1391
regional growth pole theory (Perroux) and, 2:730, 3:1391
supporters of, 3:1391
trickle-down effects issue, 3:1391
unequal regional development and, 3:1391
See also Growth poles: noted scientists
Growth poles: noted scientists
Albert Hirschman, 3:1391
Gunnar Myrdal, 3:1391
François Perroux, 3:1391
Michael Porter, 3:1391
GSNs. See Geosensor networks (GSNs)
Guadeloupe, 1:512
Guam
coral reef, Mariana Islands, 2:582 (photo)
human-induced invasion of species in, 3:1474
Guantanamo Bay military prison, 1:25
Guatemala
Cold War and, 1:504
communal land ownership in, 2:552
Conference of Latin Americanist Geographers held in, 2:568
deforestation in, 2:696
economically active females in, 3:1190 (table)
human rights violations in, 3:1480
income ratio relative to slum population in, 2006, 5:2644 (fig.)
indigenous identities manipulation studies in, 3:1101
installed capacity for electricity production forecast, 2010,
3:1268 (fig.)
Internet links illegal in, 2:750
land inequalities in, 4:1693
marine aquaculture in, 4:1854 (fig.)
sediment erosion in, 3:1334
soil erosion in, 5:2385
trading blocs and, 3:1520
Guattari, Felix, 2:649, 2:722, 4:2070
Guinea
economically active females in, 3:1190 (table)
Negritude movement and, 2:1029
tropical rain forest of, 1:453
Guinea-Bissau, 1:402, 3:1190 (table)
Gulf of Mexico, dead zone in, 1:207, 1:486, 1:487 (photo), 1:488, 2:939
Gully erosion, 3:1392–1394
causes of and factors in, 3:1392–1393
definition of, 3:1392
ephemeral and permanent erosion and, 3:1392–1393
ephemeral gully erosion, Western Iowa, 5:2465 (photo)
on-site and off-site damages from, 3:1393
prevention and control of, 3:1393
soceoconomic problems resulting from, 3:1393
in southeast Spain, 3:1392 (photo), 3:1393 (photo)
velocity measurement of, 3:1393
Gunderson, Lance, 5:2439
Guyana
economically active females in, 3:1190 (table)
open-pit Elizabeth Gold Mine, Mahdia, 4:2087 (photo), 4:2088 (photo)
tropical rain forest of, 1:234
Guyot, Arnold, 3:1394
Louis Agassiz’s influence on, 3:1394
alpine glaciation research of, 3:1394
geography education reform views of, 3:1394
physical geography work of, 3:1394
Carl Ritter and, 3:1394
teleological views of, 3:1394
GWR. See Geographically weighted regression (GWR)
Habermas, Jürgen, 4:1754
communicative action, 2:548, 4:2043
public sphere work of, 2:541
Hack, John T., 3:1275
Hading, George, 1:132
Hadley cell, 3:1395–1397
Atlantic tropical cyclones and, 3:1397
Bermuda High and Pacific High elements of, 3:1397
components of, 3:1396 (fig.)
definition of, 3:1395
El Niño-Southern Oscillation (ENSO) and, 2:888, 3:1397
energy transfer element in, 3:1397
idealized global circulation and, 6:3105 (fig.)
Intertropical Convergence Zone (ITCZ) or equatorial low,
3:1395–1397, 6:2832
La Niña and, 4:1755
meridional overturning atmospheric circulation model of, 3:1395
Northeast and Southeast trade winds and, 3:1395, 3:1396 (fig.)
potential widening of, 3:1397
seasonal precipitation variations and, 3:1396
subtropical jet stream at poleward edge of, 3:1395
surface flow from poles to equator and, 3:1395, 3:1396 (fig.)
Haeckel, Ernst, 2:666, 5:2366
Hägerstrand, Törsten, 3:1397–1399
Anne Buttimer’s collaboration with, 3:1398
diffusion of innovations research of, 3:1397, 3:1398, 4:1799, 5:2329
GIS developments and, 3:1312
human geography contributions of, 3:1397–1399
individual behavior in space and time research of, 3:1397
Monte Carlo simulation technique of, 3:1397, 3:1399
population movements research of, 3:1397, 3:1398
projects of daily life and, 2:1044
quantitative methods in geography work of, 5:2327, 5:2329
service work of, 3:1398–1399
spatial diffusion work of, 3:1397, 3:1398, 3:1399, 4:1799
time-geography work of, 1:5, 1:288, 1:321, 2:1043, 2:1044, 3:1312,
Haggett, Peter, 3:1399–1400
academic career of, 3:1399
infectious diseases geographies focus of, 3:1399–1400
Locational Analysis in Human Geography written by, 3:1400
Network Analysis in Geography (Haggett and Chorley), 4:2017
publications of, 3:1400
quantitative methods and location analysis work of,
3:1399, 3:1400, 4:2017
urban and regional geography work of, 3:1399, 3:1466
Hahn, Carole, 1:479
Hahn, Eduard, 2:782
Haining, R. R. P., 2:1060
Haiti
economically active females in, 3:1190 (table)
French colony of, 1:512
HIV/AIDS in, 3:1348
humanitarian assistance, hurricane relief operations in, 3:1487 (photo)
2010 earthquake in, 2:813
undernourishment in, 3:1488
Hajer, Maarten, 2:836–837
Half Dome, Sierra Nevadas, 3:1354 (fig.)
Hall, James, 3:1409
Hall, Peter, 4:1987
Hall, Stuart, 3:1142, 3:1528
Halling, Crawford, 5:2437–2438
Halloway, S., 5:2345
Handicap International, 1:96
Hanson, Susan, 3:1400–1401
academic career of, 3:1400
critical human geography work of, 2:618
Gender, Work, and Space written by, 3:1401
genereated geographies work of, 3:1189, 3:1400, 3:1401, 3:1468
mixed-methods research of, 3:1401
“Oh Not Excluding Half the Human in Human Geography”
essay co-written by, 2:618
publications of, 3:1400–1401
service work of, 3:1400
urban labor markets and urban transportation work of,
3:1400, 3:1401
Haraway, Donna, 2:649, 3:1097, 3:1100
Harcourt, Wendy, 3:1101
Hardin, Garrett, 2:925
“lifeboat ethics” and, 4:1820
tragedy of the commons work of, 1:525–526, 1:529,
1:532, 1:533–535, 2:779
Harvey, Brian, 3:1401–1402
   academic career of, 3:1402
   books written by, 3:1402
   history of cartography focus of, 3:1401–1402, 3:1563

Maps and the Columbian Encounter published by, 3:1401–1402
Hartshorne, Richard, 3:1402–1404
   academic career of, 3:1402
   as Association of American Geographers president, 3:1402
   geopolitics of Nazism and, 3:1250
   Alfred Hettner and, 3:1402, 3:1423, 3:1465, 5:2387
   Immanuel Kant’s influence on, 3:1402, 3:1403, 4:1649
   location served as form of explanation views of, 1:405
   logical positivism and, 3:1403, 5:2388
   Midwest agricultural, urban, and economic landscapes focus of, 3:1402
   Nature of Geography written by, 2:849, 3:1403, 5:2387, 5:2433
   oceans views of, 4:2065
   Carl Ritter and, 5:2471
   Fred Schaeffer’s criticism of, 1:405, 3:1403, 3:1466, 4:1801, 5:2326, 5:2388, 5:2511
   spatial determinism and, 1:405, 3:1403
Harvest management. See Adaptive harvest management
Harvey, David, 3:1404–1406
   absolute space defined by, 5:2403
   academic career of, 3:1404
   accumulation by disposition, 4:2138
   Brian Berry conflict with, 1:193
   books written by, 3:1405–1406
   capitalist accumulation and crisis work of, 2:849, 3:1467, 4:2138, 5:2265
   cities as postmodern objects, 5:2268
   Condition of Postmodernity written by, 3:1405, 5:2265, 5:2268
   Explanation in Geography written by, 3:1404
   geographical explanation of capitalist crisis dynamics and, 2:609–610
   governmentality and conservation, 3:1360
   historical materialism work of, 3:1404, 3:1467, 4:1862, 5:2638
   human geography work of, 3:1404
   Henri Lefebvre and, 4:1769, 5:2297, 5:2403
   Limits to Capital written by, 2:609, 4:1862, 5:2350–2351
   mixed methods used by, 3:1404
   nature in capitalism context work of, 2:851
   neoliberalism criticized by, 4:2013
   population-resource theory views of, 4:1820
   positivism in geography views of, 3:1404
   postmodern geography work of, 3:1469, 5:2264, 5:2265, 5:2268
   power and cultural symbolism and, 1:106–107
   quantitative revolution role of, 3:1404
   radical geography and, 2:618
   relational space defined by, 5:2403
   relative space defined by, 5:2403
   RGS award of, 5:2487
   Neil Smith and, 5:2551
   social geography work of, 5:2567, 5:2574
   Social Justice and the City written by, 2:618, 3:1405, 3:1467, 4:1862, 5:2350, 5:2442, 5:2551, 5:2567
   social justice movement and, 3:1404–1405
   social reproduction work of, 3:1404
   space and place research of, 3:1404–1405, 3:1467, 4:1862, 5:2438, 5:2669
   spaces of representation and, 5:2602
   spatial fix, 3:1467, 4:1862, 5:2638–2640
   spatial variation work of, 3:1404
   time, space, and space-time themes of, 3:1404, 3:1467, 4:1788, 4:1862, 5:2297, 6:2844
   urban underclass explained by, 6:2998
   violent globalization and, 1:96–97
   Richard Walker and, 6:3043–3044
Harwood, R., 1:54
Hate, geographies of, 3:1406–1407
   “center-margin” identities and, 3:1406
   genocide geographies and, 3:1199–1202
   “inside” societal norms, boundaries and, 3:1406
   “marginalized” identities and, 3:1406
   neo-Confederate movement example of, 3:1407
   proliferation of, 3:1407
   Southern Poverty Law Center tracker of hate groups and, 3:1406–1407
   unequal power relations and, 3:1406
Hausrosher, Karl, 3:1407–1408
   geopolitical teaching and writing of, 3:1407–1408, 3:1464
   German prosperity after WWI views of, 3:1249–1250
   Germany expansionist views of, 3:1408, 5:2222
   Rudolf Hess and, 3:1408
   journal of geopolitics created by, 3:1249
   Nazism and, 3:1407–1408, 5:2222, 5:2366
   pan-region organization of world and, 3:1250, 5:2222
   Friedrich Ratzel and, 5:2366
   spatial relationships of countries focus of, 3:1250
Hawai’i ahupua’a watershed management system in, 3:1575
   atmospheric carbon dioxide levels measured in, 1:82, 1:83 (fig.)
   avian extinctions from, 3:1630
   Big Island hot spot volcano in, 4:1688
   Captain James Cook’s exploration of, 2:576
   Hawai’i fruit fly area wide pest management program and, 4:2160 (photo)
   high island geography of, 3:1634–1635
   Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)
   mass wasting processes on Hawaiian Islands and, 4:1689
   volcanic islands of, 3:1273
   Hawley, Amos H., 3:1458
   Hayami, Yujiro, 6:2737
   Hayden, D., 2:1075
Hayden, Ferdinand, 3:1408–1409
   explorations of, 3:1408–1409
   geologic reconnaissance skills of, 3:1409
   Missouri valley stratigraphy work of, 3:1409
Heavy metals as pollutants, 3:1415–1418
adverse health effects of, 3:1417
agrochemical pollution and, 1:51–53
anthropogenic sources of, 3:1415
in aquatic sediments, 3:1416–1417
aquatic sediment standards and, 3:1418
atmospheric deposition and, 3:1416
atmospheric emissions of lead and, 3:1415
beneficial effects of, 3:1417
bioaccumulation and, 3:1417
chemical spills, environment, and society and, 1:382–384
daily provisional tolerable intake values and, 3:1418
definition issues and, 3:1415
density, atomic weight, atomic number parameters of, 3:1415
environmental distribution of, 3:1415–1417
Industrial Revolution and, 3:1415
lead exposure, 3:1415, 3:1417, 3:1418
mercury exposure, 3:1415
Norilsk Nickel’s copper plant, Russia, and, 3:1416 (photo)
in organisms, 3:1417
plant health standards and, 3:1418
in plants, 3:1417
regulatory limits, 3:1417–1418
in soils, 3:1417
sources of, 3:1415
toxicity parameter of, 3:1415
toxic metals or trace metal, 3:1415
in water, 3:1416
water quality standards and, 3:1418
wet or dry deposition of, 3:1416
Heckscher, Eli, 2:557, 2:1065, 5:2395
Hegel, Georg Wilhelm Friedrich
development of rational consciousness doctrine of, 3:1433
historical circumstances and, 3:1433
phases of history, 3:1433
social evolution theory of, 2:729
time synonymous with change and, 3:1433
Hegemony, 3:1418–1420
collective forms of social and economic organization and, 4:2011
development theory and, 2:730
division of labor, division of knowledge views of, 2:781
free markets views of, 4:2011
Road to Serfdom written by, 4:2011
Hayford, Alison, 2:711
Hazardous waste
landfills and communities of color and, 2:960, 2:961 (photo)
laws and, 2:966
transboundary hazardous waste dumping and, 1:384
See also Chemical spills, environment, and society;
Landfills; Love Canal
Health and health care, geography of, 3:1409–1414
cancer geography and, 1:320–324
caregiving process and, 3:1414
cholera and, 1:401–403
foundational GIS applications and, 1:507 (fig.)
composition factors in, 3:1411
contextual factors in, 3:1411, 3:1411 (table)
definitions, 3:1409
degenerative diseases and, 3:1410
devolution policies and, 3:1414
disability geographies and, 2:757–759
economic development factors and, 3:1410
elementary geographies and, 2:877–878
environmental hazards issues and, 3:1412
environmental justice issues and, 3:1412
formal health care and, 3:1412–1414
GIS health care applications and, 3:1300–1302
global geographic health inequalities and, 3:1410, 3:1410 (fig.)
global scale of, 3:1413
health and medical climatology and, 1:473
Health Insurance Portability and Accountability Act (HIPAA)
and, 2:771–772
health policy changes and, 3:1413–1414
health transition model of, 3:1410
home and community settings of, 3:1414
humanly created conditions and, 3:1410
informal care and, 3:1414
land use and cover change impact on, 4:1736–1737
life expectancy by country (2008) and, 3:1410 (fig.)
location of health services factor in, 3:1412
mental health services, deinstitutionalization and, 3:1413–1414
national scale of, 3:1413
place role in, 3:1411–1412
primary vs. secondary vs. tertiary services and, 3:1412
privatization and, 3:1413–1414
public funded providers and, 3:1413
regional and local geographic health inequalities, 3:1411
rural area health services and, 3:1413
service need and geographical accessibility relationship and, 3:1413
territorial organization of health care and, 3:1412–1413
therapeutic landscapes and, 3:1412
“transformation to wellness,” landscape interactions and, 3:1412
uneven geographies of, 3:1409
unhealthy landscapes and, 3:1412
See also Blindness and geography; Carcinogens; Disease, geography of; Drugs, geography of; GIS in health research and health care; HIV/AIDS, geography of
Health and medical climatology, 1:473

Hayek, Friedrich
collective forms of social and economic organization and, 4:2011
development theory and, 2:730
division of labor, division of knowledge views of, 2:781
free markets views of, 4:2011
Road to Serfdom written by, 4:2011
Hayford, Alison, 2:618
Haynes, Kingsley, 5:2395–2396
Hays, J. D., 2:711
Hazardous waste
landfills and communities of color and, 2:960, 2:961 (photo)
laws and, 2:966
transboundary hazardous waste dumping and, 1:384
See also Chemical spills, environment, and society;
Landfills; Love Canal

INDEX 3271
Peter Taylor, 3:1419
Immanuel Wallerstein, 3:1419
Heidegger, Martin
appropriation for lived environmental ethic and, 5:2410
“being in the world,” 2:1046, 4:2042
existential phenomenology work of, 2:1046, 3:1467, 4:2166
Edward Relph and, 5:2410
Heilbroner, Robert, 4:1805
Heisenberg, Werner,
Heilbroner, Robert,
Hettner, Alfred,
Hess, Rudolf,
parallel computing as mainstream of,
grid computing and,
definition of,
spatial analysis use of,
metaheuristic methods,
advantages of,
function of,
locational factors, 3:1426
public policy strategies, 3:1426–1427
research and development use of, 3:1426
Silicon Valley, California, 3:1427 (photo)
small production footprints characteristic of, 3:1426
See also Electronics industry, geography of
Hill, Christopher, 5:2441
Hinchliffe, Steve, 4:1996
Hipparchus, 3:1428
cartography and astronomy work of, 3:1428
equatorial calculations of, 3:1428
gnomon used by, 3:1428
instrumentation used by, 3:1428
longitude and latitudes calculated by, 3:1428, 3:1460, 5:2300
precession of the equinoxes and, 2:1009–1010, 3:1428
solar year calculated by, 3:1428
stereographic projection developed by, 3:1428
Hispaniola Spanish colony, 1:512
Historical geography, 3:1428–1433
Capital’s Utopia (Mosher) and, 3:1431
consistencies within, 3:1429
cultural landscapes (Sauer, Berkeley School), 3:1429
cultural turn and, 3:1404, 3:1429
definition of, 3:1428
eyear historical geography, 3:1429
environmental determinism and, 3:1428–1429
eyetday life geographies (Meining) and, 3:1430
feminist geography and, 3:1430–1431
French Annales School of history and, 1:79–80
historical materialist geography and, 3:1430
humanism, historical materialism, and postmodernism and, 3:1430
journals of, 3:1432
Sea of the Land (Mitchell) and, 3:1430, 4:1913–1914
Marxist geography and, 3:1430
as a methodology (Clark), 3:1428
new critical historical geography issues and, 3:1428, 3:1429–1431
“new” cultural geography and, 3:1430
positivism and, 3:1429
postmodernism and, 3:1404
power relations issues and, 3:1430–1431
practice of, 3:1431
production of space issues and, 3:1430–1431
quantitative revolution and, 3:1429, 3:1432
regional geography (Clark) and, 3:1429
regional narratives and, 3:1429
relevance of, 3:1431–1432
Shaping of America (Meining) and, 3:1430, 4:1879–1880
social identity issues and, 3:1430–1431
social production of space and, 3:1431
spatial relations of the production of space and, 3:1430
theory of sequent occupancy (Whittlesey), 3:1429
timeline of 1890s–1920s, 3:1429
timeline of 1920s–1950s, 3:1429
timeline of 1950s–1970s, 3:1429
timeline of 1970s: new critical historical geography, 3:1429–1430
timeline of 1980s: new cultural geography, 3:1930–1931
See also Environmental history; Historical geography: noted geographers, historians, scholars
Historical geography: noted geographers, historians, scholars
Andrew Clark, 1:416–417, 3:1428, 3:1429
Henry Clifford Darby, 2:664–665
Mona Domosh, 3:1431
as gateway port, 5:2254
industrialization in, 3:1583, 4:2020
international financial center of, 1:299 (photo)
market economy free port of, 2:1067
textile exports from, 6:2816 (fig.)
urban metabolism of, 6:2964, 6:2964 (table)
U.S. industry moving to, 2:700
hooks, bell, 3:1095, 3:1439
Hopper, Edward, 5:3230
Hotelling, Harold, 5:2697
Horton, Robert, 3:504
Hous Renzhi, 3:1433–1444
academic career of, 3:1443
Cultural Revolution and, 3:1443
historical Beijing research of, 3:1443
Huang Ho River basis research of, 3:1443
modern study of geography in China and, 3:1443–1444
service work of, 3:1444
Housing and housing markets, 3:1444–1446
affordable housing issue and, 3:1446
American Housing Survey (AHS), 4:1998–1999
attributes and peculiarities of, 3:1444
built environment and, 1:298–299
commodity and investment features of, 3:1444
discrimination issue and, 3:1446
employment, demographics, and income factors in, 3:1446
ethnic segregation and, 2:1023
exurbs, 2:1074–1076
factors affecting, 3:1446
Federal Housing Administration and, 3:1446
filtering process and, 3:1110–1111
foreclosures and, 3:1445 (photo)
gated communities and, 3:1181–1183
gentrification and, 3:1203–1208
ghettos and, 3:1275–1277
homelessness and, 3:1440–1442
housing configuration, housing stock and, 3:1444–1446
housing definition and, 3:1444
housing market definition and, 3:1445–1446
housing market variables and, 3:1445–1446
Homer Hoyt’s work and, 3:1448–1450
law of supply and demand and, 3:1445
new urbanism and, 4:2024–2027
physical, family, and social functions of, 3:1444
problems in, 3:1446
production and consumption of, 3:1444
public housing and, 5:2303–2304
real estate geographies and, 5:2367–2369
seller and buyer interactions and, 3:1446
U.S. housing ownership, 1900–2000 and, 4:1965 (fig.)
Housing policy, 3:1447–1448
building codes, occupancy standards and, 3:1447
disadvantaged populations and, 3:1448
exclusionary zoning and, 3:1447
filtering process and, 3:1110–1111
goals of, 3:1447
health and safety basis of, 3:1447
land use restrictions basis of, 3:1447
mixed-income developments and, 3:1448
owning vs. renting and, 3:1447
physical goals of, 3:1447
“secondary markets” of mortgages and, 3:1448
social goals of, 3:1447–1448
sufficient credit supply factor in, 3:1447–1448
uneven development issue and, 3:1448
Howard, Ebenezer, 3:1363, 5:2372
Howard, Luke, 1:476
Hoyos, Carlos, 3:1495
Hoyt, Homer, 3:1448–1450
academic career of, 3:1449
books written by, 3:1449
Federal Housing Administration developed by, 3:1448, 3:1449
Homer Hoyt Institute and, 3:1448, 3:1449
map overlay procedures developed by, 3:1449, 3:1450
model of sectoral land use patterns work of, 3:1112
neighborhood change models of, 3:1449
One Hundred Years of Land Values in Chicago dissertation of, 3:1449
private sector and public service work of, 3:1449
real estate market analysis work of, 3:1448–1449
sector theory of urban land development of, 3:1448–1449
service work of, 3:1449
spatial pattern of urban land use and, 3:1449
suburban expansion work of, 3:1450
HPC. See High-performance computing (HPC)
Hu, Shunfu, 4:1952
Huber, Joseph, 2:836
Human dimensions of global environmental change, 3:1450–1455
adaptation research and, 3:1452
anticipatory responses and, 3:1452
contextual factors in, 3:1452
coping strategies and, 3:1452
cumulative local changes and, 3:1451
deforestation and, 2:695–699
drivers of, 3:1451
ecosystem or environmental services effects of, 3:1451–1452
environmental discourse and, 3:1454
equity and social justice issues and, 3:1453–1454
global-scale changes and, 3:1451
governance and, 3:1453
impacts of, 3:1451–1452
mitigation efforts and, 3:1453
multiple-stressor approaches to, 3:1452
neoliberal resource management and, 3:1453
physical processes and, 3:1451
policy measures and technological responses to, 3:1453
privatization and, 3:1453
resilience frameworks and, 3:1452
socioeconomic causes of, 3:1451
systemic-focused research examples and, 3:1451
topography changes and, 1:275–276
Billie Lee Turner, II and, 6:2891–2892
vulnerability research and, 3:1452
See also Environmental history
Human ecology, 3:1455–1460
adaptation focus of, 3:1455–1459
anthropology discipline, 3:1456
biological ecosystem analysis and, 3:1458
biology discipline, 3:1459
Chicago School and, 3:1458
coupled human and animal systems and, 2:597–598
cultural ecology and, 2:633
cultural landscapes and, 3:1458–1459
definition of, 3:1455
demography discipline, 3:1456
ecology definition and, 3:1455
environmental entitlements and, 2:921–925
emotional geography and, 3:1459
evolution and natural selection and, 3:1458
family and consumer sciences discipline, 3:1456
geography discipline, 3:1458–1459
holistic approach to, 3:1459
Human ecology (Hawley) and, 3:1458
interdisciplinary roots of, 3:1455–1456
interpretations of, 3:1456–1459, 3:1457 (table)
landscape ecology (Troll) and, 3:1458, 4:1714
mapping of social phenomena and, 3:1458
medical geographies and, 4:1877–1878
medicine discipline, 3:1456
gender and, 3:1456
goals of, 3:1455
quality of life issue and, 3:1455
regional landscapes and, 3:1458
sociology discipline, 3:1456
spatial analysis approach and, 3:1458
urban analysis discipline, 3:1458
See also Energy and human ecology; Human ecology: noted individuals

Human geography, history of:

European human geography, 3:1460–1467

anthropogeography and, 1:93
antipodes and, 1:98
cultural geography and chorology in, 3:1465–1466
Enlightenment and, 2:910–911
environmental determinism and, 2:916–918
European human geography in the 19th century and, 3:1462–1463
feminism and, 3:1468
French Annales School of history and, 1:79–80
geography as ontology vs. epistemology and, 3:1460
geopolitics and environmental determinism in, 3:1464–1465
humanistic geography and, 3:1467–1468
Institute of British Geographers (IBG) and, 3:1601–1603
location theory and, 4:1799
Marxist geographies and, 3:1466–1467
“more than human” geography and, 4:1993
North American geography, development of, 3:1463–1464
panopticism and, 4:2116
population geography and, 5:2246
positivism and the quantitative revolution in, 3:1466
postmodernism and poststructuralism in, 3:1468–1469

See also Cartography; Cartography, history of; Environmental history;

Historical geography, history of: specific timeline below

Human geography, history of: premodern geographies
Abu Al-Ra‘ihan al Biruni, 1:282–284, 3:1461
al-Idrisi, 1:56–67, 3:1461, 4:2179
Anaximander, 1:74–75, 3:1460
Arab Empire, 3:1461

Aristotle, 1:116–117, 3:1460
classical Greece, 3:1460
Eratosthenes, 2:1010–1011, 3:1460
exploration, 3:1461
feudal Europe, 3:1461
Herodotus, 1:324–1422, 3:1460
Hipparchus, 1:328, 3:1460
Ibn Batu, 3:1461
Ibn Khaldūn, 3:1461
Marco Polo, 2:1053, 3:1461
Ptolemy, 3:1460–1461, 5:2300, 5:2387
Roman empire, 3:1460–1461
Strabo, 3:1245, 3:1460
Thales, 3:1460

T-in-O maps, 3:141–142, 1:347, 1:349 (fig.), 3:1461, 6:2845 (fig.)

Human geography, history of: Renaissance and Enlightenment
Martin Behaim, 3:1461, 4:2179
break with theology and, 3:1461–1462
causal maps, atlases, 3:1461
cartography technology and, 3:1461
Christopher Columbus, 1:520–521, 3:1461, 4:2179
Captain James Cook, 2:575, 3:1461
Bartolomeu Dias, 3:1461
exploration and, 2:910–911, 3:1461
Vasco da Gama, 3:1461, 4:2179
Immanuel Kant, 1:343, 3:1462, 4:1647–1649
Ferdinand Magellan, 3:1461, 4:1813–1815, 4:2179
Gerardus Mercator, 3:1461
Varenius, 3:1461–1462, 4:2179, 5:2387

Human geography, history of: European human geography, 19th century, 5:2211, 3:1463
colonialism, 3:1463
industrialization, urbanization and, 3:1463
Peter Kropotkin, 3:1463
national geographical societies, 3:1463
panopticon and, 4:2116–2117
Élisée Reclus, 1:73, 2:617, 3:1463, 5:2211, 5:2371–2372

Human geography, history of: North American geography development
American Geographical Society and, 3:1463
Association of American Geographers, 3:1464
Harlan Barrows, 3:1463
Chicago School and, 3:1463–1464
civilization and American identity and, 3:1463
William Morris Davis, 3:1463, 3:1464, 4:2180
Richard Hartshorne, 3:1463, 5:2387–2388
Thomas Jefferson, 4:1642–1643
George Perkins Marsh, 4:1858–1859, 4:2180
Matthew Fontaine Maury, 4:1872–1873
Jedediah Morse, 3:1463, 4:1946
National Geographic Society and, 3:1463
Carl Sauer, 3:1463
university geographical programs and, 3:1463–1464
westward expansion, 3:1463
Gilbert White, 3:1463
Dewront Whittlesey, 3:1463

Human geography, history of: geopolitics and environmental determinism
biologized international relations (Ratzel), 3:1464
Isaiah Bowman, 1:295–296, 3:1464
classical geopolitics (Kjellen and Ratzel), 3:1464
environmental possibilism (Sauer and Vidal de la Blache), 3:1464–1465
globe as integrated political system, 3:1464
Alfred Thayer Hahan, 4:1815–1816
Karl Haushofer, 3:1407–1408, 3:1464
Ellsworth Huntington, 3:1464
Rudolf Kjellen, 3:1464
Jean Baptiste Lamarck, 3:1464
Sir Halford Mackinder, 3:1464, 4:1812–1813, 5:2222
nation-states as organic, biological organism (Ratzel), 3:1464
population geography and, 5:2226
Friedrich Ratzel, 3:1464
Carl Sauer, 3:1464
social Darwinism, 3:1464
Herbert Spencer, 3:1464
Paul Vidal de la Blache, 3:1464, 3:1465, 5:2387
World War II, 3:1465
Human geography, history of: cultural geography and chorology
Annales School, 3:1465
chorology, 3:1465
empiricist cultural geography, 3:1466
Lucien Febvre, 3:1465
Richard Hartshorne, 3:1465, 5:2387–2388
Alfred Hettner, 3:1422–1423, 3:1465, 5:2387
John Leighly, 3:1465
Carl Sauer, 3:1465
Paul Vidal de la Blache, 3:1465, 3:1476, 5:2387
Derwent Whittlesey, 3:1465
Human geography, history of: postmodernism and quantitative revolution
William Bunge, 3:1466, 3:1645, 5:2238, 5:2350
Richard Chorley, 3:1466
Michael Dacey, 3:1466
William Garrison, 3:1466
Peter Haggett, 3:1466, 4:2017
John Nystuen, 3:1466
logical positivism, Vienna Circle, 3:1466
spatial demographics and political districting (Morrill), 3:1466
University of Washington, 3:1466
Human geography, history of: Marxist geographies, 3:1467
centrality of class, 3:1466
economic determinism, 3:1467
David Harvey, 3:1404–1406, 3:1467, 4:1862, 5:2350
historical materialism (Harvey), 3:1467
power and politics of society, 3:1466
production process and labor, 3:1466
Neil Smith, 3:1466, 5:2551–2552
Social Justice and the City (Harvey), 3:1467, 4:1862, 5:2350
Michael Storper, 3:1467, 4:1863, 5:2695–2696
time and space studies (Harvey), 3:1467, 4:1862
Richard Walker, 3:1467
Human geography, history of: humanistic geography
body geographies, 3:1468
criticisms of, 3:1468
Martin Heidegger, 3:1467, 4:2166
Edmund Husserl, 3:1467, 3:1475, 4:2166
phenomenology and existentialism and, 3:1467
Edward Relph, 3:1467, 3:1476, 4:2167
sense of space and place, 3:1467–1468
textual meanings and, 3:1467
Yi-Fu Tuan, 3:1467, 3:176, 4:1786, 4:2167, 6:2890–2891
Human geography, history of: geography and feminism
gender differences in commuting, 3:1468
gendered resources allocation, 3:1468
gendered social reality and, 3:1468
grounded theory, 3:1468
Susan Hanson, 3:1468
Linda McDowell, 3:1468, 4:2136
participant observation, 3:1468
patriarchal inequality and, 3:1468
Gillian Rose, 3:1468
socially constructed gender roles, 3:1468
standpoint theory, 3:1468
Human geography, history of: postmodernism and poststructuralism
actor-network theory and, 3:1469
critics of, 3:1469
deconstruction, 3:1468
discourses role, 3:1468
Michel Foucault, 3:1468
David Harvey, 3:1469
knowledge and power, 3:1468
Bruno Latour, 3:1469
Diane Massey, 3:1469
metanarratives, 3:1469
role of language and ideology in social life and, 3:1468
Edward Soja, 3:1469, 5:2351, 5:2593
Human-induced invasion of species, 3:1470–1474
carnivore species introduction, 3:1473
definition of, 3:1470
ecosystems affected by, 3:1472
examples of Balearic lizard and midwife toad examples of, 3:1473
elements of brown tree snake, 3:1473–1474
elements of Great American Exchange and, 3:1361–1362
elements of rabbits in Australia, 3:1474
elements of water hyacinth, Mississippi Delta, 3:1471 (photo)
elements of weasel, 3:1473
exotic species and, 2:1048–1050
extinctions and, 2:1069–1072, 3:1337
future trends in, 3:1474
historically recent invasions and, 3:1473–1474
hybridization and genetic contamination and, 3:1472
intentional causes of, 3:1471
invasion and succession and, 3:1627
invasive capacity determination and, 3:1471
invasiveness of the species factor in, 3:1470
involuntary causes of, 3:1472
large engineering projects and, 3:1473
maritime traffic increase and, 3:1473
mutualisms elimination and, 3:1472
opportunistic predators and, 3:1473
parasites and pathogens and, 3:1472
past invasions on islands and, 3:1472–1473
as predators and competitors, 3:1472
prehistoric extinctions and, 3:1472
susceptibility and suitability of a territory factor and, 3:1470
transportation methods factor in, 3:1473
tropical scrub biome and, 1:245–246
Humanistic geography, 3:1474–1478
archanism and, 1:73–74
Bhopal, India, chemical disaster and, 1:194–195, 4:2158
body and mind interface and, 3:1477
brief history of, 3:1474–1475
construction of knowledge and, 3:1476
critical historical geography and, 3:1430
critics of, 3:1477
cultural geography and, 3:1477
cultural landscape geographies (Vidal de la Blache) and, 3:1476, 5:2387 as dimension of cultural geography, 2:637
ethics and geography and, 2:1013–1016
everyday life geographies and, 2:1042–1045, 3:1430
existentialist geographies and, 2:1046–1047, 3:1467
fieldwork in, 3:1103–1105
geographies of consumption and, 2:574–575
geographies of emotion and, 2:891–892
geo-identity and the body and, 3:1476–1477
ghetto and, 3:1275–1277
hermeneutics, study of meanings and, 3:1474
human connections to space focus of, 2:637
human geography fieldwork and, 3:1103–1005
humanism definition and, 2:637
humanistic GIScience and, 3:1474–1478
humanistic thought and, 3:1475–1477
identity formation and, 3:1476–1477
identity geographies and, 3:1527–1531
language and geographic analysis and, 4:1754
literature narratives of place and, 4:1786
Marxism vs., 3:1477
phenomenology and existentialism approaches of, 3:1474–1475, 4:2167
positivism and, 3:1476
qualitative research and, 3:1476
researcher inserted into research and, 3:1476
sense of space and place and, 3:1476–1477
Shaping of America (Meinig) and, 3:1430, 4:1879–1880
topophilia (love of space) concept (Tuan) and, 2:637, 3:1467, 3:1476, 4:2167
See also Critical human geography
Humanistic geography: noted individuals
Anne Buttimer, 3:1309, 3:1476, 4:1786, 4:2167
Derek Gregory, 3:1380
Martin Heidegger, 3:1475, 4:2166
Edmund Husserl, 3:1467, 3:1475, 4:2166
Soren Kierkegaard, 3:1474–1475
David Levy, 3:1476
David Lowenthal, 3:1476, 4:2167
Donald Meinig, 3:1430, 4:1879–1880
Gunnar Olson, 4:2077–2078
Douglas Pocock, 4:1786
Edward Relph, 3:1476, 4:2167, 5:2410–2411
Jean-Paul Sartre, 3:1475
Yi-Fu Tuan, 3:1476, 4:1786
Paul Vidal de la Blache, 3:1476, 5:2387

Humanistic GIScience, 3:1478–1479
alternative conceptualizations explored by, 3:1478
critical GIScience and, 3:1478
definition of, 3:1478
emotional mapping, 3:1479
examples of, 3:1478
feminist GIS and, 3:1478
goal of, 3:1478
human subjectivity in, 3:1478
Mei-Po Kwan’s work in, 3:1478, 4:1674
local ethnographies and, 3:1478
mapping and visualization technology and, 3:1478–1479
multimedia forms and, 3:1478
neogeography, Web-based “mash-ups” and, 3:1211, 3:1478, 3:1624, 5:2305
nonrepresentational theory and, 3:1479
ontological and epistemological implications of, 3:1479
performative theory of truth and, 3:1479

researcher in center of research and, 3:1479
social networking and, 3:1478
volunteered geographic information (VGI) and, 3:1478
Web 2.0 technology and, 3:1478
See also Critical GIS; GIS specific subject: Public participation GIS (PPGIS)

Human rights, geography and, 3:1480–1481
Giorgio Agamben’s work and, 1:26–27
antisystemic movements and, 1:99–100
cultural rights and, 3:1480
definition, 3:1480
globalization processes and, 3:1481
grassroots antiglobalization activities and, 1:96
Holocaust and, 3:1480
human rights documents and, 3:1480
Human Rights Watch and, 1:96
international organizations and, 3:1480
local context of, 3:1480–1481
locality, movement, and nature-society relations themes in, 3:1480
mass atrocities and, 3:1481
spatial scales of analysis of, 3:1480
Universal Declaration of Human Rights list and, 3:1480
U.S. countering terrorism, human rights violations and, 3:1481
U.S. human rights abuses, Guantanamo Bay, Cuba, and, 3:1381
See also Environmental rights
Human Rights Watch, 3:1480
Humboldt, Alexander von, 3:1482–1485
agnostic, holistic view of nature and, 3:1462
cosmic, evolution and, 2:666
Giorgio Agamben influenced by, 3:1422
Humboldt Current and, 2:887, 3:1462
“human rights” concept (Tuan) and, 2:637
inequality of fortunes, 5:2211
isolines, isotherms used by, 3:1462
lapse of time and, 3:1430
Latin America and Siberia travels of, 3:1462
landscape definition of, 4:1713
latitude diversity gradient observed by, 1:198, 3:1484
Map of the Kingdom of New Spain created by, 3:1483 (fig.), 3:1484
Matthew Fontaine Maury and, 4:1872
physical geography work of, 4:2180, 5:2447
as pioneer of modern geography, 3:1484, 4:2180
“Renaissance man” label of, 3:1482
scientific travels of, 3:1482, 3:1484
South American tribes studied by, 3:1462
“taking photographs pictures” and, 4:2175
Hume, David, 2:893, 4:1647, 4:1928
Humidity, 3:1485–1486
absolute humidity, 3:1485
adiabatic temperature changes and, 1:15–17
dew-point temperature, dew-point depression and, 3:1485
mixing ratio parameter of, 3:1485
relative humidity, 3:1485
slugging ratio measurement of, 3:1485
specific humidity, 3:1485
water vapor content and temperature factors in, 3:1485
See also Atmospheric moisture
Hungary
AGILE membership of, 1:124 (table)
Cold War and, 1:504
Hurricane Katrina, 3:1493–1496
costliness of, 3:1493
engineering failures in New Orleans during, 3:1494
environmental racism issues and, 2:987, 4:1985–1986
evacuation efforts and, 3:1493–1494, 4:1986
Federal Emergency Management Administration and, 3:1494
flooding from, 3:1135
future hurricane forecasting and, 3:1494–1495
GIS spatial decision support system, insurance companies and, 1:307
infrastructure failure during, 3:1594
institutional racism and, 2:987
lack of preparedness for, 3:1501
mapping mashup of, 3:1211
as midlatitude extreme weather, 1:437
New Orleans and, 3:1493–1494, 3:1495 (photo), 4:1986
“refugees” of, 5:2377
Saffir-Simpson Hurricane Damage Potential Scale and, 3:1493
scipionus.com Web site, 3:1211
storm history of, 3:1493–1494
storm surge, flash floods and, 3:1125, 3:1494
“total dissipation index,” potential destructiveness measure, 3:1494–1495
TRMM observation of, 1:160
Web mapping mashup, 5:2305

Hunten, Harry, 4:207
Hunten, Terry, 3:1473
Hunting and gathering, 3:1489–1492
agriculture emergence and, 3:1490
animistic religious beliefs and, 3:1490–1491
Australopithecus and Homo genuses and, 3:1490
birth and death rates and, 3:1491
domestication of animals and, 2:781–783, 3:1490
early trade networks and, 3:1490
egalitarian cultures and, 3:1490–1491
fire, needle and thread innovations and, 3:1490
gendered division of labor and, 3:1490
modern existence of, 3:1492
nation-state development and, 3:1491–1492
nomadism and, 4:2033
organized warfare and, 3:1490
paleolithic art and, 3:1491
pygmy subsistence hunter, Cameroon and Central African Republic, 3:1491 (photo)
seasonal rhythms of plants and animals and, 3:1490
stone and bone tools and, 3:1490
symbols and abstract though and, 3:1491

Huntington, Elsworth, 3:1492–1493
academic career of, 3:1492
American Eugenics Society and, 3:1492
dendrochronology, tree-right dating work of, 2:711
explorations of, 3:1492–1493
“geodeterminism” of, 3:1492
publications of, 3:1492–1493
role of climate in human demography and development and, 3:1492

Huntington, Ellsworth, 3:1492–1493
academic career of, 3:1492
American Eugenics Society and, 3:1492
dendrochronology, tree-right dating work of, 2:711
explorations of, 3:1492–1493
“geodeterminism” of, 3:1492
publications of, 3:1492–1493
role of climate in human demography and development and, 3:1492

Hunting and gathering, 3:1489–1492
agriculture emergence and, 3:1490
animistic religious beliefs and, 3:1490–1491
Australopithecus and Homo genuses and, 3:1490
birth and death rates and, 3:1491
domestication of animals and, 2:781–783, 3:1490
early trade networks and, 3:1490
egalitarian cultures and, 3:1490–1491
fire, needle and thread innovations and, 3:1490
gendered division of labor and, 3:1490
modern existence of, 3:1492
nation-state development and, 3:1491–1492
nomadism and, 4:2033
organized warfare and, 3:1490
paleolithic art and, 3:1491
pygmy subsistence hunter, Cameroon and Central African Republic, 3:1491 (photo)
seasonal rhythms of plants and animals and, 3:1490
stone and bone tools and, 3:1490
symbols and abstract though and, 3:1491

Hurricane Katrina, 3:1493–1496
costliness of, 3:1493
engineering failures in New Orleans during, 3:1494
environmental racism issues and, 2:987, 4:1985–1986
evacuation efforts and, 3:1493–1494, 4:1986
Federal Emergency Management Administration and, 3:1494
flooding from, 3:1135
future hurricane forecasting and, 3:1494–1495

Hurricanes, physical geography of, 3:1496–1499
atmospheric circulation explanation of, 1:134
coastal dead zones and, 1:486
Coriolis effect and, 1:134
damage from, 3:1498
extratropical cyclones and, 2:650–654
eye of a hurricane and, 3:1496, 3:1497, 3:1498
flooding from, 3:1498
global hurricane activity and, 3:1499
landfall of, 3:1498
large-scale wind streams and, 3:1497–1498
low air pressure over warm ocean waters and, 3:1496
in mild midlatitude climate, 1:437
modeling studies of, 3:1499
ocean water temperatures factor of, 3:1495, 3:1499
parabola-shaped track of, 3:1497–1498
pressure differences factor in, 3:1496
radius of maximum winds and, 3:1497
Saffir-Simpson Hurricane Damage Potential Scale and, 3:1493, 3:1496–1497
size variations of, 3:1497
slope of the continental shelf factor in, 3:1498
storm surge and, 3:1498
tracking of, 3:1499
watches and warnings for, 3:1499
winds from, 3:1496–1498
See also Hurricane Katrina; Hurricanes, physical geography of:
specific hurricane; Hurricanes, risk and hazard

Hurricanes, physical geography of: specific hurricane
Florida Keys Hurricane (1935), 3:1497
Galveston Hurricane (1900), 3:1500
Hurricane Andrew (1992), 3:1497
Hurricane Camille (1969), 3:1497, 3:1500
Hurricane Celia (1970), 3:1500
Hurricane Dennis (2005), 1:486, 3:1494
Hurricane Floyd (1999), 1:486
Hurricane Francis (2004), 3:1497 (photo)
Hurricane Georges (1998), 3:1494
Hurricane Ike (2008), 3:1501 (photo)
Hurricane Irene (2005), 1:486
Hurricane Ivan (2004), 3:1494
Hurricane Lili (2002), 3:1494
Hurricane Mitch (1998), 4:1986
Hurricane Rita (2005), 3:1493

Hurricanes, risk and hazard, 3:1499–1502
Atlantic hurricanes and, 1:165
coastal population growth and, 3:1500
damage from, 3:1498
economic losses from, 3:1500
Hybrid geographies, Husserl, Edmund, Hybridization of plant and animal species, Hydroelectric power, elements from multiple origins and, integration across disparate categories and, geography of differences and, genetically modified organisms (GMOs) and, cyborg ecologies and, See also warning systems and, “total dissipation index,” potential destructiveness measure of, 1:1494–1495

Charles Darwin and, Jonathan Murdoch, domestic dogs example of, biological species concept and, agro-ecosystem diversity and, Sarah Whatmore, Bruno Latour, actor-network theory (Latour) and, 1:8, 3:1503

critical landscape studies and, 3:1502
cyborg ecologies and, 2:648–650

definition of, 3:1502

elements from multiple origins and, 3:1502

genetically modified organisms (GMOs) and, 3:1197–1199, 3:1503–1504

geography of differences and, 2:740

“golden” rice and oranges examples of, 3:1503–1504

integration across disparate categories and, 3:1502

military conversions and, 3:1504

national wildlife refuges and, 3:1504

obliteration of prior categories and, 3:1502

radical philosophy and, 3:1503

relationships emphasis and, 3:1503

technology and land use and, 3:1503

U.S. National Wildlife Refuge System and, 3:1504

See also Hybrid geographies: noted individuals

Hybrid geographies: noted individuals


Jonathan Murdoch, 3:1503

Sarah Whatmore, 3:1503

Hybridization of plant and animal species, 3:1504–1506

agro-ecosystem diversity and, 3:1505

benefits of, 3:1505

biological species concept and, 3:1505
corn (maize) example of, 3:1505

Charles Darwin and, 3:1505

definition of, 3:1504
diversification barriers from, 3:1504–1505
domestic dogs example of, 3:1505

extinction from, 3:1505

genetic erosion from introgressive hybridization and, 3:1505

heterosis, or hybrid vigor from, 3:1505

interfamilial hybrids, 3:1505

intergeneric hybrids, 3:1505

interspecific hybrids, 3:1505

intrasectic hybrids, 3:1505

limitations of, 3:1506

offspring health and genetic limitations from, 3:1505

relictual speciation from, 3:1505

speciation result from, 3:1505

types of hybrids and, 3:1505

Hydroclimatology, 1:473

Hydroelectric power, 3:1506–1512

definition of, 3:1506
efficiency of, transmission distance factor and, 3:1507

expansion measures of, 3:1507, 3:1508 (figs.)

Michael Faraday’s invention of, 3:1506

future trends in, 3:1511, 3:1512
global inequities in, 3:1507–1511

hydroelectric systems planning and building and, 3:1507

hydropower dams and, 3:1507

industrial diffusion of, 3:1506–1507, 3:1509

installed generating capacity values since 1950 and, 3:1510, 3:1511

Itaipu-Binacional hydropower system, Brazil, and, 3:1510 (photo)
superconductivity technology and, 3:1507

Tennessee Valley Authority and, 3:1507

transmission system for, 3:1507

Thechuri-Tocantins Rivers hydroelectric dam, Brazil, and, 3:1509, 3:1509 (photo)
in the United States, 3:1507

See also Hydrological connectivity

Hydrological connectivity, 3:1512–1513

applications of, 3:1513
dam management issue and, 3:1517
definition of, 3:1512
disconnection types and, 3:1512
ecohydrology and, 3:1513

human intervention impact studies and, 3:1516–1517

hydro agent model of, 3:1513

indices of, 3:1512–1513

irrigation network management and, 3:1518

Lagrangian particle-tracking model and, 3:1513

landscape and storm characteristics and, 3:1512

Network Index and, 3:1512

nonpoint source pollution risk modeling and, 3:1513

ParFlow model and, 3:1513

Phosphorus Index (P-Index) and, 3:1513

semi-arid environmental conditions and, 3:1512

simulation models of, 3:1513

storm temporal characteristics and, 3:1512

strength of factors and, 3:1512

Sullivan County’s Interactive Mapping Application (SCI-MAP) and, 3:1513

temperate environment conditions and, 3:1512

temperature options and, 3:1512

water pollutants and, 3:1517

Hydrology, 3:1513–1518

above-ground throughfall and, 3:1515
capillary water of soil moisture and, 3:1515
catchment or drainage basin cycle and, 3:1515
catchment or drainage cycle and, 6:2771
definition of, 3:1513–1514

Earth’s rotation factor in, 3:1514

Earth’s total water calculation and, 3:1514

future water shortages and, 3:1517–1518
 Gus in water management and, 3:1316–1318

global water scarcity predictions and, 3:1516

gravitational force factor in, 3:1514

gravitational water of soil moisture and, 3:1515

hydrogen and oxygen biogeochemical cycle and, 1:205–206

hydrological accounting systems and, 3:1515

hydrological cycle and, 1:205–206

International Hydrological Decade (1960s) and, 3:1515

land use and cover change impact on, 4:1736, 4:1737 (photo)
multi-disciplinary elements of, 3:1514–1515

permafrost degradation and, 4:2156–2157

physical laws applied in, 3:1514

precipitation intensity and volume and, 3:1515
social aspects of water use and, 3:1515
solar energy factor in, 3:1514
surface hydrologic cycle and, 3:1514
rio tectonic water cycle and, 3:1514
underground water flows and, 3:1514
volcanic eruptions and, 3:1514
water balance equations and, 3:1515
water conflict between nation-states and, 3:1516
water law and, 3:1518
water scarcity index and, 3:1516
world hydrological accounting system and, 3:1515–1516
yearly fluxes of water through upper crust and, 3:1514
See also Groundwater; Rivers

Hyndman, Jennifer, 3:1104

Iberiocentrism, 2:1030 (table)
IBG. See Institute of British Geographers (IBG)
Ibn Battuta, 3:1519–1520
Ibn Khaldūn and, 3:1520
North African origins of, 3:1519
tavel hardships experienced by, 3:1519–1520
tavel literature written by, 3:1519–1520, 4:2179

Ibn Khaldūn, 3:1520–1522
al-Idrīsī’s Geography and, 3:1521
Arab historian, 3:1520–1521
autobiography of, 3:1520
as founder of multiple disciplines, 3:1521
Muqaddima written by, 3:1521
thesis of cyclical progress of, 3:1521
thesis of world history of, 3:1520–1521
tavel of, 3:1520–1521, 4:2179

ICC. See International Criminal Court (ICC)
ICCAs. See Indigenous and community conserved areas (ICCAs)
Ice, 3:1522–1526
abrupt climate change and, 3:1524
calyze change and, 1:455–461, 3:1522, 6:2772
continental glaciers and, 3:1323–1328
cryosphere, ice-based environment and, 3:1522, 3:1523 (fig.)
Earth-observing satellites and, 3:1524, 3:1524 (fig.), 3:1525 (fig.)
earth-environment change factor of, 3:1522
fossil fuel consumption and, 3:1525–1526
gene climate actions of, 3:1522
ice avalanches and, 1:176–177
Intergovernmental Panel on Climate Change and, 3:1525
modeling of, 3:1524–1526
mountain glaciers and, 3:1328–1333
Northwest Passage Opening and, 3:1522
polar climate and, 1:449–452
Poles, North and South and, 5:2203–2209
projected temperatures, 21st century, 3:1526 (fig.)
research programs, 3:1522
retreating of, 3:1522–1524

See also Periglacial environments; Permafrost

Iceland
cancer incidence and mortality in, 1:322 (fig.), 1:323 (fig.)
documented history of climate in, 1:456
gene thermal energy use in, 3:1267
“Geysir” geothermal geysers in, 3:1273
glaciers in, 3:1333
Ice Ages and, 1:457
individual transferable quotas (ITQs) in, 6:2756
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Kyoto Protocol of 1997, GHG emissions and, 1:463
marine aquaculture in, 4:1854 (fig.)
mid-Atlantic tectonic ridge system and, 5:2197
normal faults in, 3:1086
tundra vegetation in, 1:248 (table)
Viking exploration of, 2:1051
volcanoes in, 3:1273

Iceland, J., 5:2345
Idaho, 5:2469

Identity, geography and, 3:1527–1531
agency of decentered subjects and, 3:1529
binary oppositions and, 3:1529
Black Skin, White Masks (Fanon) and, 3:1528
boundaries, construction of, 3:1529
boundaries between “us” and “them” and, 3:1527
changing geographies and, 3:1530–1531
citizenship and, 1:412–414
cosmopolitanism and, 2:590–592
damental process, 3:1528
discourses focused on, 3:1528
ethnic segregation and, 2:1022–1026
etnocentrism and, 2:1027
external ascriptions of, 3:1527–1528
feminist geographies and, 3:1530
fluid and situational features of identities and space and, 3:1527
functions of, 3:1527
geo-historical imagination and, 3:1221–1225
gographies of emotion and, 2:891–892
graphy of differences and, 2:739
globalization, transnationalism and, 3:1527, 3:1530–1531
group identity and, 3:1528–1529, 3:1530
hybridity feature of, 3:1529–1530
identities and space relationships and, 3:1530
identity politics and, 3:1528–1529
“in between” hybridity and, 3:1530
labeling and categorization of, 3:1528
landscapes of humanistic geography and, 3:1530
multiple identifications and, 3:1527
nation concept and, 4:1971–1974
nation-state systems, national identity and, 3:1527
negotiation of new meanings and representations and, 3:1529–1530
Other/Otherness and, 4:2106–2107
performative feature of, 3:1529
postcolonialism and, 3:1528, 5:2261
poststructuralism, postmodernity and, 3:1528
social construction of, 3:1527
social group boundaries and, 3:1527
spatial phenomena and, 3:1527
televising and, 6:2791–2793
uneven power relations and, 3:1528
urban social geography studies and, 3:1530
within-group differences, power imbalances and, 3:1527

Idiographic, 3:1531–1532
chorology, areal differentiation and, 3:1531
definition of, 3:1531
Richard Hartshorne’s work and, 3:1531
Doreen Massey’s changing spatial division of labor work and, 3:1532, 4:1790–1791, 4:1866–1867
nomothetic vs., 4:2034–2035
regions in changing spatial division of labor and, 3:1532
Fred Schaefer’s critique of regional geography and, 3:1531–1532
uniqueness of places and, 3:1531–1532
IGU. See International Geographic Union (IGU)

Illinois, 5:2278. See also Chicago, Illinois

Image enhancement, 3:1532–1533
contrast enhancement, 3:1532–1533
evaluation of quality of, 3:1532
Fourier transform, 3:1533
functions of, 3:1532, 3:1533
remote sensing and, 3:1532
spatial filtering, 3:1533

See also Image specific subject

Image fusion, 3:1533–1534
color-related techniques of, 3:1533
combination of multisource images and, 3:1533
definition of, 3:1533
Pohl and Van Genderen’s work in, 3:1533
limitations of, 3:1534
methods of, 3:1533–1534
statistical/numerical methods of, 3:1533
terms related to, 3:1534

See also Image specific subject

Image interpretation, 3:1534–1536
color-coded approach to, 3:1535
conversion of similar pixels approach to, 3:1535–1536
explanation of, 3:1534
functions of, 3:1536
Ikonos sensors and, 3:1534
Landsat Thematic Mapper series and, 3:1534
limitations of, 3:1536
process of, 3:1534–1535, 3:1535 (fig.)
remote sensing image source and, 3:1536
visual approach to, 3:1534–1535

See also Image specific subject

Image processing, 3:1536–1538
classification and, 3:1537–1538
enhancement and, 3:1537
functions of, 3:1536
fuzzy classification and, 3:1537–1538
geometric correction and, 3:1536
geo-referencing and, 3:1536
GIS software and, 3:1536, 3:1538
hybrid image classification and, 3:1538
photogrammetric methods and, 4:2173–2175
preprocessing and, 3:1536–1537
radiometric correction process and, 3:1536–1537
raster format of digital imagery and, 3:1538
supervised classification and, 3:1537
unsupervised classification and, 3:1537
uses of, 3:1536
visual interpretability increase and, 3:1537

See also Image specific subject

Image registration, 3:1538–1540
area-based feature matching methods and, 3:1539
definition of, 3:1538
feature-based feature matching methods and, 3:1539
feature detection and extraction in, 3:1538–1539
geometric correction and, 12:1239–1240
image mosaic example and, 3:1538, 3:1539 (fig.)
image resampling and, 3:1540, 3:1540 (fig.)
image transformation and image resampling in, 3:1540
purposes of, 3:1538
steps in, 3:1538
transformation selection and, 3:1539

See also Image specific subject

Image texture, 3:1540–1541
definition of, 3:1540
first-order texture statistics and, 3:1540
gray level co-occurrence matrices (GLCM) and, 3:1541
image-processing algorithms and, 3:1541
parameters control and, 3:1541
second-order texture statistics and, 3:1541

Imaging spectroscopy, 3:1541–1542
dark lines in the solar spectrum and, 3:1542
definition of, 3:1541
imaging spectrometer in space and, 3:1542
LiDAR and airborne laser scanning and, 4:1778–1779
James Maxwell’s equations of electromagnetic waves and, 3:1542
microwave/RADAR data and, 4:1888–1890
multispectral imagery and, 4:1953–1956
Newton’s corpuscular theory and, 3:1542
photogrammetric methods and, 4:2173–2175
terms related to, 3:1541
Treatise of Light (Newton) and, 3:1542
uses of, 3:1541–1542
wave theory and, 3:1542

Imbrie, J., 2:711

IMF. See International Monetary Fund (IMF)

Immigration, 3:1542–1545
cancer studies of immigrants and, 1:335
citizenship and, 1:413
William Clark’s work, 1:417–418
definition of, 3:1542
diaspora and, 2:734–735
documented vs. undocumented s and, 3:1544
economic migrants and, 3:1545
Ellis Island, 3:1544 (photo)
emigrant, 3:1544
entry vs. exit visas and, 3:1544
environmental migrants and, 3:1545
free or volitional vs. forced immigration and, 3:1544
global slave trade and, 3:1544
guest workers and, 3:1544
naturalization and, 3:1545
political migrants and, 3:1545
political refugee vs. seeking political asylum and, 3:1545
push and pull factors of, 3:1544–1545
requisite conditions of, 3:1542
rights of citizenship and, 3:1545
skilled, semi-skilled, and unskilled laborers and, 3:1545
“sojourner” international migration and, 3:1545
transnational households and, 3:1545

See also Migration

Imperialism, 3:1545–1548
asymmetrical core-periphery relationship and, 3:1546, 3:1547, 5:2219
colonialism and, 3:1546
colony definition and, 3:1546
core regions concept and, 3:1546
cultural hegemony established by, 3:1547
definition of, 3:1545–1546
empires’ collapse and, 3:1547–1548
globally diffuse networks and, 3:1548
ideology of effects colonization of the mind and, 3:1547
ideology support and, 3:1546
new despatialized form of, 3:1548
people subsumed within boundaries of empire and, 3:1547
social hierarchies established by, 3:1547
“soft power” domination and, 3:1548
specifies of alien rule and, 3:1546
“unipolar preponderance” concept and, 3:1548
See also Colonialism

Impermeable surfaces, 3:1548–1549
anthropogenic impermeable surfaces, 3:1548–1549
flash floods and, 3:1549
lava flows, 3:1549
natural processes impermeable surfaces, 3:1548, 3:1549
salt in evaporating waters and, 3:1549
subsoil accumulations of iron and aluminum and, 3:1549
urbanization of watersheds and, 3:1549
water pollution caused by, 3:1549

Import substitution industrialization (ISI), 3:1549–1551
advantages of, 3:1551
in developing world, 3:1549–1551
export-led development and, 2:1063–1066
high tariffs on imported goods and, 3:1550
“infant industry” (List) concept and, 3:1550
infant industry model (IIM) of, 3:1550
Latin American Free Trade Association and, 3:1551
Latin American Integration Association and, 3:1551
Friedrich List’s work and, 3:1550
newly industrializing countries and, 4:2021–2024
practice of, 3:1550–1551
results of, 3:1551
Singer-Prebisch thesis and, 3:1550
state-funded infrastructure projects and, 3:1551
state interventions and, 3:1550
supporters of, 3:1550
theoretical roots and background of, 3:1550
trading blocs and, 3:1550–1551
United Nations Economic Commission for Latin America (ECLA) and, 3:1550
value-added industries and, 3:1550

Incubator zones, 3:1551–1553
benefits of, 3:1552
Ben Franklin Partnership Program and, 3:1552
business support services provided by, 3:1551
definition of, 3:1551
growth of, 3:1552
history of, 3:1551–1552
industrial districts and, 3:1576–1577
industrial sector varieties and, 3:1552
National Business Incubation Association and, 3:1551–1552
new products to market and, 3:1552–1553
role in economic development of, 3:1552–1553
services provided by, 3:1552
Small Business Administration and, 3:1552
U.S. incubator zones and, 3:1552

India
acid rain in, 1:7
agrobiodiversity in, 1:50
antiglobalization, anticolonialism in, 1:97
automobile industry in, 1:169
Bhopal chemical disaster in, 3:194–195, 4:2158
bovine domestication in, 2:783
British colonialism in, 1:516, 3:1222
British East India Company in, 1:514
British railroad technology and, 2:747
cadastral systems, land ownership and, 1:315
cattle grazing as common resource in, 1:526
China’s foreign direct investment in, 3:1155
chipko movement and, 1:394–395, 1:395 (fig.), 5:2563
cholera in, 1:401
Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)
climatic change action plans in, 2:902
clothing exports from, 6:2186 (fig.)
coal in, 1:485
coastal litter, Mumbai, 1:503 (photo)
CO₂ emissions in, 3:1377
colonial migrations of, 1500–1914, 3:1543
crop centers of domestication in, 1:374
Alexandra David-Néel exploration of, 2:1057–1058
deficient calorie consumption in, 3:1487
deposit refund systems in, 4:1857
drought in, 2:791
eco logical footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
El Niño-Southern Oscillation (ENSO) and, 2:887
effect on, 2:902
extreme weather events in, 5:2666 (fig.)
foreign aid from, 3:1153
foreign direct investment by, 1:130
foreign direct investment in, 4:2023
gendered land reform in, 4:1694
green building programs in, 3:1369
greenhouse gas emissions of, 1:462, 1:463, 1:464
Green Revolution, rice and wheat in, 3:1553–1556
groundwater usage in, 2:783
Gyps vultures extinction in, 2:1070, 2:1070 (photo)
HIV/AIDS in, 3:1438, 3:1439
human rights atrocities in, 3:1481
hydroelectric power in, 3:1510
Ibn Battuta exploration of, 2:1054, 3:1519
import substitution industrialization in, 3:1551
income ratio relative to slum population in, 2006, 5:2644 (fig.)
independence movement in, 2:692
Indo-centrism and, 2:1029
Indo-European languages and, 4:1749, 4:1750 (fig.)
industrialization in, 3:1580
informal sector of economic activity in, 3:1591
Infosys Technologies, Mysore, 3:1078
Internet access in, 2:845
joint forestry management in, 2:552
Khonoma Tragopan Sanctuary, Angami tribe of Nagaland, 3:1558, 3:1558 (photo)
Kyoto Protocol of 1997, greenhouse gas emissions and, 1:463
marine aquaculture in, 4:1853
McDonald’s restaurant in New Delhi and, 3:1347 (photo)
military expenditures in, 4:1899 (table)
military-industrial complex in, 4:1900
morphine-rich narcotics produced in, 2:796, 2:797 (table)
multinational corporations investment in, 5:2220
National Disaster Management in, 2:763
nationalism in, 1:517
Naxalite peasant movement and, 4:2141
as newly industrializing country, 4:2022 (fig.), 4:2023
next generation nuclear reactors in, 4:2051
NGOs and rural development research in, 3:1193
oil imports of, 4:2073
opium production in, 2:795
particulate matter pollution in, 1:151
per capita income inequality in West Bengal districts, 5:2643 (fig.)
pesticides use in, 1:52–53
Phoenicians exploration of, 2:1051
population growth in, 5:2241
railroads in, 5:2363
remittance flows to, 5:2412
remote sensing multitemporal imaging satellite of, 4:1959
rice paddies cultivation in, 1:48
Roman exploration of, 2:1051
search for new route to, 2:1054
Sepoy Rebellion, anticolonialism in, 1:94, 1:508, 1:514
shopping mall restructuring construction, 5:2459 (photo)
silver trade and, 1:512
social forestry in, 5:2363–2564
squatter settlements in, 5:2682
steel industry in, 5:2689, 5:2690, 5:2691
Subaltern Studies Collective and, 5:2260
as symbol of distance and mystery (Herodotus), 3:1422
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
total factor productivity (TFP) of, 6:2780 (table)
tropical deciduous forest in, 1:230
tropical humid climate in, 1:453
tropical monsoon climate in, 1:454–455
tropical rain forest of, 1:234
tropical savanna climate in, 1:455
tropical savanna in, 1:239, 1:240
tropical scrub in, 1:244
Tsunami of 2004, Indian Ocean and, 6:2888–2890
waste management in, 5:2372
water supply contamination and, 3:1387
water treatment technologies in, 3:1574
wind and solar energy in, 2:902
woodfuel for cooking, Maharashtra, 6:3123 (photo)
Yamunotri Temple, Indian Himalayas, 5:2407 (photo)
Indiana (Southern) flood, June 2008, 5:2426 (figs.), 5:2427 (fig.)
Indian Ocean
Antarctic Convergence zone and, 1:451
Arab exploration and trade and, 2:1053
atmospheric angular momentum in, 1:143
atmospheric energy variations and, 1:164
cyclones in, 1:134
Vasco de Gama exploration of, 2:1054, 3:1178 (fig.), 3:1461
major tectonic areas of, 5:2196 (fig.)
Tsunami of 2004 and, 6:2888–2890, 6:2889 (fig.)
See also Tsunami of 2004, Indian Ocean
Indigeneity, 3:1553–1555
definition of, 3:1553, 3:1554–1555
Deskaheh of Cayuga and, 3:1553
ethnocentrism and, 2:1027
European colonialism and, 3:1553, 3:1555
“Indigenous and Tribal Population Convention,” of
International Labour Organization, 3:1553–1554
indigenous forest dwellers and, 3:1164
indigenous peoples’ movement and, 3:1553–1554
indigenous ways of knowing, nature-society theory and, 4:1996
land loss and, 2:1021
noble savage concept, 2:1020–1021, 3:1362
origin of term and, 3:1553
paternalistic views toward, 2:1020–1021
political status of indigenous peoples and, 3:1553
self-determination and, 3:1534
self-identification as “first peoples” or “first nations” and, 3:154–1555
Six Nations of the Iroquois Confederacy and, 3:1553
strategic essentialism and, 3:1554
“strategic essentialism” and, 2:1021
UN policy and actions regarding, 3:1554
ways of knowing, ethical codes and, 3:1553
“white man’s burden,” 2:1021
See also Indigenous specific subject
Indigenous agriculture, 3:1555–1557
agrobiodiversity and, 1:50
agroecology and, 1:54
agroforestry and, 1:60–62, 3:1557, 5:2579
as alternative development basis, 3:1555
cultural ecology, agrarian populism and, 3:1556
dominant modernization paradigm vs., 3:1553–1556
extensive vs. intensive cultivation methods and, 3:1557
“farmer first” paradigm and, 3:1557
Green Revolution and, 3:1553–1556
indigenous irrigation and, 3:1557
indigenous knowledge focus of, 3:1555
learning from smallholder practice and, 3:1557
local control vs. origin and, 3:1555
new farming methods, Andranolava, Madagascar, 3:1555–1556
place-bound tradition and, 3:1555
rainwater harvesting and, 3:1557
raised field cultivation in wetlands and, 3:1557
shifting cultivation and, 5:2540–2543
swidden cultivation and, 3:1557
in West Africa, 3:1556–1557
See also Indigenous specific subject
Indigenous and community conserved areas (ICCAs), 3:1557–1561
characteristics of, 3:1559
Coron Island, coral island seascape, Tagbanwa people, the
Philippines, 3:1560 (photo)
definition of, 3:1557–1558
diversity of, 3:1559
future, 3:1561
geographies of, 3:1559
global climate change and, 3:1560
international conservation forums and, 3:1558–1559
International Convention on Biological Diversity
and, 3:1561, 3:1568
International Union for Conservation of Nature and, 3:1561
Khomna Tragopan Sanctuary, Angami tribe of Nagaland,
India, and, 3:1558, 3:1558 (photo)
points of view classification of, 3:1559
significance of, 3:1559–1561
strengths and weaknesses of, 3:1560–1561
threats to, 3:1561
world’s oldest protected areas and, 3:1558
See also Indigenous specific subject
Indigenous cartographies, 3:1561–1564
Bdote Memory Map of Dakota people, 3:1563
cartobibliographic record of, 3:1561–1562
characteristics of, 3:1562
Columbian Encounter conferences and, 3:1562
countermapping and, 2:595
definition of, 3:1561
diversity in, 3:1561–1562
Euro-American map deconstruction and, 3:1563
elements of, 3:1561–1562
GIS technology and, 3:1563
History of Cartography Project and, 3:1562–1563
Hudson’s Bay Company maps and, 3:1562
indigenous self-determination and, 3:1563
justice geographies and, 3:1645
Lewis and Clark expedition maps, 3:1562
New Spain maps and, 3:1562
nonindigenous perception difficulty and, 3:1562
Pepamateiati Nitassinat Web site and, 3:1563
performative structures of, 3:1563
processual approach to, 3:1562
strored place names and, 3:1563
technology and global media impact on, 3:1563
theoretical perspectives on, 3:1562–1563
See also Indigenous cartographies: noted individuals; Indigenous specific subject
Indigenous cartographies: noted individuals
Barbara Belyea, 3:1562
Jacques Derrida, 3:1562, 4:1754
Michel Foucault, 3:1562
Brian Harley, 3:1562
Robert Runderstrom, 3:1562, 3:1563
Indigenous environmental knowledge, 3:1564–1567
Fikret Berkes’s research on, 3:1564
Gregor Cajete’s research on, 3:1565
central paradox study of, 3:1564, 3:1566
characteristics and interpretation of, 3:1564–1565
circumpoles peoples research and, 3:1566
community-based conservation paradigm and, 3:1568
cultural values focus of, 3:1564
dichotomies of, 3:1568
“ecological imperialism” concept and, 3:1565
ethnocentrism of Western tradition and, 3:1564
European colonialism and, 3:1565
heritage paradigms es., 3:1564
historic studies of, 3:1564
holistic and inclusive environment approaches and, 3:1565
indigenous ways of knowing, nature-society theory and, 4:1996
indigenous writers and, 3:1566
mutual reciprocity theme in, 3:1565
native science (Cajete) and, 3:1565
in natural resource management, 3:1565
overgeneralization risk and, 3:1564
permaculture and, 4:2152–2153
relationships between living beings focus of, 3:1564
research on, 3:1566
resource management and, 3:1565–1566
Mere Roberts’ Maori research and, 3:1566
role of fire example and, 3:1565
romanticization danger and, 3:1565–1566, 3:1569
sacredness of the living world and, 3:1564–1565
situated knowledge and, 5:2548–2549
Sandie Suchet’s research on, 3:1565
sustainability issue and, 3:1565, 3:1568
terms related to, 3:1564
territory and place, indigenous identities and, 3:1564
UN Permanent Forum on Indigenous Issues and, 3:1564
See also Indigenous specific subject
Indigenous environmental practices, 3:1567–1568
Amazonian rubber tappers and, 2:1072–1073
behaviors, knowledge, beliefs and, 3:1567
community-based natural resource management and, 2:549–551
Convention on Biological Diversity and, 3:1561, 3:1568
definition of, 3:1567
diverse and local condition specific features of, 3:1567
“environmental” label implications and, 3:1568
European colonialism misconceptions and, 3:1568
examples of, 3:1567
extractive reserves and, 2:1072–1073
nomadic herding and, 4:2029–2032
nonindigenous construct of, 3:1567–1568
“practices” label implications and, 3:1568
sociocultural context of, 3:1567
stewardship of the environment and, 2:1020–1022
sustainable development issues and, 3:1568
transmission methods of, 3:1567
UN Conference on Environment and Development and, 3:1568
world’s fragile ecosystems protected by, 3:1568
Indigenous forestry, 3:1569–1570
agroforestry and, 1:60–62
Amazonian rubber tappers and, 2:1072–1073
benefits of, 3:1569
climate change and, 3:1570
community-based natural resource management and, 2:549–551
conventional or scientific forestry es., 3:1569
Declaration on the Rights of Indigenous Peoples and, 3:1569
definition of, 3:1569
exclusionary forestry policy and, 3:1570
geographic locations of, 3:1569
local culture, norms, and values and, 3:1569
modern democratic society values and, 3:1569
oppressive practices perpetuated by, 3:1569–1570
ownership rights of forests and, 3:1569
romanticization danger and, 3:1565–1566, 3:1569
state-dominated forestry failure and, 3:1569
subsidiarity principle, justification of, 3:1569
sustainability issue and, 3:1569
See also Indigenous specific subject
Indigenous reserves, 3:1570–1572
administration of, 3:1572
in Canada, 3:1570–1571
colonial processes and, 3:1570
cultural importance of, 3:1570
culture, traditions, and languages protected by, 3:1572
economic development limitations on, 3:1572
federal government programs and, 3:1572
First Nations’ and Native Americans’ land ownership and, 3:1570
General Allotment Act (1887, U.S.) and, 3:1572
bogan, Navajo Indian Reservation, Arizona, 3:1571 (photo)
Indian Act (Canada) and, 3:1570, 3:1572
Indian Removal Act (U.S.) and, 3:1571
reduction in size of, 3:1571–1572
reservations and, 3:1570
self-government agreements and, 3:1572
social conditions of, 3:1572
subjugative control over, 3:1572
taxation exemption of, 3:1572
tide to lands and, 3:1572
two forms of government on, 3:1572
U.S. Indian Reorganization Act (1934) and, 3:1570, 3:1572
See also Indigenous specific subject
Indigenous water management, 3:1573–1576
access and, 3:1573
bunds water collection method, 3:1575
culture and, 3:1573
definition of, 3:1573
foreign technologies mixed with, 3:1573, 3:1575 (photo)
gender factors in, 3:1573, 3:1574 (photo)
international watershed management and, 3:1618–1620
pits water collection, 3:1575
ritual factors in, 3:1573
runoff harvesting collection method, 3:1575
“sakau” drink, Pohnpei, Federated states of Micronesia,
ex ample of, 3:1573
scales of, 3:1573
sharing water and, 3:1573
social structures and, 3:1573
subsistence economies and, 3:1573
techniques for collecting and treating water in, 3:1573–1575
water as “common pool resource” and, 3:1573
water collection technologies and, 3:1574–1575
watershed delineation and management and, 3:1575
water treatment technologies and, 3:1574
See also Indigenous specific subject
Indochina
French colonies in, 1:509, 1:515
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
tropical deciduous forest in, 1:230
tropical rain forest of, 1:234
tropical savanna climate in, 1:455
Indonesia
APEC membership of, 1:121
ASEAN membership of, 1:127, 1:128, 1:128 (table), 1:129, 1:129 (table)
biodiesel produced in, 202
cholera in, 1:485
colonization of, 1:516
countermapping forests of, 2:595
deforestation in, 2:696, 5:2193
Dutch East Indies Company in, 1:515
economically active females in, 3:1190 (table)
El Niño-Southern Oscillation (ENSO) and, 2:887, 2:888
forest fragmentation in, 3:1159
Grasberg-Erstsberg copper mine in, 4:2086
Grasberg-Erstsberg open-pit mine in, 4:2087
HIV/AIDS in, 3:1438
income distribution, percentile of world income, 5:2641 (fig.)
independence of, 2:692
industrialization in, 3:1583, 4:2022, 4:2022 (fig.)
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Internet access in, 2:845
island species variations in, 1:209
Japanese electronics industry in, 2:885
“jungle rubber” smallholder plantations in, 5:2195
Malay archipelago and, 1:105
Malay-Polynesian languages in, 4:1753, 4:1753 (fig.)
marine aquaculture in, 4:1853, 4:1854 (fig.)
monsoons in, 1:134
tropical rain forest of, 1:234
Tsunami of 2004, Indian Ocean and, 6:2888–2890
tsunami of 2004 and, 4:1985
volcanic structures in, RADAR image, 4:1889 (fig.)
Industrial districts, 3:1576–1577
agglomeration economies and, 1:31–32
clusters and, 1:480–481, 1:480–482, 1:482
cooperation and competition within, 3:1576
creative industrial districts and, 2:851–852
definition controversy and, 3:1576
flexible production and, 3:1125–1127, 3:1576
innovation geographies and, 3:1597–1599
lead time minimization and, 3:1576
learning regions and, 4:1766–1768
Los Angeles School of urban economy and, 4:1803–1805
Alfred Marshall’s work and, 1:480–481, 1:482
network of relationships and knowledge sharing in, 3:1576
small- to medium-sized enterprises (SMEs) and, 3:1576
specialization within, 3:1576
structural changes in, 3:1576

Industrial ecology, 3:1577–1580
behavioral studies and, 3:1579
challenges faced by, 3:1579–1580
change in existing systems and, 3:1578–1579
chemical spills, environment, and society and, 1:382–384
closed-loop cycles fueled by solar energy and, 3:1578
“cradle to cradle” concept and, 3:1577, 3:1578
design for environment approach to, 3:1579
ecological analogy and, 3:1578
ecosystem processes and product life cycles and, 3:1578
energy balances and resource flow accounting and, 3:1578
environmental effects of industry and, 3:1577
environmental impact assessments and, 3:1578
environmental impacts of manufacturing and, 2:940–944
evaluation of existing systems and, 3:1578
future trends in, 3:1579–1580
integrated production network, Kalundborg, Denmark, example of, 3:1579
interdisciplinary research topics of, 3:1577
levels of analysis: tools and applications in, 3:1578
life cycle assessments (LCAs) of, 3:1578
mutualism strategies examples of, 3:1579
network of production and consumption and, 3:1577
policy development and, 3:1579–1580
practical applications of, 3:1579
small-vs. large-scale applications of, 3:1579
social context, 3:1579
socioeconomic environment factor in, 3:1577
sustainable use of resources goal of, 3:1577
systems modeling and, 3:1578
systems perspective on, 3:1577
unintended rebound effects and, 3:1577
See also Corporate voluntary environmental initiatives and self-regulation
Industrialization, 3:1580–1581
advanced manufacturing functions and, 3:1580
Communism and, 2:542
conditions and forces of, 3:1580–1581
core-periphery development unevenness and, 3:1581, 5:2219
definition of, 3:1580, 3:1581
environmental impacts of manufacturing and, 2:940–944
Fordism and, 1:1148–1151
government and industry links and, 3:1581
import substitution industrialization and, 3:1549–1551
Industrial Revolutions and, 3:1580, 3:1581–1586
initial stages of, 3:1580
Manufacturing Belt and, 4:1820–1824
spatial unevenness of, 3:1581
trade policies and, 3:1581
Industrialized agriculture. See Agriculture, industrialized;
Agriculture, preindustrial
Industrial Revolution, 3:1581–1586
agricultural industrialization and, 3:1582
assembly line and, 3:1582
business cycles and, 1:303
capitalism and, 3:1581, 3:1583, 3:1586
child labor and, 3:1584, 3:1585 (photo)
class conflict during, 3:1585
coa as energy source and, 3:1582
colonialism and, 1:509
complex process elements of, 3:1581
consequences of, 3:1584–1586
cycles of industrialization and, 3:1583–1584
division of labor and, 3:1582
electronics industry wave of, 3:1584
Environmental impacts of, 2:928, 2:941
Factory system and, 3:1582
Fordist systems of mass production and, 3:1582, 3:1584
Geography of, 3:1583
Global economy and, 3:1586
Heavy industry wave of, 3:1584
Inanimate energy dimension of, 3:1581–1582
Industrialization definition and, 3:1581
Interchangeable parts and, 3:1582
International finance and, 3:1586
Labor unions and, 3:1585
Malthusian population principle of famine and, 3:1586, 4:1819–1820
Manufacturing Belt and, 4:1820–1824
Middle class growth and, 3:1582
Modern working class and, 3:1584
Organized labor markets and, 3:1584
Petroleum and automobile industry wave of, 3:1584
Population growth rates and demographic composition and, 3:1586
Producer services and, 3:1584
Productivity increase dimension of, 3:1582
Rise of modernity and, 3:1584
Running water energy source and, 3:1581
Spinners at Cherryville Mfg. Co., North Carolina, 3:1585 (photo)
Standard of living improvements and, 3:1582
Steam engine energy source and, 3:1581–1582
Technology innovation dimension of, 3:1582, 3:1584
Textile industry wave of, 3:1583–1584
Urbanization and, 3:1585–1586
Wood as energy source and, 3:1582
Industrial Revolution: noted individuals
  Henry Ford, 3:1582
  Thomas Malthus, 3:1586, 4:1819–1820
  Thomas Newcomen, 3:1582
  Adam Smith, 3:1582
  James Watt, 3:1582
  Eli Whitney, 3:1582
Inequality and geography, 3:1586–1590
Class-based conflict and, 3:1587
Dependency theories and, 3:1587
Educational geographies and, 2:874–875
Ethics and geography and, 2:1013–1016
David Harvey’s work in, 3:1404–1406, 3:1467, 5:2350
Human geographers and, 3:1587
Importance of, 3:1587–1588
Inequity and poverty relationship issue and, 3:1589
Inevitability of, 3:1587–1588
Marginalized groups and, 3:1587
Marxism influence and, 3:1587, 3:1588
Measurement of, 3:1588
Policy issues and, 3:1587
Political issues, 3:1587
Postcolonialism and, 3:1587
Postmodernism and poststructuralism and, 3:1587
Spatial differences examination and, 3:1586–1587
Welfare and justice issues and, 3:1587
Welfare states and, 3:1590
Informal economy, 3:1590–1592
Absence of institutional regulation in, 3:1590–1591
Characteristics of, 3:1591–1592
Conditions of work in, 3:1590
Contradictions within, 3:1591
Definition of, 3:1590
Dependency structures in, 3:1591
Formal economy connection of, 3:1591
Heterogeneous feature of, 3:1591
Informal Economy (Portes and Castells), 3:1591
Informal sector of economic activity and, 3:1591
Institutional management form in, 3:1590–1591
Marginal economy and, 3:1591
Politico-economic process of, 3:1591
Self-employed and, 3:1591
Status of labor affected in, 3:1590
Universality of, 3:1591
Work process affected by, 3:1590–1591
Information society, 3:1593–1594
Codification, infrastructure, and education importance to, 3:1594
cyberspace and, 2:646–648
digital age of information and, 3:1593
Economic benefits of, 3:1593
Explicit vs. tacit information layers and, 3:1593
Exposure and access inequities and, 3:1593
Information and communication technologies and, 3:1593
Information economy and, 3:1593
Information pattern layers and, 3:1593
Internet technology and, 3:1593
Knowledge geographies and, 4:1659–1663
Modern societies dependence on, 3:1594
Radio and phone technology and, 3:1593
Spatial economic patterns and, 3:1593
Television and, 3:1593
Value-added information, tradability of, 3:1594
See also Communications geography
Infrastructure, 3:1594–1597
Commodity and information flows of globalization and, 3:1594
Externalities issue and, 3:1595–1596
“Hidden hand” behind urban development and nation building, 3:1594
Hurricane Katrina and, 3:1594
Individual vs. social benefits and, 3:1596
Interurban vs. intra-urban infrastructures and, 3:1595
I-35 bridge collapse over Mississippi River and,
  3:1596 (photo), 3:1597
Thomas Jefferson and, 3:1595, 4:1642
Military term of, 3:1594
Neoliberalism and, 3:1596–1597
Nonrivalness and nonexcludability issues in, 3:1595
Public and private works and, 3:1594
Social disaster from lack of, 3:1594
Support network of society and, 3:1594
Urban infrastructure conception and, 3:1595
Innovation, geography of, 3:1597–1599
Colocation element in, 3:1598
Common knowledge base and, 3:1598
Competitive advantage and, 2:558–559
diffusion and, 2:745–748
Knowledge spillover and, 3:1598, 4:1663–1664
Learning regions and, 4:1766–1768
Local linkage and collaboration issue in, 3:1598
“Location-scanning” perspective on, 3:1598
Alfred Marshall’s “industrial districts” research and, 3:1597–1598
Qualitative and dynamic perspectives on, 3:1598
Regionally based prosperity and, 3:1598
“Resources allocation” and, 3:1598
Spatial agglomeration of economic activity and, 3:1597
Spatial clustering and, 3:1598

Intergovernmental environmental organizations and initiatives: specific organizations

Convention on Biological Diversity, 3:1604
Convention on Migratory Species, 3:1604
International Maritime Organization, 3:1604–1605
International Whaling Commission, 3:1604
Kyoto Protocol, 3:1605
Ozone Secretariat, 3:1605
Regional Fishery Management organizations, 3:1604
UN Conference on Environment and Development, 3:1609
UN Conference on the Human Environment (UNCHE), 3:1604, 6:2747
UN Economic Commission for Europe, 3:1605
UN Environmental Programme (UNEP) and, 3:1604
UN Millennium Development Goals and, 3:1604
UN World Commission on Environment and Development and, 3:1604, 5:2220

UN World Summit on Sustainable Development and, 3:1604, 6:2738, 6:2750
Intergovernmental Panel on Climate Change (IPCC), 3:145
carbon dioxide levels and, 1:82–85
cardiac policy and, 1:462
climatic relics and, 1:470
cloud feedbacks, global climate change assessment and, 1:480
coalitional hazards and, 1:500
global mean radioactive forcing by GHGs and, 3:1375 (table)
global sea-level rise predictions of, 3:1346
greenhouse gases and, 3:1374
ice sheet change data of, 3:1525
International Polar Year and, 5:2204
sea level data of, 5:1525
snow and ice melt and, 5:2204
Working Groups and Task Force of, 1:82
International Agency for Research on Cancer, 1:335
International Association of Landscape Ecology, 4:1706
International Association of Geomorphologists, 3:1245
International Cartographic Association, 1:118
International Consortium of Environmental History Organization, 2:929

International Criminal Court (ICC), 3:1605–1608
accountability issues of, 3:1605–1606
“American exceptionalism” issue and, 3:1606
Coalition for the International Criminal Court and, 3:1607
Cold War period and, 3:1606
“complementarity” principle and, 3:1606
formation of, 3:1606–1607
functions of, 3:1605
Hague and, 3:1607
historical background of, 3:1606
impacts of, 3:1607–1608
jurisdiction of, 3:1605, 3:1607
NGOs role in, 3:1607
objectors to, 3:1606
participant members of, 3:1608
Peace Palace, The Hague, Netherlands, and, 6:3130 (photo)
as product and producer of globalization, 3:1605
restrictions on powers of, 3:1606–1607
Rome Statute of, 3:1607
Rwanda genocide and, 3:1606
Sierra Leone and Cambodia tribunals and, 3:1606
state power unchallenged by, 3:1607–1608
“trigger” mechanisms of, 3:1606–1607
Uganda, Sudan, Congo, and Central African Republic cases of, 3:1607
“victor’s justice” issue and, 3:1607
Yugoslavia breakup, violence during, 3:1606

International environmental movements, 3:1608–1612
antinuclear movement, 3:1609
Basel Action Network (BAN) and, 3:1610
Climate Action Network (CAN) and, 3:1610
definition of, 3:1608
environmental problems geographic scales and, 3:1609
functions of, 3:1608
global environmental justice movement, 3:1610
Greenbelt movement, 3:1610
intergovernmental organizations and initiatives and, 3:1603–1605
international institutions and, 3:1611
international political opportunity structures and, 3:1611
movement against genetically modified organisms, 3:1609–1610
“Network of GMO Free Regions” and, 3:1610
“new social movements” characteristics and, 3:1608–1609
origins and development of, 3:1608–1609
political opportunities and, 3:1610–1611
Rainforest Action Network (RAN) and, 3:1610
UN Conference on Environment and Development and, 2:835,
3:1568, 3:1609
See also European green movements

International environmental NGOs, 3:1612–1614
forms of, 3:1612
goals of, 3:1612
international environmental movements and, 3:1608–1612
international environmental think tanks and, 3:1614
international environmental umbrella organizations and, 3:1614
international mass membership organizations, 3:1612–1613
multilateral environmental agreements and, 3:1613
national mass membership organizations operating as, 3:1613–1614
See also International environmental NGOs: specific organizations
International environmental NGOs: specific organizations
Environmental Defense Fund, 3:1613
European Federation for Transport and Environment and the
European Environmental Bureau (EEB), 3:1614
Friends of the Earth International, 3:1612–1613
Greenpeace, 3:1612
International Institute for Environment and Development, 3:1614
National Audubon Society, 3:1613
National Resources Defense Council, 3:1613
National Wildlife Federation, 3:1613
Nature Conservancy, 3:1614
Oko-Institute (Germany), 3:1614
Sierra Club, 3:1613
UN Biodiversity Convention and, 3:1613
World Resources Institute, 3:1614
World Watch Institute, 3:1614
International Farmers’ Movement. See Via Campesina
(International Farmers’ Movement)
International Geographic Union (IGU), 3:1614–1615
Ronald Abler’s service to, 1:1
academic geographers membership of, 3:1614
Anne Buttimer’s service to, 1:309
commissions and task forces of, 3:1615
communications geography and, 2:541
English and French working languages of, 3:1615
Geography of the Information Society and, 2:541
governing organization of, 3:1615
International Council of Science and, 3:1615
International Social Sciences Council and, 3:1615
Melvin Marcus and, 4:1850
objectives of, 3:1614–1615
International Geosphere-Biosphere Programme (IGBP), 4:1735
International Human Dimensions Programme (IHDP) on Global
Environmental Change, 4:1735
International Institute of Agriculture (Rome), 1:54
International Maritime Organization (IMO), 3:1604–1605
International Monetary Fund (IMF), 3:1615–1618
antiglobalization issues and, 1:96
Articles of Agreement of, 3:1615
assets controlled by, 3:1615
Bretton Woods Conference and, 3:1615, 3:1616
colonial powers domination of, 5:2261
“conditionalities” to receive a loan and, 3:1616
convertibility of member currencies and, 3:1616
credit-orientation feature of, 3:1616
demonstration against, West Berlin, 1988, 5:2443 (photo)
enforcement mechanisms of, 3:1616, 3:1617
exchange rate management by, 3:1618
floating exchange rates and, 3:1616
functions of, 3:1616–1618
General Arrangements to Borrow funding of, 3:1617
global remittance flows, 2007 and, 5:2412 (fig.)
governance by, 3:1358
Heavily Indebted Poor Countries debt relief and, 3:1617
IMF Institute and, 3:1618
Mexican debt default and, 2:688–689
Monetary and Capital Markets Department of, 3:1618
neoliberal economic policies of, 4:2003
neoliberal environmental policy and, 4:2008
NIC export-led development and, 2:165
offshore financial centers oversight by, 3:1618
“ pegs” to regulate exchange rates and, 3:1616
Poverty Reduction and Growth Facility of, 3:1617
Poverty Reduction Strategy Papers and, 4:2014
regional remittance flows, 2007 and, 5:2413 (fig.)
Reports on the Observance and Codes of, 3:1618
restructuring reform of, 3:1617–1618
Special Drawing Rights of, 3:1617
Special Missions and Resident Advisors of, 3:1618
structural adjustment of economies role of, 3:1616, 5:2703
Structural Adjustment Programs (SAPs) of, 1:96, 2:1065,
subscription funding source and, 3:1617
supranational economic activity, glocalization and, 3:1347
surveillance functions of, 3:1618
technical assistance provided by, 3:1618
transparency standards and, 3:1618
U.S. shortage of currency and, 3:1616
voting power allocation of, 3:1617
International Satellite Cloud Climatology Project (ISCCP), 1:478
International Union for Conservation of Nature and Natural
Resources, 1:470
International Union for Conservation of Nature
(IUCN), 4:2117
International watershed management, 3:1618–1620
adaptive watershed management approach to, 3:1620
community-based water resources management and, 3:1620
Convention on the Protection and Use of Transboundary
Watercourses and International Lakes and, 3:1619
conventions and treaties in, 3:1619
definition of, 3:1618
ecosystem-based river basin management approach to, 3:1620
establishing effective practices in, 3:1619–1620
flexible and integrative framework for, 3:1619–1620
GIS in water management and, 3:1316–1318
Helsinki Rules on the Uses of the Waters of International
Rivers and, 3:1619
integrated water resources management (IWRM) strategy of, 3:1619
Ramsar Convention on Wetlands of International Importance
and, 3:1619
stages in process of, 3:1619–1620
subfields of geography and, 3:1619
transboundary, national, and international scales of, 3:1618–1619
UN Convention on the Law of the Non-Navigational Uses of
International Watercourses and, 3:1619
International Whaling Commission, 3:1604


Invasion and succession, 3:1627 changes to ecological communities through time and, 3:1627 definitions of, 3:1627 exotic species and, 2:1048–1050 invasion as a negative process and, 3:1627 physical transportation agents and, 3:1627 primary vs. secondary succession and, 3:1627 See also Human-induced invasion of species

Iowa ephemeral gully erosion, Western Iowa, 5:2465 (photo) prairie restoration in, 5:2278 same-sex marriage supporters, Iowa City, 5:2332 (photo) watershed management of Union Grove Lake, Tama County, 6:3073 (photo)

Iran automobile industry in, 1:169 “axis of evil” concept (G. W. Bush) and, 2:612 basin and range topography in, 1:186 camel domesticated in, 2:783 Cold War and, 1:504, 1:505 economically active females in, 3:1190 (table) global petroleum trade and, 2:900 goats domestication in, 2:783 groundwater usage in, 1:3186 human rights atrocities in, 1:3481 oil sources in, 4:2163 OPEC membership of, 4:2099, 4:2100 (fig.) opium and heroin production in, 2:797
Iraq
“axis of evil” concept (G. W. Bush) and, 2:612
bovine domestication in, 2:783
British colonization of, 1:514
cholera in, 1:402
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
global petroleum trade and, 2:900
human rights atrocities in, 3:1481
oil sources in, 4:2163
OPEC membership of, 3:1629
Road surveyor and construction, Dhi Qar Province, 6:2736
sheep domestication in, 2:783

Ireland
AGILE membership of, 1:124 (table)
cultural nationalism in, 4:1980
economically active females in, 3:1190 (table)
ethnic (Catholics and Protestants) self-segregation in, 2:1023
European Union (EU) membership of, 2:1015
foreign direct investment from, 3:1156
Industrial Development Authority, rural development in,
mixed farming patterns in County Armagh, Northern Ireland,
national boundaries identification and, 4:1972
Newgrange summer solstice in, 5:2598
occluded cyclone weather in, 2:657–661
protests, Catholic and Protestant neighborhoods, Belfast,
public-private partnerships in, 5:2312
U.S. foreign direct investment in, 3:1155
Viking exploration of, 2:1031
Isaac, Erich, 2:782
Isard, Walter, 3:1627–1628
academic career of, 3:1628
building cycles and transportation development work of, 3:1628
economic geography work of, 3:1627
as father of regional science, 1:81, 3:1627, 5:2393, 5:2394
journals founded by, 3:1628
location theory work of, 3:1628
Peace Science discipline founded by, 3:1628
publications of, 3:1628
Regional Science Association founded by, 3:1628, 5:2393
research fields of, 3:1627–1628
ISI. See Import substitution industrialization (ISI)
Island biogeography, 3:1629–1634
adaptive radiation process and, 1:14–15, 3:1630–1631
anthropogenic changes and, 3:1629
archipelagoes and, 1:105–106
atolls and, 1:165–169
biodiversity and, 1:197–201
biotas of islands vs. continental biotas and, 3:1629
conservation biography and, 3:1631–1632, 3:1633 (fig.), 3:1634
continental fragments and, 3:1629
continental islands and, 3:1629
Jared Diamond’s work in, 2:734
dynamic equilibrium model if ETIB and, 3:1630
ecosystems of islands and, 3:1629
endemic species and, 3:1629
equilibrium theory of island biogeography (ETIB) and,
forest patches as, 4:2131
fragmentation research and, 3:1631–1632, 3:1633 (fig.)
general dynamic model (GDM) of, 3:1632 (fig.)
“hot spots” and of endangered and extinct species and,
human-induced invasion of species and, 3:1473–1474
island “ontogeny” and, 3:1630, 3:1632 (fig.)
island theories and, 3:1630–1631
island types and, 3:1629
MacArthur-Wilson model of, 1:199, 1:210, 5:2672
natural experiments replication and, 3:1629
natural island landcover and, 3:1629
oceanic islands and, 3:1629
significance of islands and, 3:1629–1630
SLOSS debate and, 3:1632
ture islands vs. habitat islands and, 3:1629
See also Islands, small
Islands, small, 3:1634–1637
archipelagoes and, 1:105–106
atolls and, 1:165–169
biodiversity conservation challenge and, 3:1635
Chuuk Lagoon from satellite imagery, Chuuk State, Federated
States of Micronesia, and, 3:1636 (photo)
Conference of the Parties to the Conservation on Biological
Diversity and, 3:1635
coral reefs and, 2:581–584, 3:1635
Darwin’s theory of evolution and, 3:1635
global climate change and, 3:1637
habitat diversity of, 3:1635
high island of Tonowas, Chuuk State, Federated States of
Micronesia, and, 3:1635 (photo)
high islands, 3:1634–1635
low islands, Marshall Islands, 3:1637 (photo)
low islands and atoll structures and, 3:1634, 3:1635–1637
Micronesia region of Pacific Ocean and, 3:1635, 3:1635 (photo),
3:1636 (photo)
saltwater intrusion and, 3:1636
small-island developing states designation and, 3:1634
Wilson’s theory of island biogeography and, 3:1635, 5:2672
Isopleth maps, 3:1638–1639
choropleth maps and, 1:406–408
continuity between high and low centers and, 3:1638, 3:1638 (fig.)
contour maps and, 3:1638 (fig.)
definition of, 3:1638
isarithm and isogram and, 3:1638
isoline maps and, 3:1638
isometric vs. isopleth mapping and, 3:1638
isopleth interval and, 3:1638
lines of equal value to portray patterns and, 3:1638
specialized names for different data and, 3:1639 (table)
as thematic map, 3:1638
Israel
AGILE membership of, 1:124 (table)
antiglobalization, anticolonialism in, 1:97
British colonization of, 1:514
central place theory in urban planning in, 1:382
Dead Sea in, 1:115
deposit refund systems in, 4:1857
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
incubator zones in, 1:552
“natural ethnicity” of a region concept and, 2:1020
Isthmus of Panama, 1:213
Italy
agglomeration economies in, 1:32
AGILE membership of, 1:124–125 (table)
avtomobile industry in, 1:169, 1:171
coal energy source in, 3:1582
colonial empire of, 1:509, 1:509 (fig.)
community-based natural resource management in, 2:549
competitive advantage areas in, 2:558
eyear cadastral map from, 1:314 (fig.)
earthquakes in Calabria, 1783–1785, 2:812
ecological footprint of, 2:826, 2:827 (fig.)
economically active females in, 3:1190 (table)
Emilia-Romagna high-tech region in, 3:1127, 3:1598, 4:1766, 4:1767, 5:2519
European Union (EU) membership of, 2:1035
GDP of, 3:1382, 3:1383 (fig.)
groundwater usage in, 3:1386
hydroelectricity in, 3:1507
industrialization in, 3:1383, 4:2020
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Italocentrism in, 2:1030 (table)
Larderello chemical industry zone in, 3:1267
Lombardy knowledge region in, 5:2435
military expenditures in, 4:1899 (table)
Mount Etna and, 2:605
movement against genetically modified organisms in, 3:1610
national geographical society in, 3:1462
particulate matter pollution in, 1:151
percentage of economically active females in, 3:1190 (table)
railroads in, 5:2358
San Marco Square and Palazzo, Ducale, Venice, 5:2314 (photo)
“science” of geopolitics in, 3:1249, 3:1250
total factor productivity (TFP) of, 6:2780 (table)
Vineyards, Chianti region, Tuscany, 6:3116 (photo)

Jackson, John Brinkerhoff, 4:1641–1642
academic career of, 4:1641
American popular landscape focus of, 4:1641
architecture, historic preservation, and urban planning interests of, 4:1641
Association of American Geographers award of, 4:1642
cultural landscape analysis work of, 3:1435, 4:1641
folk-architecture documentation work of, 1:106
influences on, 4:1641
Landscape: The Human Geography of the Southwest magazine and, 4:1641
Peirce Lewis influenced by, 4:1773
Jackson, Peter, 1:108, 1:524
Jackson, William Henry, 3:1409
Jacobs, Allan, 4:2025
Jacobs, Jane, 4:2025, 4:2126, 5:2395
Jamaica
British colony of, 1:512
economically active females in, 3:1190 (table)
land inequalities in, 4:1693
James, Preston, 2:567, 5:2534
Jameson, Frederick, 5:2264
Janelle, Don, 5:2404
Jäncke, Martin, 2:836–837
Jankowski, Piotr, 2:616, 4:2056
Japan
above-ground park, Tokyo, 6:2934 (photo)
acid rain in, 1:7
APEC membership of, 1:121
as archipelago island formation, 1:105
ASEAN membership of, 1:129
automobile industry in, 1:169, 1:170, 2:700
basin and range topography in, 1:186
birthrates in, 2:708
carbon trading market in, 1:330
Chuetsu earthquake (2004) in, 2:811
colonialism resisted by, 1:508, 1:514
colonial migrations of, 1500–1914, 3:1543
competitive advantage areas in, 2:558
densely inhabited districts definition in, 5:2239
deposit refund systems in, 4:1857
earthquake losses in, 4:1984
East and southeast Asian economic bloc proposed by, 1:128
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
electronics and pop culture content, Akihabara, Tokyo, and, 2:886
electronics manufacturing in, 2:885–886
energy policies in, 2:901–902
environmental history studies in, 2:929
“environmental miracle” of, 2:943
fertility levels in, 2:709
fishing cooperatives in, 1:534
foreign aid flow from, 3:1152
foreign direct investment and, 3:1155
GDP of, 3:1382, 3:1383 (fig.)
gerothermal wells in, 3:1267
government and industry links in, 3:1581
green building programs in, 3:1368
greenhouse gas emissions of, 5:2220
high-bread use in, 3:1421
high-speed trains in, 5:2364
historical climate records in, 1:456
industrialization in, 3:1580, 3:1583
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Japan-South Korea World Baseball Classic game, Dodger Stadium, Los Angeles, 5:2681 (photo)
just-in-time inventory systems and, 3:1126, 5:2401
Kobe earthquake, 2:814
Kyoto Protocol of 1997, greenhouse gas emissions and, 1:462–463, 1:3174
land reform in, 4:1693
life expectancy in, 3:1410
lower birth rates in, 4:1981
military expenditures in, 4:1899 (table)
military-industrial complex in, 4:1900
Minamata disease, mercury poisoning and, 1:501–502
next generation nuclear reactors in, 4:2051
oil imports of, 4:2073
PCBs contamination in, 5:2226
petroleum consumption in, 4:2164 (fig.)
railroads in, 5:2358
rice paddy cultivation in, 1:48
rock garden at Kongobuji Temple, Mount Koya, 4:1704 (photo)
“science” of geopolitics in, 3:1249
steel industry in, 5:2689, 5:2690
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
Tokyo airline networks, 1:179
topographic mapping in, 1:350
tuna harvesting in, 4:2066 (photo)
undernourishment in, 3:1488
Ural Altaic or Finno-Ugric languages in, 4:1751 (fig.)
See also Tokyo, Japan
Jarvis, Edward, 2:775–776
Jarvis, H., 2:1042
Jasanoff, Sheila, 5:2518
Jaspers, Karl, 2:1046
Java, 1:209
Jefferson, Mark, 5:2290
Jefferson, Thomas, 4:1642–1643
“equality of opportunity” and, 5:2573
federal infrastructure investment and, 3:1595
Alexander von Humboldt and, 4:1642
interests of, 4:1642
Land Ordinance of 1784, survey format written by, 4:1642
land ordinance system and, 3:1464
Lewis and Clark expedition and, 3:1464, 4:1642, 4:1773–1777
Louisiana Purchase and, 4:1642
Map of the Kingdom of New Spain by Baron von Humboldt, 3:1463 (fig.), 4:1464
public education geography supported by, 4:1642
Township and Range land survey method and, 4:1642, 6:2861
universal human rights and, 5:2573
westward expansion and, 3:1464

Jellico, Geoffrey, 4:1699
Jellico, Susan, 4:1699

Jenkins, Alan, 4:1657

Jencks, Christopher, 4:1642

Jensen, R., 4:1657
Jensen, Jens, 4:1648

Jenoff, Svein, 2:551

Jerusalem
Biblical map of, 1:196 (fig.)
T-in-O maps, 1:347, 1:349 (fig.)
Wailing Wall of, 2:638 (photo)

Jihad vs. McWorld (Barber), 1:94

Johannessen, Carl, 2:782
Johnsson, Olga, 4:1969

Johnston, D. L., 1:267
Johnson, D. N., 1:267
Johnson, D. W., 4:1896
Johnson, Samuel, 4:1985
Johnson, Simon, 5:2218

Johnston, Peter, 5:2264

Johnston, R. J., 4:1643
academic career of, 4:1643
British electoral system focus of, 4:1643
history of human geography since WWII and, 4:1643
human geography focus of, 4:1643
political and electoral geography work of, 4:1643
three dimensions of place and, 5:2574
urban social geography work of, 4:1643
Jones, Clarence Fielden, 2:849
Jones, Clive, 4:1657
Jordan
British colonization of, 1:514
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)

Jordan, Terry, 5:2537

Justice, geography of, 4:1643–1645
antisystemic movements and, 1:99–100
attaining justice and, 4:1644
citizenship and, 4:143–414
countermapping and, 2:595–596, 3:1645
denouncing and correcting injustices and, 4:1644–1645
ecological justice and, 2:830–832
ethics and geography and, 2:1013–1016
government subfields and, 3:1643, 4:1644
goals of work in, 4:1644
human rights geographies and, 3:1480–1481
indigenous cartography and, 3:1645
inequality geographies and, 3:1586–1590
International Criminal Court (ICC) and, 3:1605–1608
justice definition work and, 4:1644
multidisciplinary fields and, 3:1645
spatial approach to, 4:1644–1645
“spatial turn” in academic fields and, 3:1645
See also Democracy; Environmental justice; Law,
geography of; Social justice

Justice, geography of; noted individuals
William Bunge, 3:1645
David Harvey’s work in, 3:1404–1406, 3:1467, 5:2350
Wil Kymlicka, 4:1644
John Rawls, 4:1644
Elise Reclus, 1:73, 2:617, 3:1463, 5:2211, 5:2371–2372
Charles Taylor, 4:1644

Kabak, K. I., 1:326–327
Kahn, Robert, 2:646
Kaika, Maria, 3:1595
Kalahari Desert, 1:239
Kammen, Daniel, 6:2741

Kansas
“natural systems agriculture” in, 6:2745–2746
prairie restoration in, 5:2278, 5:2278 (photo), 5:2281

Kant, Immanuel, 4:1647–1649
Cartesian view of absolute space and, 4:1648
chorology and, 1:404
contributions to geography, 4:1648–1649
cosmopolitanist doctrine of, 4:1648–1649
Critique of Pure Reason written by, 4:1647
environmental deterministic views of, 4:1648
ethics and epistemology interests of, 4:1647
Richard Harrshome influenced by, 3:1402–1403, 4:1649, 5:2387–2388
Alfred Hettner influenced by, 3:1422, 4:1649
human knowledge organization developed by, 4:2179
David Hume’s influence on, 4:1647
international confederation of nations idea of, 4:1648
metaphysics vs. theoretical and empirical science and, 4:1647–1648
Newtonian notion of absolute time and space and, 4:1648
normative theories of transnational relations of, 4:1648–1649
noumena views of, 4:1647, 4:1648
people and their relations to material world and, 4:1648
perception issues and, 4:1648
physical geography work of, 4:1647, 4:1648, 4:2179
rational mind views of, 4:1647
regions as mental constructs views of, 3:1403, 3:1462
space existing prior to experience and, 4:1648
time and space philosophies of, 3:1462, 4:1647–1648
Tobler’s First Law and, 4:1648
“Towards Perpetual Peace” essay of, 4:1648
universal ideologies of nature and, 1:424

Kaplan, D., 5:2345
Kaplan, Rachel, 4:1716
Kaplan, Robert, 2:999, 4:2016
Kaplan, Stephen, 4:1716

Kart topography, 4:1649–1654
atolls formation and, 1:166–167, 1:168 (fig.)
bare karst, 4:1650, 4:1653
baselevel polja, 4:1632
biokarsts, 4:1634
blind valley, 4:1632
border polja, 4:1632
chalk rock and, 4:1649
characteristics of, 4:1649–1650
clints, 4:1653
coastal karrens, 4:1654
keystone plants, 4:1656
keystone predators, 4:1656
system-based perspective on, 4:1658
thresholds element in, 4:1655
See also Keystone species: noted individuals

Keystone species: noted individuals
Mark Berton, 4:1658
John Bruno, 4:1658
J. Estes, 4:1656
Clive Jones, 4:1657
Katherine Kendall, 4:1656
L. Scott Mills, 4:1658
Robert Paine, 4:1655, 4:1656
John Stachowicz, 4:1658

Kidder, S. Q., 1:160
Kiefer, Ralph, 4:1783
Kierkegaard, Søren, 3:1474–1475
Kindleberger, Charles, 3:1116
King, Clarence, 3:1409
Kirchhoff, Gustav, 3:1542
Kirchin, Rob, 2:646
Kirk, William, 2:977, 4:2167
Kissing, Henry, 2:611
Kittel, Friedrich, 4:1874
Kjellén, Rudolf, 3:1249, 3:1464, 5:2222
Klages, K., 1:54
Klahr, David, 1:391
Kniffen, Fred, 1:106

cultural landscape work of, 2:642
historic preservation and, 3:1435
settlement geography work of, 5:2535, 5:2536–2537

Knigge, LaDonna, 2:616

Knowledge, geography of, 4:1659–1663
centers of power and, 4:1662
communication technologies and, 4:1659
cultural preservation and, 4:1662
Robert Geipel’s work in, 4:1659
geographies of creativity and, 4:1661–1662
geographies of education and, 4:1659–1661, 4:1660 (photo)
geographies of science and, 4:1661
information society and, 3:1593–1594
innovation geographies and, 3:1597–1599
knowledge and education and, 4:1659
knowledge and power and, 4:1659
knowledge definition and, 4:1659
knowledge regions and, 5:2435
language of instruction issue and, 4:1662
learning regions and, 4:1766–1768
nation-states and, 4:1662
schools as ethnic resistance sites and, 4:1662
school system socialization and, 4:1662
social survey movement and, 4:1659
spatial disparities in, 4:1659
See also Education, geographies of; Knowledge spillovers

Knowledge spillovers, 4:1663–1664
definition of, 4:1663
economic growth and, 4:1663
externalities and, 2:1068–1069, 5:2395
innovation geographies, tacit knowledge and, 3:1599
Jacobs spillover perspective, 4:1663
knowledge externalities and, 4:1663
locally bounded spillovers and, 4:1663
MAR spillovers perspective and, 4:1663
nonexcludability and, 4:1663
nonrivalry and, 4:1663
Porter spillover perspective, 4:1663
tacit knowledge and, 4:1663
technology diffusion and, 6:2780
urban growth affected by, 4:1663, 5:2395
See also Knowledge, geography of
Kobayashi, A., 5:2335
Kohn, Hans, 4:1978
Kohonen, Teuvo, 5:2526
Komiya, Hiroshi, 6:2738
Kondratiev, Nikolai, 1:302–304
Kondratiev waves, business cycles, 1:303–304
business services element in, 1:304
“creative destruction” concept and, 1:303
information technology and, 1:303
Simon Kuznets’ evaluation of, 1:303
Joseph Schumpeter’s evaluation of, 1:303
spatial development of labor and, 1:304
technology diffusion element of, 1:303
Kong, Lily, 4:1968
Kopp, Anatole, 2:617
Köppen, Wladimir, 4:1664–1665
books written by, 4:1664
botany work of, 4:1664
climatology work of, 4:1664, 4:2180
fields of study by, 4:1664
forecasting work of, 4:1664
temperature regions and vegetation growth research of, 4:1664, 4:1665
See also Köppen-Geiger climate classification

Köppen-Geiger climate classification, 4:1665–1668
A-type climates, 1:467, 4:1665–1666
B-type climates, 1:467–468, 4:1665–1666
climate symbols and defining criteria of, 4:1666 (table)
C-type climates, 1:468, 4:1665–1666
dry climate and, 1:432
D-type climates, 4:1668–469, 4:1665–1666
E-type climates, 1:469, 4:1665–1666
Rudolf Geiger and, 4:1665
humid continental and subarctic climates, 1:439, 1:440 (fig.)
humid vs. dry climates and, 4:1665–1666
subsidiary classification properties of, 4:1665–1666, 4:1666 (table)
temperature and precipitation data of, 1:465
Alfred Wegener and, 4:1665
world climate map based on, 4:1666, 4:1667 (table)
world’s land area occupied by each climate type and, 4:1667 (table)

Korea
domino theory and, 3:1224
industrialization in, 4:2020
Japanese colonization of, 1:514
rice paddy cultivation in, 1:48
textile exports from, 6:2815 (fig.), 6:2816 (fig.)

Kosek, Jake, 5:2339

Kreizman, Gregg, 3:1308

Kropotkin, Peter, 4:1668–1669
anarchist beliefs of, 4:1668
Arts and Crafts Movement and, 4:1669
bioregionalism supported by, 4:1669
cooperation among species studied by, 2:667–668, 3:1463
decentralized self-governing communities and, 3:1463
free trade and comparative advantage visions of, 4:1668
geographic anarchism, radical geography work of, 1:73, 2:617
green design and development work of, 3:1372
Mutual Aid written by, 5:2211
Elisée Reclus and, 4:1669, 5:2372
self-reliance and communality work of, 3:1372
Siberia exploration of, 4:1668
spatial hierarchies work of, 3:1463
“What Geography Ought to Be” essay written by, 2:617, 3:1463
Krugman, Paul, 5:2365, 5:2395
Krumholz, 4:1669–1672
definition of, 4:1669
ecotone of, 4:1669 (photo)
Engelmann spruce and, 4:1669
factors affecting type and degree of, 4:1670
flag krumholz, 4:1669–1671, 4:1670 (photo)
flag mat krumholz, 4:1671, 4:1671 (photo)
forms of, 4:1670–1671
importance of, 4:1671–1672
mat krumholz, 4:1671, 4:1672 (photo)
microclimate factors and, 4:1669–1670
 quaking aspen and, 4:1669
term derivation and, 4:1669
windward growth of, 4:1670 (photo)
Kuhn, Thomas, 5:2537
Kuhn, Werner, 4:1672–1673
academic career of, 4:1673
Conference of Spatial Information Theory and, 4:1673
geosystems study by, 4:1673
geoinfomatics work of, 4:1672, 4:1673
GIScience work of, 4:1672–1673
Open Geospatial Consortium, 4:1673
research fields of, 4:1673
semantics of spatial information work of, 4:1672–1673
Kuwait
economically active females in, 3:1190 (table)
Kuwaiti oil well fires, 2:953, 2:956 (photo)
oil sources in, 4:2163
OPEC membership of, 4:2099, 4:2100 (fig.)
Kuznets, Simon, 1:303
Kwan, Mei-Po, 4:1674
feminist geography work of, 2:615, 4:1674
gender and geography work of, 3:1193
géographisation work of, 4:1674
GIS systems work of, 4:1674
dimensional data modeling and, 4:1674
time-geography work of, 4:1674
transportation geography work of, 4:1674
Kyem, Peter Kwaku, 1:308–1309
Kymlicka, Will, 4:1644
Kyoto Protocol of 1997. See Climate policy
Kyrgyzstan
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)
Labor, geography of, 4:1675–1679
“agency” conceptualization and, 4:1678
“capitalist imperative” and, 4:1676
Capital’s Utopia (Mosher) and, 2:852
CIO picketers, Greensboro, Georgia (1941), 4:1677 (photo)
classical location theory and, 4:1675
contemporary labor geography and, 4:1676–1677
economic landscapes and geography and, 2:852, 4:1675
environmental determinism and, 4:1673
feminist geographers and, 4:1678
feminist spatial science and, 2:852
Fordism and, 3:1148–1151
future trends in, 4:1678
gender and race relations in labor markets and, 4:1678
gendered character of labor markets (Massey) and, 2:852, 4:1790, 4:1866–1867
geographical dilemma facing workers and, 4:1677, 4:1678
Andrew Herod and, 4:1675, 4:1676, 4:1678
historical roots of, 4:1675–1676
informal economy and, 3:1590–1592
internationally mobile labor market and, 2:852
labor definition and, 4:1675
labor unions, commodity chain analysis and, 1:524–525
local labor militancy and, 4:1676
location of firms factors and, 3:1077–1080
Marxism and, 4:1675
“master collective agreements” and, 4:1677
Linda McDowell and, 4:1678, 4:2136
neoliberal economic restructuring and, 4:1676
quantitative revolution and, 4:1675
radical geography and, 4:1675
remittances from migration and, 5:2413–2414
Rust Belt to Sun Belt shift and, 4:1676
“scale appropriateness” of labor strategy and, 4:1677
subdiscipline of economic geography and, 4:1675
textile industry strike, Lawrence, Massachusetts (1912), and, 4:1676 (photo)
trade union decline and, 4:1676
unpaid labor geography and, 4:1678
Lacan, Jacques, 3:1528
Laclau, Ernesto, 3:1419, 3:1420
Lacoste, Yves, 2:617
Laflamme, R., 2:753
Laidlaw, Walter, 1:374
Lake Nyos carbon dioxide disaster, Cameroon, West Africa, 1:68–69
Lamarck, Jean-Baptiste
environmental determinism of, 3:1464
evolution work of, 2:666, 2:667, 5:2561
Lamb, Hubert, 2:711
Land degradation, 4:1679–1684
anthropogenic causes of, 4:1681
definition of, 4:1679
deforestation, 4:1683–1684
ecosystem decay and, 2:858–862
environmental restoration and, 2:991–994
estimates of, 4:1680 (table)
estimates of global extent by type and, 4:1680 (table)
exploitation of marginal lands and, 4:1683
factors responsible for, 4:1680, 4:1681–1682, 4:1681 (fig.)
gully erosion and, 3:1392–1394
increasing population and, 4:1683–1684
open-pit mining and, 4:2086–2088
pervasiveness of, 4:1679
poverty and, 4:1683
soil erosion in Baringo District, Kenya, East Africa, 4:1682 (photo)
terms related to, 4:1679
Landfills, 4:1684–1686
design regulations, 4:1686
disposal of, 4:1686
environmental issues of, 4:1685
first landfill in Fresno, California, and, 4:1684
geography of least political resistance, 4:1686
hazardous waste and garbage mixture in Lowry Landfill, Colorado, 4:1685 (photo)
hazardous waste landfills and, 4:1684
hazardous waste landfills and communities of color and, 2:960, 2:961 (photo)
Land reform, 4:1684–1685
incineration alternative to, 4:1685
industrial wastes and, 4:1685
leachate and gas emissions from, 4:1684, 4:1685
long-term care and monitoring of, 4:1684
Love Canal and, 4:1806–1808
nonhazardous wastes and, 4:1685
open dumps and, 4:1684
Resource Conservation and Recovery Act, 4:1684–1685
siting of, 4:1686
U.S. Superfund sites at, 4:1684
Warren County, North Carolina, environmental justice example and, 2,960, 2,961 (photo), 2,986
Landforms, 4:1686–1692
anthropogenic influences on, 4:1686–1687, 4:1691–1692
Atlantic vs. Pacific coastline landforms and, 4:1689
basin and range topography and, 1:186
calderas and pyroclastic deposits (volcanoes) and, 4:1688
definition of, 4:1686
dunes and, 2,800–803
eolian landforms, 4:1690
erosion creation process of, 4:1686
fjords and, 3:1121–1123
fluvial erosion, Canyonlands National Park, Utah, 4:1691
fluvial landforms, 4:1690
formation process classification of, 4:1686
Grand Prismatic Spring, in Midway Geyser Basin, Yellowstone National Park, 4:1687 (photo)
Hawaiian island volcanic chain and, 4:1688–1689
karst landforms, 4:1690
landform formation and sculpting process of, 4:1689–1690
mass wasting processes on Hawaiian Islands and, 4:1689
natural processes of, 4:1687
periglacial landforms, 4:1690
plate tectonics creation process of, 4:1686
polygenetic processes and 1601, 4:1690
rift zone volcanism and, 4:1688
rivers creation of, 4:1690
role of scale in, 4:1690–1691
volcanoes and, 4:1687–1689
See also Geomorphic cycle; Geomorphology; Volcanoes
Land reform, 4:1692–1696
“agrarian reform” vs., 4:1696
“Alliance for Progress” in Latin America and, 4:1694
balance-of-payment crises and state indebtedness and, 4:1694
barriers to, 4:1694
Brazil’s Landless Workers Movement (MST), 4:1695 (photo)
calculations across borders and, 4:1695
colonial antecedents to, 4:1692
development and, 4:1693
in developing world, 4:1692
“from above” vs. “from below,” 4:1694, 4:1696
gender issues overlooked in, 4:1694
Green Revolution input-intensive techniques barrier to, 4:1694
land inequality and, 4:1693
land tenure reform vs., 4:1725
La Via Campesina example of, 4:1695
Movimiento Sem Terra (MST) and, 4:1948–1951
1970s and, 4:1693–1694
1990s land struggles and, 4:1694–1695
peasants and peasantry and, 4:2137–2142
political economy, 4:2137–2142
post–World War II period and, 4:1693
redistribution of private or public lands and, 4:1692
social struggle and, 4:1693
World Bank and, 4:1695
Landsat Data Continuity Mission proposal and, 5:2356
radiometric resolution and, 5:2356
Landscape and wildlife conservation, 4:1696–1698
animal ecological uniqueness factor in, 4:1697
animal geographies and, 1:75–79
animal mobility factor in, 4:1697
animal size factor in, 4:1697
animals moving across landscapes and, 4:1696
animal specialist vs. generalist habitat type factor and, 4:1697
animal territoriality factor in, 4:1697
applications to resource management and conservation and, 4:1697–1698
Canadian Society of Landscape Architects and, 4:1699
categorization approach to study of, 4:1696
computer-based modeling used in, 4:1697–1698
Jared Diamond’s biodiversity studies and, 4:1697
environmental impacts of roads and, 2:951–953
evolutionary ecology and, 4:1696
game ranching and, 3:1179–1181
GIS software and GPS technology and, 4:1697
habitat corridors concept and, 4:1697
human-caused environmental change and, 4:1697
human-wildlife conflict and, 4:1698
open space and, 4:2091–2094
parks and reserves and, 4:2117–2120
particular species protection strategies and, 4:1697–1698
patch dynamics and, 4:1697
patches and corridors and, 4:2131–2133
patch mosaic theory and, 4:1697–1698
process and patterns research and, 4:1696
research on wildlife-landscape interactions and, 4:1696–1697
site specific vs. species-specific approaches to, 4:1697–1698
size, connectivity, and protected area shape and, 4:1697
spatial configurations of habitat identification and, 4:1697
cpecies ecology and habitat spatiality approaches to, 4:1697–1698
theory of island biogeography and (MacArthur and Wilson) and, 4:1696
Landscape architecture, 4:1698–1701
American Society of Landscape Architects and, 4:1699, 4:1700
art and landscape relationship and, 4:1700
built environment and, 4:1699
Central Park, New York City and, 4:1700
current environmental sustainability issue and, 4:1701
current state of, 4:1701
definitions of, 4:1698, 4:1699
demarcating the field issues and, 4:1698
Design on the Land (Newton) and, 4:1699
Design With Nature (McHarg), 4:1700
divisions within, 4:1698
employment statistics, 4:1700
Encyclopedia of Gardening (Loudon) and, 4:1699
garden design and landscape gardening history and, 4:1699
geography similarities to, 4:1698
GIS area of, 4:1698
Granite Garden (Spin) and, 4:1700
greenways and brownfields, repair and restoration of, 4:1700
history and theory of, 4:1699–1700
human settlement instructions and, 4:1700
international, large-resort development and, 4:1700
International Federation of Landscape Architects and, 4:1700
landscape analysis (McHarg) and, 4:1700
Landscape Architecture Magazine and, 4:1700
Landscape design and, 4:1703–1705
landscape gardener and, 4:1699
Landscape Design, A History of Urban Parks in America
Landscape of Man
Landscape architecture: noted architects, botanists
lawyers of the World Heritage Committee of UNESCO and, 4:1700
Landscape ecology, 4:1705–1713
complete randomization neutral model, 4:1710, 4:1711 (fig.)
complexity theory and, 2:867
definition of, 4:1705
development of, 4:1705–1707
ecological zones and, 2:834–844
ecology-centered, spatial view of, 4:1707
ecosystems and, 2:867
environmental impacts of roads and, 2:951–953
European vs. North American traditions in, 4:1707
forest degradation and, 3:1156–1159
forest fragmentation and, 3:1159–1163
fundamental concepts in, 4:1707–1708
future trends in, 4:1712
GIS software used in, 4:1709, 4:1709 (fig.)
hierarchy and scale in, 4:1708
humanity and landscape composition relationship in, 4:1705
hybrid-human-natural systems and, 4:1708
International Association of Landscape Ecology and, 4:1706
land cover in Leon County, Florida and, 4:1709 (fig.), 4:1710–1711, 4:1710 (table)
landscape and wildlife conservation and, 4:1696–1698
landscape biodiversity and, 4:1701–1703
landscape dynamics and, 4:1708
landscape metrics and, 4:1707–1710, 4:1714–1715
methodology used in, 4:1708–1712
modeling techniques of, 4:1707
neutral model and process-based models in, 4:1710–1712, 4:1711 (fig.)
patch dynamics and, 4:1697, 4:1708–1709
patch mosaic theory and, 4:1696–1697
pattern metrics and, 4:1708–1710
pattern-process interactions and, 4:1707–1708
patterns and, 4:1707
process-based models and, 4:1712
randomization with fractal approach neutral model, 4:1710, 4:1711 (fig.), 4:1712
randomization with hierarchical randomization neutral model, 4:1710, 4:1711 (fig.), 4:1712
RULE software and, 4:1711 (fig.), 4:1712
simulated forest landscapes using neutral models and, 4:1711 (fig.)
size, edge, shape, diversity, and contagion metrics and, 4:1709–1710
society-centered, holistic view of, 4:1707
spatial autocorrelation and, 4:1707
spatial heterogeneity and, 4:1707
spatial pattern and ecological process relationship and, 4:1707
subjects included in, 4:1705, 4:1706 (fig.)
theoretical approaches to, 4:1707
Carl Troll and, 3:1458, 4:1705, 4:1714
Landscape interpretation, 4:1713–1715
aerial photographs and, 4:1714
chorological approach to, 4:1713
cultural geography and, 2:635–636
definition (Humboldt) of, 4:1713
disciplines related to, 4:1713
gender differences in, 4:1714

Landscape design: noted individuals
A. J. Downing, 4:1703

Lawrence Halprin, 4:1703
Dan Kiley, 4:1703
J. C. Loudon, 4:1703
Roberto B. Marx, 4:1703
Gilbert Laing Meason, 4:1703
Frederick Law Olmstead, 4:1703
Martha Schwartz, 4:1703
Roger S. Ulrich, 4:1704–1705

Landscape ecology, 4:1705–1713
complete randomization neutral model, 4:1710, 4:1711 (fig.)
complexity theory and, 2:867
definition of, 4:1705
development of, 4:1705–1707
ecological zones and, 2:834–844
ecology-centered, spatial view of, 4:1707
ecosystems and, 2:867
environmental impacts of roads and, 2:951–953
European vs. North American traditions in, 4:1707
forest degradation and, 3:1156–1159
forest fragmentation and, 3:1159–1163
fundamental concepts in, 4:1707–1708
future trends in, 4:1712
GIS software used in, 4:1709, 4:1709 (fig.)
hierarchy and scale in, 4:1708
humanity and landscape composition relationship in, 4:1705
hybrid-human-natural systems and, 4:1708
International Association of Landscape Ecology and, 4:1706
land cover in Leon County, Florida and, 4:1709 (fig.), 4:1710–1711, 4:1710 (table)
landscape and wildlife conservation and, 4:1696–1698
landscape biodiversity and, 4:1701–1703
landscape dynamics and, 4:1708
landscape metrics and, 4:1707–1710, 4:1714–1715
methodology used in, 4:1708–1712
modeling techniques of, 4:1707
neutral model and process-based models in, 4:1710–1712, 4:1711 (fig.)
patch dynamics and, 4:1697, 4:1708–1709
patch mosaic theory and, 4:1696–1697
pattern metrics and, 4:1708–1710
pattern-process interactions and, 4:1707–1708
patterns and, 4:1707
process-based models and, 4:1712
randomization with fractal approach neutral model, 4:1710, 4:1711 (fig.), 4:1712
randomization with hierarchical randomization neutral model, 4:1710, 4:1711 (fig.), 4:1712
RULE software and, 4:1711 (fig.), 4:1712
simulated forest landscapes using neutral models and, 4:1711 (fig.)
size, edge, shape, diversity, and contagion metrics and, 4:1709–1710
society-centered, holistic view of, 4:1707
spatial autocorrelation and, 4:1707
spatial heterogeneity and, 4:1707
spatial pattern and ecological process relationship and, 4:1707
subjects included in, 4:1705, 4:1706 (fig.)
theoretical approaches to, 4:1707
Carl Troll and, 3:1458, 4:1705, 4:1714
Landscape interpretation, 4:1713–1715
aerial photographs and, 4:1714
chorological approach to, 4:1713
cultural geography and, 2:635–636
definition (Humboldt) of, 4:1713
disciplines related to, 4:1713
gender differences in, 4:1714
geomancy and, 3:1238–1230
geomorphology and plant ecology origins of, 4:1713
GIS technology and, 4:1715
historical context factor in, 4:1714
landscape architecture and, 4:1698–1701
landscape definition and, 4:1713
landscape design and, 4:1703–1705
landscape ecology and, 4:1714
landscape metrics and, 4:1714–1715
landscape analysis concept (Hoskins) and, 2:636
Peirce Lewis and, 4:1713, 4:1772–1773
Kevin Lynch and, 4:1714
masculine gaze concept and, 3:1196, 4:2043
mental mapping technique and, 4:1714
Don Mitchell’s work and, 4:1913–1914
palimpsest concept and, 4:2111–2112
physical environment knowledge and, 4:1714
place legibility concept and, 4:1714
principles of, 4:1713–1714
qualitative examination of social relations and, 4:1714
quantitative approach to, 4:1714–1715
reading the landscape and, 4:1713–1714
remote sensing and, 4:1715
seeing with eyes and thinking about what is seen and, 4:1713
structure, function, and change themes in, 4:1713
technology and, 4:1714–1715
theoretical influences on, 4:1714
Carl Troll and, 4:1714
urban landscape interpretation and, 4:1714
Landscape quality assessment, 4:1715–1718
affective theory (Urlich) on, 4:1716
applications for, 4:1717–1718
Cape Bauer, South Australia, and, 4:1717 (photo)
definition of, 4:1715
digital terrain model (DTM) and, 2:753–756
evolutionary perspectives on, 4:1716
experiential studies of, 4:1717
habitat theory (Orian) of, 4:1716
health benefits from, 4:1716
information-processing theory (Kaplan) on, 4:1716
local and national identities and, 4:1716
national parks and, 4:1716
origins of terms and, 4:1715
physical studies of, 4:1717
preference studies of, 4:1717
prospect-refuge theory (Appleton) of, 4:1716
Scenery Management System and, 4:1717
scenic quality and, 4:1715
science of measurement and, 4:1716–1717
self-image of a region, sense of place and, 4:1716
significance of, 4:1716
terms associated with, 4:1715
theoretical basis of, 4:1716
Visual Resource Management systems (VMS) and, 4:1717
World Heritage Areas and, 4:1716, 4:1717–1718
See also Landscape quality assessment: noted individuals
Landscape quality assessment: noted individuals
Jay Appleton, 4:1716
Stephen and Rachel Kaplan, 4:1716
Gordon Orian, 4:1716
Roger Urlich, 4:1716
Landscape restoration, 4:1718–1720
ecosystems application of, 4:1718
emotional, socioeconomic, and cultural elements of, 4:1718
environmental, socioeconomic, and cultural problems
relationships and, 4:1719
ethical issues, 4:1719
Everglades restoration example of, 2:1038–1042
forest restoration and, 3:1166–1168
integrated theoretical framework of, 4:1718
landscape perspective on, 4:1718
multifaceted nature of environmental problems and, 4:1718
multistakeholder approach to, 4:1719–1720
nongovernmental organizations and, 4:1719
“reference state,” original or predisturbance condition and, 4:1719
restore word origin and, 4:1718
revalorization process and, 4:1718–1719
reversibility issues and, 4:1719
sustainability and natural resource management themes in, 4:1718
variables in, 4:1718–1719
See also Environmental restoration
Landslide, 4:1720–1723
classification and causes of, 4:1720–1722
classification of mass movements and, 4:1721 (table)
debris avalanches and, 1:177–178, 1:178 (photo)
definition of, 4:1720
environmental consequences of, 4:1720, 4:1722
Gros Ventre Slide, Grand Teton National Park, Wyoming, 4:1721 (photo), 4:1723
landslide dams and, 4:1722
Landslides and Engineering Practice (Varnes), 4:1720
Loma Prieta, California, earthquake and, 4:1722 (photo)
mass wasting and, 4:1868–1871
research, 4:1723
rock avalanches and, 1:178–179
shear stress and shear strength factors in, 4:1720, 4:1722
shear stress factors and, 4:1720–1721
social consequences of, 4:1722–1723
Land tenure, 4:1723–1725
adaptation paradigm transition and, 4:1724
capital/poverty/property rights approach to, 4:1724
“community” aspect of tenure security and, 4:1724
decision making and, 4:1723
definition of, 4:1723
evidence-based “argument for claim” to land rights and, 4:1724
formal vs. informal or traditional vs. indigenous types of, 4:1724
identity-based claims to land and, 4:1724
loan collateral and, 4:1723
paradigms in, 4:1724
rights recognition approach to, 4:1724
tenure security and, 4:1723–1724, 4:1725–1726
types of, 4:1724
See also Distribution of resource access; Land tenure reform
Land tenure reform, 4:1725–1726
definition of, 4:1725
economic transactions approach to, 4:1725
ideological, social, political, and economic perspectives of, 4:1725, 4:1726
inequities, 4:1726
international development and, 4:1725
land policy reform and, 4:1725
land reform vs., 4:1725
legal and social relations concerning land and, 4:1725
political or ethnic motivations of, 4:1725
resistance to, 4:1726
social relations approach to, 4:1725
tenure security and, 4:1725–1726
See also Land reform
Land use and cover change (LUCC), 4:1726–1732
agricultural land use category, 4:1730
Anderson land use classification scheme and, 4:1728–1730, 4:1729 (table)
barren land use category, 4:1730
Burgess model of urban social structure and, 1:386, 1:387–388, 1:387 (fig.), 3:1112, 3:1449, 3:1458, 4:1728
changes in over time and, 4:1727
concentric zone model of, 4:1728
definition issues and, 4:1726
forest land use category, 4:1730
functional models of spatial interaction and trade and, 4:1727
geographic models of, 4:1727–1728
GIS and, 4:1732
land area classifications and, 4:1727
land-based classification standard system (LBCS) and, 4:1730–1731, 4:1730 (tables), 4:1731 (tables)
land cover and, 4:1726
locally unwanted land uses (LULUs) and, 4:1727
“not in my backyard” (NIMBY) advocacy and, 4:1727
open space and, 4:2091–2094
perennial snow or land use category, 4:1730
rangeland land use category, 4:1730
regulation of, 4:1726–1727
space-time convergence models and, 4:1727–1728
spatial characteristics of, 4:1727
Thünen concentric farm-land use model and, 4:1728
transportation planning and, 4:1728
tundra land use category, 4:1730
urban and built-up land classification of, 4:1729–1730, 4:1729 (table)
urban vs. rural land use regulation and, 4:1727
valuation of land uses and, 4:1727
wetland land use category, 4:1730
zoning laws and, 4:1727
See also Land use analysis; Land use and cover change (LUCC);
Land use and land cover mapping; Land use history; Land use planning

Land use analysis, 4:1733–1734
basic reasoning in, 4:1733
built land cover and, 4:1733
characteristics of scale and, 4:1733
definitions in, 4:1733
digital terrain model (DTM) and, 2:753–756
ecological risk analysis (ERA) and, 2:840–843
forest land cover and, 4:1733
GIS applications in, 3:1302–1305
land change model of, 4:1733
land cover definition and, 4:1733
methodological and conceptual challenges in, 4:1733
participatory exercises used in, 4:1734
quantitative and qualitative techniques used in, 4:1733
scenario analysis and, 4:1734
social data collection and, 4:1733
See also Agricultural land use; Distribution of resource access;
Land use; Land use and cover change (LUCC); Land use and land cover mapping; Land use history; Land use planning

Land use and cover change (LUCC), 4:1734–1739
aerial photography monitoring of, 4:1737
albedo of Earth’s surface and, 3:1335, 4:1735
biodiversity affected by, 4:1736
biogeochemical cycles affected by, 4:1736
biological impacts on, 3:1334–1335
built environment and, 4:298–300
carbon cycle research and, 4:1735
causes of, 3:1335
detection measurement of, 4:1738
consequences of, 4:1736–1737
coupled human and natural systems (CHANS) and, 2:602
cultural ecology and, 2:633
definitions, 4:1734
deforestation, hydrologic cycling in Sabah, Malaysia, and, 4:1737 (photo)
deforestation and, 2:695–699, 3:1334, 4:1734–1735
global environmental change and, 3:1334–335
human health affected by, 4:1736–1737
human impacts and, 3:1334
hydrologic cycle affected by, 4:1736
International Geosphere-Biosphere Programme (IGBP) and, 4:1735
International Geosphere-Biosphere Programme (IGBP) and, 4:1736
International Human Dimensions Programme (IHDP) on Global Environmental Change and, 4:1735
LUCC research and, 4:1734–1736, 4:1736 (fig.)
Man and Nature (Marsh, 1864) and, 4:1734, 4:2180
George Perkins Marsh and, 4:1734, 4:2180, 5:2584
measuring of, 4:1738
modeling of, 4:1738
Moderate Resolution Imaging Spectroradiometer (MODIS) monitoring of, 4:1738
monitoring of, 4:1737–1738
multitemporal imaging and, 4:1959–1960
NASA Land Cover and Land Use Change research program and, 4:1736
remote sensing monitoring of, 4:1737–1738
satellite imagery monitoring of, 4:1737–1738
transition matrices measurement of, 4:1738
Billie Lee Turner, II and, 6:2891–2892
USGS nationwide inventory of land cover and land use of, 3:1302
See also Land use; Land use analysis; Land use and land cover mapping; Land use history; Land use planning

Land use and land cover mapping, 4:1739–1741
applications of, 4:1740–1741
archived image data and, 4:1741
“cartographic standards” component of, 4:1739
canopy complexity theory and, 2:561
continuous space-and-time models and, 2:566
definitions, 4:1738
GIS applications in, 3:1302–1305
image interpretation and, 3:1534–1536
information extraction governed by rules of generalization and, 4:1739
integrated global monitoring system of, 4:1739–1740, 4:1739 (table)
international initiatives in, 4:1741
“interpretation process” component of, 4:1739
land cover in Leon County, Florida and, 4:1709 (fig.), 4:1710 (table)
land cover vs. land use and, 4:1739
land processes revealed through, 4:1739
maps and dynamic land monitoring of, 4:1740–1741
moderate-, fine-, and resolution satellite data and, 4:1740
multispectral image of U.S.-Mexico border, California, and, 4:1955 (photo)
multispectral imagery and, 4:1953
multitemporal imaging and, 4:1741, 4:1959–1960
Dawn Parker’s work in, 2:561
process of, 4:1739
secondary outputs of land cover characteristics and, 4:1739
in situ observations and, 4:1740
“thematic” component of, 4:1739
UN Land Cover Classification System and, 4:1740
uses of and importance of, 4:1739
See also Land use; Land use analysis; Land use and cover change
(LUCC); Land use history; Land use planning
Land use history, 4:1741–1744
definition of, 4:1741
elements of, 4:1742–1743
land use impact on global ecosystems and, 4:1741
natural archives and, 4:1742
remote sensing techniques and, 4:1742
research topics and methods and, 4:1742
scientific disciplines covered in, 4:1742
timeline of early agriculture, 4:1742
timeline of medieval Europe, 4:1742, 4:1743 (fig.)
timeline of European settlement in North America, 4:1742–1743
written sources and, 4:1742
See also Environmental history; Land use; Land use analysis;
Land use and cover change (LUCC); Land use and land
cover mapping; Land use planning
Land use planning, 4:1744–1747
built environment and, 1:298–300
California Environmental Quality Act and, 4:1746
California’s Coastal Protection Act (1972) controversy and, 4:1746
cellular automata used in, 1:370
changing revenue sources and, 4:1747
Coastal Zone Protection Act (1972, 1996) and, 4:1746
conservation zones and, 2:571–572
Constitutional requirements, 4:1744, 4:1746–1747
definition of, 4:1744
ecological risk analysis (ERA) and, 2:840–843
economic development policy and, 4:1745
Endangered Species Act (1973) and, 4:1746
environmental issues and, 4:1745–1746
general-law city vs. home rule (charter) city and, 4:1744–1745
large-scale land use planning and, 4:1746
legal framework for, 4:1744
local decision makers and economic interests link and, 4:1745
open space and, 4:2091–2094
Oregon Land Use Act (1973) and, 4:1746
participatory planning and, 4:2126–2129
planning, zoning, and local economic development in, 4:1745
state and local authority and, 4:1744–1745
“urban growth machine” relationship and, 4:1745
urban land use and greenhouse gas emissions issues and, 4:1746
water availability issues and, 4:1746
Yucca Mountain nuclear waste repository issue and, 4:1744
See also Land use; Land use analysis; Land use and cover change
(LUCC); Land use and land cover mapping; Land use
history; Regional environmental planning
Land-water breeze, 4:1747–1748
definition of, 4:1747
differential heating and, 2:741
land breeze and, 4:1747–1748
water breeze (sea breeze) and, 4:1747, 4:1748 (fig.)
Lane, Belden, 5:2408
Languages, geography of, 4:1748–1754
African languages, 4:1751
Afro-Asiatic languages, 4:1749, 4:1750 (fig.)
Asian languages, 4:1751–1753
Austro-Asiatic language, 4:1753
Baltic languages, 4:1749
Bantu or Niger-Kordofanian languages, 4:1751, 4:1753 (fig.)
Berber language, 4:1749
Celtic languages, 4:1749
Dravidian tongues, 4:1753
English language, 4:1749
Finnish and Estonian languages, 4:1749
geographic analysis of, 4:1754
Germanic languages, 4:1749
Hungarian language, 4:1749, 4:1751
Indo-European languages, 4:1749, 4:1750 (fig.)
Indo-Pacific language, 4:1753
William Jones and, 4:1749
Kushitic language, 4:1749
definition and geographic analysis in, 4:1754
language death and, 4:1753–1754
language definitions and, 4:1748
language families and, 4:1748
language functions and, 4:1748
Latin-based Romance languages, 4:1749
Malayo-Polynesian languages, 4:1753, 4:1753 (fig.)
Mandarin language, 4:1751, 4:1753
Mongol and Manchu languages, 4:1751
national languages and, 4:1749
Native American languages, 4:1753
poststructuralist authors and, 4:1754
printing technology and, 4:1749
representation of space and, 4:1754
semantic and historic relationship of, 4:1748
Semitic language, 4:1749
Sino-Tibetan language, 4:1751, 4:1752 (fig.)
Slavic languages, 4:1749
South American languages, 4:1753
Swahili trade language, 4:1751
Thai-Kadai language, 4:1753
Turkic languages, 4:1751
Ural-Altaic (Finno-Ugric) languages, 4:1749, 4:1751
La Niña, 4:1754–1757
atmospheric moisture and, 1:148
atmospheric Rosby wave train associated with, 4:1755, 4:1755 (fig.)
beach rotation and, 1:491
boreal winter and summer weather conditions and, 4:1755
decadal-scale variability of, 4:1755, 4:1757
definition of, 4:1754
delayed-oscillator theory, 4:1755
global atmospheric circulation changes and, 4:1755
global precipitation and temperature anomalies associated with
(1988), 4:1755, 4:1756 (fig.)
global warming trends and, 4:1757
“high” phase of El Niño-Southern Oscillation and, 4:1754–1755
mean sea level changes and, 1:497
ocean dynamical thermostat mechanism and, 4:1757
Pacific Decadal Oscillation (PDO) and, 1:164
George Philander and, 4:1754
Laos
ASEAN membership of, 1:128 (table), 1:129 (table)
Cold War and, 1:504
economically active females in, 3:1190 (table)
French colonization of, 1:515
income ratio relative to slum population in, 2006, 5:2644 (fig.)
opium and heroin production in, 2:797
Laplace, Pierre-Simon, 2:667
Lapse rate, 4:1757–1761
adiabatic temperature changes and, 1:15–17, 4:1757–1758,
4:1758 (fig.)
air parcel movement and, 4:1759–1761, 4:1759 (fig.)
applications of, 4:1758–1759
atmospheric hazards and, 4:1759–1761, 4:1759 (fig.), 4:1760 (fig.)
definition of, 4:1757
dry adiabatic lapse rate, 4:1757, 4:1758 (fig.)
environmental lapse rate, 4:1757, 4:1759 (fig.)
latent heat and, 4:1761–1762
mountain example of, 4:1758–1759, 4:1758 (fig.)
normal lapse rate, 4:1757, 4:1758 (fig.)
temperature inversion and, 4:1761 (fig.)
etopic adiabatic lapse rate, 4:1758, 4:1758 (fig.)
Larkin, Robert, 5:2247
Latent heat, 4:1761–1762
adiabatic temperature changes and, 1:15–17
definition of, 4:1761
International System of Units for, 4:1761
latent heat of evaporation and, 4:1761
latent heat of fusion and, 4:1761
ocean heat budget and, 4:1761–1762
temporal mean of latent heat, Mediterranean Sea and, 4:1761–1762, 4:1762 (fig.)
Latin America
adults and children living with HIV in 2007 in, 3:1437 (fig.)
agroecology emphasis in, 3:15
agroforestry in, 1:57, 5:2579
AGS library maps of, 1:71
“Alliance for Progress” land reform in, 4:1694
Andes expeditions, American Geographical Society and, 1:295
automobile industry in, 1:169
Isaiah Bowman’s work, 1:295
Cartagena Declaration on Refugees (1984) and, 5:2378
Central American Common Market and, 3:1550–1551
chain of exploitation from core to periphery and, 2:712–713
China’s foreign direct investment in, 3:1155
Cold War and, 1:304–505
colonialism, end of, 1:517
colonialization of, 1:511–512
COMECON membership and, 2:593
Conference of Latin Americanist Geographers (CLAG) and, 2:567–568
critical geographers in, 2:618
decolonization in, 2:691
deforestation in, 2:696, 2:698
democratization in, 2:702
dependency theory and, 2:712–713
export processing zones in, 2:1067
fertility levels in, 2:709
foreign aid to, 3:1152
gender inequalities in, 3:1589
geopolitics in, 1:1232
hacienda plantation form in, 5:2193
Heavily Indebted Poor Countries initiative (World Bank) and, 2:690
HIV/AIDS in, 3:1438
Alexander von Humboldt’s studies of, 3:1462
import substitution industrialism (ISI) in, 2:1064, 3:1550–1551
inequality geography and, 3:1587
land inequalities in, 4:1693
land privatization in, 5:2494
Latin American Free Trade Association and, 3:1551
Latin American Integration Association and, 3:1551
marine aquaculture in, 4:1854, 4:1854 (fig.)
Movimento Sem Terra (MST) in, 4:1948–1952
nationalism in, 1:509
neoliberalist policies in, 4:2012
newly industrializing countries in, 4:2021, 4:2022 (fig.), 4:2023
North American Free Trade Agreement (NAFTA) and, 4:2023
people living in extreme poverty and, 3:1082 (table)
population growth of, 5:2233 (fig.)
poverty rates in, 5:2274, 5:2275

Carl Sauer’s cultural landscape work in, 3:1458
sewage entering coastal zones of, 1:501
silver flows, 16th to 18th centuries and, 1:513 (fig.)
squatter settlements in, 5:2682
Third World debt crisis and, 2:688
trading blocs in, 3:1550–1551
undernourishment in, 3:1488 (table)
United Nations Economic Commission for Latin America (ECLA) and, 2:712–713
women’s lives in, 3:1097
Latitude, 4:1762–1763
degree differences in, 4:1763
authalic latitude, 4:1763
congriform latitude, 4:1763
coordinate geometry and, 2:577–579
coordinate systems and, 2:579–580
data and, 2:685–686
definition of, 4:1762
Earth’s coordinate grid and, 2:815–816
equator and, 2:1008–1009
Eratosthenes’s work and, 2:1010
groccentric latitude, 4:1763
grocery and, 3:1217–1219
grosetic latitude, 4:1763
geographic latitude definition and, 4:1763
isometric latitude, 4:1763
parametric latitude, 4:1763
rectifying latitude, 4:1763
units and formats of, 4:1763
Latour, Bruno
actor-network theory and, 1:8, 2:649, 5:2272
built environment, society and culture and, 1:298–299
modernity redefinition views of, 4:1931
networks, hybrid geometries and, 3:1503
nonrepresentational theory and, 4:2042
poststructuralism work of, 3:1469, 5:2272
scientific knowledge production and, 4:1996
space as series of networks and, 5:2272
Latvia, 3:1190 (table)
Lauri, Nina, 3:1193
Laurini, R., 4:1952
Lavellée, Théophile, 4:1896
Law, geography of, 4:1763–1766
built environment issues and, 4:1765
community and identity issues and, 4:1765
critical legal studies and, 4:1764, 4:1765
environmental law and, 2:965–967
geographies of resistance and, 4:1766
global space organization and, 4:1764
Guantanamo Bay, Cuba and, 4:1764
how low frames space and, 4:1765
law in urban planning policy and, 4:1766
“law-space nexus” and, 4:1764
legal aspects of geospatial information and, 4:1770–1772
legal connection between law and space focus of, 4:1764
legal geography and, 4:1763
lived geographies of law issues and, 4:1765–1766
methodological frameworks in, 4:1765
noncollaborative nature of, 4:1764
origins of relationship and, 4:1764
police work ethnographies and, 4:1765–1766
positivist and normative perspectives on, 4:1764
power emphasis in, 4:1765
privacy and autonomy issues and, 4:1766
property law and, 4:1764
research directions, 4:1765–1766
spatial organization of relations of power and rule emphasis in, 4:1765 “stateless” and “lawless” spaces and, 4:1764
trade and human migration issues and, 4:1765
"See also Crime, geography of"
Law, John, 1:8, 5:2273
Leach, Melissa, 2:921, 2:922–923
Learning regions, 4:1766–1768
agglomeration economies and, 1:31–32
American vs. European contexts of, 4:1766–1767
definition of, 4:1766–1767
economic geography and, 4:1767
evolutionary and institutional economics and, 4:1767
industrial areas and, 4:1766
innovation as contextualized social process and, 4:1766
Italy’s Emilia-Romagna area example of, 4:1766, 4:1767, 5:2519
knowledge geographies and, 4:1659–1663
knowledge spillover and, 4:1663–1664
narrow vs. broad innovation system definition and, 4:1767
post-Fordist societies as learning economies and, 4:1766
regional innovation system concept and, 4:1767–1768
regionally-based development coalitions perspective on, 4:1767
rational development coalitions and, 4:1767
Lebanon, 1:514, 3:1190 (table)
Lees, Loretta, 1:107–108
Lefebvre, Henri, 4:1768–1770
activism of, 4:1768–1768
alienation views of, 4:169
Gaston Bachelard and, 4:169
Henry Bergson criticized by, 4:1769
books written by, 4:1769
capitalism framework of space and, 5:2297
Manuel Castells and, 4:1769
critical geopolitics work of, 2:611
critical human geography work of, 2:617
cultural studies work of, 4:1768–1769
Michel de Certeau and, 4:1769
everyday life views of, 2:1042, 4:1768, 4:1769
existential Marxism work of, 2:1046–1047, 4:1769
David Harvey and, 4:1769, 5:2297, 5:2403
interdisciplinary nature of his work and, 4:1768
Don Mitchell, 4:1769
“public space” work of, 2:1047
Catherine Régulier and, 4:1769
rhythm analysis work of, 2:1043
Right to the City movement and, 5:2352
Edward Soja and, 4:1769, 5:2593
spaces of representation and, 5:2602
spatial character of capitalism and, 4:1768, 4:1769
urban geographies work of, 2:1047, 4:1769, 5:2352
visual knowledge views of, 4:2043
Legal aspects of geospatial information, 4:1770–1772
codes of ethics and, 4:1771
copyright issues, 4:1771
digital intellectual property and, 4:1771
evidentiary admissibility of GIS products issues, 4:1771–1772
Fourth Amendment, in our homes vs. public space and, 4:1771
Freedom of Information Act (FOIA) and, 4:1770
GIS evidence as “hearsay” and, 4:1771
GIS products as art issue and, 4:1771
GIS products’ authentication and, 4:1771–1772
intellectual property rights issues, 4:1770–1771
liability issues, 4:1770
privacy and confidentiality issues, 4:1771
property rights issues, 4:1770
public access and data ownership issues, 4:1770
World Intellectual Property Organization and, 4:1771
"See also Geospatial industry; Geospatial semantic web; Law, geography of; Privacy and security of geospatial information; Usability of geospatial information"
Leibniz, Gottfried, 5:2402
Leighly, John, 1:191
Leimgruber, W., 4:1852 (figs.)
Lejano, Raul, 3:1309
Lemkin, Raphael, 3:1199
Lengerich, E., 2:1061
Leontief, Wassily, 3:1399–1600
Leopold, Aldo
conservation movement and, 2:981
ecological interpretation of history work of, 2:929
land ethics work of, 2:926
prairie restoration work of, 5:2278
Sand County Almanac written by, 5:2278
LeSage, Jim, 5:2637
Lesotho
economically active females in, 3:1190 (table)
income ratio relative to slum population in, 2006, 5:2644 (fig.)
Levin, Simon, 5:2438
Levins, Richard, 4:2131
Lévi-Strauss, Claude, 5:2270, 5:2706
Levy, David, 3:1104
Lewis, Meriwether, 4:1773–1777
Lewis, Peirce, 4:1772–1773
AAG service of, 4:1772
academic career of, 4:1772
Axions for Reading the Landscape written by, 4:1773
cultural geography and landscapes work of, 4:1772–1773
landscape interpretation work of, 4:1773–1774, 4:1772–1773
space, place, and landscape work of, 4:1772–1773
Lewis and Clark expedition, 4:1773–1777
expedition details and, 4:1773–1777
geographical knowledge from, 3:1464
Thomas Jefferson and, 3:1464, 4:1642
Louisiana purchase and, 4:1774–1775 (fig.)
conceptions derived from, 4:1776
Northwest Passage search and, 4:1773
Westward expansion initiated by, 4:1776–1777
Ley, David, 4:1777–1778
Black Inner City as Frontier Outpost written by, 4:1777, 4:2122
Jim Duncan and, 4:1777
gentrification views of, 3:1207, 4:1777
Peter Gould and, 4:1777
humanistic geography work of, 4:1777–1778
landscape geography work of, 4:1777
Marxist geography work of, 4:1863
participant observation methodology of, 4:2122
postmodernism and, 5:2268
qualitative research work of, 4:2122
research topics of, 4:1777
service work of, 4:1777–1778
structure and agency in social analysis and, 4:1863
urban and social geography work of, 4:1777, 5:2567
urban ethnography work of, 3:1476, 4:1777, 5:2567
Leysong, Andrew, 4:1968
Liberia
economically active females in, 3:1190 (table)
independence of, 1:512
Libya
linear referencing and dynamic segmentation, 4:1784–1785
dynamic segmentation definition and, 4:1784
geometric nodes and arcs and, 4:1784
GIS in utilities management and, 3:1316
GIS software and, 4:1785
graph theory and, 4:1785
linear features examples and, 4:1784
linear referencing system and, 4:1784
logical data model in, 4:1785
mile-post tables and, 4:1784
utilities and transportation networks and, 4:1784
lightning, 4:1779–1783
atmospheric electrical charges and, 4:1779–1780
characteristics of, 4:1780–1781
within the cloud, between clouds, and cloud-to-ground types of, 4:1780
cloud electrification, 4:1779–1780
cloud-to-ground lightning and, 4:1780 (photo)
detection of, 4:1781
Earth’s electrical field and, 4:1779–1780
fatalities related to, 4:1781–1782
“forked” appearance of, 4:1781
Benjamin Franklin, 4:1779
geographical studies of, 4:1782
geographic visualization and mapping techniques and, 4:1782
GIS technology and, 4:1782
impacts of, 4:1781–1782
land use role in, 4:1782
lightning channels of, 4:1781
magnetic direction finders and, 4:1781
National Interagency Fire Center and, 4:1782
National Lightning Detection Network and, 4:1781
noninducting charging mechanism and, 4:1780
positive flash type of, 4:1781
property and agricultural damage from, 4:1782
regional lightning networks and, 4:1781
return stroke of, 4:1781
satellite lightning sensors and, 4:1781, 4:1782
scientific perspective on, 4:1779
thunder and, 4:1781
urban area lightning climatology studies and, 4:1782
wildland fires ignited by, 4:1782
Lillesand, Thomas, 4:1783–1784
academic career of, 4:1783
interdisciplinary research activities of, 4:1783–1784
publications authored by, 4:1783
Remote Sensing and Image Interpretation co-written by, 4:1783
remote sensing work of, 4:1783–1784
service work of, 4:1783–1784
literature, geography and, 4:1785–1788
cooking scene from Robinson Crusoe, 4:1788 (image)
“cultural turn” and, 4:1787
fields of, 4:1785
form vs. content of literature and, 4:1787
historical-geographical literary analysis and, 4:1786
humanistic geography, narratives of place and, 4:1786
literature as an aesthetic category, 4:1786, 4:1787
literature as site of ideological critique and, 4:1786–1787
Marxist geographers and, 4:1786
notions of truth and, 4:1787
postcolonial geographic imagination and, 4:1787
spatiality and urbanism and, 4:1787
spatiality and urbanism and, 4:1787
spatial metaphors and, 4:1785–1786
structures of feeling” and, 4:1787–1788
study of narrative and, 4:1785–1786
text and context relationship element in, 4:1785
truth and fiction relationship and, 4:1787
uneven distribution of cultural capital and, 4:1786–1787
See also Literature, geography and: noted individuals
literature, geography and: noted individuals, 4:1788
Walter Benjamin, 4:1788, 5:2298
Pierre Bourdieu, 4:1786, 4:1787
Anne Buttimer, 4:1786
Joseph Conrad, 4:1787
Daniel Defoe, 4:1787
David Harvey, 4:1788, 4:1862
James Joyce, 4:1788
Franco Moretti, 4:1786
Douglas Pocock, 4:1786
Edward Said, 4:1787
Yi-Fu Tuan, 4:1786
J. K. Wright, 4:1786
Lithuania
Clean Development Mechanism (CDM), carbon offsets and,
1:333 (fig.)
economically active females in, 3:1190 (table)
Liu, Tancohuo, 2:719–720
Liverman, Diana, 2:793
Livingston, David, 2:560
Livingstone, David, 4:1789–1790
books written by, 4:1789
Enlightenment as a geographical phenomenon views of, 2:910
geographical knowledge as a cultural product views of, 4:1789
Geographical Tradition written by, 4:1789
geography of scientific knowledge and, 4:1789
honors received by, 4:1789
re-interpretation of theory work of, 5:2231
science and religion conflict and, 4:1789
Llewelyn, Mark, 1:108
Lloyd, Robert, 2:977
Locality, 4:1790–1792
Changing Urban and Regional System (CURS, U.K.) and, 4:1790–1791
definition of, 4:1790
Economics and Social Research Council (U.K.), 4:1790–1791
empiricism and, 4:1790
interdisciplinary research, 4:1790–1791
Localities School and, 1:405
Marx’s historical materialism and, 4:1790
Doreen Massey’s work in, 2:852, 4:1790–1791, 4:1866–1867
significance of locality studies and, 4:1791
infrastructure networks in, 3:1597
national geographical society in, 3:1462
railroad line and, 5:2357, 5:2358
as supergentrification urban center, 3:1204
wildlife corridors in Wandsworth, southwest London, 6:2944 (photo)
See also United Kingdom

**Longitude**, 4:1802–1803
coordinate geometry and, 2:577–579
coordinate systems and, 2:579–580
datum and, 2:685–686
Earth’s coordinate grid and, 2:815–816
equator and, 2:1008–1009
Eratosthenes’s work and, 2:1010
goedeye and, 3:1217–1219
Longley, Paul, 3:1308, 5:2603
Lorde, Audreya, 3:1095
Lorentz, H. A., 1:89
Lorimer, Hayden, 4:2041
Los Angeles, California
command and control economy in, 1:304
community garden planning, Echo Park area of, 2:548 (photo)
environmental impact of, 2:940–941
as gateway port, 2:2254
Japan-South Korea World Baseball Classic game, Dodger Stadium, 5:2681 (photo)
population migration flow studies in, 1:417
smog in, 1:69
waste incinerator environmental justice issue in, 2:960
See also Los Angeles School

**Los Angeles School**, 4:1803–1805
changes in residential space and, 4:1804
Chicago School vs., 1:389, 4:1803
flexible production and, 4:1804
flexible production and, 4:1804
gentrification and, 4:1804
globalized urban areas, international economy and, 4:1804
Los Angeles as exemplar of contemporary capitalism and, 4:1803
postmodernism and, 4:1804
production systems as core of urban analysis and, 4:1803–1804
regulation and regime theory and, 4:1804
spatial structure of capitalism and, 4:1803
state urban planning processes and, 4:1804
urban division of labor and, 4:1803–1804
urban political economy and, 4:1803
See also Los Angeles School: noted individuals

Los Angeles School: noted individuals, 4:1804
Mike Davis, 4:1803
Michael Dear, 2:688, 4:1803, 4:1804
Allen Scott, 4:1803, 4:1863, 5:2519–2520
Edward Soja, 2:688, 4:1803, 5:2593
Michael Storper, 4:1803, 4:1863, 5:2695–2696

Lösch, August, 4:1805–1806
central place theory and, 1:410, 4:1805
Walter Christaller and, 1:410, 4:1805
Economics of Location written by, 4:1798
hierarchy of places work of, 4:1805
logistical positivism of, 4:1805
regional science and, 4:1805
Joseph Schumpeter and, 4:1805
Spatial Organization of the Economy written by, 4:1805
Loudon, John, 4:1699
Louisiana
hot rooftops, Baron Rouge, Louisiana, 6:2947 (image)

Hurricane Camille (1969), 3:1500
Hurricane Katrina and, 3:1493–1494
hurricanes in, 3:1503
Louisville, Kentucky, 4:1821

**Love Canal**, 4:1806–1808
brownfields and, 4:1808
Citizen’s Clearinghouse for Hazardous Waste and, 4:1808
Comprehensive Environmental Restoration, Compensation, and Liability Act and, 4:1808
discovery of contamination in, 4:1806–1807
environmental monitoring of, 4:1805–1806, 4:1807 (photo)
Lois Gibbs and, 4:1805–1806
hazardous waste management prior to, 4:1806
hazardous waste policy influenced by, 4:1807–1808
historical geography of, 4:1806
Hooker Chemical and Plastics Corporation and, 4:1805
locally unwanted land uses (LULUs) and, 4:1792
Superfunds and, 4:1808
Lovejoy, Thomas, ecosystem decay work of, 2:858, 2:859, 2:861
Lovelock, James, 1:204, 2:819, 3:1175
Leveridge, Scott, 5:2394
Lowenthal, David, 2:977, 3:1435, 3:1476, 4:2167
Luckman, T., 5:2297
Lukacs, Georg, 4:1862
Lund School of cultural geography (Sweden), 2:745
Luxembourg
European Union (EU) membership of, 2:1035
foreign aid flow from, 3:1152
Luxembourg, Rosa, 4:1862
Lyde, Lionel, 2:848
Lynch, Kevin, 4:1714, 5:2609–2610
Lynch, William, 4:1808–1809
biblical vs. science debates and, 4:1808–1809
Dead Sea Bible references and, 4:1808, 4:1809
Dead Sea explored and mapped by, 4:1808–1809
publications of, 4:1809

Maathai, Wangari, 3:1610
MacArthur, Robert, theory of island biogeography and, 1:199, 3:1631 (fig.), 4:1696, 5:2672
Macau, 1:514
MacCabe, Charles, 3:1219–1220
Macchu Pichu, 1:295
MacEachren, A. M., 2:789, 2:1061
MacEachren, Alan, 4:1811–1812
cartography and GIScience research fields of, 4:1811–1812
(Cartography) diagram published by, 4:1811
criticism of, 4:1812
dynamic and interactive displays and, 4:1811
geographic visualization of, 4:1811
GeoVISTA Center, Penn State established by, 4:1811
geovisual analytics work of, 4:1811–1812
heartland geopolitical model and, 4:1812
How Maps Work written by, 4:1811
map categorization work of, 4:1811
visual analytics and, 4:1811
Macedonia, 3:1190 (table)
Machlup, Fritz, 3:1593
MacKenzie, Donald, 3:1116–1117
Mackinder, Sir Halford, 4:1812–1813
Cold War predictions and, 4:1813
criticism of, 4:1812–1813
Euro-Asian landmass focus of, 3:1464, 4:1812–1813
Geographical Pivot of History written by, 3:1464, 5:2222
geopolitical Heartland model of, 4:1812–1813
geopolitics work of, 2:611, 1:3251, 3:1464, 4:1812–1813,
1:1896, 5:2222, 5:2404
Karl Haushofer influenced by, 3:1407–1408
Heartland theory of, 4:1813, 5:2222
holistic approach of, 4:1992
imperial rivalry and, 5:2404
London School of Economics and, 3:1251
RGS award of, 5:2487
Madagascar
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
forest fragmentation in, 3:1159
Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)
maritime culture of, 4:1854 (fig.)
new farming methods in, 3:1536 (photo)
tropical deciduous forest in, 1:230, 1:231, 1:232 (photo),
1:233 (photo)
tropical monsoon climate in, 1:455
tropical rain forest of, 1:234, 1:236
tropical savanna in, 1:239

tropical scrub in, 1:244
Madeira, 2:1051
Madison, James, 5:2584
Magellan, Ferdinand, 4:1813–1815
Bartolomé de las Casas and, 4:1813
circumnavigation of the globe by, 3:1461, 4:1813–1815, 4:1814
(fig.), 4:2179
expedition’s first-hand accounts and, 4:1815
Mahan, Alfred Thayer, 4:1815–1816
geostrategic importance of sea power focus of, 4:1815
Influence of Sea Power Upon History written by, 4:1815, 4:1893
military geography work of, 4:1893
Theodore Roosevelt’s “Great White Fleet” and, 4:1816
U.S. colonialism and, 4:1815–1816
Maine, 1:534
Malacca, 1:514
Malacca Straits, 1:515
Malanson, G., 2:866 (photos)

Malaria, geography of, 4:1816–1819
anopheles mosquito and, 4:1816
cultural interventions and, 4:1817
DDT insecticide control strategy and, 4:1817
developing world and, 2:726–727
genetic immunity to, 4:1817
Global Malaria Eradication Program and, 4:1817
global warming and, 4:1817
HIV/AIDS relationship with, 2:727
human resistance differences and, 4:1817
infection exposure resistance to, 4:1817
parasite characteristics and, 4:1816–1817
plasmodium parasite and, 4:1816
symptoms of, 4:1816
underdevelopment relationship to, 4:1817
wetland drainage and, 4:1817
world malaria transmission areas and, 4:1818 (fig.)
Malawi, 3:1190 (table)
Malaysia
acid rain in, 1:7
APEC membership of, 1:121
ASEAN Free Trade Area and, 1:130
ASEAN membership of, 1:127, 1:128, 1:128 (table), 1:129,
1:129 (table)
biodiesel production in, 1:203–204
biofuels produced in, 1:203–204, 202

British colonization of, 1:515
Clean Development Mechanism (CDM), carbon offsets and,
1:335 (fig.)
deforestation from land use and cover change, Sabah, 4:1737 (photo)
deforestation in, 2:696
economically active females in, 3:1190 (table)
forest fragmentation in, 3:1159
guerrilla conflicts in, 2:692
industrialization in, 3:1583, 4:2020, 4:2022, 4:2022 (fig.)
Japanese electronics industry in, 2:885
Malay archipelago and, 1:105
Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)
marine aquaculture in, 4:1854 (fig.)
plantations in, 5:2192
rice farming in, 1:48 (photo)
satellite dishes illegal in, 2:750
sea plantations Cameron Highland, Pahang, 5:2193 (photo)
tropical rain forest of, 1:234, 1:237, 1:237 (photo), 1:238 (photo)
Vision 2020 and, 4:2022
Mali, 3:1190 (table)
Malinowski, Bronislaw, 5:2323
Malkki, L., 5:2380
Mall of America, Bloomington, Minnesota, 1:107,
2:574 (photo), 2:575
Malpas, Jeff, 4:2168
Malta, European Union (EU) membership of, 2:1035
Malthusianism, 4:1819–1820
agricultural intensification and, 1:36
carrying capacity concept and, 5:2238–2239
definition of, 4:1819
demographic transition and, 2:707
environmental security scholarship and, 2:999, 4:1820
Essay on the Principle of Population (Malthus) and, 4:1819, 4:2015
fertility restrictions of families and, 4:1819
international policy and, 4:1820
John Maynard Keynes and, 4:1820
Thomas Robert Malthus and, 4:1819, 4:2015, 6:2747
natural resources finitude and, 4:1820, 4:2015
political economy meaning and, 5:2214
population and land degradation debate and, 5:2233–2234
Population Bomb (Ehrlich) and, 4:1820
“population principle” of famine and, 3:1082–1083, 3:1586
“principles” of population and, 4:1819
resource wars, or greenwar concepts and, 4:1820
social intervention via social welfare and, 4:1819
See also Neo-Malthusianism; Sustainable development
Mamdani, Mahmood, 3:1570
Manchuria, 1:514
Manson, Steven, 2:560
Manufacturing Belt, 4:1820–1824
agglomeration economics and, 4:1821
creative destruction pattern and, 4:1822, 4:1824
decline and restructuring of, 4:1822–1824
dynamics and geography of, 4:1821–1822
industrialization and, 3:1580–1581, 4:1820–1821
Industrial Revolution and, 3:1584
Mittal Steel’s Cleveland Works, Ohio, 4:1823 (photo)
regional specialization and, 4:1821
Rust Belt and Snowbelt and, 4:1824
second industrial revolution (1880s) and, 4:1822
Sunbelt and, 4:1822
trade unions and, 4:1822
westward expanding industrial belt and, 4:1821
Manzer, Ronald, 2:874
Map evaluation and testing, 4:1824–1825
  cartographic modeling and, 4:1824
definition of, 4:1824–1825
  linear referencing and dynamic segmentation, 4:1784–1785
local, focal, and zonal operations categories and, 4:1825
raster data model and, 4:1824–1825
self-organizing maps and, 5:2526–2628
spatial analytic tasks decomposed by, 4:1825
spatial scope of operations and, 4:1825
spatio-temporal data sets and, 4:1825
dimensional spaces and, 4:1825
for vector fields, 4:1825
Map animation, 4:1825–1828
Adobe Flash and Microsoft PowerPoint tools and, 4:1826
ArcGIS, Google Earth, and NASA World Wind and, 4:1826
categories of, 4:1826
definition of, 4:1825
duration, rates of change, and order of maps variables in, 4:1826
dynamic and interactive displays and, 2:804–808
early GIS animations and, 4:1825–1826
GIS and satellite remote sensing and, 4:1826
history of, 4:1825–1826
technology advances and interactive animation in, 4:1826–1827
visual variables and, 4:1826, 4:1827 (fig.)
See also Map animation: noted individuals
Map animation: noted individuals
David DiBiase, 4:1826
Mark Harrower, 4:1826
Norman Thrower, 4:1826
Waldo Tobler, 4:1826
Map design, 4:1828–1832
aesthetic considerations, visual design lessons, 4:1828–1829
base map and, 4:1829–1830
cartograms and, 1:338–339
cartographic abstraction in, 4:1829–1830
color in map design and, 1:516–522
data classification schemes and, 2:677–679
directional indicator and, 4:1831
dot maps and, 2:787–790
elements of a map, 4:1830–1831
figure achieved by closure vs. differentiation, or contour and, 4:1828, 4:1829 (fig.)
figure-ground relationships and, 4:1828, 4:1829 (fig.)
flow maps and, 3:1138–1139
inset maps and, 4:1831
internal consistency and, 4:1828
interparallelism form of internal consistency and, 4:1828
legend and, 4:1831
map animation and, 4:1825–1828
map generalization and, 4:1835–1841
map image definition and, 4:1828
map projections and, 4:1841–1849
map visualization and, 4:1849–1850
neat lines and, 4:1831
scale indicator and, 4:1831
selection and generalization of themes in, 4:1830
simplicity and, 4:1829
symbolization strategies in, 4:1830
title and, 4:1831
21st Century map design and, 4:1831
visual balance and, 4:1828
Map evaluation and testing, 4:1832–1833
effectiveness and efficiency issues of maps and, 4:1832
functional map use research and, 4:1832
interview technique of, 4:1833
map functions and, 4:1832
map generalization and, 4:1835–1841
map production process and, 4:1832
map visualization and, 4:1849–1850
new map types and, 4:1832
observation technique of, 4:1833
participant observation technique of, 4:1833
perceptual/cognitive map use research and, 4:1832
product analysis technique of, 4:1833
qualitative and quantitative character of, 4:1833
questionnaire technique of, 4:1833
user-centered design approach and, 4:1832
user-centered design approach and, 4:1832
Map generalization, 4:1833–1841
agent-based modeling and, 4:1834
application of cartographic license concept and, 4:1836, 4:1836 (fig.)
cartographic generalization, 4:1834, 4:1836, 4:1836 (fig.), 4:1837, 4:1838 (fig.)
“cartographic syntax” framework research and, 4:1840
data enrichment concept and, 4:1837
decision-making in, 4:1837
definition of, 4:1833–1834
digital paradigm shift and, 4:1834
evaluation of, 4:1837, 4:1839
“eyes of the cartographer” requirement and, 4:1834, 4:1839, 4:1840 (fig.)
isopleth maps and, 3:1638–1639
model and cartographic generalization and, 4:1834–1836, 4:1836 (fig.)
model generalization, 4:1834, 4:1836–1837, 4:1836 (fig.), 4:1838 (fig.)
multiscale processes interaction and, 4:1833–1834
Portsmouth, England, at three scales and, 4:1834, 4:1835 (fig.)
primary digital landscape model (DLM) and, 4:1834, 4:1836 (fig.)
retail park in Southampton, England, 4:1838 (fig.)
secondary DLMs and, 4:1834, 4:1836 (fig.)
techniques to improve map legibility and, 4:1834 (fig.), 4:1839 (fig.)
Voronoi modeling example and, 4:1837, 4:1839, 4:1840 (fig.)
Map projections, 4:1841–1849
Albers equal-area projection, of North America, 4:1846 (fig.), 4:1847
Buckminster Fuller or “Dymaxion map” projection, 6:3169
compromise projections and, 4:1842
conformity (shape) property of, 4:1842
coordinate geometry and, 2:577–579
distance property of, 4:1842
direction property of, 4:1842
distance property of, 4:1842
equal area or equivalence property of, 4:1842
geodesy and, 3:1217–1219
geometric measures and, 3:1240–1241
Good's Interrupted Homolosine projection and, 3:1351, 3:1351 (fig.)
interrupted Goode homolosine projection, 3:1351, 3:1351 (fig.), 6:3169
Lambert conformal conic projection, of North America, 4:1846 (fig.), 4:1847–1848
Mercator projection, 4:1843 (fig.)
Mollweide projection, 4:1844, 4:1844 (fig.), 6:3152–3153, 6:3169
Plate Carrée projection, 4:1844, 4:1846 (fig.)
portolan charts and, 5:2251–2252
projection definition and, 4:1841
projection properties and, 4:1842
properties of matching purpose of, 4:1841
Robinson projection, 4:1844, 4:1845 (fig.)
samples of, 4:1842–1848
Sinusoidal projection, 4:1844, 4:1846 (fig.), 4:1847
T-in-O maps and, 6:2844–2846
variables in, 4:1841–1842
visualization of, 4:1841–1842
Winkel Tripel projection, 4:1844, 4:1845 (fig.)
See also Mercator, Gerardus
MapQuest, 3:1258, 3:1260, 3:1284, 3:1308
Maps
al-Idrisi medieval geographer, map maker and, 1:66–67, 4:2179
Anaximander’s map (recreation), 1:74–75, 1:74 (fig.)
cadastral map examples, 1:313–315 (figs.), 1:317 (fig.)
cancer maps, 1:322 (fig.), 1:324 (fig.)
Euroregions of cross-border cooperation and, 2:631 (fig.)
mobile map services spatial applications and, 1:307
See also Agricultural maps; Argumentation maps; Cartography;
Cartography, history of; Map projections; Map visualization;
Political maps; United States: maps; World maps
Map visualization, 4:1849–1850
accessibility and applicability of, 4:1849
active spatial analysts and mapping participants and, 4:1849
analog to digital cartography shift and, 4:1849
cartograms and, 1:338–339
color in map design and, 1:516–522
data classification schemes and, 2:677–679
definition of, 4:1849
dynamic and interactive displays and, 2:804–808
environmental mapping and, 2:976
familiarity with and expectations from, 4:1849–1850
flow maps and, 3:1138–1139
geovisualization field and, 4:1849
information technology advancements and, 4:1849
isopleth maps and, 3:1638–1639
Werner Kuhn’s work in, 4:1672–1673
map animation and, 4:1825–1828
map generalization and, 4:1835–1841
media mapping and, 4:1951–1953
multivariate mapping and, 4:1963–1967
nanogeography and, 4:1849
viewer interaction and, 4:1849
See also Environmental mapping
Marble, Duane, 1:192, 3:1466, 5:2603
Marc, Franz
Dream, 76
Elephant, 77
Marcel, Gabriel, 2:1046
Marcus, Melvin G., 4:1850–1851
academic career of, 4:1850
glaciology and mountaineering interests of, 4:1850
human-environment interactions studies of, 4:1850
John Russell Mather and, 4:1872
service work of, 4:1850
Marcuse, Herbert, 3:1419, 3:1420, 4:1862
Marginal regions, 4:1851–1853
agents of social transformation and innovation and, 4:1852
associated region, 4:1851
dead angle place or region, 4:1851
definition of, 4:1851
different ways to view, 4:1851–1853
diversity of human societies perspective on, 4:1851–1852,
4:1852 (fig.)
geometrical marginality and, 4:1852
gross domestic product (GDP) per capita perspective on, 4:1851
isolated region, 4:1851
materialistic perspective on, 4:1851, 4:1852 (fig.)
peripheries vs., 4:1851
political perspective on, 4:1852
positive side to, 4:1852
social marginality perspective on, 4:1851, 4:1852 (fig.)
Margulis, Lynn, 1:204
Marine aquaculture, 4:1853–1855
aquatic organisms diversity and, 4:1853
balancing growth with sustainability and, 4:1853–1855
definition of, 4:1853
diversity in, 4:1853
environmental impacts of, 4:1854
fish farming and, 3:1119–1121
nations most reliant on, 4:1854 (fig.)
opponents of, 4:1854–1855
production and distribution in, 4:1853
social tensions in coastal communities and, 4:1854
statistics, 4:1853
water quality degradation issue and, 4:1854
wetlands privatization and, 4:1854
world’s fisheries decline and, 4:1853
See also Aquaculture
Maritime trade. See Ports and maritime trade
Mark, David M., 4:1855–1856
academic career of, 4:1855
algorithmic flow modeling work of, 4:1855
cross-disciplinary collaboration of, 4:1856
D8 flow routing algorithm developed by, 4:1855
ethnophysiology and, 4:2080
ethnophysiology work of, 4:1856
fractal nature of geographic phenomena work of, 4:1855
GIScience research of, 4:1855–1856
publications of, 4:1856
service work of, 4:1856
topographic data modeling work of, 4:1855
triangulated irregular networks (TINs) work of, 4:1855
Market-based environmental regulation, 4:1856–1858
Acid Rain (control) Program and, 4:1857
carbon trading and carbon offsets and, 1:329–335
cost-effectiveness focus of, 4:1856–1867
criticisms, 4:1858
definition of, 4:1856
deposit refund systems and, 4:1857
environmental charge/tax systems and, 4:1857
EPA’s Acid Rain Control Program and, 4:1867
greenhouse gas trading between nations, Kyoto Protocol and, 4:1857
neo-liberal features of, 4:1856
pay-as-you-throw or unit-pricing policy and, 4:1857
payments for environmental services (PES) and, 4:1858
pollution tax and, 4:1857
Superfund Program, 4:1857
tradable permits and, 4:1857
water trading permit systems and, 4:1857
See also Corporate voluntary environmental initiatives and self-regulation
Markusen, Ann, 1:119, 4:1902
Marsh, George Perkins, 4:1858–1859
conservation work of, 2:569, 2:928, 2:2180, 5:2515, 5:2584
environmental history and restoration work of, 2:991–992
as first environmentalist, 4:1858
forest management practices and, 4:1859, 5:2584
land use and cover change (LCCC) work of, 4:1734
Man and Nature written by, 2:928, 2:991, 4:1858, 4:1859, 4:2180
Smithsonian Institution and, 4:1859
world travels of, 4:1859
Marx, Leo, 1:480–481
Marshall Islands atoll, 1:166, 1:166 (photo)
Martin, Deborah, 5:2575
Martin, Philippe, 2:781
Martineau, 1:512
Marx, Karl, 2:544 (photo)
  classic social theory of, 3:1277
  critical human geography and, 2:617
  cultural turn concept origins and, 2:645
  historical record a series of production modes and,
    3:1433–1434
  modernity and commodification relationship and, 4:1936
  political economy meaning and, 5:2214
  social evolution theories of, 2:729
Marx, Leo, 2:1075
Marxism, geography and, 4:1859–1865
  academic versions of, 4:1862
  anarchism and geography and, 1:73, 1:74
  body geography and, 1:288
  books written by, 4:1860
  bourgeoisie vs. proletariat and, 1:423
  capitalism must grow to survive concept and, 4:1861, 4:1864
  centrality of labor, political economy and, 4:1860
  circuits of capital and, 1:410
  class–capitalism, and uneven development themes in, 3:1189, 4:1861
  class and nature and, 1:423–424
  commodities as embodiments of social relations and, 2:573
  critical human geography and, 2:617
  critical studies of nature and, 2:624–625
  criticism of, 4:1864
  cultural geography and, 4:1863
  denaturalization of nature and, 4:1863–1864
  dependency theory and, 4:1862
  dialectics and, 4:1860
  economic determinism and, 4:1860
  economic landscape changes over time and, 2:666
  environmental justice and, 2:625, 4:1863
  environmental politics and, 4:1863
  existential Marxism and, 2:1046–1047
  feminist scholars and, 4:1863
  foundations of, 4:1860–1861
  Frankfurt School version of, 4:1862
  gender and geography and, 3:1188–1189
  gender and nature and, 3:1196
  gendered division of labor and, 3:1196
  geographies of consumption and, 2:573
  historical materialism and, 4:1860, 4:1862
  holistic focus of structuralist ontology and, 4:1860
  humanistic geography and, 4:1786
  human-nature interactions and, 4:1863
  human relations with the natural world and, 1:423
  inequality geography and, 3:1587, 3:1588
  international political economy and, 4:1862
  labor theory of value and, 4:1860–1861
  Limits to Capital (Harvey) and, 3:1405, 4:1862, 5:2350–2351
  logical positivism criticism and, 4:1802
  Malthusianism and, 4:1863
  Maoist version of, 4:1861
  Marxism in geography and, 4:1862–1864
  Marxist crisis theories and, 2:609–610
  Marxist spatial analysis and geography and, 2:617
  Karl Marx’s and worldview and, 4:1859–1862
  Marx’s publications and, 4:1860
  natural hazards, class, race, and gender relations and, 4:1863–1864
  neo-Marxist dependency theory and, 2:712
nonstructuralist version of, 4:1862
overproduction issue and, 4:1861
panopticon and, 4:2116–2117
place and, 5:2186
political ecology and, 4:1863, 5:2211–2212
political geography and, 5:2223
production cycle (Harvey) and, 4:1862, 5:2669
production vs. consumption contraction and, 4:1861
radical geography and, 4:1861, 5:2223
resistance geographies and, 5:2441–2442
ruling class as the “public interest” and, Thompson:1863
social and intellectual impact of, 4:1859
social constructivism and, 4:1863
socialism and, 5:2571
Social Justice and the City (Harvey) and, 5:2442
social justice geographies and, 4:1644
sociospatial relations under capitalism and, 3:1430
Edward Soja and, 5:2593
space as a social and historical product (Lefebvre) and, 4:1862, 4:1864
Stalinist version of, 4:1861
state linked to class interests and, Thompson:1863
structuralist ontology and, 4:1860
structuration theory (Giddens) and, 4:1863
structure and agency in social analysis and, 4:1863
subaltern studies and, 5:2711–2712
“theory of scale” and, 5:2506–2507
underdevelopment and, 4:1862
uneven development under capitalism and, 3:1340, 4:1862
Union of Socialist Geographers and, 4:1862
urban division of labor and, 4:1863, 4:1864
Urban Question (Castells) and, 3:1364
use values vs. exchange values and, 4:1860–1861
Richard Walker and, 6:3043–3044
workers’ movements and, 4:1860
world-systems theory and, 4:1862
See also Communism and geography; Marxism, geography and:
  noted geographers and scholars; Socialism and geography
Marxism, geography and: noted geographers and scholars
  Thodor Adorno, 4:1862
  Louis Althusser, 4:1863, 5:2270
  Walter Benjamin, 4:1862
  Brian Berry, 1:193
  James Blaut, 4:1862
  William Bunge, 4:1862
  Manuel Castells, 1:365–366
  Condorcet, 4:1860
  Denis Cosgrove, 4:1863
  Frederich Engels, 4:1859
  Michel Foucault, 4:1863
  Charles Fourier, 4:1860
  Andre Gunder Frank, 4:1862
  Antonio Gramsci, 4:1862
  David Harvey, 1:193, 3:1404, 3:1405, 3:1467, 4:1862, 5:2350
  Georg Hegel, 4:1860
  Max Horkheimer, 4:1862
  Henry Lefebvre, 4:1768–1770, 4:1862
  David Ley, 4:1863
  Georg Lukacs, 4:1862
  Rosa Luxemburg, 4:1862
  Herbert Marcuse, 4:1862
  Don Mitchell, 3:1430, 4:1863, 4:1913
  Richard Peet, 4:2144
  David Ricardo, 4:1860
  Comte de Saint-Simon, 4:1860
  Allen Scott, 4:1863
media as text, and textual metaphor use and, 4:1876
media in different geographic discourses and, 4:1875
media to craft place images and, 2:541
“the medium is the message” phrase and, 4:1874
“mixed media” and, 4:1876
nationalism and media culture and, 4:1875
photography and, 4:2176–2178
postmodernism and, 4:1876
powerful transformative potential of, 4:1874–1875
public and private interconnections and, 4:1875
qualitative methodology and, 4:1876
spatiality of social interaction and, 4:1876–1877
sectorial topoanalysis (Bruno) and, 4:1876
visualization approaches and, 4:1875
visual vs. aural geographic metaphors and, 4:1875, 4:1876

Medical geography, 4:1877–1879
behavioral role in, 4:1877
cancer geography and, 3:1320–324
cholera and, 1:401–403
cluster analysis applied to, 4:1878
critical approaches to, 4:1878
critical race studies and, 4:1878
databases and analytical tools development, 4:1879
digitization of health information and, 4:1878
feminist methods and, 4:1878
future directions, 4:1879
genetics role in, 4:1877
GIS and spatial analysis of, 4:1878
GIS health care applications and, 3:1300–1302
global political economy factors research and, 4:1879
habitat component in, 4:1877–1878
habitats of disease vectors and, 4:1879
Peter Haggett’s work in, 3:1399–1400
health applications of remote sensing and, 4:1879
HIV/AIDS studies and, 4:1879
human ecology and, 4:1877–1878
human-environment interactions and, 4:1877
impact of climate change studies and, 4:1879
integrative nature of health and, 4:1877
issues addressed by, 4:1877
local, regional, and global contexts of, 4:1877
malaria geographies and, 4:1816–1819
migration and health studies and, 4:1879
multidisciplinary nature of, 4:1878
postmodern perspectives on, 4:1878
power structures and, 4:1878
structuralist interpretation and, 4:1878

See also Carcinogens; Disease, geography of; Drugs, geography of;
GIS in health research and health care; Health and health care, geography of; HIV/AIDS, geography of

Mediterranean Sea
Greek and Roman exploration of, 2:1050
map of from portolan atlas (ca. 1544), 5:2225 (fig.)
sewage discharge into, 1:501
temporal mean of latent heat and, 4:1762 (fig.)
Viking exploration of, 2:1051
Meek, Fielding Bradford, 3:1409
Meigs, Peveril, 1:192
Meinig, Donald, 4:1879–1880
core, domain, and sphere concepts of, 4:1880
criticism of, 4:1880
cultural landscape work of, 2:642, 4:1879, 4:2111
“Geography as an Art” views of, 1:118
language focus of, 4:1880
palimpsest landscape and, 4:2111

regional geography work of, 4:1880
Shaping of America written by, 3:1430, 4:1879–1880
understanding of place work of, 3:1431–1432
Meliker, J. R., 1:324 (figs.)

Mental maps, 4:1881–1883
aligning spatial information and, 4:1882–1883
cartography, wayfinding and, 1:347, 1:350
cognitive information source and, 4:1881
cognitively salient environmental elements and, 4:1882
definition of, 4:1881
distortions in, 4:1881–1883
exteroceptive senses and, 4:1881
Peter Gould’s work in, 3:1356
hierarchical organization of spatial knowledge and, 4:1882, 4:1882 (fig.)
organizing spatial knowledge and, 4:1882–1883
“007 principle” (Clark) and, 4:1882
proprioceptive information and, 4:1881
secondary sources and, 4:1881
simplification of complex spatial relationships and, 4:1882
terms synonymous with, 4:1881
urban landscape interpretation and, 4:1714
vestibular information and, 4:1881
visual information and, 4:1881

Menzie, Nicholas, 2:552

Mercator, Gerhardus, 4:1883–1885
Age of Exploration and, 4:1883
atlas (term) coined by, 4:1883
cartography work of, 1:342, 1:350, 1:353 (fig.), 3:1461
European expansionism aided by, 4:1884
Mercator projection map of, 4:1843, 4:1843 (fig.), 4:1883–1884, 4:1884 (fig.), 6:3168
Ortelius and, 4:2106
Ptolemy’s Geography and, 4:1883
Merchang, Carolyn, 2:818
Merchant, Carolyn, 2:819, 3:1100
Merleau-Ponty, Maurice, 4:2042, 4:2166, 4:2168
Mesoamerica
as center of domestication, 1:376
indigenous cartographies in, 3:1561

Metadata, 4:1885–1886
analysis and decision making use of, 4:1885
applications of, 4:1885
definition of, 4:1885
error propagation and, 2:1011–1012
formats for, 4:1885
information contained in, 4:1885
interoperability and spatial data standards and, 3:1623–1625, 4:2078, 4:2085
maintenance and documentation of, 4:1885
national and international standards of, 4:1885
Open Source GIS and, 4:2091
role played by, 4:1885
situation evaluation of data usability and, 4:1885

Metropolitan area, 4:1886–1888
census tracts and zip-code-based areas and, 4:1886, 4:1888
“consolidated” vs. “primary” metropolitan areas and, 4:1886
definition of, 4:1886
largest U.S. metropolitan areas, 2007, 4:1888 (table)
large U.S. metropolitan areas and, 4:1887 (fig.)
as legal units, 4:1886
“megapolis” concept (Gottmann) and, 3:1355–1356
New England County Equivalent Metropolitan Areas and, 4:1886
related settlement terms and, 4:1888
rules for delimitation of, 4:1886, 4:1888
Microwave/RADAR data, 4:1888–1890
advantages over optical sensors of, 4:1888–1889
applications of, 4:1889–1890, 4:1889 (figs.), 4:1890 (fig.)
backscatter and, 4:1889
Doppler effect in processing and, 4:1889

Middle East
adults and children living with HIV in 2007 in, 3:1437 (fig.)
Afro-Asiatic language in, 4:1750 (fig.)
Arab exploration of, 2:1053
birthrates in, 2:708
British Empire colonies in, 1:509
cholera in, 1:401
CO₂ emissions in, 3:1377
Cold War and, 1:504
“colonial present” in, 5:2337
desert biome in, 1:218
drought in, 2:791
ecological footprint and biocapacity of, 2:827 (table)
environmental history studies in, 2:929
fertility levels in, 2:709
Derek Gregory’s work, 3:1381
groundwater resource in, 3:1386
Ibn Battuta exploration of, 2:1054, 3:1519, 4:2179
Indo-European languages in, 4:1749, 4:1750 (fig.)
military expenditures in, 3:1086
oil sources in, 4:2163
people living in extreme poverty and, 3:1082 (table)
Silk Road and, 2:1053
squatter settlements in, 5:2682
temperate arid deserts in, 1:221
temperate hyperarid deserts in, 1:222
tropical arid deserts in, 1:221
tropical/subtropical hyperarid deserts in, 1:222
tropical/subtropical semiarid deserts in, 1:220
See also specific country

Migration, 4:1890–1896
absorption and dispersion theory of, 4:1893
Andrew Clark’s contributions to study of, 4:147–418
definition of, 4:1890
diaspora and, 2:734–735
distance decay theory and, 2:774–776
emigration and, 4:1891
environmental refugees and, 2:989–991
forms of, 4:1890–1893
gender differences in, 3:1097
global environmental change and, 3:1337
immigration and, 3:1542–1545, 4:1891
internal migration, 4:1890
internal patterns of movement and, 4:1893
international criminal groups and, 4:1895
international migration, 4:1891, 4:1893–1894
interurban migration vs. intra-urban residential mobility and, 4:1891
irregular migration, 4:1893
land degradation and, 5:2232
“laws of migration” (Ravenstein) and, 4:1893
megacities, global cities grown and, 4:1891
Mexico-U.S. migration system and, 4:1893–1894
migrant family in Caluba, Brazil, and, 4:1894 (photo)
Military geography, 4:1896–1898
academic geography and, 4:1896–1897
Cold War and, 4:1897
definition of, 4:1896
early Greek origins of, 4:1896
environmental impacts of war and, 2:955–957
fields and disciplines of, 4:1896–1897
imperialism, nation-state formations and, 4:1896
issues addressed in, 4:1896
NATO and, 4:2046–2048
peace and peacetime studies and, 4:1897
revitalization of, 4:1897
technology advances and, 4:1896
Vietnam War and, 4:1897
war, imperialism, and geography relationship and, 4:1897
wartime experiences and, 4:1896
World War II and, 4:1896
See also Military geography: noted scholars

Military geography: noted scholars
Edward Ackerman, 4:1897
R. A. Bagnold, 4:1896–1897
Trevor Barnes, 4:1897
W. C. Brown, 4:1896
Matthew Farish, 4:1897
Colin Flint, 4:1897
Alfred Thayer Hahan, 4:1815–1816
Alan Jenkins, 4:1897
D. W. Johnson, 4:1896
Théophile Lavelle, 4:1896
Halford Mackinder, 4:1896
Alfred Thayer Mahan, 4:1896
F. Webster McBryde, 4:1897
Julian Minghi, 4:1897
Trevor Paglen, 4:1897
Eugene Palka, 4:1897
David Pepper, 4:1897
Albrecht von Rozen, 4:1896
Fred Schaefer, 4:1897
Arnon Soffer, 4:1897
Sun Tzu, 4:1896
Thucydides, 4:1896
Harold Winters, 4:1897
Rachel Woodward, 4:1897

Military spending, 4:1898–1905
accelerating costs and, 4:1901
advanced weaponry proliferation and, 4:1898
arms trade and, 4:1902
Cold War and, 4:1900
“cost-plus” contracting practice and, 4:1901
defense mergers and, 4:1901
definition of, 4:1898
expenditure data veracity and, 4:1898, 4:1903–1904
geographic patterns of military expenditures and, 4:1898, 4:1902
governmental power production and, 4:1898–1899
market exchange rate (MER) calculations of, 4:1898–1899
military-industrial complex and, 4:1898, 4:1899–1902
national military spending by country, 4:1899 (tables)
nuclear weapons funding in U.S. budget and, 4:1903
pricing mechanism vs. market economy operations and, 4:1901
procurement and RDT&E expenditures and, 4:1900
as proportion of gross domestic product (GDP), 4:1901
purchasing parity power (PPP) calculation of, 4:1899
*Rise of the Gunbelt* (Markusen) and, 4:1902
“smart weapons” and, 4:1900
Stockholm International Peace Research Institute data on, 4:1898
subcontracting and outsourcing and, 4:1901
technology advances and, 4:1900
transnational impacts of, 4:1902
undervaluation of U.S. military budget and, 4:1903
U.S. Defense Advanced Research Projects Agency and, 4:1900
U.S. defense budget as percent of GDP (1948–2005) and, 4:1904 (fig.)
U.S. Gunbelt (2008), 4:1903 (fig.)
U.S. hegemony in world affairs relative to, 4:1899
U.S. impacts of, 4:1902
war preparation and, 4:1898
World War II model of warfare and, 4:1900
Miller, Byron, 5:2575
Miller, C., 2:753
Miller, Christopher, 5:2305
Miller, Daniel, 1:108

Miller, Harvey J., 4:1905
academic career of, 4:1905
awards and honors received by, 4:1905
Torsten Hagerstrand and, 4:1905
people-based spatial analysis views of, 4:1905
service work of, 4:1905
space-time accessibility work of, 4:1905
time-geography research of, 4:1905
transportation geography work of, 4:1905
Miller-Raaffort, F., 4:1952
Mills, Edwin, 5:2236, 5:2395
Mills, L. Scott, 4:1656, 4:1658
Milton, John, 4:1971, 4:1479
Milwaukee, Wisconsin, 1:297 (photo)

Minerals, 4:1905–1911
atomic structure factor in, 4:1907
azarite and malachite secondary copper minerals, Bisbee, Arizona, 4:1910
calcite group species and, 4:1906, 4:1907 (photo)
characteristics and classification of, 4:1906–1907
crystallographic formation environment of, 4:1909–1910
crystallographic classification hierarchy of, 4:1906
crystallization from magma formation environment of, 4:1909
definition of, International Mineralogical Association and, 4:1905–1906
as enablers of civilization, 4:1906
extrinsic factors in development of, 4:1907
green tourmaline on quartz, Minas Gerais, Brazil, 4:1909 (photo)
“habit,” overall appearance of, 4:1907
halite crystals, internal cubic structure of, 4:1906 (photo)
industrial vs. ore minerals and, 4:1906
Millerite in calcite geode from Milwaukee, Wisconsin, 4:1908 (photo)
mineral forming environments and, 4:1908–1910
mining geographies and, 4:1911–1913
names derivation of, 4:1906–1907, 4:1908 (photo)
open-pit mining and, 4:2086–2088
precipitation from aqueous solution forming environment of, 4:1908–1909
quartz crystal varieties and, 4:1907, 4:1908 (photo)
reccrystallization in the solid forming environment of, 4:1910
strip mining and, 5:2701–2702

Minghi, Julian, 4:1897

Mining and geography, 4:1911–1913
colonial mining settlements and, 4:1911
coop er mine underground processing facility, Chile, 4:1912 (photo)
global mining production systems and, 4:1912
human labor exploitation and, 4:1911–1912
mining and the environment and, 4:1912–1913
mining definition and, 4:1911
mining frontier and, 4:1911
mining technologies and, 4:1911–1912
open-pit mining and, 4:2086–2088
Raw Materials Group and, 4:1911
“resource curse” hypothesis and, 4:1913, 5:2217, 5:2693
strip mining and, 5:2701–2702
sustainable economic development issues and, 4:1912–1913
untested technologies in, 4:1913
U.S. Geological Survey data on, 4:1911
See also Minerals

Minnesota
Mall of America, Bloomington, 1:107, 2:574 (photo), 2:575
Minnesota Land Management Information System, 3:1302
Minnesota Pollution Control Agency, 1:69 (photo)

Misan, I:402
Mississippi River, Mississippi Delta
“dead zone” area of, 1:207, 1:486–487, 1:488, 2:939
Deepwater Horizon oil spill, Mississippi Delta, 4:2074 (photo)
floodplain crop cultivation and, 3:1132
floodplain land use of, 3:1130 (photo)
floods (1993), 3:1137
French colonization of, 1:512
Hurricane Katrina and, 3:1494
I-35 bridge collapse over Mississippi River, 3:1596 (photo)
Louisiana purchase and, 4:1773, 4:1774–1775 (fig.)
Map of the Kingdom of New Spain by Baron von Humboldt, 3:1483 (fig.), 3:1484
Mississippi Delta, Louisiana, 2:703 (photo)
St. Louis flood (1993) and, 3:1135
water hyacinth invasion of Mississippi Delta, 3:1471 (photo)

Missouri, Pruitt-Igoe public housing project, St Louis, 5:2303

Mitchell, Don, 4:1913–1914
academic career of, 4:1913
awards and honors received by, 4:1913
California landscape, labor relations and, 3:1430, 4:1913
Community Geography Initiative and, 4:1913
cultural geography work of, 2:643, 4:1863, 4:1913–1914
distance decay theory and, 2:774–776
different mobilities, different geographies and, 4:1921
distance decay theory and, 2:774–776
different mobilities, different geographies and, 4:1921
distance decay theory and, 2:774–776
different mobilities, different geographies and, 4:1921
distance decay theory and, 2:774–776
different mobilities, different geographies and, 4:1921
distance decay theory and, 2:774–776
encountering difference feature of, 4:1922
human characteristics and, 4:1921
location-based services (LBSs) and, 4:1794–1796
migration and, 4:1890–1896
motion as normal and meaningful and, 4:1921
relational nature of, 4:1921–1922, 4:1922 (photo)
remote mobility or moorings and, 4:1921
social inequalities in, 4:1922–1923
space is interconnected networks through which flows occur
and, 4:1921
technology advances and, 4:1921
traveling meaningfulness and, 4:1922

Models and modeling, 4:1923–1928
agent-based model, 4:1927, 4:1927 (fig.)
algebraic mathematical models, 4:1926
authenticity of a model and, 4:1923
Brian Berry and, 1:193
cellular automata form of, 4:1926
climatology models and, 1:474
definition of, 4:1914
in Eastern Mallorca, Spain, 4:1915 (photo)
factors affecting, 4:1914
mixed enterprises and, 4:1917
multiscales affected by, 4:1914
in Southern Africa, 4:1917 (photo)
in the United Kingdom, 4:1914

Mobile GIS, 4:1918–1921
ad hoc wireless systems and, 4:1919
alternative display methods limitation of, 4:1920
architecture of, 4:1919 (fig.)
bandwidth issues and, 4:1918
cellular phones and, 4:1919
client-server architecture of, 4:1918
communication networks of, 4:1918
components and communications for, 4:1918–1919
data-editing capabilities and, 4:1918
definition of, 4:1918
ESRI’s ArcPad and, 4:1918
field-based GIS and, 4:1918, 4:1920
future directions, 4:1920
geoservlery and, 3:1255–1256
GIS software and, 4:1918
Google’s iPhone mobile map and, 4:1918
limitations of, 4:1920
location-based services (LBSs) and, 4:1794–1796, 4:1918, 4:1919–1920
Mapinfo’s MapXtend and, 4:1918
MapXtend and, 4:1918
narrowband vs. broadband wireless systems and, 4:1918–1919
neogeography and, 4:2003–2006
server-side components of, 4:1918
Wi-Fi or WiMAX communication systems and, 4:1918–1919
wireless service coverage issues and, 4:1918
See also Global positioning system (GPS)

Mobility, 4:1921–1923
absolute mobility and, 4:1921
access to means of mobility and, 4:1921
airport example of, 4:1921
automobility and, 1:171–175
aviation and, 1:170–172
Andrew Clark’s contributions to study of, 1:417–418
commuting and, 2:553–555
different mobilities, different geographies and, 4:1921
distance decay theory and, 2:774–776
demanding difference feature of, 4:1922
human characteristics and, 4:1921
location-based services (LBSs) and, 4:1794–1796
migration and, 4:1890–1896
motion as normal and meaningful and, 4:1921
relational nature of, 4:1921–1922, 4:1922 (photo)
relative immobility or moorings and, 4:1921
social inequalities in, 4:1922–1923
space is interconnected networks through which flows occur
and, 4:1921
technology advances and, 4:1921
traveling meaningfulness and, 4:1922
dynamic modeling process and, 4:1924, 4:1924 (fig.)
everyday decision making and, 4:1923
formal modeling and, 4:1923–1924
forms of models and, 4:1923
GIS map models, 4:1927 (fig.)
graphical model form of, 4:1925–1926
input-output models and, 3:1599–1601
Walter Isard and, 3:1627–1628
location-allocation modeling, 4:1793–1794
maps as models and, 4:1926
mental models and, 4:1924
mixing model paradigms and, 4:1927 (fig.)
model definition and, 4:1923
modeling paradigms and, 4:1926–1928
modeling process and, 4:1923–1925
modeling purpose and, 4:1923
model utility and, 4:1925–1926, 4:1925 (fig.)
monocentric model of urban form and, 5:2236–2237
nomothetic vs., 4:2034–2035
object-oriented programming model, 4:1926–1927
parsimony principle, art of leaving things out and, 4:1925
physical model form of, 4:1925–1926
problem of problem formulation and, 4:1925
relative transparency element in, 4:1925
science of modeling and, 4:1924–1925
spatially extended models, 4:1927–1928
statistical models, 4:1926
stock-and-flow models, 4:1926, 4:1927 (fig.)
See also Agent-based models (ABMs)
Moderate Resolution Imaging Spectroradiometer (MODIS)

Modernity, 4:1928–1931
cyborg ecologies, purification and mediation processes of, 2:649
“dark side” of, 4:1928
definition of, 4:1928
Enlightenment and, 4:1928
Eurocentrism of, 4:1928
feminism and, 4:1930
human agency and, 4:1929
independent self concept and, 4:1929
late modernity and, 4:1931
multiple modernities and, 4:1930
newness and progress in, 4:1929–1930
new social order and, 4:1928, 4:1930–1931
one universally right and true way of being, knowing, and doing
“otherness” concept and, 4:1929
postcolonialism and, 4:1930
poststructural challenge to, 4:1929–1930
“risk society” concept and, 4:1931
roots of, 4:1928–1929
scientific reasoning and, 4:1928–1929
See also Modernity: noted scholars; Modernization theory

Modernity: noted scholars
Francis Bacon, 4:1928
Dennis Diderot, 4:1928
Anthony Giddens, 4:1931
Thomas Hobbes, 4:1928
David Hume, 4:1928
John Locke, 4:1928
Voltaire, 4:1928

Modernization theory, 4:1931–1935
bureaucracies emergence and, 4:1932
capitalism and, 4:1931–1932
criticisms, 4:1934
cultural traditions and, 4:1933
democratic transition model and, 4:1933
dependency theory and, 2:712–714, 4:1934
developing countries, airplane take off analogy and, 4:1932–1933
development theory and, 2:730
ecological modernization and, 2:832–834
international development patterns and, 4:1931
newly industrializing countries and, 4:2021–2024
origins of, 4:1931–1932
Parsonian Turn and, 4:1932–1934
political theorizations of, 4:1933–1934
population control programs and, 4:1933
rational economic development and, 4:1932
rationalization (Weber) and, 4:1931–1932
spatial diffusion on two scales and, 4:1933
Stages of Economic Growth (Rostow) and, 4:1932–1933
structural functionalism concept (Parsons) and, 4:1932
Western, developed world ethnocentrism of, 4:1931, 4:1932, 4:1934
world-systems theory and, 4:1934
See also Modernity; Modernization theory: noted scholars

Modernization theory: noted scholars
Robert Bellah, 4:1933
Milton Friedman, 4:1934, 4:2011
Samuel Huntington, 4:1934
David McClelland, 4:1933
Talcott Parsons, 4:1932
Walter Rostow, 4:1932–1933
K. H. Silvert, 4:1934
Max Weber, 4:1931–1932

Modifiable areal unit problem (MAUP), 4:1935
aggregated data sources and, 4:1935
ecological fallacy and, 2:824
methods of analysis applied to, 4:1935
modifiable and, 4:1935
resolution of data analysis and, 4:1935
scale and aggregation problem of, 4:1935
statistical and geographical elements of, 4:1935
within-area homogeneity and, 4:1935

Mol, Arthur, 2:835, 2:836, 3:1369

Moldova
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)
Euroregions, cross-border cooperation and, 2:631 (fig.)
GUAM Organization for Democracy and Economic Development co-founded by, 2:538
Mollison, Bill, 4:2152
Mollweide, Carl, 4:1844, 4:1844 (fig.), 6:3152–3153, 6:3169
Molotch, H. L., 4:1745

Money, geographies of, 4:1936–1938
“Bretton Woods system” and, 4:1936
capitalism and, 4:1936
Chicago School of sociality and, 4:1936
dollar pegged to gold and, 4:1936
electronic funds transfer systems and, 4:1937–1938
emerging markets and, 2:890–891
Euromarkets and, 2:1030–1032, 4:1936–1937
finance and space relationship and, 4:1936
finance geographies and, 3:1115–1118
fixed exchange rate system and, 4:1936
floating exchange rates and, 4:1936, 4:1938
foreign currency trading and, 4:1938

INDEX 3315
General Agreement on Tariffs and Trade and, 4:1936
hypermobility of capital and, 4:1936–1937
investment to speculation shift and, 4:1937–1938
microelectronics revolution and, 4:1937
modernity and commodification and, 4:1936
NASDAQ fully automated electronic marketplace and, 4:1937
national capital markets integration and, 4:1937
nation-state relationship to, 4:1938
offshore finance and, 4:2071–2073
private capital flows and, 4:1938
securitization of global finance and, 4:1938
society of money origins of, 4:1936
stateless money emergence and, 4:1936
trade balances and foreign exchange markets and, 4:1936
various currencies and, 4:1937 (photo)
volatile nature of, 4:1937–1938
See also Money, geographies of: noted geographers, scholars
Monsoons, 4:1940–1945
definition of,
characteristics of,
characteristics and predictability of, 4:1943–1944
Australian monsoon, 4:1941
El-Niño-Southern Oscillation (ENSO) and, 2:792
global change and the South Asian monsoon, 4:1944
Holocene warm period and, 1:459
in India, 1:134, 2:741
Inter-Tropical Convergence Zone (ITCZ) and, 4:1940–1944
interropical deciduous forest, 1:230
monsoonal regions identification and, 4:1940
North American monsoon, 4:1941–1943
oceanic circulation and, 4:2058–2064
seasonal reversal in mean summer and winter winds of, 4:1943 (fig.)
social impacts of, 4:1943
South American monsoon, 4:1941
South Asian monsoon, 4:1943–1944
three-dimensional circulation associated with, 4:1940, 4:1941 (fig.)
tropical monsoons, 4:1454, 4:155
Montana, Yankee Doodle copper mining tailings pond and, 4:2087
Montello, David, 1:189
Moore, Donald, 5:233
Moos, Adam, 5:2710
Morehouse, Scott, 1:408
Morley, David, 6:2791
Morocco
African Union nonmembership status of, 1:125
clothing exports from, 6:2186 (fig.)
economically active females in, 3:1190 (table)
France colonization of, 1:514
income ratio relative to slum population in, 2006, 5:2644 (fig.)
poverty rates in, 5:2274
textile exports from, 6:2186 (fig.)
Morrill, Richard, 4:1945–1946
academic career of, 4:1945–1946
Brian Berry and, 1:192
books written by, 4:1945–1946
William Garrison and, 4:1945
quantitative revolution work of, 4:1945–1946
service work of, 4:1945
cultural and spatial justice views of, 4:1945
demographic and political districting and, 3:1466
Walter Tobler and, 4:1945
Morrison, J. L., 1:344
Morse, Jedediah, 4:1946–1947
collection of American identity and, 3:1463
father of American geography and, 3:1463
as founder of American geography, 4:1946
geographic imaginary and, 4:1946
definition of, 4:1946
geography textbooks written by, 4:1946
theological views of, 4:1946
Mortality rate, 4:1947
biological factors and, 4:1947
causes of, 4:1947
crude mortality rate definition and, 4:1947
definition of, 4:1947
demographic transition stages, 2:708–710
“epidemiological transition” and, 4:1947
infant mortality rates and, 4:1947
morbidity vs., 4:1947
population pyramid and, 5:2249–2250
preindustrial social contexts of, 4:1947
Moscow May Day celebrations, 2:544 (photo)
Mosse, John J., 1:274 (photo)
Most favored nation status (MFN), 4:1948
definition of, 4:1948
eyear U.S. treaties and alliances and, 4:1948
normal trade relation (NTR) status and, 4:1948
unconditional vs. conditional MFN status and, 4:1948
U.S. use of, 4:1948
Mouffe, Chantal, 3:1419, 3:1420
Mountain Trust (Nepal), 1:96
Mount Everest, 1:336 (fig.)
Mount Kilimanjaro, 1:453
Movimento Sem Terra (MST), 4:1948–1951
agricultural landownership distribution, in Brazil, 2003, 4:1949 (figs.)
biofuel agriculture and, 4:1951
Brazil land granting system and, 4:1949
Brazil land reform and, 4:1949
challenges faced by, 4:1950–1951
donatários and, 4:1949
expropriation of land and, 4:1949–1950
Multispectral imagery, 4:1949–1950
Landless Rural Workers Movement, 4:1948
Muir, John, 4:1949–1951
official government numbers of land reform beneficiaries and, 4:1950 (table)
political and economic activism of, 4:1950
praxis of, 4:1950–1951
purpose of, 4:1948–1952
socioeconomic context of, 4:1949–1950
urban centers and, 4:1951
Via Campesina international peasant’s movement and, 4:1948
Mozambique
economically active females in, 3:1190 (table)
GDP per capital in, 3:1382
Internet access in, 2:749
MST. See Movimento Sem Terra (MST)
Mugerauer, Robert, 4:2168
Muir, John, 2:981
Multimedia mapping, 4:1951–1953
Apple’s Hypercard software and, 4:1952
augmentation maps and, 1:108–110
BBC’s Doomsday Project and, 4:1952
definition of, 4:1951
development stages of, 4:1951–1952
digital mapping, multimedia content, and GPS convergence and, 4:1952
electronic atlases and, 2:884, 4:1952
ESRI MapObjects software and, 4:1952
GeoVideo software and, 4:1952
Glasgow Online digital atlas and, 4:1952
Good’s World Atlas and, 4:1952
hypermap and, 4:1952
hypermedia system and GIS integration and, 4:1952
Hypersnige, 4:1952
integrated multimedia approach system implementation process and, 4:1952
interactive map and, 4:1951–1952
MediaMapper software, 4:1952
media types used in, 4:1951
multimedia hypertext, or hypermedia and, 4:1952
multimedia information in GIS and, 4:1952
Red Hen Systems and, 4:1952
Multispectral imagery, 4:1953–1956
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and, 4:1954 (photo)
airborne platform and, 4:1954
ASTER spectral library and, 4:1954
astronomy applications of, 4:1953
automated image classification and, 4:1953–1954
black-and-white vs. true-color photographs and, 4:1953
charge coupled device (CCD) arrays and, 4:1954
Death Valley, California, 4:1954 (photo)
definition of, 4:1953
digital imaging technology and, 4:1953
Earth remote sensing application of, 4:1953
Earth Resources Technology Satellite and, 4:1954
film-based multispectral imaging systems and, 4:1954
first orbital multispectral photograph and, 4:1954–1955
frame sensors versus line sensors and, 4:1954
general principles of imaging and, 4:1953
image interpretation and, 3:1534–1536
laboratory-based spectral databases and, 4:1954
Landsat satellites and, 4:1954, 4:1955
land use and land cover mapping application of, 4:1953, 4:1955 (photo)
LiDAR and airborne laser scanning and, 4:1778–1779
multiyear data set and, 4:1953
panchromatic imagery and, 4:2112–2115
radiometry and, 4:1953
reflectivity differences and, 4:1954
satellite remote sensing and, 4:1955
spectral radiometry principles and, 4:1953
spectral signature and, 4:1953
U.S.-Mexico border, California, 4:1955 (photo)
USGS digital spectral library and, 4:1954
See also Aerial imagery: data; Aerial imagery: interpretation
Multistakeholder participation, 4:1956–1959
assessment framework for, 4:1958
benefits of, 4:1956
decision analysis complexity and, 4:1956
development processes examples and, 4:1956
ethical perspective on, 4:1956–1957
external stakeholders and, 4:1957, 4:1959
methods and tools of, 4:1958–1959
positive vs. negative outcomes of, 4:1956–1957
power relations issues and, 4:1958–1959
purposes for participation and, 4:1956–1957
social learning versus information purposes and, 4:1957
stakeholder category examples and, 4:1956
stakeholder identities and, 4:1957–1958
stakeholder mapping and, 4:1957–1958
subprocesses of, 4:1958
timeline of participation and, 4:1958
Multitemporal imaging, 4:1959–1961
Advanced Very High Resolution Radiometer (AVHRR) of NOAA and, 4:1960
aerial photography and, 4:1959
applications of, 4:1960–1961
artificial neural networks use and, 4:1960
course spatial resolution and, 4:1959–1960
definition of, 4:1959
digital analysis techniques for, 4:1960
Earth observing satellite systems and, 4:1959–1960
Landsat satellites and, 4:1959
Moderate Resolution Imaging Spectrometer (MODIS) and, 4:1960
multidate images and, 4:1960
multitemporal studies and, 4:1959–1960
multiple land use and land cover change monitored by, 4:1959
physical geography studies and, 4:1960
preprocessing techniques and, 4:1960
principal components analysis (PCA) and, 4:1960
remote sensing data and, 4:1959
satellite systems and, 4:1959–1960
spatial, spectral, and temporal resolution selection and, 4:1959–1960
spectral change vector analysis and, 4:1960
study objectives and, 4:1960
very high resolution and, 4:1960
See also Aerial imagery: data; Aerial imagery: interpretation
aspatial vs. aspatial contexts of, 4:1962
canonical correlation analysis, 4:1961
cluster analysis technique, 4:1962
definition of, 4:1961
dependence techniques and, 4:1961–1962
factor analysis technique, 4:1962
GIScience use of, 4:1961
interdependence techniques and, 4:1962
logistic regression modeling, 4:1961
multidimensional scaling, perceptual mapping technique, 4:1962
multiple discriminant analysis, 4:1961
multiple regression analysis, 4:1961
multivariate analysis of covariance (MANCOVA), 4:1962
multivariate analysis of variance (MANOVA) and, 4:1961–1962
“quantitative revolution” and, 4:1961
technique selection factors and, 4:1962
univariate analysis of variance (ANOVA), 4:1962

Multivariate mapping, 4:1963–1967
complex data relationships and, 4:1963
definition of, 4:1963
geospatialization course, U.S. murder rates example of, 4:1963–1966
human cognitive factors and perception elements in, 4:1963
U.S. murder rates, possible factors, 4:1964 (fig.)
U.S. murder rates and families in poverty, 4:1965 (fig.)
U.S. of housing ownership, 1900–2000, 4:1966 (fig.)
visual variables of, 4:1963

Mumford, Lewis, 4:1700, 5:2719
Murdoch, Jonathan, 3:1503
Murray, Charles, 6:2998

Archival of American Folk Song and, 4:1968 (photo)
Berkeley School of cultural geography and, 4:1967
Canadian musical content regulation and, 4:1968–1969
contemporary music genres and, 4:1967
corporate aspects of music market and, 4:1968
cultural geography studies of, 4:1967
“cultural turn” in economic geography and, 4:1967–1968
discordant sounds and, 4:1969
Larry Ford and, 4:1967
home studios factor and, 4:1968
lyrics significance and, 4:1967
melodic element variations and, 4:1967
Mountain Music Festival, Asheville, North Carolina, 1930s,
4:1968 (photo)
“new cultural geography” and, 4:1968–1969
“the next big thing” in modern music and, 4:1969
nontraditional music outlets and, 4:1968
origin and diffusion of musical styles and, 4:1967
place names and, 4:1967
popular culture ambient sounds and, 4:1969
recording technology and, 4:1967

Muth, Richard, 5:2236, 5:2395

Myanmar
ASEAN membership of, 1:128, 1:128 (table), 1:129 (table)
economically active females in, 3:1190 (table)
HIV/AIDS in, 3:1438
human rights issues in, 1:130
plantations in, 5:2192
Myers, Norman, 2:989, 2:990
MySpace, 2:648

Nabane, Nontokozo, 1:526
NAFTA. See North American Free Trade Agreement (NAFTA)
Nagar, Richa, 3:1193
Namibia
cholera in, 1:402
economically active females in, 3:1190 (table)
!Kung hunting and gathering tribe in, 3:1492
Ovaherero genocidal event in, 3:1202

Narain, Sunita, 3:1575
NASA. See National Aeronautics and Space Administration (NASA)
Nass, Arne, 3:1369
Natal, 3:1180

Nation, 4:1971–1974
Benedict Anderson and, 4:1972
collective group emphasis (Herder) and, 4:1972
definitions of, 4:1971
deterritorialization and reterritorialization and, 2:722–724
Enlightenment scholars and, 4:1971–1972
environmental determinism and, 4:1972
Johann Gottfried Herder and, 4:1972
Eric Hobsbawm and, 4:1972
identity geographies and, 3:1527–1531
imagined communities concept (Anderson) and, 4:1972
invented traditions concept (Hobsbawm) and, 4:1972
multiple meanings of, 4:1971–1973
nation-state ideal and, 4:1973
nature as national identity determinant and, 4:1972
politicalized ethnic, racial, and tribal groups and, 4:1973
race- and genetic-based spatial distributions and, 4:1972
resources availability (Rousseau) and, 4:1971–1972
security of citizens (Rousseau) and, 4:1971–1972
self-awareness and, 4:1973
self-governance requires territory and, 4:1973
shared culture and, 4:1972
Anthony Smith and, 4:1972–1973
ture age of nations (A. Smith) and, 4:1972–1973
vernacular languages and, 4:1972
word derivation and, 4:1971
National Academy of Sciences
Isaiah Bowman’s service to, 1:296
William Clark’s service to, 1:417
Robert Kates’ service to, 1:296
National Aerial Photography Program (NAPP), 1:19
National Aeronautics and Space Administration (NASA), 4:1974–1975
Aqua satellite, Earth’s water cycle and, 4:1974
ASTER spectral library of, 4:1954
atmospheric remote sensing and, 1:158 (fig.), 1:160 (fig.)
collaborative activities of, 4:1974
communication and weather satellites and, 4:1974
Earth observation satellites and, 4:1974
Dwight D. Eisenhower and, 4:1974
Greenland Ice Sheet image, 3:1325 (fig.)
Hubble Space Telescope and, 4:1974
imaging spectrometer in space and, 3:1542
Kennedy Space Center Launch Complex, Florida, and, 4:1975 (photo)
Land Cover and Land Use Change research program of, 4:1736
Landsat satellites co-developed by, 3:1283, 3:1534, 4:1954,
Mercury and Gemini missions and, 4:1974
mission directives of, 4:1974
National Advisory Committee on Aeronautics (NACA) and, 4:1974
panchromatic imagery technology and, 4:2114
raster-based GIS developed by, 3:1283
remote sensing advances by, 4:1974
remote sensing defined by, 1:157
sea ice minimums and, 3:1524 (photo), 3:1525 (photo)
Soviet satellite launch and, 4:1974
space exploration missions and, 4:1974
Terra Earth-orbiting mission and, 4:1974
Tropical Rainfall Measuring Mission (TRMM) of, 1:159, 1:160
WorldWind and, 1:426, 3:1284, 4:1826

National Agriculture Imagery Program (NAIP), 1:19, 1:21
National Assessment of Educational Progress (NAEP), 3:1233
National Atmospheric Deposition Program, 1:6
National Business Incubation Association, 3:1551–1552
National Cancer Institute, 1:335
National Center for Geographic Information and Analysis (NCGIA), 4:1975–1976
establishment of, 4:1975
Geography and Regional Science program (Abler) of, 4:1975
GIScience field establishment and, 3:1285–1286, 4:1975
GIS education materials and, 4:1976
mission of, 4:1975
National Science Foundation and, 4:1975
Project Varenius (GIScience) and, 3:1286
research initiatives of, 4:1975–1976
See also National Center for Geographic Information and Analysis (NCGIA): noted members

National Center for Geographic Information and Analysis (NCGIA): noted members
Ronald Abler, 1:1, 4:1975
Andrew Frank co-founder of, 3:1170
Michael Goodchild, 3:1349
David M. Mark, 4:1856

conferences and meetings of, 4:1977
efficiency in geography education focus of, 4:1977
government in the American curriculum focus of, 4:1976
governing organization of, 4:1977
Guidelines for Geographic Education (AAG and NCGE) and, 3:1233
membership policy of, 4:1976
George J. Miller founder of, 4:1976
mission of, 4:1976
publications of, 4:1976–1977
special interest groups of, 4:1977

National Geographic Society, 4:1977–1978
American foreign policy and, 3:1463
conservation and environmental awareness of, 4:1978
cultural understanding of geography shaped by, 4:1977
educational mission of, 4:1978
field research projects funded by, 4:1978
founding of, 4:1977
government education funded by, 3:1233
Gilbert Grosvenor and, 3:1463, 4:1977
mission of, 4:1977
National Geospatial-Intelligence Agency, 4:2165
National High Altitude Photography (NHAP) program, 1:19
National Institutes of Health (NIH), 1:280

borderlands and, 1:291–292
civic nationalism and, 4:1978–1979
collective nationalism and, 4:1979
collectivism vs. self-determination and, 4:1979
compulsory public education and, 4:1980
cosmopolitanism and, 2:591–592
cultural nationalism and, 4:1979–1980
definition of, 4:1978
English as God’s chosen people concept and, 4:1979
ethnicity and nature and, 2:1020–1021
ethnic nationalism and, 4:1979
ethnocentrism and, 2:1027
geopolitics and, 3:1249–1252
German das Volk and, 4:1979
history of, 4:1979–1981
identity geography and, 3:1527–1531, 6:2802–2083
mass production and mass media and, 4:1980
multinational states and, 4:1980
national identity concept and, 4:1978
nation concept and, 4:1971–1974
nation-state borders and, 1:291–294
peripheral nationalism and, 4:1980
political ideology and, 4:1978
political nationalism and, 4:1980–1981
popular sovereignty and, 4:1979
post–World War I territorial settlements and, 4:1980
sovereignty of the people concept and, 4:1979
state nationalism and, 4:1980
types of, 4:1978–1979
See also Nationalism: noted individuals

Nationalism: noted individuals
Thomas Hobbes, 4:1979
Eric Hobsbawm, 4:1980
Hans Kohn, 4:1978
John Locke, 4:1979
John Milton, 4:1979
National Priorities List (NPL), 1:297
National Science Foundation
Ronald Abler’s service to, 1:1
biotechnology research funds and, 1:280
Michael Goodchild’s service to, 3:1285
Integrative Graduate Education and Research Traineeships program of, 4:1856
David M. Mark’s service to, 4:1856
National Center for Geographic Information and Analysis (NCGIA) and, 4:1975
Donna Peuquet’s service to, 4:2165
quantitative revolution and, 3:2329
National Toxicology Program, 1:335
National Weather Service, 3:1123
Native Americans
 assimilation attempts, national identity and, 4:1980
 Deskaheh, leader of the Cayuga and, 3:1553
diseases and, 3:1362
Great American Exchange and, 3:1362
hogan, 4:2329
Indian reservations, 3:1233
indigenous reserves, reservations and, 4:1856
land loss of, 3:1223
“nature” regarded as a living landscape views of, 4:1993
“The Redman’s Appeal for Justice” (Deskaheh) and, 3:1553
Rousseau’s “noble savage” concept and, 3:1020–1022, 3:1362
Six Nations of the Iroquois Confederacy and, 3:1553
NATO, See North Atlantic Treaty Organization (NATO)
Natural growth rate (NGR), 4:1981–1983
definition of, 4:1981
demographic change and, 4:1981
world natural growth rates, 1950–2050, 4:1983 (fig.)
world population levels, 7000 BC to AD 2000, 4:1981, 4:1982 (fig.)
See also Population pyramid
Natural hazards and risk analysis, 4:1983–1989
capacity for protective action and coping and, 4:1984
case studies in, 4:1983–1986
climates extremes and, 4:1983
coastal hazards and, 1:496–500
continuum of magnitude of, 4:1984
control over resources factor in, 4:1985
differential vulnerability and, 2:742–744
disaster magnitude and trends in, 4:1984
drought risk and hazard and, 2:790–794
Earth’s crust movements and, 4:1983
environmental perceptions of, 2:979
failure to learn from failure and, 4:1986–1987
flash floods and, 3:1123–1125
floods and, 3:1133–1137
Global Assessment of Disaster Risk Reduction 2009 (UN) and, 4:1984
human rights implications, 4:1985
Hurricane Katrina and, 4:1985–1986
Hyogo Framework of Action (HFA) of UN and, 4:1987
international framework for disaster risk reduction and, 4:1987
Robert Kates’ work, 4:1654–1655
knowledge from natural hazard experience and, 4:1985
landslides and, 4:1720–1723
lightning and, 4:1779–1783
lightning and, 4:1779–1783
marginalized groups and, 4:1984
meteor in Tunguska, Siberia (1908), and, 4:1983
monsoon in Mumbai and, 4:1985–1986
Niger famine and, 4:1986
place, locality, and communication factors in, 4:1987–1988
“planning” definition and, 4:1987
power relations factor in, 4:1985, 4:1987
remote sensing in disaster response and, 5:2424–2428
risk analysis and, 4:1984
risk reduction and, 4:1986–1987
root causes of disaster risk and, 4:1985
sustainable development and climate change links to, 4:1985
UN International Strategy for Disaster Reduction and, 4:1987
vulnerability and, 4:1984, 4:1986, 4:1992
See also Disaster preparedness; GIS in disaster response; Natural hazards and risk analysis; Risk analysis and assessment
academic geography fragmentation and, 4:1990
biophysical phenomena and, 4:1990
class and nature and, 1:423–425
climatic geography and, 4:1990
critical theories of society and, 4:1992
cultural ecology and, 4:1992
deep ecology movements and, 2:692–695
definitions, 4:1989
“denaturalizing nature” (N. Smith and Braun) and, 4:1993, 5:2551–2552
Earth systems science and, 4:1992
economic geography and, 4:1990
environmental determinism and, 4:1990, 4:1991
environmentalists, “end of nature” views (McKibben) and, 4:1992–1993
gender and society and, 4:1993
geography and the nature-society interface and, 4:1989–1990
gender as a world discipline and, 4:1989
hazards and disasters geography and, 4:1992
human-environment geography revival and, 4:1992
human-environment geography schism and, 4:1991
“human nature” and, 4:1991
Hybrid Geographies (Whatmore) and, 4:1993
lack of books and theory, 4:1991
local ecology and, 4:1992
Man’s Role in Changing the Face of the Earth (W. Thomas) and, 4:1991
“more than human” geography and, 4:1993
Native American views of, 4:1993
“new” cultural and rural geography and, 4:1993
nonrepresentational geography and, 4:1993
Physical Geography (Somerville) and, 4:1989
physical geography subdivisions and, 4:1991
political ecology and, 4:1992
political geography and, 4:1990, 4:1992
production of nature concept (N. Smith) and, 4:1993, 5:2351, 5:2551–2552
racing buttressed by naturalism and, 4:1995
radical economic geographers and, 4:1992–1993
recent developments in, 4:1991–1993
regional-scale study of landforms and, 4:1990
as socially constructed idea (Braun) and, 4:1993
spatial analysis and, 4:1991
“spatial sciences” and, 4:1991
sustainability science and, 4:1992
“unity of geography” concept and, 4:1991
See also Critical studies of nature; Nature: noted scholars;
Nature-society theory
Nature: noted scholars
Isaiah Bowman, 4:1990
George Chisholm, 4:1990
William Morris Davis, 4:1989, 4:2180
Alexander von Humboldt, 4:1989
Bill McKibben, 4:1992
Friedrich Ratzel, 4:1899
Carl Sauer, 4:1990, 4:1992
C. P. Snow, 4:1991
Mary Somerville, 4:1989
William Thomas, 4:1991
Paul Vidal de la Blache, 4:1989
Sarah Whatmore, 4:1993
Nature Conservancy, 2:871
bioregionalism and, 1:255
challenges to, 4:1994–1995
class and nature and, 1:423–425
cyborg ecologies and, 2:648–650
deep ecology and, 4:1995
deep ecology movements and, 2:692–695
ecofeminism and, 2:817–820
ecological imaginaries and, 2:828–830
ecological justice and, 2:830–832
ecological modernization and, 2:832–834
exploitation of people and nature and, 4:1996
extinctions and, 2:1069–1072
feminist and ecofeminist theories and, 4:1996
feminist environmentalism and, 3:1090–1092
gender and nature and, 3:1194–1197
hybrid geographies and, 3:1502–1504
indigenous ways of knowing and, 4:1996
land and resources access issue and, 4:1996
linguistic contexts of, 4:1995–1996
nature as opposite of society and, 4:1995–1996
nature from culture, nature from society separations and, 4:1994
nature term and, 4:1994
political ecology and, 4:1996
politicized construction of social natures and, 4:1995
power and space relationship issues and, 4:1996
putting political back into ecology and, 4:1996
rethinking the divide between nature and society in, 4:1996–1997
romantic view of nature and, 4:1995
scientific knowledge production and, 4:1993
social constructivism, 4:1995
social dimensions of nature and, 4:1995
social equity, resources management and, 4:1996
social justice and, 4:1996
“true nature” and, 4:1995
universal nature to global nature shift and, 4:1997
See also Critical studies of nature; Nature; Nature-society
theory: noted scholars
Nature-society theory: noted scholars
Jessica Budds, 4:1996
Donna Haraway, 4:1996
Steve Hinchliffe, 4:1996
Cindi Katz, 4:1996
Bruno Latour, 4:1996
Paul Robbins, 4:1996
Michael Watts, 4:1996
Sarah Whatmore, 4:1996
Nauser, Markus, 3:1455
NCGIA. See National Council for Geographic Education (NCGE)
NCGIA. See National Center for Geographic Information and
Analysis (NCGIA)
Negritude movement, 2:1029
American Housing Survey (AHS) data and, 4:1998–1999
behavioral hazards and physical conditions in, 4:2000–2001
census tracts and, 4:1998
collective self-regulation and, 4:2002
Croatian neighborhood festival, Chicago, 4:2000 (photo)
definition of, 4:1998
ethnic segregation and, 2:1023
federal, state, and local improvement programs and, 4:2001–2002
gated communities and, 4:2002
gender-related differences in neighborhood quality and, 4:2000
haven concept and, 4:1999
homeowner and neighborhood associations and, 4:2002
home quality and neighborhood quality relationship and, 4:1998
housing and housing markets and, 3:1444
Homer Hoyt’s work and, 3:1449–1450
Mott Street, Chinatown, New York City, and, 4:1999 (photo)
neighborhood life cycle theory and, 4:2001
neighborhood quality control and, 4:2001–2002
popular names for, 4:1998
racial transition in, 4:2001
redlining and, 4:2001
unsafe neighborhood perceptions and, 4:1999–2000
urban renewal programs and, 4:2001
wards, political districts and, 4:1998
Nelson, A., 2:1075
Neocolonialism, 4:2002–2005
cheap raw materials and unskilled labor elements in, 4:2003
decolonized countries and, 4:2002–2003
de facto Western control and, 4:2003, 4:2004–2005
definition of, 4:2002–2003
economic dependence element in, 4:2003
economic surplus extraction element of, 4:2003, 4:2020
imperialism and, 3:1545–1548
local elites element in, 4:2003
multinational or transnational corporations elements in, 4:2004
plantations and, 5:2192
trade determination of international control and, 4:2004–2005
unequal trade element of, 4:2003
U.S. role in, 4:2004–2005
Western foreign aid element of, 4:2003
Western lending practices, Bretton Woods institutions and, 4:2003–2004
See also Decolonization
Application Programming Interfaces (API) and, 4:2006
Asynchronous Javascript And XML (AJAX) technology and, 4:2005–2006
cellular automata and, 1:368–371
collaboration and openness features of, 4:2006
“crowd sourcing” concept and, 4:2006
definition of, 4:2005
ethical implications of, 4:2006
eXtensible Markup Language and, 4:2006
geosensor networks and, 3:1252–1254
Google Maps and, 4:2006
Google Street View and, 4:2006
humanistic GScience and, 3:1474–1478
Internet GIS and, 3:1620–1623
mobile GIS and, 4:1918–1921
nongeographic Internet, Web 2.0 and, 4:2005–2006
OpenStreetMap and, 4:2006
participatory mapping and, 4:2124–2125
Web GIS and, 4:2006
“wikification of GIS” concept (Sui) and, 4:2006
Neoliberal environmental policy, 4:2007–2010
agricultural implications of market liberalization and, 4:2009
biopiracy concept and, 4:2008
criticisms of, 4:2007–2008
debt payments and foreign exchange earnings and, 4:2007
definition of, 4:2007
direct and indirect policies and, 4:2007
ecotourism and, 2:872
environmental degradation and, 4:2008
environmental governance supported by, 4:2007
environmental privatization critics and, 4:2008
environmental services privatization and, 4:2009
export agricultural and, 4:2009
foreign investment and, 4:2009
goals and tools of, 4:2007
human rights issues and, 4:2008
income disparity and poverty and, 4:2007–2008
international organizations criticism and, 4:2008
market liberalization and, 4:2008–2009
movement against genetically modified organisms and, 3:1610
multinational institutions and, 4:2007
natural-resource-dependent sectors and, 4:2007
new environmental markets and, 4:2009–2010
nongovernmental environmental certification systems and, 4:2010
policies promoted by, 4:2007
privatization and marketization issues and, 4:2008
spatial conservation strategies and, 5:2494
resource geography and, 5:2450
structural adjustment programs (SAPs) and, 4:2008, 4:2012
trade negotiations and, 4:2008
transnational corporations criticism and, 4:2008
varied outcomes and social responses to, 4:2010
See also Neoliberalism
Neoliberalism, 4:2010–2015
civil society advocacy against, 1:414
classical liberalism combined with social conservatism and, 4:2010
criticism of, 2:836
criticisms of, 4:2013–2014
debt crisis and, 2:689, 2:690
definition of, 4:2010
development of, 4:2010–2012
ecological modernization theory (EMT) and, 2:836–837
economic geography and, 2:850
energy policy of, 2:900–901
export-led development and, 2:1065–1066
Fordism mass production and, 4:2011–2012
free markets promoted by, 2:850, 4:2011
Milton Friedman and, 4:2011
gay and lesbian geographies and, 3:1184
geographical imagination and, 3:1224
global free trade and, 2:1065
globalization and, 2:850, 3:1341
global North and, 4:2011–2112
global South and, 4:2012
governance ideology, glocalization and, 3:1347–1348
government delivery of infrastructure and, 3:1596–1597
gentrification and, 3:1207
growth theory and, 2:730–731
Friedrich Hayek and, 4:2011
income inequalities and poverty levels associated with, 4:2013–2014
inequality geographies and, 3:1589
Keynesian demand management approach and, 4:2011–2012
labor responsiveness capital dynamics and, 4:2013
laissez-faire capitalism and, 4:2011
in Latin America and Chile, 4:2012
liberalism es., 2:836
market regulation removal and, 4:2013
neoliberal philosophies term and, 4:2010
new institutionalism and, 2:732–733
newly industrializing countries and, 4:2021–2024
oil price crisis (1974) and, 4:2012
poverty reduction strategy papers and, 4:2013–2014
proponents of, 4:2011
protest against in Panama City and, 4:2014 (photo)
public-private partnerships and, 5:2312–2313
public space and, 5:2315
Ronald Reagan and, 3:1596
regulation theory and, 5:2400
responsible autonomy issue in, 2:836
restructuring and, 5:2459
rural development and, 5:2490
state and civil society social relationship and, 4:2013
states, markets, and civil society relationships and, 4:2012–2013
structural adjustment programs (SAPs) and, 4:2008, 4:2012, 5:2703–2704
supply and demand forces and, 4:2011
sustainable development and, 2:836
tenets of, 2:836
uneven development criticism of, 4:2013, 6:2901–2902
urban underclass and, 6:2998
Washington Consensus term and, 4:2012
welfare services reduction and, 4:2013
See also neoliberal environmental policy

agricultural intensification and, 1:36, 4:2015
birth control decriminalization and, 4:1819
“The Coming Anarchy” essay (Kaplan) and, 4:2016
conservation and, 2:570
critical studies of nature and, 2:625
definition of, 4:2015
demographic transition and, 2:707
environmental security scholarship and, 2:999, 4:2016
essay on the principle of population (Malthus) and, 4:1819, 4:2015
eugenics movement and, 4:1819
fertility rates decline and, 4:2015
food insecurity persistence and, 4:2015
genetically modified crops and, 4:2016
Malthusianism and, 4:1819–1820
political ecology, critical studies of nature and, 2:622, 5:2212
population and land degradation debate and, 5:2233–2234
post-Cold War thinking and, 4:2016
resources shortages and, 4:2016
U.S. anti-immigration policies and, 4:2015
Nepal
Annapurna conservation area project of ecotourism in, 2:871–872
soil erosion in, political ecology and, 2:622
water supply contamination and, 3:1387
Nesmith, Cathy, 3:1092
Nestle, Marion, 3:1198
Netherlands
AGILE membership of, 1:125 (table)
carbon or climate change taxes in, 4:1857
central place theory in urban planning in, 1:382
colonial empire of, 1:509 (fig.), 1:510, 1:511, 1:512
deltas of, 2:702–703
Dutch East India company of, 1:510
economically active females in, 3:1190 (table)
European union (EU) membership of, 2:1035
green design and development in, 3:1371
“heroin parks” in, 2:799
Indonesia colonized by, 1:515
national geographical society in, 3:1462
Peace Palace, The Hague, 6:3130 (photo)
pollution taxes in, 4:1857
storm surge defense structures in, 1:497
Network analysis, 4:2016–2018
definition of, 4:2016
early applications of, 4:2016–2017
game theoretic applications of, 4:2017
GIS and, 4:2017–2018, 4:2019
GIS in utilities management and, 3:1316
graph theory and, 4:2016–2017
hierarchy in networks and, 4:2017
hub-and-spoke airline networks and, 4:2017
hydrological connectivity and, 3:1512–1513
interurban vs. intrarurban network level analysis, 4:2016
later developments in, 4:2017
linear referencing and dynamic segmentation, 4:1784–1785
link-node structure of, 4:2016
matrix representations of, 4:2016
network analysis in geography (Haggett and Chorley) and, 4:2017
network data model and, 4:2018–2019
network elements and, 4:2016
planar vs. nonplanar networks and, 4:2016
quantitative revolution and, 4:2017
shortest-path algorithms and, 4:2017
small-region (small-world) networks and, 4:2017
spatial allocation application of, 4:2019
spatial analysis of transport networks and, 4:2016, 4:2017
structural change over time studies and, 4:2017
transport geography field and, 4:2017
See also Network analysis: noted individuals
Network analysis: noted individuals
Richard Chorley, 4:2017
INDEX 3323

William Garrison, 4:2017
Peter Haggett, 4:2017
Network data model, 4:2018–2019
address matching, geocoding applications of, 4:2019
attributes of, 4:2018
closest facility and allocation applications of, 4:2019
definition of, 4:2018
edges and junctions elements of, 4:2018–2019
go database network and, 4:2019
geometric features of, 4:2018
GIS in utilities management and, 3:1316
hierarchies in, 4:2018
network analysis and, 4:2016–2018
shortest-path analysis and, 4:2019
topology networks and, 4:2019
Nevada
Beowawe Geyser Field in, 3:1273
normal fault, Basin and Range Province in, 3:1086
nuclear weapons site in, 5:2469
suburban sprawl, Las Vegas, 5:2717 (photo)
Valley of Fire and, 5:1575
Yucca Mountain nuclear waste repository issue and, 4:1744
Nevidimova, O., 4:1130
New Caledonia, 1:244
Newfoundland
John Cabot exploration of, 2:1054
Canadian musical content regulation and, 4:1968–1969
Captain James Cook’s exploration of, 2:576
Viking exploration of, 2:1051
Vineland map, 15th-century from 13th-century original, 2:1051, 2:1052 (fig.), 2:1053
New Guinea
gardening practices, Maring people of New Guinea research and, 2:895–896
glaciers in, 3:1332
hunting and gathering tribes in, 3:1492
See also Papua New Guinea
New international division of labor, 4:2019–2021
criticism of, 4:2020–2021
definition of, 4:2019
foreign direct investment, international subcontracting and, 4:2020
global factory term and, 4:2020
industrialization and deindustrialization patterns and, 4:2020
newly industrializing countries and, 4:2021–2024
“old” international division of labor and, 4:2019
preconditions of, 4:2020
production decentralization and, 4:2020
surplus value extraction and, 4:2033, 4:2020
transnational corporations role in, 4:2020
uneven capitalist development and, 4:2019
“well-disciplined” labor concept and, 4:2020
women in labor force and, 4:2020
New Jersey
cancer-oriented migrant studies and, 1:335
Green Acres program in, 4:2093
open space regulation in, 4:2093
Newly industrializing countries (NIC), 4:2021–2024
APEC and, 1:121–122
ASEAN and, 1:126–131
China and, 4:2022–2023, 4:2022 (fig.)
comparative advantage concept and, 4:2021
definitions, 4:2021
dependency theory and, 4:2021
developing countries and, 4:2023
development theory and, 4:2021
export-oriented industrialization (EOI) in, 2:1064–1065
foreign direct investment and, 4:2023
global free trade and, 2:1065
import substitution to export-led industrialization shift and, 4:2021
India and, 4:2023
land reform and, 4:2023
Malaysia, 4:2022, 4:2022 (fig.)
neoclassical economic thought and, 4:2021
neoliberal policies and, 4:2023
new international division of labor and, 4:2019–2020
newly industrializing economies term and, 4:2021
North American Free Trade Agreement (NAFTA) and, 4:2023
problems associated with, 4:2023
U.S. intervention and, 4:2021–2022
world map of, 4:2022 (fig.)
world-systems theory and, 4:2021, 4:2023
New Mexico
composite map of wildfire hazard, Jemez Mountains, 5:2232 (image)
Landsat Thematic Mapper image, Cerro Grande Fire, 5:2321 (image)
nuclear weapons site in, 5:2469
water-sharing in irrigation in, 1:534
New Orleans, Louisiana
French colonization of, 1:512
Guste New Homes Public Housing, 5:2303 (photo)
Hurricane Katrina and, 3:1493–1494, 3:1495 (photo)
Shuttle Imaging Radar image of, 4:1890 (fig.)
Newton, Isaac, 2:774, 3:1342, 4:1648
Newton, Norman, 4:1699
New urbanism, 4:2024–2027
American dream redefinition and, 4:2024
Celebration, Osceola County, Florida, and, 4:2025, 4:2025 (photo)
Congress for the New Urbanism, 4:2024
definition of, 4:2024
Directory of New Urbanism and, 4:2027
Kentlands, Maryland and, 4:2025
Laguna West, Sacramento County, California, 4:2026–2027, 4:2026 (photo)
livable places manifesto (Appleyard) and, 4:2025
Orenco Station, Portland, Oregon, 4:2026 (photo), 4:2027, 4:2027 (photo)
origins of movement and, 4:2024–2027
“pedestrian pocket” concept and, 4:2026
postmodernism and, 4:2024, 5:2268
Seaside, Walton County, Florida, resort town and, 4:2025, 4:2025 (photo)
sustainable communities design movement and, 4:2026
traditional-neighborhood development and, 4:2024
transit-oriented development (TOD) and, 4:2024, 5:2240
Village Homes, Davis, California, and, 4:2026
walkability and physical activity focus of, 4:2024
See also New urbanism: noted individuals
New urbanism: noted individuals
Donald Appleyard, 4:2025
Peter Calthorpe, 4:2026
Judy Corbett, 4:2026
Michael Corbett, 4:2026
Andrés Duany, 4:2025
Allan Jacobs, 4:2025
Jane Jacobs, 4:2025, 4:2126
Douglas Kelbaugh, 4:2026
Léon Krier, 4:2024–2025
Elizabeth Plater-Zyberk, 4:2025
Jacquelyn Robertson, 4:2025
Nomadic herding, 4:2029–2033
  camp group, clan, tribe, and confederation hierarchies of, 4:2032
  characteristics of, 4:2030
  coupled human and animal systems and, 2:597–598
  derivation of term and, 4:2029
  dung-stubble connection and, 4:2030–2031
  environmental management and, 4:2032
  herding groups and, 4:2031–2032
  labor needs and, 4:2031–2032
  Masai nomads with cattle, Southern Kenya, 4:2031 (photo)
  military potential of, 4:2032
  modern developments in, 4:2032
  nomadic Tuareg herders and camels, Sahara Desert, Mali, West Africa, 4:2034 (photo)
  overgrazing prevention and, 4:2030
  pastoralist drylands environmental management and, 2:971
  pastoral zone changes and, 4:2029–2030
  pasture ownership and, 4:2032
  political power to enforce pastoral rights and, 4:2031
  as preindustrial agriculture method, 1:48
  private ownership of herds and, 4:2032
  regional spatial framework of, 4:2030
  resource rights and, 4:2030–2031
  “tragedy of the commons” and, 4:2032
  vertical and horizontal movements in, 4:2030
See also Nomadism

Nomadism, 4:2033–2034
  aimless wandering myth and, 4:2033
  animal herders and, 4:2033
  coupled human and animal systems and, 2:597–598
  definition of, 4:2033
  examples of, 4:2033
  hunting and gathering and, 3:1489–1492
  migration vs., 4:2033
  mobility behavior pattern of, 4:2033
  nomadic Tuareg herders and camels, Sahara Desert, Mali, West Africa, 4:2034 (photo)
  regular movements of, 4:2033
  rotational grazing and, 4:2033
  transhumanence seasonal oscillation and, 4:2033
See also Nomadic herding

Nomothetic, 4:2034–2035
  absolute space and, 4:2035
  criticism of, 4:2035
  definition of, 4:2034
  empiricism rejected by, 4:2035
  exceptionalism (Schaeffer) and, 4:2034
  features of, 4:2035
  Jean Gottmann and, 3:1355–1356
  idiographic-nomothetic debate and, 4:2034–2035
  logical positivism and, 4:2035, 5:2388
  quantitative revolution and, 4:2034–2035, 5:2329
  role of theory and explanation and, 4:2035
  spatial analysis and location theory and, 4:2035
  statistics and mathematical models and, 4:2035
  systematic vs. regional geography debate and, 4:2034–2035
See also Nonrepresentational theory (NRT): noted scholars

Nongovernmental organizations (NGOs), 4:2035–2038
  accountability issue, 1:415, 4:2037
  activities variations among, 4:2033–2036
  antiglobalization and, 1:96
  antisystemic movements and, 1:99–100
  beneficial examples of, 1:415–416
  as civil society component, 1:414–416
  criticism of, 4:2037–2038
  definition of, 4:2035
  donor organizations and, 4:2037
  elitism criticism of, 1:415
  governance at national and international scales and, 4:2038
  grassroots organizations and, 1:414, 4:2036
  international NGOs vs. community-based organizations (CBOs) and, 4:2036
  local, national, and international scales of, 4:2036
  marginalized groups advocacy by, 4:2036
  objectives variations among, 4:2035
  political or charitable motivation of, 4:2036
  power issues, 4:2037
  praise and criticism of, 4:2037–2038
  professionalizing activities issue and, 4:2037
  recent history of, 4:2036–2037
  telecommunications advances and, 1:415 (photo)
  “third sector” perspective of, 4:2037
  transnational networks of, 4:2036–2037
  variations among, 4:2035
See also Nonpoint sources of pollution (NPS), 4:2038–2039

Nonpoint sources of pollution (NPS), 4:2038–2039
  common NPSs, 4:2038–2039
  controlling NPSs, 4:2039
  definition of, 4:2038
  impermeable surfaces factor in, 3:1549
  insecticides and fertilizers as, 4:2039
  livestock fecal material as, 4:2039–2040
See also Nonrenewable resources

Nonrenewable resources, 4:2039–2041
  discount rate issue and, 4:2040
  empirical relevance issue and, 4:2040
  examples of, 4:2039
  Grey and Hotelling-style models of, 4:2040, 5:2445
  human-made resources replacement of, 4:2040
  optimal extraction of, 4:2039–2040
  optimal extraction of, history and potential future models of, 4:2041
  partial equilibrium approach to, 4:2040–2041
  sustainability issues and, 4:2041
  systems view, 4:2041
  traditional models of, 4:2040
See also Petroleum

Nonrepresentational theory (NRT), 4:2041–2042
  actor-network theory and, 1:8
  affect, practice, and performance interplay and, 4:2041
  “being-in-the-world” concept and, 4:2042
  bodily performances concept and, 1:290
  cartographies of the virtual and, 4:2041–2042
  cultural geography and, 2:639
  definition of, 4:2041
  gay and lesbian geographies and, 3:1185
  geography of emotions and, 2:892
  habitual practices and tacit knowledge elements of, 1:290
  inherent instability of lived spatiality and, 2:639
  “more-than-representational theory” term and, 4:2041
  movement focus of, 2:639
  performance as free-floating venture, 1:290
  text to practice focus of, 1:290
  witnessing of the world and, 4:2042
See also Nonrepresentational theory (NRT): noted scholars
Maurice Merleau-Ponty, 4:2042
Nigel Thrift, 1:230, 4:2042, 6:2827–2829
John Wiley, 4:2042

Nonvisual geographies, 4:2042–2044
behavioral geography and, 4:2042
body language and, 4:2043
definition of, 4:2042

Habermas’s theory of communicative interaction and, 4:2043
hegemony of vision and, 4:2043

Henri Lefebvre and, 4:2043
masculine gaze concept and, 3:1996, 4:2043
poststructuralism and, 4:2042

“smellscape” and “soundscape” concepts of, 4:2043

barrier islands in, 4:2043
atmospheric pollution in, 4:1889 (table)
poststructuralism and, 4:2043

geothermal energy use in, 4:2164 (fig.)
polar climate in, 1:449

symbolic understanding of space and, 4:2042

Normandy, 2:1051

North America

adults and children living with HIV in 2007 in, 3:1437 (fig.)

Afro-Asiatic language in, 4:1749, 4:1750 (fig.)

Arab exploration of, 2:1053

beaver dams in, 1:217

HIV/AIDS in, 3:1438

military expenditures in, 4:1889 (table)

people living in extreme poverty and, 3:1082 (table)

Sahara desert, dry climate of, 4:129

Sahara shield and platform topography in, 1:111

underemployment in, 3:1488

North America

acid rain in, 1:6

adults and children living with HIV in 2007 in, 3:1437 (fig.)

Albers equal-area projection map of, 4:1846 (fig.)

atmospheric pollution in, 1:152, 1:153, 1:154

automobile industry in, 1:169–171, 1:170 (fig.)

barrier islands in, 1:183–185, 1:184 (photos)

Basin and Range, mountain and basin desert setting in, 1:111

beaver dams in, 1:274, 1:274 (photo)

Bering land bridge, Asia and, 1:213

biogeography dispersal modes in, 1:213

birthrates in, 2:708

boreal forests in, 1:214–217, 1:216 (photo)

cadastral systems, land ownership and, 1:315

colonial migrations of, 1500–1914, 3:1543

colonization of, 1:512

craneberry farming, domestication centers and, 1:377

cross-border cooperation and, 2:630

deforestation in, 2:696

decolonization impacts in, 2:945

developed countries in, 2:725 (fig.)

fertility levels in, 2:709

forest fragmentation, bird species and, 3:1161–1162

forest fragmentation in, 3:1159, 3:1160 (fig.)

forest plantations in, 5:2195

genetically modified foods in, 3:1198

genetically modified organisms, crops and, 1:279

gerothermal energy use in, 3:1267 (fig.)

geological studies of, 1:81
geochemical cycles in, 1:457

sectors in, 3:1333

groundwater usage in, 3:1386

herbicide use in, 3:1421

HIV/AIDS in, 3:1438

indigenous cartography in, 3:1562
industrialization in, 3:1583
Istmus of Panama, South America and, 1:213
Lambert conformal conic map projection of, 4:1846 (fig.)
land degradation estimates in, 4:1680 (table)

low birth rates in, 4:1981

midlatitude, mild climate of, 1:435

midlatitude deciduous forest in, 2:223–226

military expenditures in, 4:1889 (table)

Native American eradication in, 1:512

North American monsoon, 4:1941, 4:1943

petroleum consumption in, 4:2164 (fig.)

plays of, 5:2199–2200

polar climate in, 1:449

political map of, 6:3163

population growth of, 5:2233 (fig.), 5:2241

potential water availability in, 2007, 2050, 6:3059 (fig.)

prehistoric exploration of, 2:1050

renewable water resources and availability in, 6:3057 (table)

San Andreas fault zone in, 1:186

severe midlatitude climate in, 1:439, 1:440 (fig.)

temperate, semiarid deserts in, 1:219

temperate arid deserts in, 1:221

tropical/subtropical hyperarid deserts in, 1:222

tropical/subtropical semiarid deserts in, 1:220

nuclear weapons issue and, 4:522

original members of, 4:2044

Afghanistan actions of, 4:2044–2046

APEC and, 1:121

benefits of, 4:2044–2045

capital mobility restrictions issue and, 4:2044

criticism of, 4:2045

environmental issues and, 4:2008

future controversies, 4:2046

goals of, 4:2044

industrialization in, 3:1583

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

See also specific nation

North American Free Trade Agreement (NAFTA), 4:2044–2046

APEC and, 1:121

benefits of, 4:2044–2045

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

capital mobility restrictions issue and, 4:2044

North Atlantic Treaty Organization (NATO), 4:2046–2048

Afghanistan actions of, 4:2048

Bosnia civil war and, 4:2047

Cold War and, 4:2047

Europe’s post–World War II recovery and, 4:2047

humanitarian and combat activities of, 4:2047

Kosovo peacekeeping activities of, 4:2047

members of, 4:2047, 4:2048 (fig.)

nuclear weapons issue and, 4:2047

original members of, 4:2047

principle of, 4:2046–2047

Russia issue and, 4:2048
September 11 terrorist attacks and, 4:2047–2048
Serbian bombings of, 4:2047
Soviet Union, Warsaw Pact and, 4:2047
Soviet Union attack deterrence issue and, 4:2047
Soviet Union collapse and, 4:2047
uncertain future of, 4:2048
North Carolina
hurricane risk in, 3:1500
Mountain Music Festival, Asheville, 1930s, 4:1968 (photo)
Research Triangle Park in, 5:2435, 5:2436
Northern Hemisphere
air masses of, 1:63
Aleutian low and Icelandic low pressure cells in, 1:133
atmospheric angular momentum in, 1:142–143
continuous, discontinuous, sporadic, and isolated permafrost in, 4:2153 (fig.)
Coriolis force and, 2:586
dry climates in, 1:429–430, 1:430 (fig.)
forest degradation in, 3:1157–1158
glacial/interglacial cycles in, 1:457–459
Hadley cell atmospheric circulation in, 3:1395
humid continental and subarctic climates, 1:440 (fig.), 1:441–442
Little Ice Age in, 1:459, 3:1333, 3:1335
midlatitude cyclones in, 1:134
periglacial environments of, 4:2147 6, 4:2147 (fig.)
polar climate in, 1:450
surface air temperature variations over past millennium in, 1:460 (fig.)
volcanic eruptions in, 1:163
See also specific country
North Korea
"axis of evil" concept (G. W. Bush) and, 2:612
collectivized farming in, 2:543
demilitarized zone (DMZ) of, 1:293 (photo)
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
humid continental climate of, 1:440
South Korea borderlands and, 1:292, 1:293 (photo)
North Pole. See Poles, North and South
North Vietnam
collectivized farming in, 2:543
Norway
AGILE membership of, 1:125 (table)
Atlantic salmon fish farming in, 3:1119–1120
cancer incidence and mortality in, 1:322 (fig.), 1:323 (fig.)
carbon or climate change taxes in, 4:1857
cultural nationalism in, 4:1980
economically active females in, 3:1190 (table)
ergy policies in, 2:902
European Union (EU) membership of, 2:1035
foreign aid flow from, 3:1152
glacial loss in, 3:1333
glacial mountains of Spitsbergen, Norway, 1:450 (photo)
hydropower in, 3:1509
Kyoto Protocol of 1997 and, 1:463
marine aquaculture in, 4:1854 (fig.)
North Sea oil reserves and, 2:902
Norwegian Current and, 1:450
Norwegian mugwort as floral climatic relict and, 1:470
oil production in, 4:2099
Sognefjorden fjord in, 3:1121, 3:1122 (photo), 3:1123 (fig.)
Not in My Backyard (NIMBY), 4:2049–2050
criticism of, 4:2049
environmental justice and, 4:2049
environmental threat examples and, 4:2049
landfill disposal sites and, 4:1686
land use regulation and, 4:1727
locally unwanted land uses (LULUs) and, 4:1792, 4:2049
spatial distribution of undesirable effects and, 4:2049
strength variables and, 4:2049
structuralist interpretation of, 4:2049
toxic waste landfills, environmental racism and, 2:987, 4:1686
urban development process and, 4:2049
waste incineration and, 6:3048–3049
Novak, Jakub, 5:2710
NPS. See Nonpoint sources of pollution (NPS)
NRT. See Nonrepresentational theory (NRT)
Nuclear energy, 4:2050–2052
antinuclear movement and, 3:1609
boiling water vs. pressurized water reactors and, 4:2049
Chernobyl nuclear accident and, 1:385–386, 1:385 (photo), 3:1357
geography of fear, geography of necessity and, 4:2051–2052
global reserves of uranium and, 2:903 (fig.), 2:909 (fig.)
Greenpeace and, 3:1612
low-carbon power produced by, 3:1337
next generation of reactors and, 4:2050–251
nuclear arms race and, 4:2052
nuclear fission and, 4:2049
nuclear power plant in Lower Saxon, Germany, 4:2051 (photo)
nuclear terrorism issue and, 4:2052
nuclear testing and, 1:167–168, 2:956
Nuclear War Atlas (Bunge) and, 3:1300
Nuclear Waste Policy Act (U.S.), 2:899
pros and cons of, 4:2049
remediating former nuclear weapons sites, risk analysis and, 5:2469–2470
subatomic nuclear energy and, 4:2050
THORP nuclear power-reprocessing plant, UK controversy and, 5:2517
Three Mile Island nuclear accident and, 2:899
Three Mile Island nuclear power plant, Middletown, Pennsylvania, 6:2827 (photo)
uranium resources and, 2:908, 4:2049
U.S. electricity demands and, 4:2052
U.S. energy policies and, 2:899, 2:901
Vattenfall atomic power plant protest, Hamburg, Germany, 2:1033 (photo)
Yucca Mountain nuclear waste repository issue, Nevada and, 4:1744
Nussbaum, Martha, 2:591
Nutrient cycles, 4:2052–2055
assessment methods of, 4:2053–2055
coastal dead zones and, 1:486–488
definition of, 4:2052
in ecosystems, 4:2053
forest ecosystems and, 4:2053, 4:2054 (fig.)
macronutrients and micronutrients and, 4:2052
mineralization process and, 4:2053
nitrogen cycle and, 4:2028–2029, 4:2053
nutrient fluxes and, 4:2053
nutrient stock variations and, 4:2053
nutrient turnover and, 4:2053
pesticides and, 2:939
phosphorus cycle and, 4:2169–2171
rock-derived nutrients cycling and, 1:207
solid-phase-associated fluxes and, 4:2053
Water-bound fluxes and, 4:2053
Nye, Timothy, 4:2055–2056
academic career of, 4:2055
critical geographies and, 2:615
Oceanic circulation, 4:2058–2064
absolute vorticity and, 4:2059
Agulhas western boundary current and, 4:2064
atmospheric energy variations and, 1:163–165
boundary currents and, 4:2059–2060
correction change and, 6:2770–2771
Coriolis force and, 4:2058, 4:2059, 4:2060, 4:2061, 4:2062 (fig.)
currents, eddies, and water mass formation in, 4:2064
East Arabian Current and, 4:2064
Ekman transport and, 4:2058–2059, 4:2060, 4:2061
El Niño-Southern Oscillation (ENSO) and, 2:886–890, 4:2058, 4:2062 (fig.)
equatorial current systems and, 4:2061–2063, 4:2061 (fig.)
forces affecting ocean circulation and, 4:2058, 6:2770–2771
global environmental change and, 3:1336
gyres and, 4:2058–2059
Kelvin and Rossby waves and, 4:2061–2062
La Niña and, 4:1754–1757
major currents that drive oceanic circulation and, 4:2059 (fig.)
meridional overturning circulation, 3:1336
monsoonal current reversals and, 4:2063–2064
monsoonal cycle and, 4:2058, 4:2063, 4:2063 (fig.)
Northern Hemisphere high-pressure gyre and, 4:2060 (fig.)
periglacial environment changes and, 4:2149–2150
pressure gradients and geostrophic currents and, 4:2060–2061, 4:2060 (fig.), 4:2061 (fig.), 4:2062 (fig.)
Somali current and, 4:2064
thermohaline circulation and, 4:2058, 4:2149–2150
weather and climate determined by, 4:2058, 4:2059 (fig.)

Younger Dryas Northern Hemisphere cooling (Pleistocene) and, 3:1336

See also El Niño-Southern Oscillation (ENSO); La Niña

Oceans, 4:2064–2071
Atlantic Multi-decadal Oscillation (AMO) and, 1:165
Atlantic Ocean cool and warm phases and, 1:164–165
Black Atlantic (Gilroy) and, 4:2070
bluefin tuna farm, mid Adriatic, Croatia, and, 4:2066 (photo)
carbon cycle and, 1:206
coastal hazards and, 1:496–500
coastal state’s exclusive economic zone (EEZ) and, 4:2069
conservation zoning in, 2:572
corals and, 2:581–584
Coriolis force and, 2:586–587
cultural geography issue and, 4:2069–2070
delineation of ocean space and, 4:2069
development of ocean territories and, 4:2069–2070
Devil and the Deep Blue Sea (Rediker) and, 4:2070
Earth’s climate and, 4:2068
economic geography issues and, 4:2066–2068
El Niño-Southern Oscillation (ENSO) and, 2:886–890
enforced marine environment and, 4:2066–2067, 4:2068
“Great Pacific Climatic Shift” and, 1:164
as integral space of society, 4:2069
environmental geography issues and, 4:2066–2068
extinctions from, 3:1630 (table)
freedom of the seas doctrine, 4:2066
global environmental change and, 3:1336
heat content of, 1:163–164
hypoxia of, 3:1336
Indian Ocean, 1:164
industrial effluents and, 4:2068
La Niña and, 4:1754–1757
Mare Liberum (Grotius) and, 4:2066
Maximum Minimum Temperature Systems and, 1:164
monsoons and, 4:1940–1945
National Ocean Industries Association and, 4:2067
nature as social construct and, 4:2068
oceans as a space of nature and, 4:2065
ocean-using industries and, 4:2067
oil and gas drilling platform, Pacific Ocean, 4:2067 (photo)
spills and, 4:2073–2076
Pacific Decadal Oscillation (PDO) and, 1:164
Pacific Ocean cool and warm phases and, 1:164
political geography issues and, 4:2068–2069
politicized geography issues and, 4:2069–2070
poststructuralism and, 4:2069
public awareness, 4:2068
sea as arena for culture formation and, 4:2070
sea-level rise and, 3:1327, 3:1336
as space of mobility, 4:2068–2069
statistics, 4:2064–2065, 4:2067
Strabo and, 4:2065
technology advances and, 4:2066–2067
UN Convention on the Law of the Sea and, 4:2069
world-ocean and “seven seas” terms and, 4:2064
world-system theory and, 4:2069

See also Hurricanes, physical geography of; Hurricanes, risk and hazard; Oceans: noted scholars

Oceans: noted scholars
Fernand Braudel, 4:2070
Gilles Deleuze, 4:2070
Michael Foucault, 4:2070
Paul Gilroy, 4:2070
Felix Guattari, 4:2070
Richard Hartshorne, 4:2065
Marcus Rediker, 4:2070
Ellen Churchill Semple, 4:2065
Odum, Howard, 4:2073
Olmsted, Frederick Law, 4:2070
Olson, Mancur, 4:2071
Oldenburg, Ray, 4:2071
Oklahoma GIS humanities and social sciences applications and, 4:2067
Encyclopedia of Voronoi Diagrams city systems work of, 4:2067
"weathering" of oil and, 4:2067
"geopragmatic" view and, 4:2080
humanistic GIScience and, 3:1479
Werner Kuhn's work in, 4:1672–1673
metadata and, 4:1885, 4:2078–2079, 4:2085
ontological commitments definition and, 4:2079
ontology definition and, 4:2079
Donna Peuquet's work and, 4:2165
postmodern ontologies and, 5:2265–2266
semantic heterogeneities definition and, 4:2079–2080
semantic interoperability definition and, 4:2079–2080
semantic similarity definition and, 4:2079–2080
spatial granularity element in, 4:2081
term ambiguities and, 4:2078–2079
Ontology, 4:2081–2083
abstractions and, 4:2082
critical geography and, 4:2083
criticism of, 4:2083
definition of, 4:2081
diversity recognition and, 4:2082
epistemology and methods transition and, 4:2082
flat ontology and, 4:2082
Andrew Frank's work in, 3:1170
geographic methods and, 4:2082
geographic technology and, 4:2083
GIS and, 4:2083
humanistic GIScience and, 3:1479
Marxist geographies and, 4:2082
ontology of a study and, 4:2082
ontology role in geography and, 4:2081–2082
physical and cultural geography and, 4:2082
place, environment, society, and philosophy
interconnectedness and, 4:2082
postmodern geography and, 4:2082
realism and, 5:2369–2371
relations among features and, 4:2082
scale and generalization structures and, 4:2082
spatial ontologies and, 4:2081–2082
transformative nature of, 4:2082
See also Ontological foundations of geographical data

OPEC. See Organization of the Petroleum Exporting Countries (OPEC)

Open geodata standards, 4:2083–2085
data conversion and, 4:2084
definition of, 4:2083
functions of, 4:2083–2084
geodata storage and transmission complexities and, 4:2081
International Standards Organization/Technical Committee 211 and, 4:2084–2085
interoperability and spatial data standards and, 3:1623–1625
ISO 19101:2002 and, 4:2084
ISO 19115** family of standards and, 4:2084
metadata and, 4:1885, 4:2085

Omaha, Nebraska
African Americans in, 2000, 2:1025 (fig.)
poverty in, 2:1025 (fig.)
Whites in, 2000, 2:1025 (fig.)

Ohman, 3:1190 (table)

Ontological foundations of geographical data, 4:2078–2081
application context factor in, 4:2080
background context of, 4:2079–2080
bona fide boundary and, 4:2080–2081
critical GIS and, 2:614–615
cultural differences role in, 4:2080
ethnophysiology term and, 4:2080
flat boundary and, 4:2081
geodemosphere view and, 4:2080
humanistic GIScience and, 3:1479

Ohio GIS and, 4:2067
geographic technology and, 4:2067
Marxist geographies and, 4:2067
ontology role in geography and, 4:2067
ontology role in geography and, 4:2067
realism and, 5:2369–2371
relations among features and, 4:2067
scale and generalization structures and, 4:2067
spatial ontologies and, 4:2081–2082
transformative nature of, 4:2067
See also Ontological foundations of geographical data

Okabe, Atsuyuki, 4:2076–2077
city systems work of, 4:2077
Encyclopedia of Voronoi Diagrams written by, 4:2076
GIS humanities and social sciences applications and, 4:2076
spatial analysis on networks and, 4:2076
Voronoi diagrams work of, 4:2076
Oklahoman “colored” water cooler, Oklahoma City, 1939, 5:2345 (photo)
first tornado captured by NSSL Doppler radar,
Union City (1973), 6:2853 (photo)
spillway at Broken Bow Reservoir, Mountain Fork River,
McCurtain County, 6:3077 (photo)
Oldenburg, Ray, 4:2168
Oliver, John E., 1:467
Olmsted, Frederick Law, 4:1699
Olson, Mancur, 5:2215
Olsson, Gunnar, 4:2077–2078
deconstructionism within poststructuralist geography and, 4:2077
limits of language, limits of understanding and, 4:1754
post-positivist geography and, 4:2077
quantitative work of, 4:2077
radical cartography of power views of, 4:2077–2078

OECD. See Organisation for Economic Co-operation and Development (OECD)

Offshore finance, 4:2071–2073
anti-money-laundering policies and, 4:2072
Breton Woods fixed exchange rates issue and, 4:2071
definition of, 4:2071
development of, 4:2071
Eurodollar market factor in, 4:2071
Euromarkets and, 2:1031
Financial Action Task Force (FATF) and, 4:2072–2073
low-tax jurisdictions and, 4:2071 (fig.), 4:2072 (fig.)
Middle East petrodollar recycling factor in, 4:2071
offshore financial centers (OFCs) and, 4:2071
offshore-onshore tensions and, 4:2071–2072
problems of modern global economy and, 4:2071
savings tax agreement (EU) and, 4:2072
spatial distribution of OFCs and, 4:2071–2072
supranational regulatory and supervisory bodies and, 4:2071–2072
technology advances factor in, 4:2071

Ontological foundations of geographical data, 4:2078–2081:
application context factor in, 4:2080
background context of, 4:2079–2080
bona fide boundary and, 4:2080–2081
critical GIS and, 2:614–615
cultural differences role in, 4:2080
ethnophysiology term and, 4:2080
flat boundary and, 4:2081
“geopragmatic” view and, 4:2080
humanistic GIScience and, 3:1479
Werner Kuhn’s work in, 4:1672–1673
metadata and, 4:1885, 4:2078–2079, 4:2085
ontological commitments definition and, 4:2079
ontology definition and, 4:2079
Donna Peuquet’s work and, 4:2165
postmodern ontologies and, 5:2265–2266
semantic heterogeneities definition and, 4:2079–2080
semantic interoperability definition and, 4:2079–2080
semantic similarity definition and, 4:2079–2080
spatial granularity element in, 4:2081
term ambiguities and, 4:2078–2079

Ontology, 4:2081–2083
abstractions and, 4:2082
critical geography and, 4:2083
criticism of, 4:2083
definition of, 4:2081
diversity recognition and, 4:2082
epistemology and methods transition and, 4:2082
flat ontology and, 4:2082
Andrew Frank’s work in, 3:1170
graphic methods and, 4:2082
graphic technology and, 4:2083
GIS and, 4:2083
humanistic GIScience and, 3:1479
Marxist geographies and, 4:2082
ontology of a study and, 4:2082
ontology role in geography and, 4:2081–2082
physical and cultural geography and, 4:2082
place, environment, society, and philosophy
interconnectedness and, 4:2082
postmodern geography and, 4:2082
realism and, 5:2369–2371
relations among features and, 4:2082
scale and generalization structures and, 4:2082
spatial ontologies and, 4:2081–2082
transformative nature of, 4:2082

See also Ontological foundations of geographical data

Open geodata standards, 4:2083–2085
data conversion and, 4:2084
definition of, 4:2083
functions of, 4:2083–2084
geodata storage and transmission complexities and, 4:2081
International Standards Organization/Technical Committee 211 and, 4:2084–2085
interoperability and spatial data standards and, 3:1623–1625
ISO 19101:2002 and, 4:2084
ISO 19115** family of standards and, 4:2084
metadata and, 4:1885, 4:2085
Open Geospatial Consortium (OGC) and, 4:2083, 4:2084, 4:2085–2086
See also Open Geospatial Consortium (OGC); Open Source Geospatial Foundation (OSGeo); Open Source GIS (OSGIS)

Open Geospatial Consortium (OGC), 4:2085–2086
basic spatial operations defined by, 4:2084
Canadian Geospatial Data Infrastructure interoperability project and, 4:2085
client-server architecture standards of, 1:426
Egenhofer and Herring’s nine-intersection scheme and, 6:2848–2849
functions of, 4:2085
Geographic Resources Analysis Support System (GRASS) and, 4:2085
geospatial industry focus of, 3:1259
geospatial semantic Web and, 3:1260
GIS Web services and, 3:1321, 5:2228
Google’s Keyhole Markup Language (KML) and, 3:1624, 4:2085
implementation standards of, 4:2085
International Standards Organization/Technical Committee 211 (ISO-TC 211) and, 4:2084–2085
Internet GIS and, 3:1621
interoperability and spatial data standards and, 3:1623–1625
interoperability focus of, 4:2085
OGC Specification Program, consensus process and, 4:2084
open geodata standards and, 4:2083, 4:2084
Open GIS Abstract Specification and, 4:2084, 4:2085
Open GIS Simple Features Interface Standard (SFS) and, 4:2084
open-source GIS software and, 4:2085
semantic interoperability and, 4:2085
Specification Program standards and, 4:2085
standards for geographic information exchange and, 4:2085
Web Coverage Service of, 4:2084
Web Feature Service of, 4:2084
Web Map Service and, 4:2084
Web services standards and, 4:2084
“well-known text” and “well-known binary” formats of, 4:2084
Kuhn Werner and, 3:1673
See also Open geodata standards; Open Geospatial Consortium (OGC); Open Source Geospatial Foundation (OSGeo); Open Source GIS (OSGIS); Spatial data infrastructures (SDI)

Open-pit mining, 4:2086–2088
ancient mines and, 4:2086
Church Rock Mine, Arizona and, 4:2087
coal extraction and, 4:2086
commonly mined minerals and, 4:2086
environmental effects of, 4:2086–2087
EPA’s Toxic Release Inventory and, 4:2087
Grasberg-Ertsberg open-pit mine, Indonesia and, 4:2087
human health affected by, 4:2087–2088
hydraulicing practice and, 4:2086–2087
Industrial Revolution resource needs and, 4:2086
mining company responsibilities and, 4:2088
open cast mine examples and, 4:2086
quarrying definition and, 4:2086
Red Dog zinc mine, Alaska and, 4:2087
“shoot-and-shove” coal mining practices and, 4:2086
St. Elizabeth Gold Mine, Mahdia, Guyana, 4:2087 (photo), 4:2088 (photo)
Surface Mining Control and Reclamation Act (1977) and, 4:2088
terms related to, 4:2086
Yankee Doodle copper mining tailings pond, Montana, and, 4:2087
Openshaw, S., 2:824
Open Source Geospatial Foundation (OSGeo), 4:2088–2089
educational outreach activities of, 4:2089
governance of, 4:2089
history of, 4:2089

Open Source GIS and, 4:2089
Open Source Software for Geoinformatics conference series of, 4:2089
projects of, 4:2089
services and mission of, 4:2088–2089
See also GIS software; Open geodata standards; Open Geospatial Consortium (OGC); Open Source GIS (OSGeo)

Open Source GIS (OSGIS), 4:2090–2091
Free Software Foundation and, 4:2090
free source code feature of, 4:2090
functionality of, 4:2091
interoperability and, 4:2090
meta data management and, 4:2091
Open Geospatial Consortium (OGC) and, 4:2090
Open GRASS Foundation (OGF) and, 4:2090
Open Source Geospatial Foundation and, 4:2090
Open Source Initiative and, 4:2090
organizations and, 4:2090
philosophy, development methods, and community in, 4:2090–2091
services provided by, 4:2091
software projects and, 4:2090
specific software titles and, 4:2090
virtual developer and user communities and, 4:2091
See also GIS software; Open geodata standards; Open Geospatial Consortium (OGC); Open Source Geospatial Foundation (OSGeo)

Open space, 4:2091–2094
access element of, 4:2092
Central Park, 4:2092 (photo)
collaborative approaches to, 4:2093–2094
definitions and values of, 4:2092–2093
deforestation and, 4:2092–2093
federal Land and Water Conservation Fund and, 4:2093
greenspace term and, 4:2092
land trusts and, 4:2093
management and protection of, 4:2091–2092
meaning of at various scales and, 4:2091–2092
purchase of, 4:2093
recreational open spaces and, 4:2092–2093
regulatory protection approach to, 4:2093
conflicts over uses of, 4:2092–2093
use terms and, 4:2092–2093
organic farmland and, 4:2093
watershed conservancies and, 4:2093

Oregon
new urbanism, Orenco Station, Portland, 4:2017, 4:2026 (photo), 4:2027, 4:2027 (photo)
Oregon Land Use Act (1973) and, 4:1746

Orfali, R., 2:777

Organic agriculture, 4:2094–2096
certification process of, 4:2094
Community Sponsored Agriculture and, 4:2095
crop rotation and, 2:627–630
definition of, 4:2094
diverse organic farm in San Juan Bautista, California, and, 4:2095 (photo)
ecosheds and, 2:857
environmental certifications in, 2:914
Environmental Working Group and, 4:2095
fair trade certification and, 3:1081
International Federation of Organic Agriculture Movements (IFOAM) and, 2:914
ISO 14001 Standard for Environmental Management Systems and, 2:914
mixed farming and, 4:1914–1917
organic food labels and, 4:2095
organic milk and, 4:2094
pesticide residue and GMOs issues and, 4:2094–2095
U.S. organic food market and, 4:2094–2095
USDA National Organic Standards and, 4:2094
“USDA Organic” seal categories and, 4:2095
Organization for Economic Co-operation and Development (OECD), 4:2096–2097
biotechnology definition and, 1:33
CO₂ emissions, GHGs of developing countries and, 3:1377
critics of, 4:2096
foreign aid and, 3:1151–1153
functions of, 4:2096
members of, 4:2096, 4:2097 (fig.)
mission of, 4:2096
official development assistance (ODA) and, 3:1151
offshore finance centers regulation and, 4:2071
poverty data of, 5:2275
public water service in, 5:2316
recent activities of, 4:2096
Organization of the Petroleum Exporting Countries (OPEC), 4:2097–2100
advantages of, 4:2097
alternative oil sources and, 4:2099
cartel definition and, 4:2097
demand growth for oil and, 4:2098
history of, 4:2098–2099, 4:2163
long-term stability of, 4:2099–2100
member nation conflicts and, 4:2099
member profiles and, 4:2099–2100, 4:2100 (2100)
member states, functions and operations of, 4:2098
oil embargo by Arab oil producers and, 4:2099
oil shortages, rising oil prices and, 4:2099, 4:2163
Organization of Arab Petroleum Exporting Countries and, 4:2099
Persian Gulf War and, 4:2099
unstable structural conditions of, 4:2097–2098
U.S. invasion of Iraq and, 4:2099
world political factors affecting, 4:2098–2099
Organophosphates, 4:2100–2101
chemical warfare and, 4:2101
definition of, 4:2100
Gulf War syndrome and, 4:2101
mechanism of, 4:2101
nerve gases and pesticides use of, 4:2101
pesticides and, 4:2157–2158
Gerhard Schrader and, 4:2101
toxic properties of, 4:2100–2101
Tokyo subway sarin attack and, 4:2101
Oswin, Natalie, 5:2332–2333
Other/Otherness, 4:2106–2108
animal geographies, “inappropriate/d other” concept and, 1:78
Simone de Beauvoir and, 4:2107
colonialism, racism, and patriarchy and, 4:2107
colonial mappings of the Other and, 4:2106
critical race theory and, 4:2107
ethnocentrism and, 2:1027
explanation of, 4:2106
geographical imagination and, 3:1221–1225
human behavior stereotypical notion of place and, 4:2107
human geography and, 4:2107
marginalization and exclusion and, 4:2106
noble savage concepts and, 2:1020–1022
Orientalism and, 4:2101–2104
“Othering” of the body, body geographies and, 1:288
postcolonialism and, 4:2107
poststructuralism and, 5:2272
power and control elements in, 4:2107
power dynamics element in, 4:2106
process of Othering and, 4:2107
Edward Said’s Orientalism work and, 4:2106–2107, 5:2259–2260, 5:2272
space and identity issues and, 4:2107
territory and borders concepts and, 4:2107
urban geography and, 4:2107
See also Ethnicity; Sexuality, geography and of
Our Common Future (World Commission on Environment and Development), 1:256, 5:2220
Outsourcing, 4:2108–2110
definition of, 4:2108
domestic vs. international outsourcing and, 4:2108
economic and sociocultural consequences of, 4:2108
Global Production Networks (GPN) and, 4:2108–2109
Global Value Chains (GVC) Initiative and, 4:2108–2109
tional outsourcing between Western Europe and Bulgaria and, 4:2109 (fig.)
as restructring technique, 5:2458
imaginative geography and, 4:2102
institutional Orientalism and, 4:2102–2103
literature and art and, 4:2104
masculine worldview of, 4:2103
modern context of, 4:2104
“the Occident” (the West) vs., 4:2101–2102
Orientalism (Said) and, 4:2102–2103, 5:2259–2260, 5:2272
pejorative Orient representation and, 4:2102
positionality and, 5:2258
postcolonial studies and, 4:2103, 4:2104
riverine despotism, “hydraulic empires” theory and, 5:2215
Self and the Other separation and, 4:2102, 5:2272
September 11, 2001, and, 4:2103
textual representations and, 4:2103
use within geographic subfields by, 4:2104
Ortelius, 4:2104–2106
cartography work of, 1:341 (fig.), 1:342, 1:350, 4:2104–2106
empirical approach of, 4:2106
historical atlas efforts of, 4:2106
Gerardus Mercator and, 4:2106
Theatrum Orbis Terrarum, atlas of the world and, 4:2105 (fig.), 4:2106
Ortner, Sherry, 4:2107
Outsourcing, 4:2108–2110
definition of, 4:2108
domestic vs. international outsourcing and, 4:2108
economic and sociocultural consequences of, 4:2108
Global Production Networks (GPN) and, 4:2108–2109
Global Value Chains (GVC) Initiative and, 4:2108–2109
international outsourcing between Western Europe and Bulgaria and, 4:2109 (fig.)
as restructring technique, 5:2458
Outsourcing, 4:2108–2110
definition of, 4:2108
domestic vs. international outsourcing and, 4:2108
economic and sociocultural consequences of, 4:2108
Global Production Networks (GPN) and, 4:2108–2109
Global Value Chains (GVC) Initiative and, 4:2108–2109
international outsourcing between Western Europe and Bulgaria and, 4:2109 (fig.)
as restructring technique, 5:2458

INDEX 3331
spatial aspects of, 4:2108
See also Division of labor
Owen, Robert, 3:1372
Ozone layer
volcanic eruptions and, 1:163
See also Chlorofluorocarbons (CFCs); Stratospheric ozone depletion
Ozone Secretariate, 3:1605

Pachamama Alliance, 1:96
Pacific Ocean
Antarctic Convergence zone and, 1:451
atmospheric angular momentum in, 1:143
atmospheric energy variations and, 1:163–165
coastline landforms of, 4:1689
conservation zoning in, 2:572
rental cell, 3:1395–1397
invasion of species in, 3:1472–1473
major tectonic areas of, 5:2196 (fig.)
mild, midlatitude climate and, 1:436–437
ocean-atmosphere variabilities drought factor in, 2:792
oil and gas drilling platform, Pacific Ocean, 4:2067 (photo)
sewage entering coastal zones of, 1:501
Tonga Trench earthquakes, South Pacific and, 2:811
"warm pool" of sea-surface temperatures in, 1:145
See also El Niño–Southern Oscillation (ENSO)
Paehlke, Robert, 2:531
Paglen, Trevor, 4:1897
Paine, Robert, 4:1635, 4:1656
Painter, Joe, 2:620
Pakistan
basin and range topography in, 1:186
clothing exports from, 6:2186 (fig.)
deficient calorie consumption in, 3:1487
economically active females in, 3:1190 (table)
groundwater usage in, 3:1386
independence of, 2:692
nation-state after colonialism in, 1:517
opium and heroin production in, 2:797
population growth in, 5:2241
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
Paleoclimateology, 1:671–672
Palestine
Biblical map of, 1:196 (fig.)
British colonization of, 1:514
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
"natural ethnicity" of a region concept and, 2:1020
Ortelius’s Map of Palestine and the Holy Lands, 1:341 (fig.)
Palimpsest, 4:2111–2112
applications of, 4:2112
criticism of, 4:2112
definition of, 4:2111
“intertext” and, 4:2112
landscape as a palimpsest and, 4:2111
layering element in, 4:2111
Donald Meinz and, 4:2111
mythogeography and, 4:2112
“new cultural geography” and, 4:2111
origins of term and, 4:2111
Carl Sauer and, 4:2111
semiotic model of, 4:2112
spatial diffusion theory and, 4:2112
symbolic landscape as, 4:2111–2112
temporal change of landscape (Sauer) and, 4:2111
Derwent Whitley and, 4:2111
Palka, Eugene, 4:1897
Pallemsa, Juhani, 4:2168
Panama
bird species in, 1:199
dominio theory and, 3:1224
economically active females in, 3:1190 (table)
Magellan’s portage across Isthmus of Panama, 4:1814 (fig.)
marine aquaculture in, 4:1854 (fig.)
Panama Canal and, 5:2254
Panchromatic imagery, 4:2112–2115
aerial photography use of, 4:2112, 4:2113–2114
application of, 4:2114–2115
definition and explanation of, 4:2112–2113
digital space-borne sensors and, 4:2114
example of, 4:2113 (fig.)
IKONOS high-spatial resolution commercial sensor and, 4:2113 (fig.), 4:2114
Landsat satellite program and, 4:2114, 4:2115 (photo)
map production and, 4:2115
multiresolution data fusion and, 4:2115
panchromatic band characteristics on Earth-imaging satellites and, 4:21115 (table)
panchromatic film and, 4:2112, 4:2113–2114
photogrammetry and, 4:2114–2115
satellite based sensors and, 4:2114
SPOT satellite (France) and, 4:2114, 4:2115 (photo)
Hermann Carl Vogel’s work in, 4:2113
Pandian, Anand, 5:2339
Panopticon, 4:2116–2117
Bentham’s panopticon, 4:2116, 5:2271
critical panopticism and, 4:2116
Discipline and Punish (Foucault) and, 4:2116
Michel Foucault and, 4:2116
Foucault’s panopticon, 4:2116
gestational technologies and, 4:2117
as prison model, 4:2116
as social theory, 4:2116
Papanek, Victor, 3:1372
Papua New Guinea
APEC membership of, 1:121
Jared Diamond’s biodiversity studies of, 2:734
economically active females in, 3:1190 (table)
forest fragmentation in, 3:1159
human-induced invasion of species in, 3:1473–1474
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Malay archipelago and, 1:105
species variations on, 1:209
tropical rain forest of, 1:234
Paraguay
deforestation in, 2:696
economically active females in, 3:1190 (table)
hydroelectric power in, 3:1509
Paris, France
command and control economy in, 1:304
infrastructure networks in, 3:1597
railroad system in, 5:2358, 5:2359 (fig.)
Park, Robert, 3:1458, 5:2323
Parker, Dawn, 2:561
Parks and reserves, 4:2117–2120
American wilderness as culture-free nature concept (Cronon) and, 5:2339
natural areas fragmentation and, 4:2131
parks and reserves and, 4:2117–2120
patches, island biogeography principles and, 4:2131
patch size and connectivity factors and, 4:2132
South Carolina’s pine forest habitat example of, 4:2131–2132
in tropical and temperate landscapes, 4:2131

Path dependence, 4:2133–2135
Brian Arthur’s work and, 4:2133
ball-and-urn models and, 4:2133
causal possibility, contingency, closure, and constraint elements in, 4:2133
contingent accidents, microlevel chance events and, 4:2133
criticism of, 4:2135
Paul David’s work and, 4:2133
definition of, 4:2133
development path of a regional system and, 4:2134 (fig.)
economic versions of, 4:2133–2134
increasing returns version of, 4:2133
institutional hysteresis version of, 4:2133–2134
nonergodicity characteristic of, 4:2133
regional lock-in and, 4:2134–2135, 4:2134 (fig.)
Mark Setterfield’s work in, 4:2133–2134
spatial systems evolution and, 4:2134–2135
stochastic systems theory and, 4:2133
systems and processes governed by their own history and, 4:2133
technological lock-in version of, 4:2133
types, degrees, and causes of, 4:2135

Patriarchy, geography and, 4:2135–2137
Michael Brown and, 4:2136
dual-systems vs. single-systems model of feminist geography and, 4:2136
feminist geography and, 4:2136
feminist political geography and, 4:2136
gender domination focus of, 4:2135–2136
gendered division of labor issue and, 4:2136
gender geographies and, 4:2136
Heidi Hartmann’s feminist social theory and, 4:2136
interlocking systems of power and, 4:2136
locations of patriarchal relations and, 4:2136
patriarchy across space and place and, 4:2136
patriarchy definition and, 4:2135
patriarchy’s main elements and, 4:2136
private vs. public spheres of, 4:2136
Lynn Staeheli and, 4:2136
systemic nature of patriarchal, 4:2135–2136
views of gender within feminist geography and, 4:2136
Sylvia Walby and, 4:2136
PCBs. See Polychlorinated biphenyls (PCBs)

PE. See Political ecology (PE)
Peake, L., 5:2335

Peasants and peasantry, 4:2137–2142
accumulation by dispossession concept (Harvey) and, 4:2138–2139
agribusiness impact on, 4:2139–2140, 4:2141
banditry, peasant protest and, 4:2141
capitalist society and, 4:2138–2140
class-differentiation, class-based identities and, 4:2140
conservative vs. revolutionary peasants and, 4:2140
dee-agrarianization of, 4:2140
differentiation among, 4:2139
discourses, 4:2137
everyday form of resistance by, 4:2141
folk society, folk-urban continuum and, 4:2137
gender division of labor and, 4:2139
historic and geographic contexts of, 4:2137
India’s Naxalite movement and, 4:2141
land reform and, 4:1692–1696
“limited good” model of, 4:2137
Marxist process-oriented view of, 4:2137–2138
Movimento Sem Terra (MST) and, 4:1948–1951
multiclass mobilization of peasants and, 4:2140–2141
neoliberal capitalism and, 4:2137, 4:2140
new peasant movements (NPMs) and, 4:2141
peasant farmer carrying straw, Hoi An, Vietnam, 4:2138 (photo)
peasant identity, agency and, 4:2140–2141
peasants as commodity producers and, 4:2139
peasants definition and, 4:2137
poor, middle, and rich peasants and, 4:2139, 4:2140
precapitalist peasant communal production mode and, 4:2139
preindustrial agriculture and, 1:47–49
primitive accumulation concept (Marx) and, 4:2138
self-sufficient economy model of, 4:2137–2138
as society, culture, or economy, 4:2137–2138
studies of, 4:2137
“weapons of the weak” concept and, 4:2141
See also Developing world; Peasants and peasantry: noted scholars

Peasants and peasantry: noted scholars
George Foster, 4:2137
David Harvey, 4:2138
Eric Hobsbawn, 4:2141
Robert Redfield, 4:2137
James Scott, 4:2141
Teodor Shanin, 4:2137
Nanda Shrestha, 4:2141
E. P. Thompson, 4:2141
Daniel Thorner, 4:2143
Michael Watts, 4:2139

Peat, 4:2142–2143
in boreal forest biome, 1:215, 1:216–217
climate change and, 4:2143
definition of, 4:2142
ecological importance of, 4:2142–2143
locations of, 4:2142
peat bog, Maamturk Mountains near Cong, Ireland, 4:2143 (photo)
peatland destruction, global warming and, 4:2143
Peck, Jamie, 4:2013, 4:2014
Peet, R., 5:2335

Peet, Richard, 4:2144
anarchism and, 1:73
Antipode edited by, 1:73, 2:618, 4:2144
books written by, 4:2144
environmental imaginaries and, 2:933
export-led development views of, 2:1063
Marxism scholarship of, 4:2144
Modern Geographical Thought and, 4:2144
nature and society relationship studies of, 4:2144
political ecology and development studies and, 4:2144
postmodernism views of, 4:2144
radical geography and, 4:2143
spatial imaginaries and, 2:932
Peluso, Nancy, 2:595, 5:2192, 5:2213

Penck, Walther, 4:2145
William Morris Davis and, 4:2145
geomorphology work of, 4:2145
Lester King influenced by, 4:2145
parallel retreat of slopes, 4:2145

Pennsylvania
Amish farm, Lancaster County, 5:2494 (photo)
graveyard and steel mill, Bethlehem, 5:2690 (photo)
Three Mile Island nuclear power plant, Middletown, 6:2827 (photo)
Permafrost, Pepper, David, 3:1372, 4:1897

Periglacial environments, 4:2145–2152
block-fields or kurums and, 4:2149
boreal forest, or taiga and, 4:2146
Circumpolar Active Layer Monitoring program and, 4:2150
climate change and, 4:2149–2151
climatic features of, 4:2146
climatic warming and, 4:2149–2150
construction techniques in, 4:2151–2152
drinking water availability issue and, 4:2151
ecosystems of, 4:2146–2147, 4:2147 (fig.)
environmental concerns, 4:2149–2152
frost heave problems and, 4:2152
frost weathering of soils and, 4:2149
gouge-ice slumps and, 4:2148
high northern latitudes location of, 4:2146, 4:2147 (fig.)
human-induced terrain damage and, 4:2152
human occupancy and, 4:2149–2152
intense frost and permafrost characteristics of, 4:2145
International Permafrost Association and, 4:2150
katabatic winds and, 4:2149
landscapes and, 4:2147–2149
locations of, 4:2145–2146
natural resources of, 4:2146
in the Northern Hemisphere, 4:2147 (fig.)
oil and gas exploration issues and, 4:2152
paraglacial landscapes and, 4:2147
pingos, Mackenzie Delta region, northwestern Arctic Canada, 4:2149 (photo)
pingos and, 4:2148
pipeline construction issues and, 4:2151 (photo), 4:2152
polar desert terrain and, 4:2146
Poles, North and South and, 5:2203–2209
proglacial landscapes and, 4:2147
solifluction and, 4:2149
Trans-Alaska Pipeline System, 4:2151 (photo)
tree line boundary of, 4:2146
tundra polygons, northern slope of Alaska, 4:2150 (photo)
tundra polygons and, 4:2148
tundra polygons terrain, Southern Banks Island, Arctic Canada and, 4:2148 (photo)
See also Ice

Permaculture, 4:2152–2153
agroecological production methods and, 4:2152
definition of, 4:2152
ethics of, 4:2153
David Holmgren and, 4:2152
human habitats and self-sufficient community
food production, 4:2152
local agrarian production techniques and, 4:2152
Bill Mollison and, 4:2152
principles and, 4:2153
systems ecology and geography synthesis and, 4:2152

Permafrost, 4:2153–2157
active layer of, 4:2154, 4:2156 (fig.)
in Alaska and Canada, 1:215
boreal forest and, 1:215
climate change and, 1:461, 4:2154
continuous, discontinuous, sporadic, and isolated permafrost in
Northern Hemisphere and, 4:2154, 4:2155 (fig.)
definition of, 4:2153
degradation of, 4:2154
degradation of, impacts, 4:2154–2157
“dry” permafrost and, 4:2154
greenhouse gas emissions and, 4:2156
hydrology systems affected by, 4:2156–2157
“permafrost-climate feedback” loop and, 1:90
Poles, North and South and, 5:2203–2209
severe midlatitude climate, 1:441–442
soils of, 4:2154
thermokarst processes and, 4:2154, 4:2156
variable thickness of, 4:2154
See also Periglacial environments

Perry, David, 3:1595
Persia, 2:1054
Peru
agrobiodiversity in, 1:50
APEC membership of, 1:121
basin and range topography in, 1:186
Cathedral of Santa Domingo, Cuzco, 5:2406 (photo)
cholera in, 1:401
coca production in, 2:798
Conference of Latin Americanist Geographers held in, 2:568
debris avalanche, Yungay, 1:178 (photo)
ecological footprint of, 2:827, 2:827 (fig.)
economically active females in, 3:1190 (table)
El Niño-Southern Oscillation (ENSO) and, 2:889
Alexander von Humboldt’s travels in, 3:1484
in situ and adjacent domestication of camu camu trees in, 1:377,
1:377 (photo)
land use practices, wildlife survival in, 1:77
llama and guinea pig domesticated in, 2:783
marine aquarium in, 4:1854 (fig.)
mineral deposits, mining in, 4:1911
nongovernmental organizations (NGOs) in, 1:415
social movements research in, 1:365
Spanish colonization of, 1:511, 1:516
squatter settlements in, 5:2684
tropical rain forest deforestation in, 1:238
tropical rain forest of, 1:234

Pesticides, 4:2157–2158
agrochemical category of, 4:2157
biomagnification process and, 2:939
classification systems of, 4:2157
DDT, 4:2158
definition of, 4:2157
environmental impact of, 2:939
environmental justice issues and, 4:2158
Environmental Protection Agency (EPA) and, 4:2158
hydrocarbon pesticides, 4:2158
inorganic pesticides, 4:2157
nutrient loading and, 2:939
organophosphates, 4:2100–2101, 4:2158
political ecology issues and, 4:2158
research related to, 4:2158
Silent Spring (Carson) and, 4:2158
synthetic pesticides, 4:2157

Pest management, 4:2158–2161
Bio Energetic Synchronization Technique (BEST) and, 4:2160 (photo)
biocontrol methods of, 4:2160–2161
chemical control (pesticides) methods of, 4:2160
coordinated management strategy, systematized decision making and, 4:2159
“creation” of new pests and, 4:2159
cultural control methods of, 4:2161
definition of, 4:2158–2159
differences in problems and priorities, 4:2159
exotic species and, 2:1048–1050
GIS mapping techniques and, 4:2161
Hawaii fruit fly area wide pest management program and, 4:2160 (photo)
history of, 4:2159
human-animal conflict research and, 4:2159
human geography and, 4:2161
individual to national scales of, 4:2159
integrated pest management (IPM) and, 4:2159–2160
mechanical control methods of, 4:2161
organophosphates and, 4:2100–2101
“pest” as subjective, context-dependent classification and, 4:2159
pest control vs., 4:2159
physical geography and, 4:2161
regional, national, and international legislation, 4:2159
threat level assessment of, 4:2159–2160
varietal control methods of, 4:2161
Petchenik, Barbara, 3:1402
Peters, Gary, 5:2247
Petroleum, 4:2161–2164
Baku-Tbilisi-Ceyhan Pipeline Company and, 4:2163
coal and, 4:183–486
crude oil term and, 4:2161
environmental impacts of oil fields and, 2:946–948
environmental impacts of pipelines, 2:948–951
environmental transformations from, 4:2163–2164
Exxon Mobil and, 4:2162
gasoline demands and, 4:2162
goography of petroleum consumption and, 4:2164 (fig.)
geological elements in formation of, 4:2161
global reserves of, 2:903 (fig.), 2:904 (fig.)
major petroleum-producing countries and, 4:2163, 4:2163 (fig.)
new geographies of distribution of, 4:2163
oil and gas drilling platform, Pacific Ocean, 4:2067 (photo)
oil crisis of 1973–1974, 4:2163
oil fields discoveries and, 4:2163
oil industry global players and, 4:2162
oil pipeline construction and, 4:2162–2163
oil spills and, 4:2073–2076
OPEC cartel and, 4:2097–2100, 4:2163
petroleum-producing countries and, 4:2163 (fig.)
political importance of, 4:2162
Standard Oil Company and, 4:2162
storage and refining techniques and, 4:2162
technical term definition of, 4:2161
transnational economic petroleum networks and, 4:2164
transportation issues and, 4:2162
well drilling technology and, 4:2162
World War I, World War II and, 4:2162–2163
Pesquet, Donna, 4:2165
academic career of, 4:2165
geographic representation work of, 4:2165
geovisualization and geographic databases work of, 4:2165
multiagent systems research of, 4:2165
“The Ontology of Fields” workshop co-developed by, 4:2165
service work of, 4:2165
Phenomenology, 4:2165–2169
academic “right” vs. “left,” 4:2168–2169
Being and Time (Heidegger) and, 4:2166
being-in-the-world concept (Heidegger) and, 4:2167
body subject concept (Merleau-Ponty) and, 4:2166, 4:2168
constitutive or transcendental phenomenology (Husserl) and, 4:2166
criticisms, 4:2168–2169
current trends in, 4:2167–2168
definition of, 4:2165
early phenomenological work in geography and, 4:2167
existential insidedness (Relph) and, 4:2167
existentialist geographies and, 2:1046–107, 4:2166
existential phenomenology and, 4:2166–2167
graphic issues addressed by, 4:2165–2166
history and nature of, 4:2166
humanist geography and, 4:2167
intentional human awareness and, 4:2166–2167
interviewing and, 3:1625
life-world concept and, 4:2167
lived space concepts in, 4:2167–2168
natural attitude, acceptance of life-world and, 4:2167
Phenomenology of Perception (Merleau-Ponty) and, 4:2166
Place and Placeness (Relph) and, 4:2167
place ballet concept (Seamon) and, 4:2168
positionality and, 5:2257–2248
positivism and, 4:2167
responsive environment concept (Bentley) and, 4:2168
sense of place concept in, 4:2168
spatial-temporal regularity of individuals and, 4:2168
third places concept and, 4:2168
topophilia concept (Tuan) and, 4:2167
See also Phenomenology: noted scholars
Phenomenology: noted scholars
Chris Allen, 4:2168
Ian Bentley, 4:2168
Anne Buttimer, 4:2167
Edward Casey, 4:2168
Mindy Fullilove, 4:2168
Clarence Glacken, 4:2167
Martin Heidegger, 4:2166
Edmund Husserl, 4:2166
William Kirk, 4:2167
David Lowenthal, 4:2167
Jeff Malpas, 4:2168
Maurice Merleau-Ponty, 4:2166, 4:2168
Robert Mugerauer, 4:2168
Ray Oldenburg, 4:2168
Gunnar Olsson, 4:2166
Juhani Pallasmaa, 4:2168
John Pickles, 2:1046, 4:2182–2183
Edward Relph, 4:2167
David Seamon, 4:2168
Ingrid Leman Stefanovic, 4:2168
Kay Toombs, 4:2168
Yi-Fu Tuan, 4:2167, 6:2890–2891
J. K. Wright, 4:2167
Philadelphia, Pennsylvania
Baldwin Locomotive Works in, 4:1821
textile production in, 4:1821
Philander, George, 4:1754
Philippines
antiglobalization in, 1:95 (photo)
APEC membership of, 1:121
ASEAN membership of, 1:127, 1:128 (table), 1:129, 1:129 (table)
Coron Island, coral island seascape, Tagbanwa people, 3:1560 (photo)
economically active females in, 3:1190 (table)
forest fragmentation in, 3:1159
hacienda plantation form in, 5:2193
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Japanese electronics industry in, 2:885–886
Malay archipelago and, 1:105
Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)
marine aquaculture in, 4:1854 (fig.)
market-based land reform in, 4:1695
Mount Pinatubo’s eruption, 1991, 6:3028 (photo)
nongovernmental organizations (NGOs) in, 1,415, 1,415 (photo)
Philippine Association for Conservation and Development and, 1,96
silver trade and, 1,512
Spanish colonization of, 1,515
squatter settlements in, 5,2682
tropical rain forest of, 1,234
volcanic eruptions in, 1,163
Philipps, Jonathan, 2,562
Phillips, C. W., 3,1402
Philo, Chris, 5,2266
Phosphorus cycle, 4,2169–2171
biochemical reactions role of, 4,2169
deep ocean storage and, 4,2170–2171
global transfer of phosphorus and, 4,2170
human activities and, 4,2171
low bioavailability feature of phosphorus and, 4,2169–2170
ocean biota and, 4,2170
particulate fraction and, 4,2170
rivers role in, 4,2170
surface ocean and, 4,2170
Photochemical smog, 4,2171–2173
air quality criteria and, 4,2172
definition of, 4,2171
early-morning smog, Quito, Ecuador, 4,2172 (photo)
geochemical factors in, 4,2172
ground-level ozone in, 4,2171
health effects of, 4,2173
ingredients in, 4,2171
nitric oxide in, 4,2171
petroxyacetyl nitrates (PAN) formation and, 4,2172
reactions formulas and, 4,2171
reduction of, 4,2173
sunlight and, 4,2171
transport of pollutants and, 4,2172–2173
volatile organic compounds in, 4,2171
Photogrammetric methods, 4,2173–2175
accuracy measures of, 4,2174
activities contained within, 4,2175
aerial photograph flight runs and, 4,2174
applications and subfields of, 4,2175
central-perspective projection element in, 4,2174
close-range photogrammetry and, 4,2174
image processing methods of, 4,2175
metric properties of, 4,2174
object displacements in, 4,2174
purpose of, 4,2173
standard approach of, 4,2173–2174
stereometry principles and, 4,2173
triangulation principle in, 4,2173
Photography, geography and, 4,2175–2178
aerial, repeat, and photogrammetry photography types and, 4,2176
James Wallace Black, 4,2176
chronologically replicated photographic views and, 4,2176
cultural geographies and, 4,2177
Louis Jacques Mandé Daguerre’s method and, 4,2175
early photographic techniques and, 4,2173–2175
environmental organizations use of, 4,2177
environmental photography, photographers and, 4,2177
exploratory expeditions and, 4,2176–2177
geographical imagination and, 4,2177
geographic knowledge acquisition and, 4,2175–2176, 4,2177
Geography Lesson daguerreotype and, 4,2176 (photo)
GIS and digital imaging and, 4,2175
Nadar and, 4,2176
National Geographic Society and, 4,1977–1978
negative-positive process and, 4,2175
“One-World, Whole-Earth” Apollo space mission (Cosgrove) and, 4,2175
people and place relationships and, 4,2177
phototypography, or photogrammetry and, 4,2176
popular geography and, 4,2177
satellite imagery and, 4,2176
silver-coated copper plate method and, 4,2175
space and place scholarly issues and, 4,2177
William Henry Fox Talbot and, 4,2175
teaching and learning applications of, 4,2177
vertical and oblique aerial photographic techniques and, 4,2176
Physical climatology, 1,472
Physical geography, history of, 4,2178–2182
Ernst Antevs’ work in, 1,81–82
Richard Chorley’s geomorphology work and, 1,403–404
dendrochronology and, 2,711
fieldwork in, 3,1105–1110
Gaia theory and, 3,1175–1178
gemorphologic cycle and, 3,1241–1244
timeline of early Greeks and Romans, 4,2178
timeline of Middle Ages to 1800, 4,2178–2179
timeline of 1800–1950, 4,2179–2181
timeline of 1950–2000, 4,2181
timeline of 21st century, 4,2181–2182
See also Geomorphic cycle; Geomorphology; Physical geography, history of: specific timeline below
Physical geography, history of: early Greek and Roman
Aristotle, 4,2178
Earth as a spherical shape and, 4,2178
Earth’s circumference calculation and, 4,2178
Eratosthenes, 4,2178
Geographia (Strabo) and, 4,2178
Guide to Geography (Ptolemy) and, 4,2178
latitude and longitude concepts (Ptolemy) and, 4,2178
Ptolemy, 4,2178, 5,2300, 5,2387
Roman empire expansion and, 4,2178
Strabo, 4,2178
Physical geography, history of: Middle Ages to 1800
al-Idrisi, 4,2179
Arab geographers, 4,2179
Martin Behaim, 4,2179
Geographia generalis (Varenius) and, 4,2179, 5,2387
gemorphologic branches of knowledge (Kant) and, 4,2179
gemorphologic subdivisions (Varenius) and, 4,2179, 5,2387
human knowledge subdivisions (Kant) and, 4,2179
Ibn Battutah, 4,2179
Ibn Khaldun, 4,2179
Immanuel Kant, 4,2179
knowledge organization (Kant) and, 4,2179
Renaissance exploration and, 4,2178, 4,2179
spherical globe (Behaim) and, 4,2179
technology advances and, 4,2179
Viking exploration and, 4,2178
Physical geography, history of: 1800–1950
Louis Agassiz, 4,2180
American Geographical Society and, 4,2180
Frederic Clements, 4,2180
cycle climatic classification (Koppen) and, 4,2180
Henry Cowles, 4,2180
cycles of erosion and landscape development (W. M. Davis) and, 4,2180
Charles Darwin, 4,2180

INDEX 3337
data collection and classification and, 4:2181
William Morris Davis, 4:2180
V. V. Dokuchaev, 4:2180
geographical societies and, 4:2180
graphy subviews and, 4:2180
G. K. Gilbert, 4:2180–2182
glaciation research (Agassiz) and, 4:2180
human degradation of environment (Marsh) and, 4:2180
Alexander von Humboldt, 4:2180
James Hutton, 3:1245, 4:2179–2180
Wladimir Koppen, 4:2180
Kosmos (Humboldt) and, 4:2180
landscape evolution research (Gilbert) and, 4:2180–2181
Charles Lyell, 4:2179–2180
George Perkins Marsh, 4:2180
pedology (Dokuchaev) and, 4:2180
plant succession theories (Clements and Cowles) and, 4:2180
Principles of Geology (Lyell) and, 4:2180
Carl Ritter, 4:2180, 5:2387, 5:2470–2471
theory of evolution and, 4:2180
theory of uniformitarianism and, 4:2179–2180
Alfred Wallace, 4:2180
Physical geography, history of: 20th century, second half
academic departments and, 4:2181
biodiversity issues and, 4:2181
global warming issues and, 4:2181
Arnold Guyot, 3:1394
Ferdinand Hayden, 3:1408–1409
human activities issues and, 4:2181
Walther Penck, 4:2145
physical geography as a discipline and, 4:2181
quantitative revolution and, 4:2181
remote sensing and GIS tools and, 4:2181
systems-theory approach to, 4:2181
C. Warren Thornthwaite, 6:2821–2822
Physical geography, history of: 21st century
environmental issues and, 4:2182
human population growth issues and, 4:2182
information-processing technology and, 4:2182
interdisciplinary collaborations and, 4:2182
measurement technology advances and, 4:2182
remote sensing and satellite technology and, 4:2182
resource consumption issues and, 4:2182
Pajer, Jean, 1:391, 5:2609, 5:2610
Pick, J., 1:308
Pickles, John, 4:2182–2183
alternative mappings of contemporary society and, 4:2183
changing global economic geographies and, 4:2183
Counter-Cartographies Collective and, 4:2183
critical cartography work of, 4:2183
critical GIS and critical geography work of, 4:2182–2183
critical social theory and, 4:2182, 4:2183
eXistentialism and, 2:1046
globalization of apparel industry studied by, 4:2183
Ground Truth written by, 4:2182
A History of Spaces written by, 4:2183
Phenomenology and spatiality work of, 4:2183
political economies of power and development work of, 4:2183
regional analysis work of, 4:2109
Pigou, Arthur, 4:1857
Pilgrimage, 5:2184–2186
criticism of, 5:2184
cultural and political developments related to, 5:2184
definition of, 5:2408
group rituals and, 5:2184
Holy Mecca in Saudi Arabia, 5:2185 (photo)
importance of, 5:2184
modern tourism and, 5:2185
national shrines and, 5:2184
as religious focal points, 5:2184
revived interest in, 5:2184
as sacred demand response, 5:2184
sacred places, religious geographies and, 5:2407–2408
site examples of, 5:2184
See also Religion, geography and
Pinchot, Gifford, 2:570
Pinder, John, 2:1037
Piraro, Dan, 3:1219 (image)
Pittsburgh, Pennsylvania, 4:1821
Place, 5:2186–2188
building and dwelling connections and, 5:2187
decentering of authoritative knowledge and, 5:2187
geographical self, 5:2187
home as a metaphor for, 5:2186–2187
human agency and, 5:2187
human geography and, 5:2186
human identity and, 5:2187
humanist geography and, 5:2186
location studies and, 4:1790–1792
place is associational and, 5:2187
production of space and, 5:2297–2298
Edward Relph, 5:2410–2411
social production of spaces and, 5:2187
space/place issue and, 5:2186
spatial science and, 5:2186
Place names, 5:2188–2191
conflicts of use and spellings of, 5:2189
Dr. Martin Luther King Jr. Boulevard in Harlem, New York City, and, 5:2190 (photo)
function of, 5:2188
geocoding and, 3:1185–1186
gazetteers and, 3:1208–1209
image-generating power of, 5:2189
naming as resistance by marginalized groups and, 5:2190
permanence of, 5:2189
powerful connotations and, 5:2189
power relations and, 5:2189
sense of order and familiarity and, 5:2189
as spatial reference, 5:2189
study of, 5:2190
as symbols, 5:2189
taking ownership of places and, 5:2189
toponymy and, 6:2840–2850
United Nations Group of Experts on Geographical Names (UNEGEAN) and, 5:2189
Place promotion, 5:2191–2192
academic foci, 5:2191–2192
city image reformation and, 5:2191
critical perspectives on, 5:2191–2192
definition of, 5:2191
historical context of, 5:2191
investment capital attraction and, 5:2191
marketing efforts and, 5:2191
mass transit evolution and, 5:2191
railroads, frontier development and, 5:2191
suburbs and, 5:2191
tourism and, 5:2191
Plantations, 5:2192–2195
agro-economic production and, 5:2192
Plato
Platforms and sensors
Plate tectonics, ideal size of political unit views of, economic views of, conservation views of, absolute space views of, LiDAR and airborne laser scanning and, subduction rollback and, slab pull factor in, See also transform (conservative) plate boundaries and, teothermal features and, sea level changes and, seafloor spreading and, continental drift concepts, major lithospheric plates, plate boundaries, directions and rates, Iceland and, paleoclimatology and, hot spots and, as organizational form, land and resource conflicts, as institutional form, rural insurgencies suppression and, payments for ecosystem services and, state subsidies and, smallholder plantations and, state control, political-economic power and, social countermovements and, hacienda form of, global forestry institutions and, deforestation and, ecological effects of, forest conservation mechanisms and, definition of, colonial and postcolonial history of, blue agave plantation, Tequila, Mexico, biofuels crops and, atmospheric dispersion modeling and, emissions trading systems to control, atmospheric pollution and, Love Canal and, government regulation of, cancer rates studies of, economically active females in, energy policies in, AGILE membership of, COMECON membership of, Clean Development Mechanism (CDM), carbon offsets and, mobile sources and, stationary sources and, photochemical smog and, as spatial statistics branch, theoretical models used in, trends for events to exhibit a pattern and, Point pattern analysis, 5:2201–2202, complete spatial randomness (CSR) and, definition of, first-order properties of a spatial point pattern and, geographic quantitative revolution and, interreverent distances distribution and, local clustering examination using, plant ecology and, aspatial methods and, aspatial statistics branch, theoretical models used in, Point pattern analysis, 5:2201–2202, complete spatial randomness (CSR) and, definition of, first-order properties of a spatial point pattern and, geographic quantitative revolution and, interreverent distances distribution and, local clustering examination using, plant ecology and, aspatial methods and, aspatial statistics branch, theoretical models used in, Poland, acid rain in, AGILE membership of, automobile industry in, cancer rates studies of, Clean Development Mechanism (CDM), carbon offsets and, coal energy source in, COMECON membership of, ecological footprint and biocapacity of, economically active females in, energy policies in, escape to nature movement in, industrialization in, 19th-century cadastral map, Polar front theory (PFT), Points, North and South, 5:2203–2209, Aristotle’s views on, climate change and, continental glaciers and, continental ice sheets and, definition of, equator and, Fourth Assessment of the International Panel on Climate Change and, political impact of geography and, social justice issues and, Playas, 5:2199–2201, definition of, ecosystem functions of, Great Basin lakes and, North American High Plains of Great Plains and, origins of, playa and associated lunette and, playa lake term and, small playa in winter wheat field, High Plains, 5:2200 (photo), terms related to, Plumwood, Val, 3:1634, Point pattern analysis, 5:2201–2202, complete spatial randomness (CSR) and, definition of, first-order properties of a spatial point pattern and, geographic quantitative revolution and, interreverent distances distribution and, local clustering examination using, plant ecology and, aspatial methods and, aspatial statistics branch, theoretical models used in, trends for events to exhibit a pattern and, Point pattern analysis, 5:2201–2202, complete spatial randomness (CSR) and, definition of, first-order properties of a spatial point pattern and, geographic quantitative revolution and, interreverent distances distribution and, local clustering examination using, plant ecology and, aspatial methods and, aspatial statistics branch, theoretical models used in, trends for events to exhibit a pattern and, Point sources of pollution, 5:2203, air pollution, area sources and, atmospheric dispersion modeling and, atmospheric pollution and, definition of, emissions trading systems to control, government regulation of, Love Canal and, mobile sources and, nonpoint sources of pollution and, oil spills and, photochemical smog and, stationary sources and, Poland, acid rain in, AGILE membership of, automobile industry in, cancer rates studies of, Clean Development Mechanism (CDM), carbon offsets and, coal energy source in, COMECON membership of, ecological footprint and biocapacity of, economically active females in, energy policies in, escape to nature movement in, industrialization in, 19th-century cadastral map, Polar front theory (PFT), 5:2195–2199, African rift system and, aseismic creep and, convergent (destructive/active) plate boundaries and, 5:2196, 5:2197 (fig.), 5:2198, coral reef morphology and, 5:2196, 5:2197–2198, 5:2197 (fig.), driving forces in, 5:2198–2199, Earth’s composition and, 5:2195–2197, explosive volcanism and, 5:2198, faulting and, 3:1085–1088, geologic timescale and, 3:1235–1238, geomorphology of Earth’s crust and, 5:2195, gravity factor in, 5:2198, hot spots and, 5:2197, Iceland and, 5:2197, major lithospheric plates, plate boundaries, directions and rates of, 5:2196, 5:2196 (fig.), Pacific Ring of Fire and, 3:1273, paleoclimatology and, 1:471, seafloor spreading and continental drift concepts and, 5:2195, sea level changes and, 1:494, slab pull factor in, 5:2198–2199, subduction rollback and, 5:2199, teothermal features and, 3:1273, transform (conservative) plate boundaries and, See also Diastrophism; Earthquakes; Geomorphic cycle; Geomorphology; Landforms
Platforms and sensors
LiDAR and airborne laser scanning and, 4:1778–1779, See also Remote sensing
Plato
absolute space views of, 1:2, antipodes, 1:98, conservation views of, 5:2584, environmental determinism views of, 1:2, ethics views of, 2:1013, ideal size of political unit views of, 5:2217, biofuels crops and, 5:2194, blue agave plantation, Tequila, Mexico, 5:2194 (photo).
Hadley cells and, 3:1395–1397
International Polar Year and, 5:2204
polar climate and, 1:449–452
sea ice and, 5:2204
tundra biome and, 1:246–250
See also Antarctica; Arctic; Glaciers: continental; Greenland; Ice; Periglacial environments; Permafrost; Poles, North and South: North Pole; Poles, North and South: South Pole

Poles, North and South: North Pole
amplified warming in, 5:2204
Arctic Ocean location of, 5:2204
discovery controversy, 1:295
exploration of, 2:1055
Greenland ice sheet, 5:2204–2205, 5:2206 (fig.)
polar climate of, 1:449
sea ice and, 5:2204, 5:2205 (fig.)
sea ice minimum, 1979–1981, 3:1524 (photo)
sea ice minimum, 1982–2008, 5:2205 (fig.)
subarctic climate in, 1:441

Poles, North and South: South Pole
Antarctica ice sheet and, 5:2207–2208
Antarctic sea ice and, 5:2204
exploration of, 2:1055
new rifts form on Antarctic ice shelf, 5:2207
rates of surface elevation change from satellite measurements, 5:2207, 5:2207 (fig.)

Political ecology (PE), 5:2009–2214
animal geographies and, 2:832
bioregionalism and, 1:253
Piers Blaikie’s work in, 1:284
carbon trading and carbon offsets and, 1:329–335
chipko movement and, 1:395–396
community forestry and, 2:531–553
Cosmos (Humboldt) and, 5:2211
critiques and new directions in, 5:2213–2214
critiques of, 5:2213–2214
cultural ecology and, 2:632–633, 5:2211–2212
definition of, 5:2209
distribution of resource access and, 2:779–780
drought, famine in West Africa example of, 2:622
drought research and, 2:793
Earth: A Descriptive History (Reclus) and, 5:2211
ecological justice and, 2:832
environmental conservation issues and, 2:832, 5:2210, 5:2212
environmental refugees and, 2:989–991
environmental security and, 2:998–1000
extractive reserves and, 2:1072–1073
inequality of fortunes (Humboldt) and, 5:2211
multidiscipline origins and features of, 5:2209, 5:2212
nature-society relationship and, 2:832
neoc-Malthusianism and, 2:622, 5:2212
neo-Marxism and, 5:2212
pesticide research and, 4:2158
political economy and, 5:2211
“the politicized environment” and, 2:622
politicozizing nature, denaturalizing hazards and, 2:622
postcolonial resource issues and, 5:2212
power struggle context of environmental conflict and, 5:2210
social and political dynamics, 5:2210
social construction of environmental problems and, 5:2209–2210
social justice and, 5:2212
soil erosion in Nepal example of, 2:622
themes and goals in current research, 5:2209–2210
Third World political ecology term and, 5:2213
“third world” vs. “first world” strands of, 4:1992
timeline of early colonial and ecological critiques, 5:2210–2211
timeline of interdisciplinary influences on, 5:2211–2212
timeline of modern reemergence since 1970s, 5:2212–2213
timeline of new directions of, 5:2213–2214
equal environmental power relations and, 5:2210
uneven environmental exposure and vulnerability and, 5:2210
See also Common pool resources (CPRs); Common property resource management; Commons; tragedy of the; European green movements; Feminist political ecology; Political ecology (PE): noted individuals

Political ecology (PE): noted individuals
Grahame Beakhurst, 5:2212
Piers Blaikie, 5:2213
Harold Brookfield, 5:2212
Alex Cockburn, 5:2212
Charles Darwin, 5:2211
Suzanna Hecht, 5:2213
Alexander von Humboldt, 5:2211
Peter Alexivich Kropotkin, 5:2211
Karl Marx, 5:2211–2212
Richard Peet, 4:2144
Nancy Peluso, 2:595, 5:2213
Élisée Reclus, 5:2211, 5:2371–2372
Carl Sauer, 5:2212
Alfred Russel Wallace, 5:2211
Michael Watts, 5:2213
Eric Wolf, 5:2212
Karl Zimmerer, 5:2213

Political economy, 5:2214–2219
biodiversity theory (Diamond) and, 5:2216
Calculus of Consent (Buchanan and Tullock) and, 5:2214
curse of natural resources concept and, 4:1913, 5:2217–2218
definition of, 5:2214
disease environment and, 5:2216–2217
economic theory of democracy (Downs) and, 5:2214
game theory and, 5:2215
general geography and, 5:2215–2216
Guns, Germs, and Steel written by, 5:2216
“hydraulic empires” theory (Wittfogel) and, 5:2215
institutional economics and, 5:2215
key concepts in, 5:2214–2215
Logic of Collective Action (Olson) and, 5:2144
natural resources and, 5:2217–2218
optimal country size and, 5:2217
Oriental Despotism (Wittfogel) and, 5:2215
political and economic decision making focus of, 5:2214
political ecology and, 5:2211, 5:2216
public choice theory and, 5:2214–2215
rent seeking and, 5:2217
trade element in, 5:2218
utility maximizing individuals element in, 5:2215
See also Political economy: noted individuals; Political economy of resources

Political economy: noted individuals
Daron Acemoglu, 5:2216
James Buchanan, 5:2215
Jared Diamond, 5:2216
Anthony Downs, 5:2214
Jeffrey Herbst, 5:2217
Simon Johnson, 5:2216
Mancur Olson, 5:2215
Richard Peet, 4:2144
James Robinson, 5:2216
Gordon Tullock, 5:2215
Karl Wittfogel, 5:2215
Political geography, 5:2221–2225
African colonialism, 1:512
African Union (AU) and, 1:25
Berlin Conference of 1884 and, 1:512
citizenship and, 1:412–414
Cold War and, 1:504–505, 5:2222–2223
critical geopolitics and, 3:1251–1252, 5:2224
criticism of, 5:2222–2223
current trends in, 5:2225
democracy and, 2:705–707
domino theory and, 2:786–787
electoral geography and, 2:879–883, 5:2223
geographical justifications to pursue national goals and, 5:2222
gapolitics and, 3:1249–1252
“geopolitics” term (Kjellén) and, 5:2222
GIS technology and, 5:2224
Heartland theory (Mackinder) and, 5:2222
human rights geographies and, 3:1480–1481
location theory and, 5:2223
Marxism and, 5:2223
media power and, 2:541
military geography and, 4:1896–1897
nationalism and, 4:1978–1981
nation concept and, 4:1971–1974
nation-state borders and, 1:293–294, 5:2224
natural resources issues and, 5:2224
New World (Bowman) and, 5:2222
oceans and, 4:2068–2069
origins of, 5:2221–2222
pan-region world organization concept (Haushofer) and,
3:1407–1408, 5:2222
political economy and, 5:2223
political science and, 5:2223
Politische Geographie (Ratzel) and, 5:2221–2222
popular geopolitics and, 2:541
postmodernism and, 5:2223–2224
poststructuralism and, 5:2223–2224
quantitative revolution in, 5:2223
radical democracy and, 2:705–706
radical geography and, 5:2223
redistricting and, 5:2375–2377
spatial analysis and, 5:2223
state systems (Gottman), 5:2222–2223
territory concept in, 6:2802, 6:2803 (fig.)
transnational democracy and, 2:706
21st century and, 5:2224–2225
See also Communism and geography; Geopolitics; Political
geochemistry; noted individuals

Political geography: noted individuals
John Agnew, 1:32–33
Jean Gottman, 5:2222–2223
Karl Haushofer, 3:1407–1408
R. J. Johnston, 4:1643
Rudolf Kjellén, 5:2222
Sir Halford Mackinder, 5:2222
Friedrich Ratzel, 5:2221–2222
Andre Siegfried, 2:879, 5:2223
Peter Taylor, 6:2778

Political maps
Africa, 6:3154
Antarctica, 6:3155
Arctic Region, 6:3156
Asia, 6:3158
Australia, 6:3157
Blæus map of Europe, mid 17th century, 6:2803 (fig.)
Caribbean, 6:3162
Eastern Europe, 6:3161
Euroregions of cross-border cooperation and, 2:631 (fig.)
geography of roll-call vote to amend Voting Rights Act, Pennsylvania, 2:882 (fig.)
New Zealand, 6:3157
North America: Mexico and Central America, 6:3164
North America: United States and Canada, 6:3163
Oceania, 6:3157
South America, 6:3165
southeast Asia, 6:3159
2004 presidential election, 2:879 (fig.)
Western Europe, 6:3160
World map, Mollweide Projection, 6:3152–3153, 6:3169

See also World maps

Polo, Marco
explorations of, 2:1053, 2:1053 (fig.), 3:1461
tavel writing of, 6:2878 (image)

Polychlorinated biphenyls (PCBs), 5:2225–2226
adverse effects of, 5:2226
applications of, 5:2225–2226
chemical spills, environment, and society and, 1:382–384
definition of, 5:2225
disposal options for, 5:2226
environmental contamination incidents and, 5:2226
landfill in Warren County, North Carolina, environmental
justice example and, 2:960, 2:961 (photo), 2:986
Stockholm Convention on Persistent Organic Pollutants and,
5:2226
Toxic Substance Control Act (1976) and, 5:2226
U.S. ban of manufacture of, 5:2226
Popper, Deborah, 5:2279
Popper, Frank, 5:2279
Popper, Karl, 3:1434, 4:1801

Popular culture, geography and, 5:2226–2231
art and geography and, 1:118–120
artisan popular culture, 5:2227
audience responses factor in, 5:2231
Captain America and Spiderman examples of, 5:2228 (photo)
cultural geography vs., 2:637, 3:1142
Cultural Studies and, 5:2230–2231
different culture types and, 3:1142–1144
folk culture and, 3:1142–1144, 5:2229
forms of, 5:2226
government and, 5:2227
globalization and time-space compression of, 5:2229–2230
globalizing Western culture and, 5:2227
grassroots, oral side of modern life and, 3:1142
government and, 5:2230
“high” culture and, 5:2226–2227
hybridity and change features of, 3:1142
mass consumption and, 5:2226
mass media and, 5:2227
material culture and practice and, 5:2226–2227
 meaning and ideology used in, 5:2230–2231  
media and geography and, 4:1874–1877  
music and sound geographies and, 4:1967–1969  
Orientalism, 5:2229  
origins of, 5:2227  
participatory popular culture, 5:2227  
popular geographies of production and consumption and, 5:2227–2229  
poststructuralism and, 5:2230–2231  
urban and industrial characteristics of, 3:1142  
Web 2.0 technology and, 5:2227  
world distribution of, 5:2227–2228  
Population and land degradation, 5:2232–2236  
aricultural intensification and, 5:2235  
carrying capacity and, 1:337, 5:2238–2239  
common property tenure systems factor in, 5:2234  
conservation and, 2:570  
debate, 5:2232–2234  
degradation definition and, 5:2232  
desertification and, 2:715–719  
ecological modernization and, 2:832–834  
food security issue and, 5:2233–2234  
human population affected by, 5:2232, 5:2234–2235  
land use and land cover changes and, 5:2234–2235  
Machakos, Kenya case study of, 5:2234  
migration and, 5:2232  
in mountainous regions, 5:2235  
neo-Malthusian theory and, 5:2233–2234  
population burden on natural resources and sustainability and, 5:2232  
population growth and, 4:1683  
population growth by region and, 5:2232, 5:2233 (fig.)  
poverty factor in, 5:2233–2234  
soil erosion effects and, 5:2235  
UN Convention to Combat Desertification (UNCCD) and, 5:2232, 5:2234  
urbanism land use changes and, 5:2232  
Population and land use, 5:2236–2237  
aricultural intensification and, 1:36  
agrobiodiversity and, 1:49–50  
bid-rent process and, 5:2236–2237, 5:2237 (fig.), 5:2328  
carrying capacity and, 1:337, 5:2238–2239  
household common utility function element in, 5:2236  
land reform and, 4:1692–1696  
locational rent gradient concept and, 5:2236  
modern human settlement patterns and, 5:2236  
monocentric model of urban form and, 5:2236–2237, 5:2237 (fig.)  
Thünen’s theory of agricultural land use and, 5:2236, 6:2832–2834  
transport costs and market value elements in, 5:2236  
urbanism land use changes and, 5:2232  
Population density, 5:2238–2240  
arable land availability calculations and, 5:2238–2239  
carrying capacity concept and, 5:2238–2239  
from center to periphery decline in, 5:2240  
chaos in population dynamics and, 2:565 (fig.)  
definition of, 5:2238  
density gradient concept (Clark), 5:2240  
ecoology and, 5:2238  
frontiers and, 3:1170–1172  
global and rural population densities, 5:2238–2239, 5:2239 (fig.)  
global population density and, 5:2241, 5:2242 (fig.)  
islands of mankind concept (Bunge) and, 5:2238  
natural resources relationship to, 5:2238  
origins of concept and, 5:2238  
spence of ecology and, 5:2238  
smart growth policies and, 5:2240  
suburban density clusters and, 5:2240  
transit-oriented development (TOD) and, 4:2024, 5:2240  
urban population density, 5:2239–2240  
urban sprawl management and, 5:2240  
world population densities and, 5:2239 (fig.)  
Population, environment, and development, 5:2240–2245  
aricultural intensification and, 1:36, 5:2243  
aricultural subsistence crops and, 5:2243  
agrobiodiversity and, 1:49–50  
conservation and, 2:570  
development geography and, 5:2243–2245, 5:2244 (fig.)  
ecological modernization and, 2:832–834  
ecosystem exploitation by humans and, 5:2243  
environment and, 5:2241–2243  
Everglades restoration and, 2:1038–1042  
export crops and, 5:2243  
fertility and pesticide use and, 5:2243  
forest harvesting and, 5:2243  
global population density and, 5:2241, 5:2242 (fig.)  
nnternational institutions’ efforts and, 5:2244–2245  
Kyoto Protocol and, 5:2244  
Malthusianism and, 4:1819–1820  
Montreal Protocol and, 5:2244  
ocean exploitation and, 5:2243  
population growth models and, 5:2241  
population statistics and, 5:2240–2241  
sustainability issues and, 5:2244  
water quality issues and, 5:2241, 5:2243  
Population geography, 5:2245–2249  
academic courses on, 5:2247–2248  
census and, 1:371–373  
continuous space-and-time models and, 2:566  
criticism of, 5:2249  
definition of, 5:2245  
demographic research and, 5:2248  
demographic transition and, 2:707–710  
demography and, 5:2245, 5:2246–2247  
elderly geographies and, 2:876–878  
fertility rate and, 3:1102–1103  
future trends in, 5:2248–2249  
historical population geography and, 5:2248  
human geography development and, 5:2246  
immigration and, 3:1542–1545  
issues examined by, 5:2245, 5:2249  
Malthusianism and, 4:1819–1820  
mapping techniques and, 5:2246  
migration research and, 5:2248  
mixed-methods issue and, 5:2249  
mortality rate and, 4:1947  
pluralist approach in, 5:2249  
Population, Space and Place journal and, 5:2249  
population maps focus and, 5:2246  
quantitative data and, 5:2246  
regional population geography and, 5:2248  
research areas in, 5:2247–2248  
roots and growth of, 5:2245–2247  
textbooks on, 5:2247  
tools and techniques of, 5:2245  
See also Population geography: noted scholars; Population pyramid  
Population geography: noted scholars, 5:2247  
Jacqueline Beaujeu-Garnier, 5:2247  
John Innes Clarke, 5:2247  
Pierre George, 5:2247
Postmodernism, 5:2262–2264
class and geography intersection and, 1:420
Coming of Post-Industrial Society (Bell) ad, 5:2262
components and/or dimensions of, 5:2262
counterurbanization and, 2:596–597
“creative class” and, 5:2263
criticism of, 5:2263
leisure-based, service sector economies in, 1:420
low-value service vs. specialized, knowledge-intensive
service and, 5:2263
Marxist theories and, 5:2262, 5:2263
nation-state as unit of analysis of, 5:2263
“new middle class” of elite service workers and, 5:2263
as a predictor of change, 5:2262
producer services and, 5:2263
“regeneration” of urban landscapes and, 1:420
social transformation of, 5:2262
urban gentrification discourse and, 5:2263
See also Postindustrial society: noted individuals
Postindustrial society: noted individuals
Daniel Bell, 5:2262–2263
Colin Clark, 5:2263
Richard Florida, 5:2263
Ruth Glass, 5:2263
David Riesman, 5:2262
Postmodernism, 5:2264–2269
architecture field and, 5:2264
as attitude, 5:2265–2267
complexity and fluidity elements in, 5:2265
criticality and fluidity elements in, 5:2265
Concept of Postmodernity (Harvey) and, 3:1405, 5:2265, 5:2268
crash analysis and, 2:574
crisis of representation and, 2:619
critical historical geography and, 3:1430
critical human geography and, 2:619
cultural ecology and, 2:633
“differences within the same” concept and, 5:2266–2267
discourse analysis and, 3:1587
Enlightenment perspectives rejected by, 5:2267
epistemology in, 5:2267
gay and lesbian geographies and, 3:1184
gay and lesbian geographies and, 3:1184
identities in popular culture and, 5:2265
inequality geographies and, 3:1587
issues of, 3:1404
language analysis and, 4:1754
limitations of theory concept and, 5:2267
Los Angeles School and, 4:1804
metanarratives or grand theories of, 5:2265–2266
modern views on knowledge, rejection of, 5:2267–2268
new urbanism and, 4:2024–2027, 5:2268
nonhierarchical and localized ontologies and, 5:2266
objects and approaches in, 5:2268
ontologies in, 5:2265–2267
organizational changes in economic production and, 5:2265
particularization of critique issue and, 5:2267
political geography and, 5:2223–2224
post-Fordism term and, 5:2264
postmodern feminism and, 3:1191
Postmodern Urban Condition (Dear) and, 5:2268
postpositivist epistemology and, 2:1008, 3:1295
poststructuralism and, 2:619
qualitative research methods and, 5:2266
radical geography and, 5:2351
relativist perspective on, 5:2266
situatedness of knowledge issue and, 5:2267
social justice and, 2:628
term as an approach to understanding the world, 5:2264
term as object of study and, 5:2264–2265
text/textuality issues in, 6:2809–2810
totalizing views of the world rejected by, 3:1191
uneven power relations and oppressive patriarchal
structures and, 3:1191
urban design and social life studies and, 5:2264
See also Postmodernism: noted architects, geographers, scholars
Postmodernism: noted architects, geographers, scholars
Ash Amin, 5:2268
Jacques Derrida, 5:2266, 5:2351
Peter Eisenman, 5:2264
Michael Foucault, 5:2266
Clifford Geertz, 5:2266
Frank Gehry, 5:2264
Derek Gregory, 3:1380–1381
David Harvey, 5:2264, 5:2265, 5:2268, 5:2350
Frederick Jameson, 5:2264, 5:2268
Christopher Jenks, 5:2264
Peter Johnston, 5:2264
David Ley, 5:2268
Jean-François Lyotard, 5:2266
Peter Mohr, 5:2264
Chris Philo, 5:2266
Edward Soja, 5:2264, 5:2593
Nigel Thrift, 5:2268, 6:2827
Robert Venturi, 5:2264
Poststructuralism, 5:2270–2273
actor-network theory and, 1:8, 5:2272–2273
body geographies and, 1:289
cultural discourse of landscapes and, 3:1527–1528
critical human geography and, 2:619
cultural discourse of landscapes and, 5:2271
cultural ecology and, 2:633
cultural evolution and, 5:2270
Cultural Studies and, 5:2270–2273
cultural turn concept and, 2:645, 2:849–850
definition method and, 3:1191, 5:2271
modernity challenged by, 4:1929–1930
multiple meanings of space and, 5:2272
nonvisual geographies and, 5:2270
nonvisual geographies and, 5:2270
origins of, 5:2270–2271
panopticon and, 4:2116–2117
philosophizing of space and, 5:2272
political geography and, 5:2223–2224
postmodernism and, 2:619
postmodernism and, 2:619
poststructuralism and, 2:619
poststructuralism and, 2:619
radical geography and, 5:2270
radical geography and, 5:2351
Poverty, 5:2274–2276
absolute vs. relative measures of, 5:2274
causation of, 5:2275–2276
definition of, 5:2274
demographic and geographic distribution of, 5:2274–2275,
5:2275 (fig.)
extreme poverty definition and, 5:2274
famines and famines, and, 3:1082–1085
feminization of, 3:1097
ghetto and, 3:1275–1277
homelessness and, 3:1440–1442
income-based measures of, 5:2274
inequality geographies and, 3:1586–1590
land degradation and, 4:1683
Malthusianism and, 4:1819–1820
peasants and peasantry, 4:2137–2142
population living on less than $1 per day, 5:2275 (fig.)
poverty thresholds and, 5:2274
public housing and, 5:2303–2304
UN Human Poverty Index (HPI) and, 5:2274
“working poverty” concept, and, 5:2276
See also Hunger
Powell, John Wesley, 5:2276–2277
American geomorphology work of, 5:2276–2277
Smithsonian service of, 5:2277
streams classification work of, 3:1245
USGS service of, 3:1409, 5:2277
water issues work of, 5:2277
Western U.S. explored by, 3:1245, 5:2276–2277, 5:2448
PGIS. See Public participation GIS (PGIS)
PPPs. See Public-private partnerships (PPPs)
PR. See Participatory rural appraisal (PRA)
Prairie restoration, 5:2278–2279
bison restoration and, 5:2279
diversity recovery efforts and, 5:2278
Jens Jensen and, 5:2278
Aldo Leopold and, 5:2278
midlatitude grassland biome and, 1:227–230
Nature Conservancy and, 5:2278
Deborah and Frank Popper, 5:2279
prairie burn, Manhattan, Kansas, 5:2278 (photo)
short-grass prairie restoration and, 5:2279
Society for Ecological Restoration and, 5:2279
See also Environmental restoration; Prairies
Prairies, 5:2279–2281
definition of, 5:2279
dust storms and, 5:2280–2281
fires and, 5:2280
graphic locations of, 5:2279
grasslands term and, 5:2279
limited precipitation in, 5:2279
midlatitude grassland biome and, 1:227–230
mixed-grass prairie and, 5:2279–2280
North American grasslands and, 5:2279–2280
range management and, 5:2281
short vs. tallgrass prairies and, 5:2279–2280
temperature changes and, 5:2280
Williams Prairie preserve, Houston, Texas, 5:2281 (photo)
See also Prairie restoration
Pratt, A., 2:1042
Pratt, Geraldine, 3:1192
Prebisch, Raúl, 2:712
Precipitation, global, 5:2282–2287
active microwave sensing and, 5:2282–2283
blended techniques sensing and, 5:2284–2286
critical nature of, 5:2282
El Niño-Southern Oscillation (ENSO) and, 2:886–890, 5:2282
Global Precipitation Measurement (GPM) mission and, 5:2285–2286, 5:2286 (fig.)
hydrology and, 3:1513–1518
in situ measurements and, 5:2282
La Niña and, 4:1754–1757
passive microwave sensing and, 5:2284
radar-estimated accumulated precipitation, U.S., 5:2283 (fig.)
rain gauges measurement and, 5:2282
remote sensing techniques and, 5:2282–2286
surface-based radar systems and, 5:2282–2283, 5:2283 (fig.)
TRMM-accumulated 3 hourly rainfall estimates and, 5:2284–2285 (fig.)
Tropical Rainfall Measuring Mission (TRMM) and, 5:2284–2286
visible and infrared radiation sensing, 5:2283–2284
Precipitation formation, 5:2287–2288
adiabatic temperature changes and, 1:15–17
Bergeron Findeisin precipitation formation and, 5:2288
clouds and, 1:476–480
collision and coalescence precipitation formation and, 5:2288
humidity and, 3:1485–1486
hydroclimatology and, 1:473
hygrophobic condensation nuclei and, 5:2287
hygroscopic condensation nuclei and, 5:2287
lifting mechanism of, 5:2287
processes of, 5:2287–2288
types of, 5:2288
See also Atmospheric moisture
Pred, Allan, 5:2288–2290
American manufacturing, urban growth patterns work of, 5:2289
circum and cumulative feedback loops and, 3:1381
ethnicity and race geographies work of, 5:2289
folk culture work of, 3:1143–1144
Anthony Giddens and, 5:2289
Derek Gregory and, 3:1381
Public-private partnerships
methods of, 5:2305
participatory GISs and, 5:2304–2305
participatory GISScience and, 5:2305
participatory planning and, 4:2126–2129
participatory rural appraisal and, 4:2130
social, economic, and political power issue and, 5:2304, 5:2306
social implications of, 5:2306
spatial decision support systems (SDSS) and, 5:2305
"volunteered" geographic data and, 5:2306
Web-based grassroots GIS and, 5:2305–2306
Web mapping mashups and, 5:2305–2306
Web 2.0 technology and, 5:2305
Public policy, geography of, 5:2307–2312
collective existence and, 5:2308–2309
definition of, 5:2307–2308
derivation of words and, 5:2308
geographical complexity of, 5:2310–2311
GIS and, 5:2307, 5:2311–2312
interdisciplinary methodology of, 5:2307–2308
modeling strategies of, 5:2309
objective vs. subjective policy-relevant problems and, 5:2310
policy categories and, 5:2310–2311
policy environment and, 5:2310
policy relevant institutions and, 5:2309–2310
public policy outputs and, 5:2310–2311
public-private partnerships and, 5:2312–2313
public sector employment and, 5:2308
U.S. federal government outlays per capita, 2005 and, 5:2310–2311, 5:2311 (fig.)
See also Public policy, geography of: noted individuals
Public policy, geography of: noted individuals
Lewis Alexander, 5:2307
Brian Berry, 5:2307
Isaiah Bowman, 5:2307
George Demko, 5:2307
Henry Gannett, 5:2307
Gilbert White, 5:2307
Public-private partnerships (PPPs), 5:2312–2313
definition of, 5:2312
international financial institutions support of, 5:2312
neoliberalism and, 5:2313
political controversy, 5:2312–2313
shared responsibility feature of, 5:2312
variations in, 5:2312
Public space, 5:2313–2315
at-risk nature of, 5:2315

civic spaces and, 5:2313
communications technology and, 5:2315
in communist countries and cities and, 2:543–544, 2:544 (photo)
cultural variations of, 5:2314
definitions of, 5:2313
fragmentation of, 5:2315
importance and functions of, 5:2313
law geographies and, 4:1766
nature of social relationships within, 5:2315
neoliberal economic policies and, 5:2315
public marketplace concept origins of, 5:2313–2314
San Marco Square and Palazzo, Ducale, Venice, 5:2314 (photo)
spacelessness of the Internet and, 5:2313
universal access issues and, 5:2314, 5:2315
See also Urban specific subject
Public water services, 5:2315–2319
definition of, 5:2315
developing countries, independence, and colonial legacy in, 5:2316–2317
international water supply companies and, 5:2317
Millennium Development Goals and, 5:2318
natural monopoly characteristic of, 5:2316
organization in OECD countries of, 5:2316
recent trends in, 5:2317
regulation of, 5:2316
restructuring of, 5:2317–2318
successful public sector reform and, 5:2318
Washington Consensus and, 5:2317
Puerto Rico
economically active females in, 3:1190 (table)
Spanish colony of, 1:512
Pulido, Laura, 2:962
Purch, Edward, 1:166–167
Pyrogeography, 5:2319–2322
Analytic Hierarchy Process and, 5:2322, 5:2322 (fig.)
ASTER imagery and, 5:2320, 5:2321 (image)
carbon cycle and, 5:2320
climate change and, 6:2771–2772
Fire-Climate-Society (FCS-1) model and, 5:2321 (fig.), 5:2322, 5:2322 (fig.)
fireshed variables and, 5:2319
geospatial mapping technology and, 5:2320
GIS integrations with, 5:2322
Landsat Thematic Mapper image, CerroGrande Fire, New Mexico, 5:2320, 5:2321 (image)
landscape renewal through, 5:2319
live-fuel moisture stress, 5:2320 (images)
Old Fire/Grand Prix Fire Complex, San Bernardino mountains, 5:2320, 5:2321 (image)
origin of, 5:2319
physical description of, 5:2319
processes of, 5:2319–2320
remote sensing and GIS technology and, 5:2320
space-time interactions between fire and people and, 5:2319
surface fire, 5:2319 (photo)
technologies used in, 5:2320–2322, 5:2320 (images)
in tropical savanna biome, 1:242
wildfire hazard, Jemez Mountains, New Mexico, 5:2322, 5:2322 (image)
Pytheas, 2:1051
Qatar
economically active females in, 3:1190 (table)
OPEC membership of, 4:2100 (fig.)
Qatari National Grid coordinate system of, 2:580
Qian, W., 4:1940
Qualitative methods, 5:2323–2326
analysis of, 5:2325–2326
autographic narrative interview and, 5:2325
characteristics of, 5:2324–2325
Chicago School of sociology and, 5:2323
coding and classifying material and, 5:2325–2326
content and discourse analysis techniques and, 5:2326
critical GIS and, 2:615
development of, 5:2323–2324
focus group interviews and, 5:2325
generalization from, 5:2323
human geography fieldwork and, 3:1103–1005
in-depth data element of, 5:2324
individual cases element of, 5:2324
interviewing and, 3:1625–1627, 5:2325
media and geography and, 4:1876
Methodenstreit and, 5:2323
objective of, 5:2323
observation methods and, 5:2325
participant observation and, 4:2121–2122, 5:2325
phenomenology and, 3:1625
photographs and video and, 5:2325
positionality and, 5:2257–2248
positivism criticism of, 5:2323–2324
previously unknown element in, 5:2324
production of, 5:2325
researcher perspective element in, 5:2324–2325
self-reflexivity element in, 5:2325
social theory in geography and, 5:2324
sociology and anthropology origins of, 5:2323
subjective focus of, 5:2323, 5:2324–2325
tick description (Geertz) and, 5:2324
written field notes and, 5:2325
See also Feminist methodologies; Qualitative methods: noted individuals

Qualitative methods: noted individuals
Alison Blunt, 5:2325
Franz Boas, 5:2323
Pierre Bourdieu, 5:2325
Ernest Burgess, 5:2323
Anne Buttimer, 5:2324
Michel Foucault, 5:2326
Bronislaw Malinowski, 5:2323
Linda McDowell, 5:2325
Robert Ezra Park, 5:2323
Yi-Fu Tuan, 5:2324

Quantitative methods, 5:2326–2329
Bayesian statistics and, 1:187–188
bivariate and multivariate analyses and, 5:2328
criticism of, 5:2328
descriptive and inferential statistics and, 5:2327–2328
gecomputation and, 3:1211–1215
geographically weighted regression (GWR) and, 3:1225–1232
géométries and, 5:2328
geostatistics and, 3:1261–1265
gitothechnical innovations and, 5:2329
GIScience and, 5:2327
human geography and, 5:2327
impacts of, 5:2328–2329
infallible statistics and, 5:2327–2328
location-allocation modeling, 4:1793–1794
location theory and, 4:1798–1799, 4:1798–1800
map algebra and, 4:1824–1825
means compared over time and space and, 5:2327
measures of dispersion, frequency, and central tendency and, 5:2327
modeling in geography and, 5:2328
multivariate analysis methods and, 4:1961–1962
nonparametric techniques and, 5:2327
nonpositivist geography approaches and, 5:2328
origins of, 5:2327
parametric statistics and, 5:2327
point pattern analysis and, 5:2201–2202
positivist thinking and, 5:2328
quantitative temporal-spatial analyses and, 5:2327
race as a social category for quantitative analysis and, 5:2343
sample error and sample bias and, 5:2328
spatial autocorrelation and, 5:2607–2608
statistics in geography and, 5:2327
See also Exploratory spatial data analysis (ESDA); Feminist methodologies; Quantitative methods: noted individuals;

Quantitative revolution

Quantitative revolution, 5:2329–2331
criticism of, 5:2330
historical geography subsumed by, 3:1429, 3:1432
institutionalization of, 3:2329–2330
logical positivism and, 4:1801, 5:2326
modeling and statistics focus of, 3:1429
multivariate analysis methods and, 4:1961–1962
network analysis and, 4:2017
“new geography” and, 5:2330
nomothetic yes, 4:2034–2035, 5:2329
qualitative methods decline and, 5:2324
qualitative term and, 5:2329
representations of space and, 5:2433
socialism and, 5:2571
spatial analysis methods and, 5:2330
See also Feminist methodologies; Quantitative methods;

Quantitative revolution: noted individuals
Brian Berry, 1:193
William Bunge, 1:300, 3:1466, 3:1645
Walter Christaller, 5:2329
William Garrison, 5:2329
Torsten Hagerstrand, 5:2329
Susan Hanson, 3:1401, 3:1468
Walter Isard, 5:2329
Thomas McCarty, 5:2329
Richard Morrill, 4:1945–1946
Fred Schaefer, 3:1466, 5:2329, 5:2511–2512
Andre Siegfried, 5:2223
Edward Ullman, 5:2329

 queer theory, 5:2331–2333
anarchism and geography and, 1:73, 1:74
criticism of, 5:2332
decoupling of gender identity and, 5:2331
gay and lesbian geographies and, 3:1183–1185
gender and nature and, 3:1196
impact of, 5:2331
normative constructs and social institutions and, 5:2331–2332
Natalie Oswin and, 5:2332–2333
poststructural critique of identity and, 5:2331
privilege issue and, 5:2332
queer geography and, 3:1184
queer term and, 5:2331
same-sex marriage issue and, 5:2332–2333
same-sex marriage supporters, Iowa City, Iowa, 5:2332 (photo)
sexuality and space scholarship and, 5:2331, 5:2333
See also Sexuality, geography and of
Quine, Willard, 4:2079

Race and empire, 5:2335–2337
environmental determinism and, 5:2335, 5:2337
Eurocentrism and, 2:1028–1030, 5:2338
present-day forces of empire and, 5:2337
world’s hierarchy of races, school atlas (1883) and, 5:2336 (fig.)
See also Race and nature; Race and racism; Social Darwinism

Race and nature, 5:2337–2340
American wilderness as culture-free nature example and, 5:2339
Kay Anderson and, 5:2338, 5:2340
class and nature and, 1:423–425
critical race theory and, 5:2338
egalitarianism of, 5:2339
environmental justice and, 2:959–965
eurocentrism and, 2:1028–1030, 5:2338
European colonialism, racial thought and, 5:2339–2340
European definitions of humanity and, 5:2340
Carl von Linné and, 5:2338
"natural" categories of, 5:2337
nature as a social construct and, 5:2338–2339
nature-culture binary and, 5:2338–2339
nature of nature issue and, 5:2338
Mary Louise Pratt, 5:2338
social nature scholarship and, 5:2338–2339
See also Environmental determinism; Ethnicity and nature; Race and racism; Racial segregation; Social Darwinism
Race and racism, 5:2340–2344
antiracism research agenda and, 5:2341
assigning race and counting racial groups in, 5:2343–2344
critical race studies in geography and, 5:2341
digital divide (U.S.) and, 2:751
"the end of race" and, 5:2343
environmental determinism and, 5:2338
environmental justice and, 2:959–965
ethnic segregation and, 2:1022–1026
geographic contingency of, 5:2341–2342
geography of differences and, 2:737–740
inequality geographies and, 3:1589
justice/injustice geographies and, 3:1643–1645
physical feature differences and, 5:2340
quantitative approaches to, 5:2343
race counting quantitative data and, 5:2343
racial hierarchies within white privilege and, 5:2342
racialization and, 5:2341–2342
racialized landscapes and, 5:2342
racism, inequality between social groups and, 5:2341
racism as ideology of difference and, 5:2341
relational perspectives on, 5:2342
social construction of places and, 5:2342
social construction of race and, 5:2341
social Darwinism and, 5:2340
U.S. Census racial data and, 5:2343
See also Environmental determinism; Environmental justice;
    Environmental racism; Ethnicity; Ethnicity and nature;
    Ethnic segregation; Race and empire; Race and nature;
    Racial segregation; Social Darwinism
Racial segregation, 5:2344–2346
Chicago School and, 5:2344
choice or preference element in, 5:2345
"colored" water cooler, Oklahoma City, 1939, 5:2345 (photo)
Dissimilarity Index, spatial separation measure of, 5:2344
economic status and, 5:2345
ghetto and, 3:1275–1277
hypersegregated metropolitan areas and, 5:2344–2345
immigrant assimilation models and, 5:2344
inequality geographies and, 3:1589
institutionalized mortgage and housing practices and, 5:2345
racial residential segregation and, 5:2344
white as standard or norm and, 5:2345–2346
See also Ethnic segregation; Segregation and geography
Radcliffe, Sarah, 3:1092
Radiation: solar and terrestrial, 5:2346–2350
albedo, ratio of reflected to incident light and, 5:2348
atmospheric window terrestrial wavelength and, 5:2349
definitions, 5:2346
electromagnetic radiation and, 5:2346–2347
global energy budget and, 5:2349
human activity factor in, 5:2346, 5:2349
Mie scattering of radiation and, 5:2348
photons element in, 5:2346
radiation at Earth’s surface and, 5:2348
Rayleigh scattering of radiation and, 5:2347–2348
solar constant concept and, 5:2347
solar radiation, geographical aspects of, 5:2348
solar radiation, top of the atmosphere and, 5:2347
solar radiation, transmission of, 5:2347–2348
solar spectrum regions and, 5:2347
terrestrial radiation, in the atmosphere, 5:2349
zenith angle between surface and sun and, 5:2347
See also Radiative radiation; Albedo
Radical democracy, 2:705–706
Radical geography, 5:2350–2353
anarchism and geography and, 1:73–74
Antipode and, 1:73, 2:618, 4:2144, 5:2350
Detroit Geographical Expedition and Institute and, 1:300,
4:1862, 5:2350
feminist critique of, 5:2351
justice/injustice geographies and, 3:1643–1645, 5:2223
Marxist theoretical frameworks and, 5:2350–2351
origins of, 5:2350–2351
political geography and, 5:2223
positivism and, 5:2350
postmodern and poststructural influences on, 5:2351
praxis of, 5:2352
redefinitions of, 5:2351–2352
regulation theory and, 5:2399–2402
researcher/researched barrier and, 5:2350
social, spatial, and economic structures in human agency and, 2:618
socialism and, 5:2351
Social Justice and the City (Harvey) and, 5:2350
social justice geographies and, 4:1644
social movement issues and, 5:2350
uneven development issue and, 5:2350
See also Critical human geography; Radical geography: noted individuals
Radical geography: noted individuals
A. Amin, 5:2352
James Blaut, 1:285–286
William Bunge, 1:300, 3:1466, 3:1645, 5:2350
Michael Dear, 5:2351
Jacques Derrida, 5:2351
J. K. Gibson-Graham, 5:2351
David Harvey, 5:2350–2351
H. Lefebvre, 5:2352
Doreen Massey, 5:2351
D. Mitchell, 5:2352
Richard Peet, 2:618, 4:2144
Neil Smith, 5:2351
Edward Soja, 5:2351
Nigel Thrift, 5:2352, 6:2827–2830
Ben Wiser, 2:618
Radiometric correction, 5:2353–2355
function of, 5:2353
geometric correction and, 3:1239–1240
overview of, 5:2333, 5:2348 (fig.)
sensor radiometric calibration and, 5:2353–2354
spectral characterization and, 5:2355
surface reflectance retrieval and, 5:2354–2355
See also Radiometric normalization; Radiometric resolution
Radiometric normalization, 5:2355–2356
applications of, 5:2355
INDEX

Railroads and geography, 5:2357–2364
in Britain, 5:2357
Chicago railway hub and, 5:2360 (photo)
economic effects of rail transportation and, 5:2362
Florence-to-Rome line and, 5:2358
in France, 5:2358, 5:2359 (fig.)
Greenwich Mean Time (GMT) and, 5:2363
high-speed trains, urban transit and, 5:2363–2364
impact of, 5:2357, 5:2358–2359
in Italy, 5:2358
in Japan, 5:2358
media and, 5:2362–2363
Penydarren Tramroad, Wales and, 5:2357
in Russia, 5:2357–2358
social impacts of, 5:2362–2363
standardization of time and, 5:2363
George Stephenson, 5:2357
telegraph and, 5:2359
time-space compression and, 5:2358, 5:2360–2362
tourism and, 5:2363
Trans-Siberian railroad, 5:2357–2358
travel experience and, 5:2360–2362
twentieth century and, 5:2363–2364
in United States, 5:2358–2359, 5:2360 (photo), 5:2361 (fig.)

Raisz, Erwin, 5:2364–2365
academic career of, 5:2364
General Cartography co-authored by, 5:2364
landscape representation work of, 5:2364–2365
professionalization of cartography and, 5:2364

Raitz, Karl, 5:2357
Raivo, Petri, 5:2405
Randolph, T., 3:1533
Randolph, John, 2:980

Rank-size rule, 5:2365–2366
definition of, 5:2365
empirical fit feature of, 5:2365
formula of, 5:2365
Paul Krugman and, 5:2365
ordinary least squares bias feature of, 5:2365
power exponent feature of, 5:2365
“rank minus half” rule and, 5:2365
George Kingsley Zipf and, 5:2365

Raper, Jonathan, 2:560
Rappaport, Roy, 2:895–896
Ratcliff, Richard, 3:1114

Ratzel, Friedrich, 5:2366
Anthropogeographie written by, 2:666, 3:1464, 5:2246, 5:2366
anthropogeography views of, 1:93, 4:1989
Isaiah Bowman influenced by, 1:295
domestication of animals and, 2:782

environmental determinism work of, 2:917, 5:2246
as father of human geography, 3:1466
geopolitics work of, 3:1249, 5:2366, 5:2562
Ernst Haeckel and, 5:2366
Karl Haushofer influenced by, 3:1407, 3:1464, 5:2366
Lamarckian evolutionary theory and, 5:2366
living space, 3:1407–1408
nation states views of, 3:1464, 5:2221–2222, 5:2562
organic analogies of the Earth and, 2:666–667, 5:2562
people and the land relationship views of, 2:666–667
Politische Geographie written by, 5:2221–2222, 5:2366
population geography work of, 5:2246, 5:2366
Ellen Churchill Semple influenced by, 5:2366, 5:2351
Social Darwinism and, 5:2562
state as superorganism views of, 3:1249, 3:1464
Ravenstein, Ernst George, 2:775, 3:1113, 3:1361, 4:1893
Rawls, John, 4:1644

Real estate, geography and, 5:2367–2369
applications of, 5:2367
dynamic iterative process of, 5:2368, 5:2369 (fig.)
filtering process and, 3:1110–1111
geospatial due diligence documentation and, 5:2368
geospatial feasibility model and, 5:2368 (fig.), 5:2369
gospatial real estate market analysis and, 5:2367
geospatial tests and, 5:2367–2369
Homer Hoyt’s work and, 3:1448–1450
“information arbitrage” and, 5:2367
magnitude of profit opportunity element in, 5:2368–2369
Real Estate Investment Trusts (REITs) and, 5:2367
See also Housing and housing markets

Realism, 5:2369–2371
abstraction and, 5:2370
agency and structure relationship and, 5:2370–2371
as analytical framework and, 5:2369
as an epistemology, 5:2370
contingent conditions and, 5:2370
empirical evidence and, 5:2370, 5:2371
mechanisms and structures elements in, 5:2370
necessary conditions and, 5:2370
phenomena explained in terms of causality and, 5:2370
realist ontology and, 5:2370
social and natural sciences distinction and, 5:2369–2370
structuring theory and, 5:2370–2371

Reclus, Élisée, 5:2371–2372
Earth: A Descriptive History written by, 5:2211, 5:2371
environmental preservation work of, 3:1463
geographic anarchism, radical geography work of, 1:73, 2:617, 5:2371–2372
inequities in hegemonic structures views of, 5:2211
Peter Kropotkin and, 4:1669, 5:2372
published works of, 5:2371–2372
social geography term of, 2:617
social inequalities work of, 5:2371–2372
town planning work of, 3:1463

Recycling of municipal solid waste, 5:2372–2375
alternative theoretical approaches to, 5:2374
cardboard recycling, Englewood, Colorado, 5:2374
government decision making and, 5:2374
landfills and, 4:1684–1686
municipal solid waste term and, 5:2372–2373
National Salvation Campaigns and, 5:2372
political imperatives of, 5:2373
recycling definition and, 5:2372
research, 5:2373–2374
social science of waste and, 5:2374
sustainable consumption context of, 5:2372
throwaway society, 5:2374
waste incineration and, 6:3048–3049
waste reduction, minimization, and reuse terms and, 5:2372
waste term and, 5:2372
Wheelabrator waste-to-energy plant, Worcester, Massachusetts, 5:2373 (photo)
RED. See Regional economic development (RED)
Redfield, Robert, 4:2137
Redistricting, 5:2375–2377
bias levels and, 5:2375
boundary delimitation (international context) and, 5:2375
definition of, 5:2375
electoral geography and, 2:881
gerrymandering term and, 5:2375
“The Gerry-Mander” political cartoon, 1812, 5:2376 (image)
GIS data and, 5:2377
packing vs. cracking strategies and, 5:2375
racial and ethnic data element in, 5:2376
reapportionment term and, 5:2375
redistribution term and, 5:2375
safe districts and, 5:2375
scholarly geographic interest in, 5:2377
Shaw v. Reno and, 5:2376, 5:2377
in United Kingdom, Canada, and Australia, 5:2376–2377
in United States, 5:2375–2376
Voting Rights Act (1965) and, 5:2375–2376
Reed, M., 2:615
Rees, William, 2:828
Refugees, 5:2377–2380
Cartagena Declaration on Refugees (1984) and, 5:2378
Convention Governing the Specific Aspects of Refugee Problems in Africa and, 5:2378
Covenant on Economic, Social, and Cultural Rights and, 5:2378
definitions of, 5:2377–2378
Eurocentric definition of, 5:2378
Huguenots refugees from France and, 5:2378
humanitarian efforts and, 5:2380
Hurricane Katrina and, 5:2377
immigration and, 3:1542–1545
International Covenant on Civil and Political Rights and, 5:2378
international human rights law, 5:2378–2379
legal meaning of, 5:2377–2378
nonrefoulment principle and, 5:2378, 5:2379
politicalization of term and, 5:2377
Refugee Convention and, 5:2378
refugee warehousing and, 5:2379
State House settlement, Hargiesa, Somalia, 5:2379 (photo)
United Nations High Commissioner for Refugees and, 5:2378–2379
U.S. Committee for Refugees and Immigrants and, 5:2379
See also Environmental refugees
Regan, Tom, 2:926
Regional economic development (RED), 5:2380–2384
attracting and retaining capital and, 5:2380–2381
definition of, 5:2380
economic base analysis and, 2:846–848
export-led development and, 2:1063–1066
externalities and, 2:1068–1069
growth poles and, 3:1391–1392
importance of, 5:2380
incubator zones and, 3:1551–1553
inequality geographies and, 3:1589
institutions and infrastructure in, 5:2382, 5:2383 (table)
knowledge and competencies and, 5:2381–2382
learning and innovation in regional economics and, 4:1767–1768
mobility, sustainability, regional assets and, 5:2383 (table)
modernization theory and, 4:1931–1935
neoliberalism and, 5:2381
organizational competence and, 5:2381–2382
path dependence theory and, 4:2133–2135
purpose of, 5:2380
sustainable development factors and, 5:2380
See also Gross domestic product/gross national product (GDP/GNP); Regional environmental planning; Regional geography; Regional governance; Regional science; Regions and regionalism
Regional environmental planning, 5:2384–2386
ecological risk analysis (ERA) and, 2:840–843
environmental governance and, 5:2384
land use changes and, 5:2384
limitations of, 5:2386
new regionalism approach, 5:2386
policy context (England) of, 5:2385 (table)
Regional Development Agencies Act (1998) and, 5:2384
Regional Single Strategy and, 5:2384
region scale variations and, 5:2384, 5:2385 (table)
research, 5:2386
spatial planning in EU and, 5:2384
Strategic Environmental Assessment (SEA) Directive and, 5:2386
sustainable development focus of, 5:2384
See also Environmental planning; Regional economic development (RED); Regional geography; Regional governance; Regional science; Regions and regionalism
Regional Fishery Management organizations, 3:1604
Regional geography, 5:2386–2389
areal differentiation and, 5:2387–2388
classical regional geography and, 5:2387
criticism of, 3:1429
decline in popularity of, 3:1531–1532
Geographia Generalis (Varenius) and, 5:2387
geographic imaginations and, 5:2387
graphy’s history and disciplinary identity and, 5:2386–2387
glocalization and, 3:1346–1348
holistic character of places and, 5:2387
idiographic, uniqueness of each region and, 3:1531–1532
local lifestyles, regional landscapes and, 5:2387
logical positivism vs., 5:2388
new regional geography and, 5:2388–2389
regional narratives, culture and settlement patterns and, 3:1429
specific vs. general geography (Varenius) and, 5:2387
See also Regional economic development (RED); Regional environmental planning; Regional geography: noted geographers; Regional governance; Regional science; Regions and regionalism
Regional geography: noted geographers
Andrew Clark, 3:1429
Richard Hartshorne, 3:1402–1403, 3:1531, 5:2387–2388
Alfred Hettner, 5:2387
Doreen Massey, 5:2388
Ptolemy, 5:2387
Carl Ritter, 5:2387, 5:2470–2471
Fred Schaefer, 3:1466, 3:1531–1532, 5:2388
Bernhard Varenius, 5:2387
Paul Vidal de la Blache, 5:2387
Regional governance, 5:2389–2393
administrative infrastructure in, 5:2390
advantages of, 5:2390
characteristics of, 5:2390
criteria of, 5:2389–2390
cross-border cooperation and, 2:630–631
definition of, 5:2389
Regional science, 5:2393–2396
agglomeration issue and, 5:2395
Luc Anselin’s work in, 1:80–81
central place theory and, 1:380–382, 5:2393
definition of, 5:2393
economies of scale and, 5:2395
future of, 5:2394
gravity model and, 5:2395–2396
growth of, 5:2393–2394
history of, 5:2393–2394
interregional flows of goods and population and, 5:2395
Walter Isard and, 3:1627–1628, 5:2393
journals focusing on, 5:2394
location theory and, 5:2393, 5:2394
methods in, 5:2395–2396
multidisciplinary features of, 5:2393
new economic geography and, 5:2395
quantitative analysis methods used in, 5:2395
Regional Science Association and, 5:2393–2394
regions, social issues, and science components of, 5:2393
spatial data analysis and, 5:2395–2396
supranational regional organizations and, 5:2394
“thinking globally” and, 5:2394
topics in, 5:2394–2395
transportation costs element in, 5:2395
urban economics and, 5:2395
urban residential land use issue and, 5:2395
See also Regional economic development (RED); Regional environmental planning; Regional science; Regions and regionalism

Regional science: noted individuals
Luc Anselin, 5:2393
Walter Christaller, 5:2393
Edward Glaeser, 5:2395
Jane Jacobs, 5:2395
August Losch, 5:2393, 5:2394
Scott Loveridge, 5:2394
Edwin Mills, 5:2395
Richard Muth, 5:2395
Johann Heinrich von Thünen, 5:2393, 5:2394
Brigitte Waldorf, 5:2393
Alfred Weber, 5:2393, 5:2394
Alan Wilson, 5:2393

Regional Science Association International (RSAI), 5:2396–2397
Luc Anselin and, 1:81
conferences held by, 5:2397
European Regional Science Association and, 5:2397

Walter Isard’s founding of, 3:1628, 5:2393–2394, 5:2396
journals of, 5:2397
membership of, 5:2394
Pacific Regional Science Conference Organization and, 5:2397
Regional Science Association of the Americas and, 5:2397
structural organization of, 5:2396–2397
supra regional organizations and, 5:2394, 5:2396–2397
See also Association of American Geographers (AAG)

Regions and regionalism, 5:2397–2399
applications of regionalism and, 5:2398–2399
commonality maximization goal of, 5:2397–2398
Earth’s major region divisions and, 5:2398
functional regions and, 5:2398
Alfred Hettner and, 3:1422–1423, 3:1465, 5:2387
homogeneity basis of, 5:2397–2398
human geography courses and, 5:2398
idiographic, uniqueness of each region and, 3:1531
language regions and, 5:2398
learning and innovation in regional economics and, 4:1767–1768
locality studies and, 4:1790–1792
physical geography and, 5:2398
regionalism and, 5:2398–2399
regional science and, 5:2398–2399
regions as classification and categorization tool and, 5:2397
systematic geography and, 5:2398
See also Regional economic development (RED); Regional environmental planning; Regional geography; Regional science; Regional Science Association International (RSAI)

Regulation theory, 5:2399–2402
Michel Aglietta and, 5:2399, 5:2401
capitalist theory and, 5:2399
critique, 5:2401–2402
flexible specialization and, 5:2400–2401
Fordism and, 3:1148–1151
Fordism and its demise in, 5:2399–2400
global capitalism and, 5:2401
historical background of, 5:2399
hyperaccumulation of new capitalism and, 5:2401
Japanese just-in-time production and, 5:2401
mode of regulation concept and, 5:2399
neoliberalism and, 5:2400
peripheral Fordism term and, 5:2400
post-Fordism, nature of, 5:2400–2401
regime of accumulation concept and, 5:2399
“social contract” element in, 5:2399
Régulier, Catherine, 4:1769
Reisman, David, 5:2262

Relative/relational space, 5:2402–2405
absolute space vs., 1:2, 5:2402–2403
actor-network theory and, 1:8
airplanes and, 5:2404
Culture of Time and Space (Kern) and, 5:2403
definitions, 5:2403
geopolitics of imperial rivalry and, 5:2404
locality studies and, 4:1790–1792
Marxism and, 5:2403
measurement of time and, 5:2404
origin of, 5:2402
power geometries and relational space (Massey) and, 5:2405
production of space and, 5:2297–2298
scale of capital accumulation and, 5:2404
spatiality meaning (Kern) and, 5:2403
technology advances and, 5:2403
time-space compression and, 5:2404
see also Relative/relational space: noted individuals

Relative/relational space: noted individuals
Albert Einstein, 5:2403–2404
Anthony Giddens, 5:2403
David Harvey, 5:2403
Gottfried Leibniz, 5:2402
Sir Halford Mackinder, 5:2404
Doreen Massey, 4:1866–1867, 5:2351, 5:2405
Neil Smith, 5:2404

Religion, geography and, 5:2405–2410
Al-Muqaddasi and, 5:2407
belief systems and, 5:2405–2406
biblical mapping and, 1:195–197, 1:196 (fig.)
Cathedral of Santa Domingo, Cuzco, Peru, 5:2406 (photo)
crossing and dwelling theory of religion (Tweed) and, 5:2409
cultural geography and, 5:2406
data acquisition issue and, 5:2406
definition of, 5:2405
diffusion principles and, 5:2406
environment and, 5:2409
Haji Alija Mosque, Pocitelj, Bosnia-Herzegovina, 5:2406 (photo)
international institutions element in, 5:2406
Lane’s axioms of sacred space and, 5:2408
mapping religious regions and, 5:2407
necrogeography, landscapes of death and, 5:2409
New Historical Atlas of Religion in America (Gaubstad and Barlow) and, 5:2407
pilgrimage and, 5:2184–2186, 5:2408
recent contributions in, 5:2409
religions geography vs., 5:2405
religious diffusion, distributions, and regions in, 5:2406–2407
religious landscapes and, 5:2408–2409
religious taboos and, 5:2409
sacred space and pilgrimage in, 5:2407–2408, 5:2409
social, cultural, and environmental perspectives of, 5:2405
social construction of identity issue and, 5:2409
spatial nature of religious institutions and, 5:2406
themes of, 5:2405
Thomas Tweed and, 5:2409
Yamunotri Temple, Indian Himalayas, 5:2407 (photo)
Wilbur Zelinsky’s work in, 5:2407

Relph, Edward, 5:2410–2411
books written by, 5:2410
capitalist landscape work of, 3:1476
environmental humidity, 5:2411
existential insideness and outsideness terms of, 4:2167, 5:2411
Martin Heidegger and, 5:2410
human care of landscapes work of, 2:1046, 3:1476
human geographies work of, 2:1046, 3:1467, 5:2410–2411
phenomenology of place work of, 4:2167, 5:2411
Place and Placedness written by, 4:2167, 5:2410–2411
spirit of place vs. sense of place and, 5:2411

Remittances, 5:2411–2414
definitions of, 5:2411
development and, 5:2414
economic diversification strategy of, 5:2413–2414
geographic explosion of, 5:2412, 5:2412 (fig.), 5:2413 (fig.)
geographic importance of, 5:2412
global remittance flows, 2007 and, 5:2412 (fig.)
nonessential items purchased with, 5:2413
regional remittance flows, 2007 and, 5:2413 (fig.)
social remittances and, 5:2411–2412
uses of, 5:2412–2413

Remote sensing, 5:2414–2420
advantages and disadvantages of, 5:2414–2415
aerial photography and, 5:2416–2417
aerial sensors and satellite sensors and, 3:1257
atmospheric remote sensing and, 1:157–161
biogeochemical cycle patterns, 1:207
blackbody element in, 5:2415
Gilberto Câmara’s work in, 1:319
climatology data collection and, 1:475
data sets size issue in, 3:1212
definition of, 5:2414
digital image data and, 5:2416
ecotones identification and, 2:869
electromagnetic radiation (EMR) element in, 5:2415–2416
extent or coverage image feature and, 5:2416
floodplain delineation, 3:1131
grocomputation in, 3:1212
grosensor networks and, 3:1252–1254
geospatial data production technology and, 3:1256–1257
GIS landuse and land cover mapping and, 3:1302–1305
ground reference data and, 3:1384–1385
health applications of, 4:1879
image data acquisition methods and, 5:2417
image display methods and, 5:2419
image enhancement and, 3:1532–1533
image fusion and, 3:1533–1534
image interpretation and, 3:1534–1536
interpretation of, 5:2417–2419
Landsat 7 image, Cape Cod, Massachusetts, 5:2417 (photo)
landscape interpretation using, 4:1715
land use and cover change, 4:1737–1738
Thomas Lillesand, 4:1783–1784
map animation and, 4:1826
microwave/RADAR data and, 4:1888–1890
Moderate Resolution Imaging Spectroradiometer (MODIS)
multispectral imagery and, 4:1953–1956
multitemporal imaging and, 4:1959–1960
object-based image analysis (OBIA) and, 4:2057–2058
panchromatic imagery and, 4:2112–2115
pipeline leaks, 2:949–951
platform type of, 5:2416
Evelyn Pruitt and, 5:2414
pushbroom vs. whiskbroom sampling and, 5:2417
radiometric correction and, 5:2353–2355
radiometric normalization and, 5:2355–2356
radiometric resolution and, 5:2356–2357
raster-based GIS and, 3:1282–1283
raster image of Earth’s surface and, 3:1257
resolution or grain image feature and, 5:2416
sensor type of, 5:2416
solar reflective EMR and, 5:2415
stereoscope analysis tool and, 5:2418
sun synchronous vs. geostationary satellite orbits and, 5:2416, 5:2421
surveillance and, 6:2734
types and sources of, 5:2416–2417
USGS nationwide inventory of land cover and land use and, 3:1302
vector data and, 3:1257

See also Aerial imagery: data; Aerial imagery: interpretation; Atmospheric remote sensing; Biophysical remote sensing; Image specific subjects: Remote sensing: platforms and sensors; Remote sensing in disaster response
Remote sensing: platforms and sensors, 5:2420–2424
    active sensors, 5:2423
    aircraft platforms and, 5:2421
    atmospheric remote sensing and, 1:157–161
    future directions, 5:2423
    geostationary satellite platform and, 5:2421
    hyperspectral sensors, 5:2423
    Landsat satellites and, 5:2421
    multispectral imagery and, 4:1953–1956
    multispectral scanners, 5:2423
    multispectral sensors, 5:2423
    NASA Shuttle Radar Topographic Mission and, 5:2421
    panchromatic imagery and, 4:2112–2115
    panchromatic sensors, 5:2423
    passive vs. optical sensors and, 5:2422
    platforms, 5:2420–2421, 5:2420 (fig.), 5:2421 (fig.)
    real-aperture radar (RAR) and, 5:2423
    satellite platforms and, 5:2421
    sensors, 5:2421–2423, 5:2422 (fig.)
    sun-synchronous vs. geosynchronous satellite platforms and, 5:2421

See also Remote sensing

Remote sensing in disaster response, 5:2424–2428
    aircraft and, 5:2424
    anthropogenic disaster responses and, 5:2424
    current trends in, 5:2425
    decision support function of, 5:2425
    geopositioning satellites and, 5:2424
    geostationary satellites and, 5:2424
    GIS information integration and, 5:2424
    information sources integration and, 5:2424
    in situ devices and, 5:2424
    international agencies and initiatives of, 5:2425
    International Charter-Space & Major Disasters consortium and, 5:2424–2425
    micro unmanned aerial vehicles (MUAV) and, 5:2424
    natural disaster responses and, 5:2424
    real-time remote sensing ground stations and, 5:2425, 5:2427
    remote sensing definition and, 5:2424
    Southern Indiana flood, June 2008, 5:2426 (figs.), 5:2427 (fig.)
    vulnerable populations and, 5:2427

See also GIS in disaster response; Remote sensing

Renewable resources, 5:2428–2430
    biofuels production and, 1:201–204
    breakthroughs in renewables and, 5:2430
    definition of, 5:2428
    ecological economics and, 2:820–824
    ecological modernization and, 2:832–834
    electricity sources development and, 5:2429
    geothermal energy, 3:1265–1270, 5:2429 (photo)
    hydroelectric power and, 3:1506–1512
    issues of scale and whole-systems analysis and, 5:2429–2430
    Mammoth Pacific geothermal plant, Sierra Nevadas, California, 5:2429 (photo)
    nonrenewable resources and, 4:2039–2041
    overdependence on, results of, 5:2428
    renewability factor in, 5:2428
    solar energy example of, 5:2428–2429

See also Adaptive harvest management

Rent-gap, 5:2430–2431
    actual vs. potential rents and, 5:2430
    back-to-the-city movement of capital and, 3:1204
    capital-centered account of gentrification and, 3:1204
    capitalist dynamics and, 5:2431
    corporate reclamation of inner city spaces and, 5:2430
deindustrialization, suburban population migration and, 5:2430
    gentrification and, 3:1204, 3:1205 (fig.), 5:2430, 5:2431
    motivational implications of, 3:1204
    producer services and agglomeration economics and, 5:2430
    profitability of land in urban core and, 5:2430

Neil Smith, 5:2430, 5:2551

Representations of space, 5:2431–2434
    actor-network theory and, 5:2434
    art and geography and, 1:118–120
    cartography and, 5:2432–2433
    conquest and empire and, 5:2432–2433
    cultural geography and, 5:2433
    cultural turn and, 5:2433–2434
    film and, 3:1110–1111
    lived spaces and, 5:2431
    mental maps and, 4:1881–1883
    military expeditions and, 5:2432–2433
    Nature of Geography (Hartshorne) and, 5:2433
    nonrepresentational theory and, 5:2434
    ontological foundations of geographical data and, 4:2078–2081
    perceived space and, 5:2431
    photography and, 4:2176–2178
    physical space affected by, 5:2432
    quantitative revolution and, 5:2433
    reductionist feature of, 5:2433
    regional studies and cultural analysis and, 5:2433
    social relations shifts and, 5:2432
    theories of practice and, 5:2434
    theory of space and, 4:1768–1770, 5:2297, 5:2431–2432

See also Representations of space: noted individuals

Representations of space: noted individuals
    Walter Christaller, 5:2433
    Denis Cosgrove, 5:2432
    Jacques Derrida, 5:2433
    Michel Foucault, 5:2433
    Richard Hartshorne, 5:2433
    Henri Lefebvre, 4:1768–1770, 5:2297, 5:2431–2432
    August Lösch, 5:2433
    Gunnar Olsson, 4:2077–2078
    John Pickles, 2:1046, 4:2183
    Carl Sauer, 5:2433
    Ferdinand de Saussure, 5:2433
    Johann von Thünen, 5:2433

Research and development (R&D), geographies of, 5:2434–2437
    clustering and, 5:2435–2436
    Competitive Advantage of Nations (Porter) and, 5:2435
    contextualizing R&D and, 5:2435
    definitions, 5:2434
    in electronics industry, 2:885–886
    Experimental Program to Stimulate Competitive Research (U.S.) and, 5:2437
    flexible accumulation process in, 5:2436
    knowledge regions and, 5:2435
    learning regions and, 4:1766–1768
    partnerships and collaborations feature of, 5:2436
    regional development and, 5:2435
    science and technology term and, 5:2435
    spatial issues of, 5:2434–2435
    spatialized public policy and, 5:2437
    technopoles concept and, 5:2435–2426
    triple helix model of, 5:2436
    university spinoffs of, 5:2436–2437

Resilience, 5:2437–2441
    adaptability and, 5:2440
    adaptive ecosystem management and, 5:2438
backloop concept and, 5:2439
Steve Carpenter, 5:2439
coupled socio-ecological systems and, 5:2439–2440
definitions of, 5:2437–2438
ecosystem resilience and, 5:2438
ecosystem stability and, 5:2437
eengineering resilience and, 5:2438
extended keystone hypothesis and, 5:2439
Carl Folke, 5:2440
Lance Gunderson, 5:2439
heuristic model of adaptive renewal cycles (Gunderson and Holling) and, 5:2439
historical perspective and key elements of, 5:2438–2439
Crawford Holling and, 5:2437–2438, 5:2439
Simon Levin, 5:2438
mentality elements of, 5:2440
multiscale and multitemporal research on, 5:2438
panarchy theory and, 5:2438
Resilience Alliance network and, 5:2439
theory of complex adaptive systems (Levin) and, 5:2438
transformability and, 5:2440
Resistance, geographies of, 5:2441–2444
American and French Revolutions and, 5:2441
antiglobalization and, 1:94–97
antisystemic movements and, 1:99–100
countermapping and, 2:595
critiques of, 5:2443–2444
current research trends in, 5:2444
evolution of, 5:2441–2443
IMF and World Bank protestors, West Berlin, 5:2443 (photo)
neoliberal economic ideology and, 3:1543–1548
justice/injustice geographies and, 3:1643–1645
law geographies and, 4:1766
Making of the English Working Class (Thompson) and, 5:2442
malleability of identity and, 5:2442–2443
Marxist theories and, 5:2441–2442
“Not in My Backyard” (NIMBY) and, 4:2049
postcolonialism and feminist geography and, 5:2442
resistance term definitions and, 5:2441
thirdspace concept and, 5:2442
Weapons of the Weak (Scott) and, 5:2442
See also Resistance, geographies of: noted geographers, scholars
Resistance, geographies of: noted geographers, scholars
Andrew Charlesworth, 5:2442
Tim Cresswell, 5:2433–2444
Michel de Certeau, 5:2442
David Harvey, 5:2442
Paul Routledge, 5:2444
James Scott, 5:2442
David Sibley, 5:2442
Edward Soja, 5:2442
E. P. Thompson, 5:2441, 5:2442
Resnick, M., 5:2365
Resource economics, 5:2445–2446
benefits of leaving resource in situ and, 5:2445
discounting future profits controversy and, 5:2445–2446
ecological economics and, 2:820–824
ecological modernization and, 2:832–834
environmental management and, 2:967–970
Faustmann rule for forestry resources and, 5:2445
maximum sustained yield concept and, 5:2445
optimal extraction amounts issues and, 5:2445–2446
past and future of, 5:2446
scarcity rent rate concept (Hotelling) and, 5:2445
See also Energy and human ecology; Resource geography; Resource management, decision models in; Resource mapping; Resource tenure
Resource geography, 5:2446–2451
capitalist production and, 5:2449–2450
critical approaches to, 5:2448–2450
cultural specific perspectives on, 5:2449
Enlightenment exploration and, 5:2447
Eurocentric perspectives on, 5:2449
management of natural capital, 5:2447, 5:2448–2450
multiscale networks and, 5:2449
neoliberal economic ideology and, 5:2450
political economic and political-ecological networks and systems of, 5:2447, 5:2448–2450
statistical picturing of, 5:2448
See also Resource economics; Resource management, decision models in; Resource mapping; Resource tenure
Resource management, decision models in, 5:2451–2453
comprehensive decision support system and, 5:2453
cost-benefit analysis, 5:2451
decision analysis, decision tree, 5:2453
discrete choice models, 5:2451, 5:2452 (fig.)
issues in, 5:2451
mathematical optimization (mathematical programming) models, 5:2453
multi-criteria evaluation (MCD) decision models, 5:2451, 5:2453
Shared Vision Planning Framework and, 5:2453
typology of, 5:2452 (fig.)
See also Resource economics; Resource geography; Resource mapping; Resource tenure
Resource mapping, 5:2454–2456
biomass for energy production, Guangdong Province, China, 5:2454, 5:2455 (fig.)
Canada Land Inventory project, 1963–1995 and, 5:2454
definition of, 5:2454
digital evaluation models and, 5:2454
decision tree, 5:2453
fuzzy classification concept and, 5:2454
geospatial information technologies and, 5:2454
GIS landuse and land cover mapping and, 3:1302–1305
history of, 5:2454
remote sensing and, 5:2454
vector to raster format shift and, 5:2454
See also Environmental mapping; Resource economics; Resource geography; Resource management, decision models in; Resource tenure
Resource tenure, 5:2456–2457
boundedness of societies, variations in, 5:2456
colonialism and, 5:2456–2457
decontextualized modern property systems and, 5:2457
definition of, 5:2456
institutionalization of resource property rights and, 5:2456
resource geographies, human social formations and, 5:2456
small-scale traditional societies and, 5:2457
uneven resources distribution and, 5:2456
universality claims and, 5:2456
See also Distribution of resource access; Resource economics; Resource geography; Resource management, decision models in; Resource mapping
Restructuring, 5:2458–2461
accumulation regime changes and, 5:2458–2459
capitalist competition and cost reduction and, 5:2458–2459
capitalist restructuring and, 5:2459–2460
corporate restructuring and, 5:2458
definition of, 5:2458
economic restructuring and, 5:2458–2460
foreign direct investment and, 5:2458
industrial restructuring and, 5:2458
international organizations and, 5:2459
micro vs. macro sales of, 5:2458
neoliberal political economic strategy and, 5:2459
outsourcing and, 5:2458
service economies and, 5:2458
shopping mall construction, Gurgaon, Haryana, India, and, 5:2459 (photo)
in socialist countries, 5:2459–2460
Sunbelt transition and, 5:2458
transnational corporations and, 5:2458
Retail trade, geography of, 5:2461–2464
business geography and, 1:305–306
Census of Retail Trade data and, 5:2462
central place theory and, 5:2462
Consumer Expenditures Annual Reports and, 5:2462
customer demographic and behavioral analyses and, 5:2461
discounters and, 5:2462
GIS technology, location decision making and, 5:2462
gravity model theory and, 5:2462–2463
grocers as dominant retailers and, 5:2461
Internet-based retail trade and, 5:2464
issues relevant in, 5:2461
law of retail gravitation and, 5:2462–2463
retail establishments and spatial changes in, 5:2461–2462
sales, outlets, and selling space elements in, 5:2461
spatial interaction models of, 5:2463
suburban customers and, 5:2462
supercenters and, 5:2462
theories and models of retail trade location and, 5:2462–2463
Walmart, Southern California, 5:2463 (photo)
ReVelle, Charles, 4:1793
Rey, Sergio, 5:2637
RGS. See Royal Geographical Society (RGS); Russian Geographical Society (RGS)
Rhodes, Cecil, 3:1224
Ricardo, David
Marx influenced by, 4:1860
political economy meaning and, 5:2214
specialization views of, 2:780
two-country, two-product theory of, 2:556–557, 2:557 (table)
Richards, Paul, 3:1536
Richardson, Tim, 2:1037
Rifkin, Jeremy, 1:33
Rill erosion, 5:2464–2466
definition of, 5:2464
density of, 5:2465
ephemeral gully erosion, Western Iowa, 5:2465 (photo)
erosion gullies and, 5:2464
erosion rills and, 5:2464
gully erosion and, 3:1392–1394
“microrills” or “traces” and, 5:2464
midslope element in, 5:2465
process of, 5:2464–2465
upslope migration of, 5:2465
Ringmann, Matthias, 6:3041
Risk analysis and assessment, 5:2466–2470
benefit-cost analysis and, 5:2468
definitions, 5:2466
dose-response assessment and, 5:2466–2467
ecological risk analysis (ERA) and, 2:840–843
economics and, 5:2468
ethics/morality issues and, 5:2468
exposure assessment and, 5:2467
exposure pathways and, 5:2467
“fate and transport” of hazardous materials and, 5:2467
flash floods and, 3:1123–1125
hazard identification and, 5:2466
laboratory experiments and, 5:2466
making choices about risks and, 5:2468
natural hazards and risk analysis and, 4:1983–1989
no observed adverse effect (NOAEL) and, 5:2466
political issues and, 5:2469
public reaction and, 5:2468–2469
remediating former nuclear weapons sites example of, 5:2469–2470
risk assessment and, 5:2466
risk characterization and, 5:2467–2468
risk management and, 5:2468
risk-related policy issues and, 5:2468
short-term vs. long-term emissions and, 5:2467
threshold level issues and, 5:2466–2467
See also Natural hazards and risk analysis
Ritter, Carl, 5:2470–2471
evolutionary theory and, 2:666
Arnold Guyot and, 3:1394
Richard Hartshorne and, 5:2471
Alfred Hettner influenced by, 3:1422
human geographies work of, 3:1462–1463, 4:2180, 5:2387, 5:2471
modern geographer co-founded by, 5:7471
Ritter, Paul, 1:404
Rivers, 5:2471–2477
Amazon River, South America, 5:2472, 5:2473 (image)
bed and bank configuration form and, 5:2475
channel patterns forms and, 5:2475–2476
channel slope and, 5:2475
Clean Water Act (1972) and, 5:2476
climate change and, 5:2472
dams and, 5:2476
deltas and, 2:702–705, 5:2472
drainage networks and, 5:2472–2474
dynamic equilibrium process and, 5:2474
features of, 5:2471
floodplains and, 3:1128–1133
flow mechanics and regime factors process and, 5:2474
flow of, 3:1138
geography of, 5:2472
geology and climate variables and, 5:2472
human impacts on, 5:2472, 5:2476
humanity impacted by, 5:2476
hydroelectric power and, 3:1506–1512
hydrological connectivity and, 3:1512–1513
hydrologic cycle and, 5:2471
hydrology and, 3:1513–1518
international watershed management and, 3:1618–1620
longitudinal profile of, 5:2475
Nile, longest river and, 5:2472, 5:2476
pollution of, 5:2476
processes and forms, 5:2474–2476
sediment transport and deposition process and, 5:2475
stream term and, 5:2472–2473
variations in, 5:2472
See also Amazon River, Amazonia
Robbins, Paul, 1:526, 4:1996
cultural ecology work of, 2:632, 4:1996
nature-society theory and, 4:1996
**Rock weathering, 5:2477–2484**

- Animal weathering, 5:2479
- Biomechanical processes, 5:2479
- Carbonation, carbon cycle and, 1:325, 1:326–327
- Chelation chemical weathering, 5:2480
- Chemical weathering, 5:2479–2480
- Colorado National Monument, Colorado, 5:2483 (photo)
- Creep and, 2:604–605
- Cryostatic pressure, 5:2477
- Crystals expansion and growth and, 5:2477–2478
- Dehydration and, 5:2480
- Environmental and microscale factors in, 5:2481 (fig.)
- Fractures, 5:2483
- Gnammas (rock basins), 5:2482
- Hoodoos (rock pinnacles), 5:2482
- Hydration chemical weathering, 5:2480
- Hydrolysis or incongruent dissolution chemical weathering, 5:2479, 5:2480 (image)
- Hydrostatic pressure and, 5:2478
- Karren (solution channels), 5:2482
- Mechanical type of, 5:2477–2479
- Microscale chemical weathering, 5:2480 (image)
- Multiple weathering agents, 5:2482 (photo)
- Oxidation chemical weathering, 5:2480
- Petrology, mineralogy, and geologic-structure factors in, 5:2483
- Phosphorus cycle and, 4:2169–2171
- Pressure unloading and, 5:2478–2479
- Rock-derived nutrients cycling and, 1:207
- Small-scale landforms and, 5:2482
- Solution or congruent dissolution chemical weathering, 5:2479
- Sources of weathering agents, climate and biotic influences on, 5:2481 (fig.), 5:2483–2484
- Tafoni, or honeycomb weathering on sandstone wall, Colorado, 5:2482 (photo)
- Tafoni (honeycomb-like hollows), 5:2482
- Temperature changes and, 5:2478
- Thermal weathering, 5:2478
- Time, scale, and the geomorphic system factors in, 5:2480–2483
- Tot, near Crow Creek, Wyoming, 5:2478 (photo)
- Well-developed weathering rind and, 5:2481 (photo)

Rogers, Will, 1:317

Rumania

AGILE membership of, 1:125 (table)

Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)

Clothing exports from, 6:2186 (fig.)

COMECON membership of, 2:593 (table)

Economically active females in, 3:1190 (table)

European Union membership of, 2:1035

Eurorregions, cross-border cooperation and, 2:631 (fig.)

Plastic and trash pollution, Bicaz Lake, Romania, 6:3053 (photo)

Textile exports from, 6:2816 (fig.)

Roon, Albrecht von, 4:1896

Rooney, John, 5:2680

Roosevelt, Franklin D., 2:570

Roosevelt, Theodore, 2:569–570

Rose, Gillian, 5:2484–2485

Critical visual methodologies and, 5:2485, 6:3026

Cultural politics of landscape work of, 5:2484

Emotional geographies work of, 2:892

Explicit sexualization of knowledges and, 5:2485

Feminism and Geography written by, 5:2484

Feminist environmentalist geographies work of, 3:1094

Feminist geographies work of, 1:290

Feminist use of reflexivity, 5:2484

Gendered geographical knowledge work of, 3:1097, 5:2484–2485

Performatve and visual methodologies work of, 5:2484

Psychoanalysis and, 5:2484

Visual Methodologies written by, 5:2485

Rose, Harold, 3:1275

Rose, K., 5:2365

Rose, Mamaries, 3:1204

Roukova, Poli, 5:2109


Routledge, Paul, 5:2444, 5:2574–2575

Rowles, Graham, 3:1104, 4:2122

Royal Geographical Society (RGS), 5:2485–2487

Action Plan for Geography and, 5:2486

Awards and honors given by, 5:2487

Colonial exploration and, 5:2486

Crossing Continents project of, 5:2486

Education focus of, 5:2486

Geography Outdoors program of, 5:2486

Institute of British Geographers (IBG) and, 3:1601–1603, 5:2485, 5:2486

R. J. Johnston and, 4:1643

Journals of, 5:2486

Mission and purpose of, 5:2486

Policy work of, 5:2486–2487

Unlocking archives initiative of, 5:2486

RSAL. See Regional Science Association International (RSAI)

Rudé, George, 5:2441

Randstrom, Robert, 3:1562, 3:1563

Rural development

5:2487–2491

Actor-network theory and, 5:2490–2491

Case study research on, 5:2491

Contemporary research, 5:2490–2491

Definitions, 5:2487, 5:2488

Endogenous development, 5:2487

Fluidity and malleability, 5:2488

Focus of, 5:2488–2490

“Frontier” zones of state expansion and, 5:2488

Growth pole modernist strategy of, 5:2488

History of, 5:2487

Industrial Development Authority (Ireland) and, 5:2488

Integrated approach to, 5:2487

Land management and commodity foci of, 5:2488–2489

Measurement and assessment of, 5:2490

Neoliberal policies toward, 5:2490

New bridge construction, Guizhou Province, China (2006), 5:2489 (photo)

Peasants and peasantry, 4:2137–2142

Rural as discourse and, 5:2488

Rural land use regulation and, 4:1727

Social sustainability element in, 5:2490

Social theory and, 5:2490

Social welfare an, 5:2490

Systems theory, integrated approach to, 5:2490

Tennessee Valley Authority project and, 5:2488

U.S. rural population (2000) and, 4:1886 (table)

See also Rural geography; Rural-urban migration

Rural geography, 5:2491–2495

Agricultural issues and, 5:2492

Amish farm, Lancaster County, Pennsylvania, 5:2494 (photo)

Definition of, 5:2491

Ecotourism and, 5:2493

Rowles, Graham, 3:1104, 4:2122

Royal Geographical Society (RGS), 5:2485–2487

Action Plan for Geography and, 5:2486

Colonial exploration and, 5:2486

Crossing Continents project of, 5:2486

Education focus of, 5:2486

Geography Outdoors program of, 5:2486

Institute of British Geographers (IBG) and, 3:1601–1603, 5:2485, 5:2486

R. J. Johnston and, 4:1643

Journals of, 5:2486

Mission and purpose of, 5:2486

Policy work of, 5:2486–2487

Unlocking archives initiative of, 5:2486

See also Rural geography; Rural-urban migration
environmental and conservation issues and, 5:2494
environmental geography and, 5:2492
future directions, 5:2495
gender issues in, 5:2493
globalization context of, 5:2492–2493
isolation of rural places and, 5:2493
natural resources conflicts and, 5:2491
peasants and peasantry, 4:2137–2142
privatization of resources (neoliberalism) and, 5:2494
quality and community issues and, 5:2494–2495
quality of life element of, 5:2493
regional approach to geography and, 5:2492
regional or national identity and, 5:2492
rural cultures and, 5:2493
rural economics and, 5:2492–2493
rural environment knowledge and, 5:2492
rural migrations and, 5:2493
rural politics and, 5:2493–2495
urban population migration and, 5:2492
See also Rural development; Rural-urban migration

Rural-urban migration, 5:2495–2498
demographics of, 5:2496
in developing countries, 5:2495–2496
Harris-Todaro model of, 5:2495
household strategy approach to, 5:2496
impacts of, 5:2496–2497
Lewis dual sector model of, 5:2496
migrant worker, Beijing, China, 5:2497 (photo)
eoctal theories on, 5:2495–2496
primate cities and, 5:2291
Rushbrook, D., 5:2333
Rushton, Gerard, 4:1793
Russia
acid rain in, 1:7
Alaska colonized by, 1:512
APEC membership of, 1:121
automobile industry in, 1:169
birthrates in, 2:708
Chernobyl nuclear accident in, 1:385–386
cholera in, 1:401
Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)
coal in, 1:483, 1:485
colonial migrations of, 1500–1914, 3:1543
Commonwealth of Independent States (CIS) membership of, 2:536
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
environmental history studies in, 2:929
ethnic nationalism and, 4:1979
European Union (EU) membership of, 2:1035
fertility levels in, 2:709
fossil fuels produced in, 2:902
GDP of, 3:1382, 3:1383 (fig.)
hate groups in, 3:1407
HIV/AIDS in, 3:1438, 3:1439
homeless women, St. Petersburg, 3:1442 (photo)
horse domesticated in, 2:783
humid continental climate of, 1:440
IMF voting rights of, 3:1617
industrialization in, 4:2020
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Kyoto Protocol of 1997, GHG emissions and, 1:463
land inequality in, 4:1693
military expenditures in, 4:1898, 4:1899 (table)
military-industrial complex in, 4:1900
multinational corporations investment in, 5:2220
Murmannsk, 1:442
national geographical society in, 3:1462
NATO and, 4:2048
new Cold War and, 4:2048
Norilsk Nickel's copper plant, 3:1416 (photo)
oil production in, 4:2099
oil sources in, 4:2163
prairie restoration in, 5:2279
railroads in, 5:2357–2358
subarctic climate in, 1:441
taiga boreal forests in, 1:214
urbanization in, 2:543
Viking exploration of, 2:1051
See also Communism and geography; Soviet Union
Russian Federation
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)

Russian Geographical Society (RGS), 5:2498
academic and applied activities of, 5:2498
founding of, 5:2498
Peter Kropotkin and, 4:1668–1669
mission of, 5:2498
name changes of, 5:2498
Ruttan, Vernon, 6:2737
Rwanda
cultural annihilation in, 3:1200
economically active females in, 3:1190 (table)
ethnic cleansing, ethnicity of place and, 2:1020
hate groups in, 3:1407
independence of, 1:512
Ryan, Clare, 2:993–994
Saarinen, Thomas, 3:1219–1220
Sachs, Wolfgang, 2:1002
Safina, Carl, 4:2068
Sagan, Carl, 3:1335
Sahara Desert
basin and range topography in, 1:186
desert biome of, 1:218
diurnal surface temperature, Northern Sahara desert, 1:433–434, 1:434 (fig.)
dry climate of, 1:429
dust storm in, 1:21 (photo)
omadic Tuareg herders and camels, Mali, West Africa, 4:2034 (photo)
tropical savanna border on, 1:239
Sahlen, Marshall, 1:167
Sahrawi Arab Republic, 1:25
Said, Edward, 1:508, 2:1030, 2:1047, 4:1787, 4:1876
discursive representations and, 5:2259–2260
imaginative geographies and, 4:2102, 5:2261
postcolonial studies and, 4:2103, 5:2259–2260
poststructuralism and, 5:2272
process of Othering and, 4:2107
Saint-Simon, Comte de, 4:1860
Salt Lake City, Utah, 1:378 (photo)
Samuels, Marwyn, 2:1046
San Andreas fault zone, 1:186, 2:605
Sanchez, T., 2:1075
San Francisco, California
central business district of, 3:1379
earthquake (1906) in, 3:1087
industrialism in, 4:1822
spatially concentrated gay community in, 3:1183–1184
Samlos, Milton, 2:618
Saro–Wiwa, Ken, 2:619–620
Sartre, Jean–Paul
existentialist Marxism of, 2:1046, 2:1047
history as an accumulation outflow of spatialized acts and, 2:1047
Henri Lefebvre and, 4:1768
Sassen, Saskia, 3:1117
Satellites and geography, 5:2499–2504
Arabsat and, 5:2502
base map of Ukraine and, 1:359, 1:360 (fig.)
China–Brazil Earth Resources Satellites and, 1:319
Communication Satellite Corporation and, 5:2501
Communications Satellite Act and, 5:2501
Condor Alliance of Andean Nations and, 5:2502
contemporary satellite industry and, 5:2503–2504
Direct Broadcast Satellites (DBS) and, 5:2503
electromagnetic frequency spectra allocation issue and, 5:2501
European Telecommunications Satellite Organization and, 5:2502
Eutelsat and, 5:2502
fiber optics and, 5:2503–2504
global sea-level rise measured by, 3:1344
history of, 5:2499–2500
hurricane tracking and, 3:1497 (photo), 3:1499
indigenous telecommunications satellite, 5:2503
Inmarsat and, 5:2502
International Satellite Organization and, 5:2501–2502
land use and cover change and, 4:1737–1738
map animation and, 4:1826
national sovereignty issues and, 5:2501
Palapa satellites and, 5:2503
panchromatic band characteristics on Earth–imaging satellites and, 4:22115 (table)
panchromatic imagery and, 4:22114
Peacesat and, 5:2502
Rascom and, 5:2502
regulation of global satellite industry and, 5:2500–2503
satellite climate recording and, 1:456
Satellite Meteorology (Vander Haar and Kidder), 1:159–160
sea ice, 3:1524–1525, 3:1524 (fig.), 3:1525 (fig.)
spillovers from satellite footprints and, 5:2501
SPOT satellite (France) and, 4:21114, 4:21115 (photo)
Sputnik launch and, 5:2499
spy satellites and, 5:2499
typhoon satellite image and, 1:20 (photo)
UN International Telecommunications Union (ITU) and, 5:2500–2501
World Administrative Radio Conference and, 5:2501
world’s international satellite earth stations and, 5:2503 (fig.)
See also Global positioning system (GPS); Remote sensing
Saturated adiabatic lapse rate (SALR), 1:16–17
Sauber, Sandie, 3:1565
Saudi Arabia
Ar Rub’al Khali Wildlife Management Area in, 4:2118
economically active females in, 3:1190 (table)
Holy Mecca in, 5:2185 (photo)
IMF voting rights of, 3:1617
military expenditures in, 4:1899 (table)
oil sources in, 4:2163
OPEC membership of, 4:2098, 4:2099, 4:2100 (fig.)
Sauer, Carl, 5:2504–2506
academic career of, 5:2505
agency of humans on Earth and, 5:2505–2506
background and reputation of, 5:2505
destructive exploitation and, 5:2505
diffusion work of, 2:746
diversity and scholarship of, 5:2505
domestication of animals work of, 2:782
fieldwork views of, 3:1103, 3:1465
folk culture and, 3:1142
human ecology views of, 3:1438
John Brinkerhoff Jackson influenced by, 4:1641
Peirce Lewis influenced by, 4:1773
polymath term to describe, 5:2504
service work of, 5:2505
settlement geography work of, 5:2536
temporal change in landscapes and, 4:2111
Saussure, Ferdinand de, 5:2270
Sayer, Andrew, 5:2370
Scale, social production of, 5:2506–2509
applicability debate, 5:2507–2508
as dynamic construct, 5:2507
locality studies and, 4:1790–1792
Marxist theory of scale and, 5:2506–2507
modifiable areal unit problem and, 4:1935
ontological foundations of geographical data and, 4:2078–2081
See also Scale in GIS
Scale in GIS, 5:2509–2511
map scale, 5:2509, 5:2510 (fig.)
project scale, 5:2509–2511
sample neighborhood mapped at three scales and, 5:2510 (fig.)
scale definition and, 5:2509
spatial scale, 5:2509–2511
Scandinavia
forest plantations in, 5:2195
GDP per capital in, 3:1382, 3:1383 (fig.)
industrialization in, 3:1583
welfare states in, 3:1590
See also specific country
Schaefer, Fred, 5:2511–2512
chorology work of, 1:405, 3:1466
exceptionalism term of, 4:2034
Richard Hartshorne criticized by, 1:405, 3:1403, 3:1466, 4:1801, 5:2326, 5:2388
historical geography work of, 3:1429
methodology work of, 3:1403
positivism and, 3:1403, 3:1466, 4:1801
quantitative revolution and, 3:1466, 5:2326, 5:2511
regional geography critiqued by, 3:1466, 3:1531–1532, 4:1897
theoretical scientific geography ideas of, 5:2511
Schein, L., 5:2333
Schelling, Thomas, 2:560
Schimper, A. F. W., 4:284
Schlüter, Otto, 2:640, 2:641
Schmidt, Allan, 1:408
Schmink, Marianne, 3:1100
Schumacher, Ernst, 3:1370, 3:1372, 6:2737
Schumpeter, Joseph, 1:303, 3:1593, 4:1805
Science, technology, and environment, 5:2512–2515
civic epistemology, 5:2518
ecological crisis, risk society and, 5:2515
late modernity issue of, 5:2512
natural vs. social sciences and, 5:2513
North Sea Brent Spar oil platform controversy and, 5:2517
nuclear power issue example and, 5:2515
politics of research and, 5:2517
rationalization and instrumentalization of environment issue and, 5:2512
science, to explain natural phenomena and, 5:2513
science and technology as social activities and, 5:2515
science word origins and, 5:2512–2513
search for knowledge and, 5:2513
social and ethical dimensions of, 5:2517–2518
technology goal orientation and, 5:2514–2515
technology vs. technique and, 5:2514
technology word origins and, 5:2513
THORP nuclear power-reprocessing plant, UK, controversy and, 5:2517
using GPS equipment on a farm, Northern Louisiana, 5:2514 (photo)
See also Science and technology studies (STS)
Science and technology studies (STS), 5:2516–2519
definition of, 5:2516
institutional models, public engagement approaches and, 5:2518
journals of, 5:2516
knowledge geographies and, 4:1659–1663
phase 1: the sociology of scientific knowledge, 5:2516
phase 2: from epistemology to politics and public engagement, 5:2517–2518
phase 3: critical debates, 5:2517–2518
professional societies of, 5:2516
science wars and, 5:2516
socially constructivist approaches of, 5:2516
sociology of scientific knowledge (SSK) and, 5:2516
Alan Sokal, 5:2516
“Sokal affair” and, 5:2516
Brian Wynne, 5:2517, 5:2518
Scoones, Ian, 2:921, 2:922–923, 2:1005
Scotland, 3:1371
Scott, Allen, 5:2519–2520
academic career of, 5:2519
agglomeration economies work of, 5:2519
cultural economies of cities work of, 5:2519–2520
cultural industries work of, 5:2520
industrial organization and change work of, 5:2519–2520
location-allocation analysis modeling work of, 5:2519
Los Angeles School of urbanism and, 2:688, 4:1803, 5:2519
music and sound geographies work of, 4:1968
small firm networks, outsourcing and, 4:2108
urban division of labor and, 4:1803–1804, 4:1863, 5:2519
urban geography work of, 5:2519–2520
Scott, J. C., 2:548
Scott, James, 4:2141, 5:2192
SDI. See Spatial data infrastructures (SDI)
SDSS. See Spatial decision support systems (SDSS)
Seager, Joni, 3:1092–1093, 3:1100
Seamon, David, 3:1435, 4:2168
Second Life, 2:648
Sedimentary rock, 5:2520–2521
biochemical sedimentary rocks, 5:2521
chemical sedimentary rocks, 5:2521
clastic sedimentary rocks, 5:2520–2521
folding and, 3:1140–1142
importance of, 5:2520
sedimentary layers, Artist’s Point, Colorado National Monument, 5:2521 (photo)
See also Geomorphic cycle; Geomorphology; Sedimentation
Sedimentation, 5:2521–2523
air and water motion and, 5:2522–2523
from cessation of gravity-induced motion, 5:2522
definition of, 5:2521–2522
flocculation and, 3:1127–1128
in Little Colorado River, Grand Canyon, Arizona, 5:2552 (photo)
natural or artificial formation of, 5:2522
See also Sedimentary rock
Segregation and geography, 5:2523–2526
Catholic and Protestant neighborhoods, Belfast, Ireland, 5:2525 (photo)
census units measure of, 5:2524
consequences of, 5:2523–2526
as cultural defense, 5:2524
de facto segregation, 5:2524
de jure segregation, 5:2524
educational geographies and, 2:874–875
gated communities and, 3:1181–1183
gentrification and, 3:1203–1208
ghettoes and, 3:1275–1277
human geography topic of, 5:2523
income, life cycle, lifestyle, race and ethnicity types of, 5:2523
index of dissimilarity, or D index of, 5:2523–2524
inequality geographies and, 3:1589
measures of, 5:2523–2524
overt discrimination, 5:2524
proximity to similar people preference and, 5:2524–2525
reasons for, 5:2524–2525
segregation definition and, 5:2523
thematic map displays of, 5:2523
types of, 5:2524
See also Ethnic segregation
Self-organizing maps (SOMs), 5:2526–2528
applications of, 5:2527
definition of, 5:2526
distance measurement and, 5:2527
distances in a space of multiple attributes feature of, 5:2526
GeoSOM and, 5:2527
hexagons element of, 5:2526
iterative processes of, 5:2526
Teuvo Kohonen and, 5:2526
methodological elements of, 5:2526
spatially divergent self-organization (Phillips) and, 2:562
Tobler’s first law of geography and, 5:2526
Semantic interoperability, 5:2528–2529
domain ontology and, 5:2529
folksonomies and, 5:2529
GIS distributed network services and, 5:2528
GIS environmental model integration and, 3:1280
interoperability and spatial data standards and, 3:1623–1625
Werner Kuhn’s work in, 4:1672–1673
ontological foundations of geographical data and, 4:2078–2081
ontology term and, 5:2528–2529
Open Geospatial Consortium (OGC) and, 5:2528
semantic reference systems and, 5:2529
service-oriented architecture (SOA) of, 5:2528
service provider, service broker, and user interface and, 5:2528
shared understanding of meaning of exchanged data and, 5:2528–2529
syntactic interoperability and, 5:2528
top-level ontology and, 5:2529
See also Semantic reference systems
Semantic reference systems, 5:2529–2531
GIS environmental model integration and, 3:1280
Werner Kuhn’s work in, 4:1672–1673
ontological foundations of geographical data and, 4:2078–2081
ontologies as reference frames and, 5:2530
physical sensor and, 5:2531
semantic datums and sensors in, 5:2530–2531
spatial and temporal reference systems and, 5:2529–2530

See also Semantic interoperability

Semple, Ellen Churchill, 5:2531–2532
academic career of, 5:2531
books written by, 5:2531
Harlan Burrows and, 1:185
environmental determinism views of, 2:2667, 2:917, 3:1429,
environment as supreme agent of influence views of, 2:917,
3:1464, 4:1990
Richard Hartshorne influenced by, 3:1402
Influences of Geographic Environment written by,
1:93, 3:1464, 5:2531
ocean views of, 4:2065
Friedrich Ratzel’s influence on, 5:2536, 5:2531
Sen, Amartya, 2:921, 2:922, 2:924
famine views of, 4:1988, 4:2015
Poverty and Famines written by, 3:1084
poverty definition and, 5:2274
Senegal
economically active females in, 3:1190 (table)
Negritude movement and, 2:1029
poverty rates in, 5:2274

Sense of place, 5:2532–2534
creating and contesting place and, 5:2533
definition of, 5:2532
generalized and reductionistic perspective on, 5:2533
genius loci, spirit of place concept and, 5:2533
geographical imagination and, 3:1221–1225
group studies of place and, 5:2532
humanistic geography origins of, 5:2532
individual perspective on and element in, 5:2532
issues related to, 5:2532
landscape quality assessment and, 4:1715–1718
phenomenology and, 4:2167–2168
representations of place and, 5:2533
sacred and indigenous places and, 5:2533
third places concept and, 4:2168

See also Sense of place: noted scholars

Sense of place: noted scholars
Chris Allen, 4:2168
Ian Bentley, 4:2168
Edward Casey, 4:2168
Jeff Malpas, 4:2168
Robert Mugerauer, 4:2168
Ray Oldenburg, 4:2168
Edward Relph, 2:1046, 3:1467, 4:2167, 5:2410–2411
David Seamon, 4:2168
Ingrid Leman Stefanovic, 4:2168
Kay Toombs, 4:2168
Yi-Fu Tuan, 6:2890–2891

September 11, 2001, terrorist attacks. See Terrorism, geography of

Sequent occupancy, 5:2534–2535
applications of, 5:2534
as a biotic phenomenon, 5:2534
discrete historical layers and, 5:2534
Stanley Dodge and, 5:2534
ecological and development language of, 5:2534
endogenous changes and, 5:2534
human adaptation to the environment and, 5:2534

Preston James and, 5:2534
landscapes interpretation and, 6:3097
legacy of, 5:2533
model of landscape change and, 5:2534
occupation word and, 5:2534
regional comparisons element in, 5:2534–2535
rejuvenation and, 5:2534
reshaping of landscape and, 5:2534
visibility of relics element in, 5:2535
Derwent Whittlesey and, 5:2534, 6:3097–3098
Serbia
AGILE membership of, 1:125 (table)
cultural nationalism in, 4:1980
Setterfield, Mark, 4:2133–2134

Settlement geography, 5:2535–2537
anthropocentric nature of, 5:2535
definition of, 5:2535
European vs. American studies of, 5:2536
folk housing studies and, 5:2536
frontiers and, 3:1170–1172
holistic and sustainability elements in, 5:2536
Liausson, France, 5:2536 (photo)
rural landscape element in, 5:2536

See also Settlement geography: noted geography, scholars

Settlement geography: noted geography, scholars
Isaiah Bowman, 5:2536
Loyal Durand, Jr., 5:2536, 5:2537
Henry Glassie, 5:2535, 5:2536, 5:2537
Cole Harris, 5:2537
John Fraser Hart, 5:2537
Terry Jordan, 5:2536, 5:2537
Fred Kniffen, 5:2535, 5:2536–3537
Allen Noble, 5:2537
Karl Raitz, 5:2536, 5:2537
Carl Sauer, 5:2535, 5:2536
Kirk Stone, 5:2536, 5:2537
William Sykoff, 5:2537
Glen Trewarthwa, 5:2537, 6:2882–2883
William Wyckoff, 5:2536

Sevilla-Guzmán, Eduardo, 1:57

Sexuality, geography and/or, 5:2538–2540
biopolitics (Foucault) and, 5:2539
body scale of, 5:2538, 5:2539
Manuel Castells and, 5:2538
City and the Grassroots (Castells) and, 5:2538
cognitive accounts of public spaces and, 5:2539
“compulsive heterosexuality” and, 5:2538
critical health geography and, 5:2538
criticism of scholarly work on, 5:2539–2540
gay and lesbian geographies and, 3:1183–1185
gay and lesbian tourism and travel research and, 5:2540
“gay landscape” work (Castells) and, 5:2538
gender and geography and, 3:1188–1194
heteronormativity and, 5:2538
heteropatriarchy and, 5:2538
HIV/AIDS map and modeling and, 5:2538
institutionalization of heterosexuality and, 5:2539
intersections of space and sexual politics and, 5:2539
“in the closet” spatial metaphor and, 5:2539
legal, health, and welfare issues and, 5:2539
masculine geographies and, 4:1865–1866
nature-society relationships element in, 5:2538
patriarchic geographies and, 4:2135–2136
queer theory and, 5:2538
same-sex marriage issue and, 5:2539
Shifting cultivation, 5:2540–2543
agricultural intensification and, 1:36
agrobiodiversity and, 1:49–50
agroforestry and, 5:2541
characteristics of, 5:2540–2541
crop rotation and, 2:627–630
ecological and economic dimensions of, 5:2541–2543
harvest of dry-season crops and, 5:2541
indigenous environmental knowledge and, 5:2540, 5:2542–2543
indigenous forest dwellers and, 5:2542
in situ biodiversity and, 5:2542–2543
intercropping practice and, 5:2541
mixed farming and, 4:1914–1917
origins of, 5:2541–2542
potential sustainability of, 5:2542
production cycle of, 5:2541
staple crops varieties and, 5:2541
staple grains and, 5:2541
swidden or slash-and-burn cultivation terms and, 5:2540
traditional agricultural colonization and, 5:2542
tropical deforestation from, 5:2540, 5:2542
Shiva, Vandana, 2:818–819, 3:1101
Shoreline protection, 1:10
Shortest-path problem, 5:2543–2544
algorithms used in, 5:2543
function and purpose of, 5:2543
network analysis technique of, 5:2543
transportation and routing problems and, 5:2543–2544
types of, 5:2543
Web-based mapping and, 5:2544
Siberia
Alexander von Humboldt’s travels in, 3:1462
indigenous cartographies in, 3:1561
permafrost melting in, 3:1522
polar climate in, 1:430
polar semidesert in, 1:249, 1:451
sea ice minimum in, 2003–2005, 3:1525
shrub tundra of, 1:248
tussock and sedge-dwarf shrub tundra of, 1:248, 1:249
Valley of Geyser, Kamchatka Peninsula in, 3:1273
wet tundra of, 1:249
Sibley, David, 2:892, 5:2442
Sieferle, Rolf Peter, 2:839
Siegel, A. W., 5:2609, 5:2610
Siegfried, André, 2:879, 5:2223
Siegler, Robert, 1:391
Sierra Leone
Crocodile River, Freetown, 6:2896 (photo)
economically active females in, 3:1190 (table)
income ratio relative to slum population in, 2006, 5:2644 (fig.)
Silicon Valley, California, high-tech economic geography and,
2:851, 2:885, 2:886, 3:1127, 3:1426, 3:1427 (photo),
3:1598, 5:2435, 5:2436, 5:2519
Simmel, Georg
modernity and commodification relationship and, 4:1936
ordinariness views of, 2:1043
qualitative methodology and, 5:2323
urban sociology work of, 2:1043
Simoons, Elizabeth, 2:782
Simoons, Frederick John, 1:192, 2:782
Singapore
Airbus A380 “Superjumbo” airline and, 1:180
APEC membership of, 1:121
ASEAN Free Trade Area and, 1:130
ASEAN membership of, 1:127, 1:128, 1:128 (table), 1:129,
1:129 (table)
British colonization of, 1:515
command and control economy in, 1:304
economically active females in, 3:1190 (table)
export-oriented industrialization (EOI) in, 2:1064
extport trade success of, 2:731
foreign direct investment from and to, 3:1156
foreign direct investment in China from, 3:1155
as hub port, 5:2254
industrialization in, 3:1583, 4:2020
Japanese electronics industry in, 2:885
Malay archipelago and, 1:105
music and national identity in, 4:1968
as newly industrializing country, 4:2022, 4:2022 (fig.)
public housing in, 5:2304
U.S. foreign direct investment in, 3:1155
U.S. industry moving to, 2:700
Singer, A., 2:1075
Singer, Peter, 2:926
Single large or several small (SLOSS) debate, 5:2544–2548
controversy, 5:2546–2547, 5:2667
Jared Diamond’s biodiversity studies and, 4:1697, 5:2216, 5:2545
dynamic equilibrium model of biogeography and, 5:2545 (fig.)
Paul Ehrlich and, 5:2545
equilibrium theory of island biogeography and, 5:2544–2546,
5:2545 (fig.)
forest fragmentation and, 3:1161
habitat islands and conservation in, 5:2545–2546,
5:2546 (fig.)
island biogeography and, 3:1632, 5:2548
landscape and wildlife conservation and, 4:1697
landscape biodiversity and, 4:1701–1703
Robert MacArthur, 5:2544
Robert MacArthur and, 5:2545
nature preserves, 3:1161
patches and corridors and, 4:2131–2133
Population Bomb (Ehrlich) and, 5:2545
refuge design and, 5:2546
species-area relationship and, 5:2673
John Terborgh, 5:2545
E. O. Willis and, 5:2545
Edward O. Wilson and, 5:2544, 5:2545
Situated knowledge, 5:2548–2549
depth ecology movements and, 2:692–695
economic geography research and, 5:2549
ethnoscience or ethnogeography and, 5:2548–2549
geography subfields investigation of, 5:2548
GIS’s social implications and, 5:2549
indigenous knowledge and, 5:2548–2549
interviewing and, 3:1625–1627
participant observation and, 4:2121–2122, 5:2548–2549
positionality and, 5:2237–2248
research issues related to, 5:2548
spatial, temporal, sociocultural, and political economic
contexts of, 5:2549
terms related to, 5:2548
Situationist International (SI) political and artistic movement, 73–74
Six Nations of the Iroquois Confederacy, 3:1553
Skelton, R. A., 3:1402
Slash-and-burn/swidden cultivation technique deforestation and, 2:698
preindustrial agriculture and, 1:48, 1:301–302
Slater, David, 2:706
SLOSS. See Single large or several small (SLOSS) debate
Slovenia
acid rain in, 1:7
economically active females in, 3:1190 (table)
European Union (EU) membership of, 2:1035
Greenpeace Slovenia and Mother Earth movements in, 2:1033
Small Business Innovation Research (SBIR), 1:280
Small Business Technology Transfer (STT), 1:280
Smart growth, 5:2550–2551
definition of, 5:2550
eco-housing development, green design and, 3:1371
environmental planning and, 2:982
greenbelts and, 3:1363–1367
green building and, 3:1367–1369
land use policies and, 5:2551
leapfrog development and, 5:2551
Premier Gardens Zero Energy Home Community, Sacramento, California, 5:2550 (photo)
regional environmental planning and, 5:2386
smart growth planning and, 3:1372
in urban planning, 3:1313, 5:2240, 5:2550–2551
urban sprawl detrimental effects and, 5:2550–2551
Smith, Adam
comparative advantage work of, 5:2556
division of labor views of, 2:780, 3:1582, 4:1860
labor theory of value and, 4:1860
Marx influenced by, 4:1860
political economy meaning and, 5:2214
Smith, Adrian, 4:2109
Smith, Dorothy E., 2:1043
Smith, J. Russell, 2:848, 2:850, 2:851
Smith, Neil, 5:2551–2552
academic career of, 5:2551
capital-centered account of gentrification and, 3:1204
class and nature work of, 1:423–424
Endgame of Globalisation written by, 5:2552
external vs. universal ideologies of nature and, 1:424
gentrification as capital investment work views of, 3:1204, 3:1205 (fig.), 3:1206 (table), 3:1207, 5:2551
David Harvey and, 5:2551
International Critical Geography Group and, 5:2552
material reproduction of self and, 5:2560
nature within capitalism context work of, 2:851, 3:1467, 4:1992–1993
new geography or spatial science and, 5:2551
production of nature, 5:2551–2552
production-side theory and, 3:1204
radical geography and, 5:2351
relative space views of, 5:2404
rent-gap hypothesis and, 5:2430, 5:2551
scale appropriateness of labor strategy and, 4:1677, 5:2506–2507
uneven geographical development (UGD) and, 5:2551–2552
Snow, John
cartography work of, 1:355
geography of cholera work of, 1:401–402, 2:770, 3:1595
Social and economic impacts of climate change, 5:2552–2556
assessments of, 5:2553
biological “social mind” and, 5:2561
criticisms of, 5:2555–2556
current knowledge, 5:2553–2555
geographic perspectives on, 5:2556
Hurricane Katrina and, 5:2553
impact analyses of, 5:2555–2556
Intergovernmental Panel on Climate Change and, 5:2552
nature-society issue of, 5:2556
observed trends and, 5:2555
place-based studies of, 5:2556
projected levels of climate change and, 5:2554
quantitative assessments of, 5:2553
spatial systems importance in, 5:2556
Special Report on Emission Scenarios (SRES) and, 5:2553
Herbert Spencer and, 5:2561–2562
Paul Vidal de la Blache and, 5:2561
Social construction of nature, 5:2557–2561
class and nature and, 1:423–425
ecological imaginations and, 2:828–830
ecosystem science construction example of, 5:2558–2559
environmental discourse and, 2:918–921
environmental management and, 2:967–970
externalist perspective on, 5:2558
extrascientific, social nature of, 5:2560
gender and nature and, 3:1194–1197
human interactions in, 5:2559–2560
hybrid geographies and, 3:1502–1504
invasive species example of, 5:2558
knowing nature and, 5:2557–2558
George Perkins Marsh’s work in, 4:1858–1859, 4:2180
nature of nature and, 5:2338, 5:2557
positivist perspective of nature and, 5:2557
post-positivist perspective on, 5:2558
social production of nature and, 5:2557, 5:2559–2560
Structure of Scientific Revolutions (Kuhn) and, 5:2557
See also Critical studies of nature
Social Darwinism, 5:2561–2563
anthropogeography and, 1:93
Chicago School and, 5:2562
ethical geographies and, 2:1014
ethnocentrism and, 2:1027
Eurocentrism and, 2:1029, 5:2338
global hierarchy of societies and, 5:2562
Jean Baptiste Lamarck and, 5:2561
pseudoscience of, 5:2561
race as “scientific” human classification method and, 5:2338
racial and ethnic inequalities justified by, 5:2562
Friedrich Ratzel’s geopolitical ideology and, 5:2562
Alfred Russel Wallace and, 5:2211
See also Darwinism and geography
Social forestry, 5:2563–2564
centralized to decentralized forest management shift and, 5:2563
Chipko Movement and, 5:2563
community forestry and, 2:551–555, 5:2564
definition of, 5:2563
forestry for local people concept and, 5:2563
in India, 5:2563
midlatitude deciduous forest biome and, 1:223–226
terms associated with, S.2563, S.2564
tropical deciduous forest biome and, 1:230–233
Jack Westoby and, S.2563
Social geography, S.2564–2569
anarchism and geography and, 1:73–74
applied and theoretical research and, S.2568
behavioral approach to, S.2566
blindness and geography and, 1:286–287
blurring boundaries of, S.2569
Charles Booth and, S.2565–2566
Anne Buttimer’s work in, 1:309, 4:1786
capitalism element in, S.2566
children and youth geographies and, S.2568
cultural turn and, S.2569
current issues, S.2568–2569
definition of, S.2564
diversity feature of, S.2564–2565
feminist geography and, S.2567–2568
gated communities and, 3:1181–1183
Peter Gould and, S.2566
David Harvey and, S.2567, S.2568
history of, S.2565–2566
human and physical geography and, S.2564–2565
humanistic approach to, S.2566–2567
international migration and, S.2568
issues addressed by, S.2565
David Ley and, S.2567
Marxist theory and, S.2567
meanings attributed to place(s) and, S.2566
residential decision making and, S.2566
sexuality and sexual orientation issues and, S.2568
social identities and behavior and, S.2568
Social Justice and the City (Harvey) and, S.2567, S.2568
social phenomena in space analysis and, S.2564
space and place focus of, S.2564–2565
structuralist approach to, S.2567
suburban housing and, S.2566
Socialism and geography, S.2569–2572
communism as, S.2569–2570
critical human geography and, S.2571
democratic socialism and, S.2570
economic development theories and, S.2571–2572
forms of socialism and, S.2569–2570
geographical discourse and, S.2570–2572
Leninist socialism and, S.2570
Marxist socialism and, S.2570
quantitative revolution and, S.2571
radical geography and, S.2571
socialism term interpretations and, S.2569
utopian socialism and, S.2570
See also Communism and geography; Socialism and geography:
noted individuals, geographers, scholars
Social justice, S.2572–2574
anarchism and geography and, 1:73–74
antisystemic movements and, 1:99–100
call to action by, S.2573
cosmopolitanism and, 2:590–592
countermapping and, 2:595–596
critical cultural geography and, 2:638
critical studies of nature and, 2:625
democracy and, 2:705–707
ecological justice and, 2:830–832
educational geographies and, 2:874–875
environmental justice and, 2:959–965
ethics and geography and, 2:1013–1016
homelessness and, 3:1440–1442
human dimensions of global environmental change and, 3:1453–1454
human rights geographies and, 3:1480–1481
inequality geographies and, 3:1586–1590
International Criminal Court (ICC) and, 3:1605–1608
justice/injustice geographies and, 3:1643–1645
measures of, S.2573
participatory learning and action and, 4:2123–2124
philosophical perspective of, S.2572–2573
social justice environmentalism term and, 2:959
social scientific inquiry and, S.2573
UN Human Development Index (HDI) and, S.2573
See also Democracy; Environmental justice; Justice, geography of
Social justice: noted geographers, individuals, scholars
James Blaut, 1:285
Anne Buttimer, 1:309
David Harvey, 3:1404–1406, 3:1467, 4:1862
Thomas Jefferson, S.2573
Social movements, S.2574–2576
antiglobalization movements and, 1:96
antisystemic movements and, 1:99–100
civil society and, 1:414–416
countermapping and, 2:595–596
dimensions of place (Agnew) and, S.2574
institutional and state frameworks of, S.2575
labor unions and, S.2575
mobilization issues and, S.2575
networks and mobilization elements of, S.2574–2575
peace movement and, S.2575
peasants and peasantry, 4:2137–2142
place-based collective action frames and, S.2575
research, S.2574
scales factor in, S.2575
spatial context of, S.2574
See also Social movements: noted individuals, geographers, scholars
Social movements: noted individuals, geographers, scholars
John Agnew, S.2574
Kevin Cox, S.2575
D. Featherstone, S.2574–2575
Andy Herod, S.2575
Deborah Martin, S.2575
Byron Miller, S.2575
W. Nicholls, S.2575
Paul Routledge, S.2574–2575
Raymond Williams, S.2574
Society for Ecological Restoration International, 3:1166
Soffer, Arnon, 4:1897
Soil conservation, S.2576–2580
agroforestry, S.2579
agricultural methods of, S.2576, S.2577–2579, S.2578 (photo)
anemic societies and, S.2579
ancient stone-faced terraces, Island of the Sun, Lake Titicaca, Andean South America, S.2579, S.2579 (photo)
beans intercropped with maize and, S.2577 (photo)
bench and platform terraces and, S.2576 (photo)
check dams, S.2576
conservation tillage, S.2578
contour mapping, S.2577
contour ridges planted with wheat and maize and, S.2577 (photo)
cover crops and, S.2578
definition of, S.2576
diversion ditches, 5:2577
history and geography of, 5:2579–2580
implementation challenges and, 5:2580
indigenous conservation measures, 5:2578
international agencies and, 5:2580
mechanical methods of, 5:2576–2577, 5:2578 (photo)
strip cropping, 5:2578–2579
terraces, 5:2577
Soil degradation, 5:2581–2582
definition of, 3:1335, 5:21581
geographic variation of soil resources and, 5:2582
global environmental change and, 3:1335
Great Plains, Dust Bowl regions and, 5:21581
human and physical variables in, 5:2582
human impacts on soil and, 3:1335
Natural Resources Conservation Service and, 5:21581
soil desertification and, 5:2582
soil erosion, water runoff, Castilla-La Mancha, Spain, 5:2581 (photo)
See also Land degradation; Soil depletion; Soil erosion
Soil depletion, 5:2582–2583
calcium, 5:2582–2583
definition of, 5:2582
global soil nutrient deficit data and, 5:2583
in low-latitude countries, 5:2583
natural nutrient cycle and, 5:2583
nitrogen, phosphorus, and potassium losses and, 5:2583
sustainable agriculture and, 5:2582
See also Soil degradation; Soil erosion
Soil erosion, 5:2583–2585
ancient civilizations and, 5:2584
creek and, 2:604–605
definition of, 5:2583
factors affecting, 5:2583–2584
geographic extent of, 5:2585
Great Plains, Dust Bowl and, 5:2584
gully erosion and, 3:1392–1394
history of, 5:2584–2585
human actions and, 5:2584–2585
management practices reduction of, 5:2584
rill erosion and, 5:2464–2466
Soil Conservation Service and, 5:2585
vegetation reduction of, 5:2584
water runoff, Castilla-La Mancha, Spain, 5:2581 (photo)
in wheat field, Washington state, 5:2584 (photo)
See also Land degradation; Soil depletion
Soils, 5:2585–2592
agricultural horizons and, 5:2587
animals and, 5:2590
calcic horizons in, 5:2587
cation exchange capacity attribute of, 5:2589–2590
classification systems of, 5:2590, 5:2592
clay minerals in, 5:2587
cloret equation (Jenny) of, 5:2585
euiv horizon and, 5:2586
human interaction and, 5:2590
illuvial horizons and, 5:2586
layers (horizons) in, 5:2585, 5:2586 (fig.)
mineral-based particles in, 5:2587
nitrogen cycle and, 5:2590
particle size, ability to hold water and, 5:2587
peat and, 4:2142–2143
pH attribute of, 5:2589
plant growth support function of, 5:2589
salt deposition in, 5:2586–2587
soil chemistry, soil parent material and, 5:2589
soil definition and, 5:2585
soil-forming factors and, 5:2585–2586
soil organisms and, 5:2590
soil peds, soil structure and, 5:2588
soil profile and, 5:2586
soil separates in, 5:2587
soil textural classification and, 5:2587
soil textural triangle and, 5:2588 (fig.)
typical Mollisol profile, 5:2591 (photo)
typical Oxisol profile, 5:2592 (photo)
typical Spodosol profile, 5:2591 (photo)
water critical to formation of, 5:2586
See also Soil conservation; Soil degradation; Soil depletion; Soil erosion
Soja, Edward, 5:2593–2594
academic career of, 5:2593
class struggle over social production of space and, 3:1419, 4:1862
Michel Foucault and, 5:2593
historicism, despatialized consciousness and, 3:1433
Henri Lefebvre and, 4:1769, 5:2593
Los Angeles School of urbanism and, 2:688, 4:1803, 5:2593
Marxism in geography and, 4:1862, 5:2351, 5:2593
Postmetropolis written by, 5:2593
Postmodern Geographies written by, 5:2593
postmodern geography work of, 3:1469, 5:2264, 5:2351, 5:2593
social justice and inequality issues and, 5:2593
spaces of representation and, 5:2602
“spatial turn” work of, 5:2593, 5:2670
thirdspace, 5:2442, 5:2602
"tialectics," 5:2593
urban and political geography theories of, 5:2593
Sokal, Alan, 5:2516
Solar energy, 5:2594–2596
centralized utility-scale installations and, 5:2595
concentrating vs. nonconcentrating social energy technologies and, 5:2594
early average values of, 5:2594
grid-connected distributed installations and, 5:2595
national energy policies and, 2:900, 2:902
off grid installations and, 5:2595
passive vs. active solar energy technology and, 5:2594
solar hot water system, Adams County Detention Facility, Denver, Colorado, 5:2595 (photo)
thermal vs. photovoltaic energy technology and, 5:2594
Solstice, 5:2596–2598
Christmas holidays and, 5:2597–2598
European midsummer festivals and, 5:2597
in non-European cultures, 5:2598
pre-Christian religious traditions and, 5:2597–2598
Stonehenge, summer solstice, 5:2597 (photo), 5:2598
summer solstice, 5:2596–2597
sun stoppage, 5:2596
winter solstice, 5:2597
Somalia
ass domesticated in, 2:783
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
Kushitic language in, 4:1749
locusts infestation in, 2:727
State House refugee settlement, Hargesia, 5:2379 (photo)
Somerville, Mary, 4:1989
SOMs. See Self-organizing maps (SOMs)
Sonnenfeld, David, 2:835
Sonntag, Susan, 4:1876
South Africa
- Berg warm, dry, gusty, downslope wind in, 1:384
- Big Hole diamond mine in, 42086
- British Empire colonies in, 1:509
- casuarinas in dunes, Zululand, 6:2881 (photo)
- coal in, 1:485
- critical geographers in, 2:618
- economically active females in, 3:1190 (table)
- environmental privatization in, 4:2009
- ethnic segregation in, 2:1022
- game ranching in, 3:1179–1181
- gated communities in, 3:1181
- greenhouse gas emissions and, 1:463
- groundwater usage in, 3:1386
- income ratio relative to slum population in, 2006, 5:2644 (fig.)
- market-based land reform in, 4:1695
- midlatitude grasslands in, 1:228–229
- newly industrializing country of, 4:2022 (fig.)
- next generation nuclear reactors in, 4:2051
- public-private partnerships in, 5:2312
- tropical deciduous forest in, 1:231
- vineyard, Constantia region, Cape Winelands, 6:3118 (photo)
- South America, 3:1193
- AGS’s Millionth Map of, 1:295
- Amazon River basin, tropical rain forests of, 1:132
- Amazon River flowing through rain forest in, 5:2473 (image)
- ancient conservation, stone-faced terraces, Island of the Sun, Lake Titicaca, 5:2579 (photo)
- bush fallow farming practiced in, 1:301–302
- cadastral systems, land ownership and, 1:315
- as center of domestication, 1:376
- cholera in, 1:401
- coca cultivation in, 2:797
- colonial migrations of, 1500–1914, 3:1543
- crop domestication process and centers in, 1:375 (photo)
- deforestation in, 2:696
- developing countries in, 2:725 (fig.)
- dry climates in, 1:429, 1:430 (fig.)
- El Niño-Southern Oscillation (ENSO) and, 2:887
- forest fragmentation in, 3:1159
- gender and livelihoods research in, 3:1193
- geothermal energy use in, 3:1267 (fig.), 3:1269
- glaciers in, 3:1332
- groundwater usage in, 3:1386
- Alexander von Humboldt’s travels in, 3:1462, 3:1482
- hunting and gathering tribes in, 3:1492
- hydroelectric power in, 3:1507, 3:1509
- indigenous agriculture in, 3:1557
- Isthmus of Panama, North America and, 1:213
- land degradation estimates in, 4:1680 (table)
- midlatitude deciduous forest in, 1:224
- midlatitude grasslands in, 1:228, 1:228 (fig.), 1:229
- military expenditures in, 4:1899 (table)
- Millionth Map project of, 1:295
- monsoons in, 2:741, 4:1941
- plantation model in, 3:1362
- political map of, 6:3165
- population growth of, 5:2241
- potential water availability in, 2007, 2050, 6:3059 (fig.)
- renewable water resources and availability in, 6:3057 (table)
- soil erosion in, 5:2585
- species variations in, 1:209
- temperate, semiarid deserts in, 1:219
- temperate arid deserts in, 1:221
- transboundary aquifers in, 3:1389
- tropical deciduous forest in, 1:230, 1:232, 1:233
- tropical humid climate in, 1:453
- tropical rain forest of, 1:234, 1:237, 1:453
- tropical savanna in, 1:239, 1:241, 1:455
- tropical/subtropical hyperarid deserts in, 1:222
- tropical/subtropical semiarid deserts in, 1:220
- vicariance biogeography in, 1:211
- See also specific country

South Asia
- adults and children living with HIV in 2007 in, 3:1437 (fig.)
- chickens domestication in, 2:783
- climate change, greenhouse gas emissions and, 1:464
- coastal zone and marine pollution and, 1:501
- Cold War and, 1:504
- colonization of, 1:514
- deficient calorie consumption in, 3:1487
- developed countries in, 2:725 (fig.)
- El Niño-Southern Oscillation (ENSO) and, 2:889
- fertility levels in, 2:709
- groundwater importance in, 2:783
- HIV/AIDS in, 3:1438
- land inequalities in, 4:1693
- malaria in, 4:1816
- military expenditures in, 4:1899 (table)
- monsoon, 1:1943–1944
- people living in extreme poverty and, 3:1082 (table)
- poverty rates in, 5:2274
- prehistoric exploration of, 2:1050
- sewage entering coastal zones of, 1:501
- Silk Road and, 2:1053
- social movements in, 5:2574
- sub-altern studies, South Asian historiography and, 2:1029
- transboundary aquifers in, 3:1389
- tropical humid climate in, 1:453
- undernourishment in, 3:1488
- See also specific country

South Carolina
- hurricane risk in, 3:1500
- nuclear weapons site in, 5:2469
- pine forest habitat in, 4:2131–2132
- South Dakota, 6:3093 (photo)

Southeast Asia
- adults and children living with HIV in 2007 in, 3:1437 (fig.)
- Association of Southeast Asian Nations (ASEA) and, 1:126–131, 1:127 (fig.)
- biota studies of, 1:209
- bovine domestication in, 2:783
- bush fallow farming in, 1:301–302
- as center of domestication, 1:374, 1:376
- chickens domestication in, 2:783
- Chinese exploration of, 2:1054
- cholera in, 1:401, 1:402, 1:402 (fig.)
- coastal zone and marine pollution and, 1:501
- Cold War and, 1:504, 1:505
- colonial migrations of, 1500–1914, 3:1543
- colonization of, 1:515
- COMECON and, 2:593
- deforestation in, 2:696
- developing countries in, 2:725 (fig.)
- domino theory and, 2:787, 3:11224
- drug culture in, 2:799
- electronic waste pollution in, 1:502
- El Niño-Southern Oscillation (ENSO) and, 2:887
- forest fragmentation in, 3:1159
- HIV/AIDS in, 3:1438
INDEX 3367

hunting and gathering tribes in, 3:1492
indigenous forestry in, 3:1569
Japanese colonization in, 1:514
land use and cover change in, 4:1736
malaria in, 4:1816
Malayo-Polynesian languages in, 4:1753, 4:1753 (fig.)
mining frontier in, 4:1911
monsoons in, 2:741
nationalism in, 1:517
opium and heroin production in, 2:796–797
plantations in, 5:2192
political map of, 6:3159
rice fields in, RADAR image, 4:1889 (fig.)
sewage entering coastal zones of, 1:501
slash-and-burn preindustrial agriculture in, 1:48
South China Sea, tropical rain forests of, 1:132
taungya agroforestry system used in, 1:60
timber from, 1:238
tropical deciduous forest in, 1:232
tropical humid climate in, 1:453
tropical rain forest of, 1:237, 1:453
See also specific country

Southern Hemisphere
air masses of, 1:63
atmospheric angular momentum in, 1:143
Coriolis force and, 2:586
dry climates in, 1:429, 1:430 (fig.)
Hadley cell atmospheric circulation in, 3:1395
midlatitude cyclones in, 1:134
polar climate in, 1:449
See also specific country

South Korea
APEC membership of, 1:121
automobile industry in, 1:169
Clean Development Mechanism (CDM), carbon offsets and, 1:333 (fig.)
demilitarized zone (DMZ) of, 1:293 (photo)
deposit refund systems in, 4:1857
economically active females in, 3:1190 (table)
export-oriented industrialization (EOI) in, 2:1064
export trade success of, 2:731
foreign aid from, 3:1153
foreign direct investment in China from, 3:1155
hydropower in, 3:1507
import substitution industrialization in, 3:1551
incubator zones in, 3:1552
industrialization in, 3:1580, 3:1583
Japanese electronics industry in, 2:885
Japan-South Korea World Baseball Classic game, Dodger Stadium, Los Angeles, 5:2681 (photo)
land reform in, 4:1693
newly industrializing country of, 4:2021, 4:2022 (fig.)
North Korea borderlands and, 1:292, 1:293 (photo)
Pohang Iron and Steel Company, Pohang, 5:2691 (photo)
restricted development zoning in, 3:1364–1365
squatter settlements in, 5:2682
steel industry in, 5:2689, 5:2690

South Madagascar, 2:827 (table)

South Pole. See Poles, North and South

South Vietnam, 2:543

Sovereignty, 5:2598–2600
antiglobalization nationalism and, 5:2600
Cold War and, 5:2599
definition of, 5:2598
derivation of, 5:2599
deterritorialization and, 3:1340
geopolitical context of, 5:2599–2600
globalization and, 3:1340
International Court of Justice (ICJ) and, 5:2599
international law and, 5:2599
international recognition element in, 5:2599
Magna Carta and, 5:2599
Peace of Westphalia legal precedent for, 5:2599
theoretical components of, 5:2598
UN Law of the Sea and, 5:2599

Soviet Union
capitalist restructuring in, 5:2459–2460
Chernobyl nuclear accident and, 1:385–386
collapse of, 3:1251, 4:1978
COMECON membership of, 2:593–594, 2:593 (table)
Five Year Plans in, 2:542, 2:543
gopolitics in, 3:1251
human rights violations in, 3:1480
hydroelectric power in, 1:1507
industrialization in, 3:1583
Moscow, May Day celebrations and, 2:544 (photo)
NATO and, 4:2047
natural growth rate in, 4:1981
Stalinist version of Marxism in, 4:1861
state nationalism in, 4:1980
Warsaw Pact and, 4:2047
See also Communism and geography; Russia

Spaargaren, Gert, 2:836, 3:1369

Space. See Absolute space

Space of flows, 5:2600–2601
Manuel Castells and, 5:2600
circuits of capital and, 1:410–412
Doreen Massey, 5:2601
mobility and, 4:1918–1921
networks of interconnectiveness and, 5:2601
postmodernist power concept and, 5:2600–2601
relative/relational space and, 5:2402–2405
Eric Sheppard, 5:2601
spaces of representation and, 5:2601
time-space compression and, 5:2600–2601

Spaces of representation/representational spaces, 5:2602–2603
called challenges to, 5:2602–2603
conceived space and, 5:2602
definitions, 5:2602
everyday life geographies and, 2:1042–1045
Henri Lefebvre’s work and, 4:1768–1770, 5:2297, 5:2602
life-world, 5:2602
lived spaces and, 5:2602
media and geography and, 4:1874–1877
perceived space and, 5:2602
production of space and, 5:2297–2298
Edward Soja and, 5:2602
space of flows and, 5:2601
“third-space” concept and, 5:2602
time-space compression and, 5:2601

Spain
AGILE membership of, 1:125 (table)
agroforestry in, 1:57
automobile industry in, 1:169
Catalonia technology region in, 5:2435
colonial empire of, 1:509, 1:509 (fig.), 1:511, 1:512
Conference of Latin Americanist Geographers held in, 2:568
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
ecomienda land grant system of, 1:512
energy feed-in tariffs (FIT) in, 2:901
European Union (EU) membership of, 2:1035
groundwater usage in, 2:783
gully erosion in, 3:1392 (photo), 3:1393 (photo)
high-speed trains in, 5:2364
Hispanocentrism of, 2:1030 (table)
Ibn Battuta exploration of, 2:1054, 3:1519
Inca rebellions against, 1:508
industrialization in, 3:1583
Kyoto Protocol of 1997 and, 1:463
Latin America colonized by, 1:511–512
mixed field in Eastern Mallorca, 4:1915 (photo)
morphine-rich narcotics produced in, 2:796, 2:797 (table)
movement against genetically modified organisms in, 3:1610
Park Guell, Barcelona, 2:641 (photo)
Philippines controlled by, 1:515
Prestige oil tanker spill and, 4:2076
“science” of geopolitics in, 3:1250
silver trade and, 1:511–512, 1:513 (fig.)
social movements research in, 1:365
soil erosion, water runoff, Castilla-La Mancha, 5:2581 (photo)
wind power development in, 2:902
Spatial analysis, 5:2603–2607
Advanced Spatial Analysis (Batty) and, 1:186
Luc Anselin’s work in, 1:80–81
artificial intelligence and, 3:1212
Brian Berry’s work and, 1:193
cancer geography and, 1:320–324
central place theory and, 1:380–382
client-server architectures and, 5:2603
continuous space-and-time models and, 2:565–566
data mining techniques and, 3:1212
data sets size and analysis issues in, 3:1212
definitions, 5:2603
descriptive summary classification of, 5:2605
discrete space-and-time models and, 2:566–567
dispersion and, 5:2605
field view representational model of, 5:2604
fragmentation statistics and, 5:2605
functions of, 5:2603
future trends in, 5:2605–2606
geocomputation and, 3:1211–1215
geographical analysis definition and, 5:2603
geostatistics and, 3:1261–1265
Arthur Getis’s work in, 1:1274
GIS analytical operations and, 1:71–72, 5:2604
GIS and GISScience frames of, 5:2603
hypothesis testing and, 5:2605
Internet and, 5:2603–3604
linear referencing and dynamic segmentation and, 4:1784–1785
locational analysis and, 5:2603
map algebra and, 4:1824–1825
measurement classification of, 5:2605
medical geographies and, 4:1878
modeling and simulation approach to, 5:2605
multidisciplinary roots of, 5:2603
object view representational model of, 5:2604
Open Source Geospatial Foundation and, 4:2088–2089
Open Source GIS and, 4:2090–2091
optimization methods of, 5:2605
point pattern analysis and, 5:2201–2202
representational forms and types of, 5:2604–2605
sensor webs and, 5:2603
simple query form of, 5:2604–2605
Spatial Analysis (Berry and Marble, eds.) and, 5:2603
spatial autocorrelation and, 5:2607–2608
spatial autocorrelation measures and, 5:2605
transformation classification of, 5:2605
urban analysis dimension of human ecology and, 3:1458
See also GIS specific subject; Heuristic methods in spatial analysis; Spatial specific subject
Spatial autocorrelation, 5:2607–2608
definition and functions of, 5:2607
Geary’s C and, 5:2607–2608
gecomputation and, 3:1214
geographically weighted regression (GWR) and, 3:1225–1232, 5:2329
geostatistics and, 3:1261–1265
Getis statistic (Gi) and, 5:2608
hypothetical images, hot spots and cold spots, 5:2608 (fig.)
hypothetical images, positive and negative spatial autocorrelation and, 5:2607 (fig.)
Mora’s I and, 5:2607
patchy appearance of landscape and, 4:1707
simple kriging geostatistics and, 3:1263
spatial statistics and, 5:2664–2665
See also Exploratory spatial data analysis (ESDA)
Spatial cognition, 5:2608–2612
behavioral geography and, 1:189–190
blindness and geography and, 1:286–287
cognition vs., 5:2608–2609
cognitive maps and cognitive mapping in, 5:2609–2610
definition of, 5:2608–2609
environmental perception and, 2:977–980
exocentric frame of reference and, 5:2610
Image of the City (Lynch) and, 5:2609–2610
Internet factor in, 5:2611
knowledge acquisition and, 5:2610
landmark knowledge and, 5:2610
legibility element in, 5:2610
macrofotens theory (Siegel and White) and, 5:2610
mental maps and, 4:1881–1883
Piaget’s developmental theory and, 5:2610
public participation GIS and, 5:2611
rat maize behavior foundation of, 5:2609
recent research in, 5:2611
route knowledge and, 5:2610
spatial abilities and individual differences in, 5:2610–2611
spatial knowledge acquisition by children and, 5:2609
spatial updating and, 5:2611
survey knowledge and, 5:2610
vision element in, 5:2610–2611
See also Childhood spatial and environmental learning; Spatial specific subject
Spatial cognitive engineering, 5:2612–2616
applications of, 5:2615–2616
cognitive engineering vs., 5:2612–2614
cognitive user parameters and, 5:2614–2615, 5:2615 (fig.)
generic, group, and individual user categories and, 5:2614, 5:2615 (fig.)
goal of, 5:2612
gulf between execution and evaluation and, 5:2612, 5:2613 (fig.)
location-based decision services and, 5:2615
Donald Norman and, 5:2612
origins of, 5:2612
psychological user vs. physical system variables and, 5:2612,
5:2613–2614, 5:2613 (fig.)
spatial and temporal aspects of, 5:2613–2614
user categorization into generic, group, and individual, 5:2615 (fig.)
user-centered system design and, 5:2612
wayfinding and, 5:2614
See also Spatial specific subject

Spatial data infrastructures (SDI), 5:2616–2623
architecture model in, 5:2619–2620
characteristics of, 5:2616
data indexing and, 2:682–684
data models of, 5:2620–2623
definition and function of, 5:2616
early incompatibility of, 5:2616–2617
geographical markup language (GML) and, 5:2620
goellibraries and, 3:1234–1235
history of, 5:2616–2617
INSPIRE architecture and, 5:2619–2620, 5:2621 (fig.)
integrated model of, 5:2622 (fig.)
international SDI initiatives and, 5:2167
interoperability and spatial data standards and, 3:1623–1625
metadata encoding and, 5:2620
OGC filter encoding (FE) and, 5:2620
Open GIS Consortium (OGC) and, 5:2617
process model of, 5:2618–2619, 5:2619 (fig.), 5:2620 (fig.)
roles, process, and architecture overview of, 5:2618 (fig.), 5:2622 (fig.), 5:2623
roles and responsibilities of, 5:2617–2618
SDI committee role and, 5:2617
SDI service customer role of, 5:2617–2618
SDI service provider role and, 5:2617
service models and, 5:2620–2621, 5:2621 (fig.), 5:2623
spatial operators and query language and, 5:2620
spatial statistics and, 5:2664
U.S. national SDI and, 5:2167
view, download, transformation, and invoke service types and, 5:2623
Web services and, 5:2167
See also Exploratory spatial data analysis (ESDA); GIS specific subject; Spatial specific subject

Spatial data integration, 5:2623–2625
correlation and, 2:568–569
definition and functions, 5:2623–2624
differential elements in, 5:2623–2624
general-purpose data mining methods and, 5:2625–2626
horizontal data integration and, 5:2624
interoperability and, 5:2624
metadata and, 4:1885, 5:2624
modifiable areal unit problem and, 4:1935
spatial data quality assessment and, 5:2624
standards for, 5:2624
temporal data integration task and, 5:2624
vertical data integration and, 5:2624
See also Exploratory spatial data analysis (ESDA); GIS specific subject; Spatial specific subject

Spatial data mining, 5:2625–2627
challenges in, 5:2625
computational, statistical, and visual approaches to, 5:2626
computational efficiency of, 5:2626
decision trees and neural networks heuristics and, 3:1214
discriminate analysis and, 3:1214
geocomputation and, 3:1214
knowledge discovery from data and, 5:2625
pattern complexity and hypothesis generation in, 5:2626
real-world problems issues and, 5:2626–2627
spatial nonstationarity and, 5:2626
steps in, 5:2625
tasks in, 5:2625
transparency limitations issues and, 3:1214
U.S. decennial census and, 3:1214
visual presentation and understandability of, 5:2626
See also Exploratory spatial data analysis (ESDA); Spatial specific subject

Spatial data models, 5:2627–2629
critiques of, 5:2628
ear error propagation and, 2:1011–1012
functions of, 5:2627
GIScience and, 3:1284–1289
object data model, 5:2627, 5:2628
Open Source Geospatial Foundation and, 4:2088–2089
Open Source GIS and, 4:2090–2091
operations examples performed by, 2:674
raster data model, 5:2627
spaghetti data structure, 5:2628
"spatially enabled" tables and, 2:674
spatial references and, 5:2627
topological data structure, 5:2628
Triangulated Integrated Network (TIN) model, 5:2627, 5:2628
vector data model, 5:2627–2628
See also Exploratory spatial data analysis (ESDA); GIS specific subject; Spatial specific subject

Spatial data structures, 5:2629–2631
conceptual and local levels of, 5:2629
correlation and, 2:568–569
database management systems and, 2:671–674, 2:674
data format conversion and, 2:681–682
functions of, 5:2629
irregular tree raster data structure and, 5:2630, 5:2631 (fig.)
quadr-tree raster data structure and, 5:2630, 5:2631 (fig.)
raster data structures, 5:2630–2631, 5:2631 (fig.)
tree raster data structure and, 5:2630, 5:2631 (fig.)
vector data structures; geometry, 5:2629, 5:2630 (fig.)
vector data structures: topology, 5:2629–2630, 5:2630 (fig.)
See also Exploratory spatial data analysis (ESDA); GIS specific subject; Spatial specific subject

Spatial decision support systems (SDSS), 5:2631–2635
approaches and frameworks of, 5:2632
artificial intelligence or Expert System (ES) capabilities and, 5:2633
components of, 5:2632–2633, 5:2632 (fig.)
cost-benefit analysis used in, 2:593
criticisms, 5:2634
database management system (DBMS) and, 5:2632, 5:2632 (fig.)
definition of, 5:2632
discourse, data, and model (DDM) paradigm of, 5:2632, 5:2632 (fig.)
discourse generation and management system (DGMS) and, 5:2632 (fig.), 5:2633
ESRI's applications for, 5:2634
examples of, 5:2633–2634
GIS capabilities and, 5:2632
GIS land use management and, 3:1304
government agencies and, 5:2634
hardware and software technology advances and, 5:2633
IDRSIS's Decision Support and Integrated Land and Water Information System (ILWIS) and, 5:2633–2634
model base management system (MBMS) and, 5:2632, 5:2632 (fig.)
SDSS development tools and, 5:2633
SDSS generators and, 5:2633
semistructured decision problems and, 5:2632
technologies of, 5:2633
Web-based SDSS and, 5:2633
Web technologies and, 5:2633
weighted linear combination (WLC) method and, 3:1304
See also GIS specific subject; Heuristic methods in spatial analysis; Spatial specific subject
Spatial econometrics, 5:2635–2638
Luc Anselin’s work in, 1:80–81, 5:2635, 5:2637
apatial process and, 5:2636
bioregionalism and, 1:255
conditional autoregressive process and, 5:2636
criticisms, 5:2637–2638
functional forms of interdependence and, 5:2635–2637
functions of, 5:2635
multidirectional causal associations and, 5:2635
multidisciplinary applications of, 5:2635
open-source computational tools for, 5:2637
quantitative geography and, 5:2635
recent developments, 5:2637
regional science and, 5:2635
software advances in, 5:2637
space-time lag process and, 5:2636–2637
Spatial Econometrics (Anselin) and, 1:80
spatial error process and, 5:2636
spatial lag process and, 5:2636
time-series analysis and, 5:2635
See also Exploratory spatial data analysis (ESDA); Spatial specific subject
Spatial fix, 5:2638–2640
capital accumulation and, 5:2639
grounded capital and the built environment in, 5:2639–2640
David Harvey and, 5:2638, 5:2639
Marxist geographies and, 5:2638
relative/relational space and, 5:2402–2405
spreading out of capital and, 5:2638–2639
See also Spatial specific subject
Spatial inequality, 5:2640–2645
dynamic of change across different spatial scales and, 5:2642
girls’ education, Gansu, China, 5:2642 (fig.)
income ratio relative to slum population, global
South countries, 5:2644 (fig.)
local, national, regional, or global scale of, 5:2641–2642
capita income in West Bengal districts, India, 5:2643 (fig.)
quantification of, 5:2640
quantitative analysis and, 5:2643
socioeconomic clustering feature of, 5:2640, 5:2641 (fig.)
unequal distribution in goods or services and,
5:2640–2641, 5:2642 (fig.)
world income distribution across four countries, 5:2641 (fig.)
See also Spatial specific subject
Spatial interaction models, 5:2645–2647
applications of, 3:1169
competing destination model (Fotheringham) and, 3:1169
destination-specific attributes in, 5:2645
discrete zone systems element of, 5:2645
distance decay theory and, 2:774–776
A. Stewart Fotheringham’s work in, 3:1169
functions of, 5:2645
mathematical expression of, 5:2646
network analysis and, 4:2016–2018
network data model and, 4:2018–2019
neutral spatial interaction models and, 5:2647
origin-destination variables in, 5:2645
origin-specific attributes in, 5:2645
spatial information processing linked to, 3:1169
spatial interaction definition and, 3:1169
See also GIS specific subject; Spatial specific subject
Spatial interpolation, 5:2647–2649
Bayesian kriging and, 5:2648
computation of, 5:2648
deterministic interpolation and, 5:2648
functions of, 5:2647
geometric correction and, 3:1239–1240
geostatistics and, 3:1261–1265
k-nearest neighbor search example of, 5:2648
point vs. are entities and, 5:2648
taxonomy and, 5:2647–2648
Tobler’s first law of geography and, 5:2648
See also GIS specific subject
Spatialization, 5:2649–2653
alternate meanings of, 5:2652–2653
challenges in, 5:2651–2652
data sets to be spatialized and, 5:2650
definition and purpose of, 5:2649
dimensionality reduction techniques and, 5:2650–2651
dimensional reduction concept and, 5:2650
eXamples of, 5:2651
geographic knowledge domain example of, 5:2652 (fig.)
graph layout methods of, 5:2651
methods of dimensionality reduction and spatial layout in,
5:2650–2651
network of influential authors example of, 5:2652 (fig.)
network structure data sets and, 5:2650
production of space and, 5:2297–2298
sound spatialization term and, 5:2653
spatial layout approaches of, 5:2651
spatial metaphors and, 5:2649
tree map method and, 5:2651
types of applications and data in, 5:2649–2650
See also Spatial specific subject
Spatially integrated social science, 5:2654–2655
analytical approaches to, 5:2654–2655
development of, 5:2654
geographically weighted regression and, 5:2655
geographic contexts of, 5:2654
integrative computer-based tools and, 5:2654
Markov random field segmentation and, 5:2655
place-or locality-based analysis approach to, 5:2655
social spaces and, 5:2654
space and place elements in, 5:2654
spatial analysis approach to, 5:2655
time-geography and space-time behavior examples of, 5:2654
See also Spatial specific subject
Spatial multicriteria evaluation (spatial MCE), 5:2655–2657
alternatives identifcation and, 5:2656
analytical hierarchy process (AHP) and, 5:2656
applying a decision rule in, 5:2656–2657
Marc Armstrong’s work in, 1:117
criteria and standardizing data values in, 5:2656
criticisms, 5:2657
generating criteria weights in, 5:2656
ideal-point analysis (IPA) and, 5:2656
identifying alternatives, 5:2656
integrative origins of, 5:2655
methodology of, 5:2655–2657
outranking techniques and, 5:2656–2657
semistructured problems and, 5:2655
sensitivity analysis in, 5:2657
terms related to, 5:2655
See also GIS specific subject; Spatial specific subject
Spatial optimization methods, 5:2657–2659
artificial intelligence heuristics and, 3:1215
formulating an objective function element in, 5:2657–2658
functions of, 5:2657
Spectral characteristics of terrestrial surfaces, 5:2674–2676
asphalt, concrete, and steel and, 5:2675
human-made materials, 5:2675–2676
monitoring Earth’s materials through time importance and, 5:2674
multispectral imagery and, 4:1953–1956
natural materials and, 5:2674–2675
resolution of sensory systems and, 5:2674
soil, 5:2675
spectral remote sensors and, 5:2674
vegetation, 5:2674–2675
water, 5:2675
See also Spectral resolution; Spectral transformations
Spectral resolution, 5:2676–2678
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and, 5:2676
black-and-white film, 5:2676
color film, 5:2676
definition of, 5:2676
hyperspectral sensors and, 5:2677–2678, 5:2677 (fig.)
image interpretation and, 3:1534–1536
Landsat’s thematic mapper (TM) and, 5:2676
multispectral imagery and, 4:1953–1956, 5:2672, 5:2676
narrowly defined contiguous spectral bands, 5:2677 (fig.)
number of bands used factor in, 5:2676
spectral bands at various spectral resolutions and, 5:2676, 5:2677 (fig.)
width assigned to each band factor in, 5:2676
See also Spectral characteristics of terrestrial surfaces; Spectral transformations
Spectral transformations, 5:2678–2679
arithmetic operations/band calculations and, 5:2678–2679
color transformation, 5:2679
conditional operations and, 5:2678–2679
division or rationing of spectral bands and, 5:2678
explanation of, 5:2678
maximum value composite method and, 5:2678–2679
normalization of spectral response patterns and, 5:2678
Normalized Difference Vegetation Index and, 5:2679
principal components transformation (PCT), 5:2679
spectral ratios and vegetation indices in, 5:2679
vegetation indices (VIs) and, 5:2679
See also Spectral characteristics of terrestrial surfaces;
Spectral resolution

Spencer, Herbert
biological principles applied to study of society by, 2:916
history as linear movement and, 3:1433
social Darwinism and, 3:1464, 5:2561–2562
survival of the fittest work of, 2:666, 3:1434, 3:1464, 5:2561, 5:2669
Spriñ, Ann, 4:1700
Spivak, Gayatri, 5:2259, 5:2260, 5:2712
Spolaore, Enrico, 5:2217
Sports, geography of, 5:2680–2682
John Bale and, 5:2680
gopolitics and nationalism issues and, 5:2680
Japan-South Korea World Baseball Classic game, Dodger Stadium, Los Angeles, 5:2681 (photo)
location of sports franchises and playing facilities and, 5:2681
Olympics and, 5:2680
physical and human geographies factors in, 5:2680
physical geography factors and, 5:2681–2682
political geography of sports and, 5:2680
recruitment issues and, 5:2680
John Rooney and, 5:2680
sense of identity and attachment and, 5:2680–2681
topics and issues in, 5:2680
Springfield, Massachusetts, 4:1821
Springfield, Ohio, 4:1821
Spykman, Nicholas, 2:611, 3:1250
Squatter settlements, 5:2682–2685
characteristics of, 5:2682, 5:2683
cultural differences in, 5:2683–2684
cultural terms for, 5:2682
definition of, 5:2682
established neighborhoods from, 5:2683
globalization and, 5:2685
housing associations or cooperatives and, 5:2684
in Istanbul and Ankara, Turkey, 5:2683 (photo)
lack of low-cost housing and, 5:2685
land invasion issue and, 5:2684
legalization of, 5:2683–2684
negative views, 5:2682
political system factors and, 5:2684
solidarity factor and, 5:2684
squatter housing term and, 5:2682
terms associated with, 5:2682
Third World context of, 5:2682, 5:2685
traditional land tenure values and, 5:2684
usufruct rights and, 5:2684
violation and crime issues and, 5:2684
Sri Lanka
economically active females in, 3:1190 (table)
human rights atrocities in, 3:1481
income distribution, percentile of world income, 5:2641 (fig.)
monsoons in, 4:1943
Phoenicians exploration of, 2:1031
tropical deciduous forest in, 1:230
tropical rain forest of, 1:234
Tsunami of 2004, Indian Ocean and, 6:2888–2890
tsunami of 2004 and, 4:1985
Stachowicz, John, 4:1658
Staeheli, Lynn, 4:2136
Stalin, Joseph, 2:542, 2:543, 2:594
Stamp, L. Dudley, 5:2487
Standing, Guy, 4:1893
Stanislawski, Dan, 1:192
Stanton, Elizabeth Cady, 3:1095
State, 5:2685–2688
city-states type of, 5:2687
civil society and, 1:414–416
country and nation terms and, 5:2685–2686
definitions of, 5:2685–2686
government term and, 5:2686
modern state emergence and, 5:2687–2688
nationalism and, 4:1978–1981
nation-state type of, 5:2687
political entities and, 5:2686
recognition factor and, 5:2686
suprastate and, 5:2688
unitary or federal internal structure and, 5:2686–2687
world’s political map and, 5:2686
Stea, David, 1:189
Steel industry, geography of, 5:2688–2693
alternative raw materials and, 5:2691
credit issues and, 5:2693
directly reduced iron production and, 5:2691, 5:2692
Dutch-British Corus Group example and, 5:2692
Essar Group (India) example and, 5:2692
globalization and, 5:2691–2693
gravel yard and steel mill, Bethlehem, Pennsylvania, 5:2690 (photo)
Industrial Revolution and, 5:2688–2689
internationalization feature of, 5:2688
internationalization of, 5:2692
Japanese-American joint ventures and, 5:2690
macroeconomic factors and, 5:2693
minimills and, 5:2689–2690, 5:2692
Mittal Steel (India) example and, 5:2692
neoliberal policies and, 5:2689
Nippon Steel (Japan) example and, 5:2692
nontariff barriers and, 5:2690
oil prices and, 5:2693
Pohang Iron and Steel Company, Pohang, South Korea, 5:2691 (photo)
raw material locations and, 5:2689
“resource curse” concept and, 5:2693
state-owned industry and, 5:2692
technology and, 5:2689–2691
transportation advances and, 5:2689
unions and, 5:2690
Stefanovic, Ingrid Leman, 4:2168
Steiner, Dieter, 3:1455
Steinitz, Carl, 3:1304
Stereoscopy and orthoimagery, 5:2693–2695
baseline and, 5:2695
binocular vision term and, 5:2694
depth perception and, 5:2693–2694
explanations of, 5:2693–3694
monocular vision and, 5:2694
orthoimagery and, 5:2695
parallax element in, 5:2694
photogrammetric methods and, 4:2173–2175
relative photogrammetric accuracy vs. angle of intersection, 5:2694, 5:2694 (fig.)
land reform and, 4:1692–1696
liberalization and, 5:2703
privatization of state-owned enterprises and, 5:2703
reforms within, 5:2703–2704
repercussions from, 5:2704
“urban bias” in national development and, 5:2704
Washington Consensus and, 5:2703

Structuralism, 5:2705–2708
Louis Althusser, 5:2706
Manuel Castells, 5:2706–2707
Noam Chomsky and, 5:2705
communication (symbolic) systems in anthropology and, 5:2706
creative role of language and, 5:2705
geography and, 5:2706–2708
language study origins of, 5:2705
Claude Lévi-Strauss and, 5:2706
Marxist geography and, 5:2706
negative and positive features of, 5:2707
origins of, 5:2705
Talcott Parsons and, 4:1932
political systems analysis and, 5:2705
poststructuralism and, 5:2705
realism and, 5:2369–2371
as science of objects, 5:2706
social geography and, 5:2567
social practices and spatial organization, 5:2707 (table)
tenets and history of, 5:2705–2706

Structuration theory, 5:2708–2711
actors element in, 5:2709
duality of structure element in, 5:2709
empirical applications of, 5:2710
essentials in, 5:2708
place and, 5:2186
realism and, 5:2369–2371
school closing example of, 5:2708–2709
spatiality and duality issues and, 5:2710
structures element in, 5:2709
two versions of, 5:2709–2710
types of behavior in, 5:2710
See also Structuration theory: noted geographers, scholars

Structuration theory: noted geographers, scholars
Roy Bhaskar, 3:1278
Pierre Bourdieu, 3:1278
Derek Gregory, 3:1380, 5:2710
Allan Pred, 5:2289–2290

STS. See Science and technology studies (STS)

Subaltern studies, 5:2711–2713
critiques, 5:2712
Eurocentrism and, 2:1029
geography implications of, 5:2711
goal of, 5:2711
Antonion Gramsci and, 2:1029, 5:2711
Indocentrism and, 2:1029
Marxism and, 5:2711–2712
origins of, 5:2711
poststructuralism and, 5:2712
subaltern definition debates and, 5:2711
Subaltern Studies (Guha, ed.), 5:2711
sustainability studies and, 6:2753
uneven development and, 6:2902

Sub-Saharan Africa
adults and children living with HIV in 2007 in, 3:1437 (fig.)
agrobiodiversity in, 1:50
anticolonialism in, 1:94
Bantu or Niger-Kordofanian languages in, 4:1751, 4:1752 (fig.)
birthrates in, 2:708
debt crisis and, 2:688
desertification in, 5:2582
diseases in, 2:726
fertility levels in, 2:709
Heavily Indebted Poor Countries initiative (World Bank) and, 2:690
HIV/AIDS epidemic in, 2:727, 3:1438–1439
industrialized agriculture in, 1:47
Internet access in, 2:845
malaria in, 4:1816, 4:1817
military expenditures in, 4:1899 (table)
nongovernmental organizations (NGOs) in, 1:415
people living in extreme poverty and, 3:1082 (table)
poverty rates in, 5:2274, 5:2275
remittance flows to, 5:2412
undernourishment in, 3:1488 (table)

Suburban land use, 5:2713–2716
de edge cities and, 5:2713
exurbanis and, 2:1074–1076
interregional shifts in, 5:2713–2715
interstate highway system and, 5:2713
intragregional suburbanization and, 5:2713
monocentric to polycentric spatial organization pattern and, 5:2713
spatial point patterns and, 5:2714 (fig.)
streetcar suburbs and, 5:2713
suburban term and, 5:2713
three waves of suburbanization and, 5:2713
See also Suburbs and suburbanization

Suburbs and suburbanization, 5:2716–2721
automobility and, 1:172–175
“bourgeois utopias” and, 5:2716
built environment, social and cultural features and, 1:299–300
city central business districts and, 1:379
City in History (Mumford) and, 5:2719
commuting and, 2:553–555
contested process of, 5:2719–2720
counterurbanization and, 2:596–597
dysfunctions associated with, 5:2720
edge cities and, 5:2718
issues regarding, 5:2716
major stages of, 5:2716–2718
metropolitan political fragmentation and, 5:2720
“new towns” and, 5:2718
smart growth and, 5:2550–2551
streetcar suburbs and, 5:2716–2717
suburban sprawl, Las Vegas, Nevada, 5:2717 (photo)
suburbs, definition, 5:2716
suburb word origin and, 5:2716
urban pathology analysis and, 5:2719
urban sprawl, 5:2720
Richard Walker and, 6:3043–3044
See also Suburban land use

Sudan
African Union peace keeping in, 1:25
economically active females in, 3:1190 (table)
hate groups in, 3:1407
human rights atrocities in, 3:1481
human rights violations in, 3:1480
independence of, 1:512
locusts infestation in, 2:727
oil exports from, 4:2073
Suez Canal, 5:2254
Sui, Daniel, 5:2721–2722
academic career of, 5:2721
digital spatial technologies work of, 5:2722
GIScience work of, 5:2721–2722
media geographies work of, 4:1875
neogeography work of, 4:2006, 5:2721

Suitability analysis, 5:2722–2723
Sumatra, 1:209
Sunbelt, 5:2723–2725
graphic locations of, 5:2723
immigration gateways in, 5:2723
as industrial restructing strategy, 5:2458
manufacturing relocation from Rust Belt to, 5:2723
map of, 5:2724 (fig.)
monolithic characteristic of, 5:2724
population growth in, 5:2723
producer services growth in, 5:2723
term connotation and, 5:2723
urban growth in, 5:2458
Sundberg, Juanita, 3:1101
Sun Tzu, 4:1896
Superfund sites on National Priorities List (NPL), 1:297, 4:1684, 4:1808, 4:1857
Supervised classification, 5:2725
data collection methods and, 5:2725
definition of, 5:2725
parametric vs. nonparametric classification algorithms and, 5:2725
quality and quantity of training samples factors in, 5:2725
unsupervised classification and, 6:2914–2915
Supranational integration, 6:2726–2729
ASEAN and, 6:2727
Barents Euro-Arctic region and, 6:2728 (fig.), 6:2729
case examples of, 6:2727–2729
cross-border “nonstandard regions” and, 6:2726–2727
cultural character of, 6:2726
definition of, 6:2726
European Union (EU) and, 6:2727–2728
Euroregions and, 6:2729
globalization of world economy factor of, 6:2726
interregional competition and, 6:2726
multilateral vs. bilateral nature of, 6:2726–2727
NAFTA and, 6:2727
NATO and, 4:2046–2048
political and economic importance of, 6:2726
process of, 6:2727
rescaling of nationstates and, 6:2726
smaller-scale supranational integration and, 6:2729
sovereignty and, 6:2726
top-down vs. bottom-up nature of, 6:2727

Surface water, 6:2729–2732
coastal landforms, 6:2731
cryosphere, ice sheets and glaciers and, 6:2730
dams and, 6:2732
drainage basins, watersheds and, 6:2730
floods, 3:1133–1137
flow of, 3:1138
fluvial landforms, 6:2731
geography of, 6:2730
geomorphology and, 6:2731
glaciers, 6:2731
global climate change effects on, 6:2732
humans and, 6:2732
hydrological connectivity and, 3:1512–1513
Surveying, road surveyor, Dhi Qar Province, Iraq, open traverse type of, link traverse type and, GPS technology and, geometric measures and, UN Conference on Environment and Development (UNCED) and, UN Commission on Sustainable Development (UNCSD) and, World Commission on Environment and Development (WCED) and,

Suriname, 1:234

Surveillance, 6:2733–2735
definition of, 6:2733
fixing of attributes to things and, 6:2733
geoslavery and, 3:1255–1256
GIS and remote sensing and, 6:2734
operations in port of Vancouver, Canada, 6:2734 (photo)
panopticism and, 6:2733
panopticon and, 4:2116–2117
synopticism and, 6:2733

Surveying, 6:2735–2737
absolute and differential GPS and, 6:2736
cadastral systems and, 1:311–318
census rs., 1:371
closed-loop traverse type of, 6:2735
closed traverse type of, 6:2735
closure error in, 6:2736
definition of, 6:2735
distances, heights, and angles measures in, 6:2735
geometric measures and, 3:1240
GPS technology and, 6:2736
inaccuracy issue in, 6:2735–2736
link traverse type and, 6:2735
open traverse type of, 6:2735
road surveyor, Dhi Qar Province, Iraq, 6:2736
terms related to, 6:2735
tools used in, 6:2735
total station concept in, 6:2735
traversing and, 6:2735
triangulation and, 6:2735
trilateration and, 6:2735

Sustainability science, 6:2737–2742
basic and applied science of, 6:2740–2741
Brundtland Commission report on sustainable development and, 6:2737, 6:2747
concept of, 6:2737–2740
ecological economics and, 2:820–824
ecological footprint and, 2:825–828
ecological imaginaries and, 2:828–830
ecological modernization and, 2:832–834
emergence of, 6:2737–2738
global systems assessment and, 6:2738–2739
healthy functioning of human systems and, 6:2739
human-environment interaction origins of, 6:2737
human survival and, 6:2738–2739
Rober Kates’ work, 4:1654–1655
knowledge systems and, 6:2738
multiple systems integration and, 6:2739–2740
postnormal research paradigm and, 6:2740
research framework for, 6:2741
UN Commission on Sustainable Development (UNCSD) and, 6:2738
UN Conference on Environment and Development (UNCED) and, 6:2737–2738, 6:2746
World Commission on Environment and Development (WCED) and, 6:2737

World Summit on Sustainable Development and, 6:2738
See also Adaptive harvest management; Energy and human ecology; Sustainability science: noted individuals

Sustainability science: noted individuals
Vannevar Bush, 6:2740–2741
Hans Carl von Carlowitz, 6:2737
William Clark, 6:2741
Michael Dove, 6:2741
Peter Glacken, 6:2737
Yujiro Hayami, 6:2734
Daniel Kammen, 6:2741
Hiroshi Komiyama, 6:2738
Vernon Ruttan, 6:2737
E. F. Schumacher, 6:2737
Kazuhiko Takeuchi, 6:2738
Billie Lee Turner, II, 6:2891–2892

Sustainable agriculture, 6:2742–2746
agricultural intensification and, 1:36
agriculture’s roots and, 6:2742
agroecology and, 1:57
alternative agriculture and, 6:2744–2746
from crisis to opportunity in, 6:2744
crop genetic diversity and, 2:625–627
crop rotation and, 2:627–630
Cuban experience and, 6:2744
ecological erosion and, 6:2743
energy inefficiency of, 6:2744
food production trends and, 6:2746
food production trends and, 6:2744
genetic erosion and, 6:2743
global environmental change and, 1:36
industrial agriculture and, 6:2742–2743
lingonberry field, Alaska, 6:2745 (photo)
local knowledge element in, 6:2745
natural systems agriculture and, 6:2745–2746
organic agriculture and, 4:2094–2096
pesticides and, 6:2743
Silent Spring (Carson) and, 6:2743
social erison and, 6:2743
superpests and, 6:2743
technology advances and, 6:2745
See also Adaptation to climate change; Adaptive harvest management; Agricultural land use

Sustainable cities, 6:2746–2747
Aalborg Charter and, 6:2746
definition of, 6:2746
economic self-sufficiency and, 6:2746
ethical resource use and, 6:2746–2747
European Conference on Sustainable Cities and Towns and, 6:2746
natural capital maintenance and, 6:2747
social justice and, 6:2746
UN Conference on Environment and Development (UNCED) and, 6:2746

Sustainable development, 6:2747–2752
Agenda 21 (UN), global sustainable development action plan and, 2:914, 2:1004–1005, 6:2737–2738, 6:2746, 6:2748
biomass reserves and, 1:256–267
brownfields and, 1:296–298
Anne Buttimer’s work in, 1:309
capitalism, globalism and, 6:2750–2751
cellular automata used in, 1:370
conservation and, 2:570
crizations of UNCED approach to, 6:2749–2750
Herman Daly’s “evils of growthmania” views and, 2:835
definition of, 3:1370
ecological modernization and, 2:835–836
ecological imagination and, 2:835–836
economic self-sufficiency and, 6:2746
See also Agricultural land use; Economics of scarcity
ecotourism and, 2:869–874
environmental impact assessment and, 2:934–937
environmental planning and, 2:982–983
equitable and sustainable climate change regime and, 6:2751
feminist political ecology and, 3:1100–1102
global commons and, 6:2749
green design and development and, 3:1369–1373
indigenous environmental knowledge and, 3:1354–1567
international programs of, 5:2220
Johannesburg Declaration on Sustainable Development and, 2:1005
Robert Kates’ work, 4:1654–1655
Thomas Malthus’s term and, 6:2747
natural hazards and risk analysis and, 4:1985
neoliberalism and, 2:836
neoliberal economic agenda and, 6:2750
Our Common Future (Brundtland Report) and, 2:1003, 3:1370, 6:2747, 6:2748
political economy of resources and, 5:2220–2221
population growth and resource use balance and, 5:2244–2245
questioning current objectives in, 6:2748–2749
regional economic development and, 5:2380–2384
Maurice Strong and, 6:2748
transportation geography and, 6:2875
UN debates, 6:2747–2748
UNEDU’s global management approach to, 6:2749
World Commission on Environment and Development (WCED) and, 2:835, 2:1003–1004, 5:2220, 6:2747
World Conservation Strategy and, 2:1003
World Summit on Sustainable Development (WSSD) and, 2:1005, 6:2738, 6:2750, 6:2907
See also Regional environmental planning; Sustainable development alternatives; Sustainable specific activity; World Summit on Sustainable Development
Sustainable development alternatives, 6:2752–2754
critical sustainability studies and, 6:2753
ecological footprint and, 2:825–828
green design and development and, 3:1369–1373
local engagement and, 6:2753
subaltern sustainability, 6:2753
sustaining the environment, 6:2752–2753
sustaining the system and, 6:2752–2753
systemic intervention and, 6:2752–2753
Sustainable fisheries, 6:2754–2757
Code of Conduct for Responsible Fisheries and, 6:2757
collapsing fisheries and, 6:2754–2755
community-based natural resource management and, 2:549, 2:550
eco-labeling, green consumerism and, 6:2757
European Union policy and, 6:2755–2756
exclusive economic zones (EEZs) and, 6:2757
fish farming and, 3:1119–1121
friendlier fishing gear and, 6:2757
government responses to, 6:2755–2756
individual transferable quotas (ITQs) and, 6:2756
international policy responses to, 6:2757
maximum sustained yield concept and, 5:2445
tragedy of the commons, 6:2755
UN actions, 6:2757
UN Food and Agriculture Organization and, 6:2754
See also Adaptive harvest management; Aquaculture; Marine aquaculture
Sustainable forestry, 6:2758–2763
boreal forest biome and, 1:214–217
carbon cycle and, 6:2759
casuarinas in dunes, Zululand, South Africa, 6:2881 (photo)
challenges in, 6:2760–2761
community-based natural resource management and, 2:549–551
conservation concessions and, 6:2762
definition of, 6:2758
economic challenges in, 6:2760–2761
environmental certifications in, 2:914–915
Faustmann rule for forestry resources and, 5:2445
forest certification and, 6:2762
forest concession challenges in, 6:2761
forest productivity and, 6:2759–2760
Forest Stewardship Council and, 2:915
innovations in, 6:2762
institutional challenges in, 6:2761
managed natural forests, global extent of, 6:2758
midlatitude deciduous forest biome and, 1:223–226
Montreal Process and, 6:2758–2759
National Standard on Sustainable Forest Management (Canada) and, 2:915
political challenges in, 6:2761
Programme for Endorsement of Forest Certification and, 2:915
reduced-impact logging (RIL) and, 6:2762
secondary forest management and, 6:2762
slash pine plantation, Georgia (U.S.), 6:2835 (photo)
social dimensions of, 6:2760
social (tenurial) challenges in, 6:2761
Sustainable Forestry Initiative and, 2:915
sustainable forestry management goals and, 6:2758
sustainable urban forestry (SUF) and, 6:2762
themes in, 6:2758
tropical deciduous forest biome and, 1:230–233
UK Woodlands Assurance Scheme and, 2:915
UN Food and Agriculture Organization and, 6:2758
See also Adaptive harvest management
Sustainable production, 6:2763–2767
AccountAbility’s standards and, 6:2763
agroecology and, 1:57
benign outputs and, 6:2764
biofuels production and, 1:201–204
brownfields and, 6:2766
Anne Buttimer’s work in, 1:309
Clean Air Act (1990) and, 6:2763
commodity chains in, 6:2765
community-based natural resource management and, 2:549–551
ecological footprint and, 2:824–828
eliminating waste and, 6:2764
facility construction and, 6:2766
frameworks of, 6:2764–2766
Global Reporting Initiative guidelines and, 6:2763
goods and services and, 6:2764
industrial ecology and, 3:1577–1579
ISO standards and, 6:2763
life cycle view of, 6:2766
logistics management and, 6:2766
material and energy flows, simplified supply chain and, 6:2765 (fig.)
Montreal Protocol and, 6:2763
motivation for, 6:2763–2764
product end-of-use options and, 6:2766
Social Accountability International standards and, 6:2763
supply chains and, 6:2765, 6:2767 (fig.), 6:2766
value chains in, 6:2765
See also Adaptation to climate change; Adaptive harvest management
Swaziland
economically active females in, 3:1190 (table)
life expectancy in, 3:1410
Sweden
AGILE membership of, 1:125 (table)
bioindustry industry in, 1:280
cancer incidence and mortality in, 1:321–322, 3:132 (fig.), 1:323 (fig.)
carbon or climate change taxes in, 4:1857
coastal dead zones of, 1:487
critical human geography in, 2:620
economically active females in, 3:1190 (table)
European Union (EU) membership of, 2:1035
foreign aid flow from, 3:1152
Glaciers in, 6:2767–2768
Hydroelectricity in, 6:2767–2768
hydroelectricity in, 3:1507
import substitution industrialization in, 3:1551
industrialization in, 3:1580, 3:1583, 4:2020
Japanese colonization of, 1:514
Japanese electronics industry in, 2:885
land reform in, 4:1693
newly industrializing country of, 4:2021, 4:2022 (fig.)
PCBs contamination in, 5:2226
steel industry in, 5:2689
U.S. industry moving to, 2:700

Tajikistan
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)
HIV/AIDS in, 3:1438
Takeuchi, Kazuhiko, 6:2738
Tanzania
economically active females in, 3:1190 (table)
glaciers in, 3:1332
tropical deciduous forest in, 1:230, 1:231
tropical savanna in, 1:241

Taphonomy, 6:2775–2776
actualism strategy and, 6:2775–2776
archaeological accumulation and, 6:2776
biostratinomy vs. diagenesis and, 6:2775
comparative method used in, 6:2776
definition of, 6:2775
direct and indirect evidence and, 6:2775
histories of fossils and, 6:2776
morphological and qualitative variables and, 6:2776
multidisciplinary focus of, 6:2775
origins of term and, 6:2775
positive contributions of, 6:2775
taphonomic modes and, 6:2776
Tatham, George, 2:917
Taylor, Charles, 4:1644
Taylor, Griffith, 6:2777–2778
academic career of, 6:2777
Australia studies of, 6:2777
books written by, 6:2777
environmental determinism and, 3:1464, 6:2777
eugenics and, 3:1464
Harold Imis and, 6:2778
publications of, 6:2777
Scott’s Antarctic Terra Nova Expedition and, 6:2777
service work of, 6:2777
Taylor, Peter, 6:2778
finance geographies work of, 3:1117
hegemonies in capitalist world economy views of, 3:1419
Marxist theory of scale and, 5:2506–2507
political geography work of, 2:880, 6:2778
scale hierarchies work of, 6:2778
world-systems theory and, 2:880, 6:2778

Technological change, geography of, 6:2779–2782
diffusion and, 2:745–746, 2:780–2781
economic growth theory and, 2:851–852, 6:2779
globalization and, 6:2781–2782
innovation geographies and, 3:1597–1599
knowledge spillovers and, 6:2779

Taiwan
APEC membership of, 1:121
arsenic in drinking water, cancer mortality rates in, 1:321
deposit refund systems in, 4:1857
export-oriented industrialization (EOI) in, 2:1064
export trade success of, 2:731
import substitution industrialization in, 3:1551
industrialization in, 3:1580, 3:1583, 4:2020
Japanese colonization of, 1:514
Japanese electronics industry in, 2:885
land reform in, 4:1693
newly industrializing country of, 4:2021, 4:2022 (fig.)
PAsB contamination in, 5:2226
steel industry in, 5:2689
U.S. industry moving to, 2:700

Tahiti, 2:576
Taipei
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
learning regions and, 4:1766–1768
nonrivalry and nonexcludability concepts and, 6:2779
as production component, 6:2779–2780
public vs. private goods and, 6:2779
spatial clustering and, 6:2781
tacit vs. codified knowledge and, 6:2780–2781
technology definitions and, 6:2779
total factor productivity and, 6:2779, 6:2780 (table)
See also Electronics industry, geography of; High technology

Telecommunications and geographies, 6:2782–2789
back office and call center relocations and, 6:2786–2788
cyberspace and, 2:646–648
digital divide and, 2:748–753
e-commerce and, 2:844–846
fiber-optic and, 6:2784 (fig.)
fiber optics and, 6:2783–2785, 6:2784 (fig.)
finance and, 6:2785–2786
geographical patterns of economic activity and, 2:851
global cities and, 6:2786
information society and, 3:1593–1594
misconceptions, 6:2783
urban telecommunications infrastructures and, 6:2788–2789
See also Communications geography

Teleconnections, 6:2789–2790
atmosphere and ocean interdependencies and, 6:2789–2790
correlation analysis, 6:2790
definition of, 6:2789
El Niño-Southern Oscillation and, 6:2790
ocean changes and, 6:2789–2790
statistical techniques identification of, 6:2790
strength, phase, and location of, 6:2790
weather patterns and, 6:2789–2790
See also El Niño-Southern Oscillation (ENSO)

Television and geography, 6:2790–2793
distribution and consumption process of, 6:2791
domestic space concept and, 6:2791
geographies of television and, 6:2791
geographies on television and, 6:2791, 6:2792 (photo)
geopolitics/political geography and, 2:541
production and packaging processes of, 6:2791
social role of television and, 6:2790–2791
space, identity and, 6:2791–2793
Temperature changes. See Adiabatic temperature changes

Temperature patterns, 6:2793–2796
air mass characteristics and, 1:62–65
atmospheric circulation factor in, 6:2793–2796
cloud cover and water vapor effects on, 6:2795
derechos and, 2:714–715
El Niño-Southern Oscillation (ENSO) and, 2:886–890
humidity levels factor in, 6:2795
La Niña and, 4:1754–1757
latent heat and, 4:1761–1762
latitude and, 6:2793–2794
oceans factor in, 6:2795–2796
polar albedo factor and, 6:2794
principle of continentality and, 6:2794–2795
radiation with low sun angle factor in, 6:2794
reflective cooling of clouds and, 6:2795
seasonal variability in, 6:2794
solar and terrestrial radiation and, 5:2346–2349
solar radiation factor in, 6:2793
specific heat differences between surface materials factor in, 6:2794–2795
topography impact on, 6:2795
water surface evaporation factor in, 6:2794

Temporal GIS, 6:2796–2797
change history of individual entities and, 6:2797
continuous view of time and, 6:2797
functions of, 6:2796
GIS static view of time and, 6:2796
lifelines of individual geographic entities and, 6:2797
lifelines of moving objects and, 6:2797
mathematical models used in, 6:2797
Donna Peuquet’s work and, 4:2165
snap-shot model of, 6:2796
space-time composite model of, 6:2796–2797
spatiotemporal data and, 6:2796
time component of spatial analysis and, 6:2796
time point and time interval elements in, 6:2796
time-stamping and, 6:2796
See also Temporal resolution

Temporal resolution, 6:2798
definition of, 6:2798
GIScience role of, 6:2798
GIS role of, 6:2798
multitemporal image comparisons and, 6:2798
remote sensing definition of, 6:2798
See also Temporal GIS

Tennessee
Hurricane Katrina and, 3:1494
nuclear weapons site in, 5:2469

Terrain analysis, 6:2798–2801
catchment/watershed attributes and, 6:2799–2800
digital terrain model (DTM) and, 2:753–756, 6:2799
local morphology attributes and, 6:2799
natural components and terrain features and, 6:2799
square-grid digital elevation model and, 6:2799, 6:2800 (fig.)
Triangulated Irregular Network (TIN) data model and, 6:2883–2884

 Territory, 6:2801–2804
behavior and, 6:2802
Blair’s map of Europe, mid 17th century and, 6:2803 (fig.)
conflicts and, 6:2803–2804
definitions, 6:2801
exclusion from, 6:2801
functions of, 6:2801
locality studies and, 4:1790–1792
national identity and, 6:2802–2803
nation concept and, 4:1971–1974
network vs., 6:2804
political history and, 6:2802
politics and social behavior and, 6:2801
thing vs. process of, 6:2801

Terrorism, geography of, 6:2804–2808
al-Qaeda and, 1:97
antiglobalization violence and, 1:97
definition of, 6:2805
fear geographies and, 3:1089
future research issues in, 6:2808
geographical components of, 6:2805
intertextuality term and, 6:2809
Timothy McVeigh, Oklahoma bombing and, 1:97
multidimensional nature of, 6:2804–2805
nation-state borders and, 1:294
political jurisdiction locations and, 6:2806
radical Islamists and, 1:97
situational characteristics of terrorist acts and, 6:2807–2808
spatial and locational characteristics of, 6:2804
spatial strategy of terrorist violence and, 6:2805
treatment and control of space and, 6:2805–2806
Texas
coastal “dead zones” in, 1:486
“Gunbelt” of, 4:1902
Hurricane Ike floods in, 3:1136
hurricanes in, 3:1501
oil industry in, 4:1822
Spanish colonialism in, 1:512
Williams Prairie preserve, Houston, 5:2281 (photo)

Text/textuality, 6:2808–2812
border identities and, 6:2811
cultural anthropology and, 6:2809
cultural turn, place and politics of representation and, 6:2810
definition issues and, 6:2808–2809
discourse on, 6:2809–2810
film and, 3:1110–1111
geography and, 6:2810–2811
hermeneutic approach to, 6:2810
intertextuality term and, 6:2809
landscapes and, 6:2809
literature geographies and, 4:1785–1788
national identities and, 6:2811
postmodernism and, 6:2809–2810
poststructuralism and, 6:2809
reading of text and, 6:2809
social context of, 6:2809
sociology, anthropology, and human geography and, 6:2811
transnational identities and, 6:2811
Writing Worlds (Barnes and Duncan), 6:2810

See also Languages, geography of; Text/textuality: noted scholars

Text/textuality: noted scholars
Duncan, J., 6:2810
T. Barnes, 6:2810
James Clifford, 6:2809
S. Daniels, 6:2810
Clifford Geertz, 6:2809
George Marcus, 6:2809
Paul Ricoeur, 6:2809, 6:2810
J. M. W. Turner, 6:2810
Stephen Tyler, 6:2809

Textile industry, 6:2812–2819
commodity chain perspective and, 6:2814–2816
fashion, agglomeration, and place in, 6:2818
Industrial Revolution and, 3:1583–1584
international trade and development and, 6:2813–2814
labor rights, gender, and business ethics in, 6:2817
leading clothing-exporting countries, 6:2186 (fig.)
leaving textile-exporting countries, 6:2815 (fig.)
production sequence in, 6:2813 (fig.)
reworking labor process in, 6:2817–2818
structure of global commodity chains and, 6:2186 (fig.)
thoretical themes in, 6:2813
Thacker, Andrew, 4:1785
Thailand
APEC membership of, 1:121
ASEAN membership of, 1:127, 1:128 (table), 1:129, 1:129 (table)
automobile industry in, 1:169
British colonization of, 1:515
clothing exports from, 6:2186 (fig.)
drug culture in, 2:799
economically active females in, 3:1190 (table)
forest fragmentation in, 3:1159
HIV/AIDS in, 3:1438
industrialization in, 3:1583, 4:2020, 4:2022, 4:2022 (fig.)
installed capacity for electricity production forecast, 2010, 3:1268 (fig.)
Japanese electronics industry in, 2:885
marine aquaculture in, 4:1854 (fig.)
market-based land reform in, 4:1695
opium and heroin production in, 2:797
textile exports from, 6:2816 (fig.)
tropical scrub in, 1:244
Tsunami of 2004, Indian Ocean and, 6:2888–2890
Thales, 6:2819
accomplishments of, 6:2819
human geography and, 3:1460
Milesian school and, 6:2819
natural phenomena studied by, 6:2819
rational explanation through observation and, 6:2819
travels of, 6:2819
Thermal imagery, 6:2819–2821
acquisition in, 6:2820–2821
applications for, 6:2821
Grass Valley/Slide Fire near Lake Arrowhead/Running Springs, San Bernardino mountains, California, 6:2820 (photo)
remote sensing platforms and, 6:2821
thermal radiation principle and, 6:2820
Thom, Bruce, 1:488
Thompson, D’Arcy, 1:569
Thompson, E. P., 4:1862, 4:1863, 4:2141, 5:2441, 5:2442,
5:2711–2712
Thoreau, Henry David, 2:569, 2:981
Thorner, Daniel, 4:2137
Thorne, John, 4:1875
Thornthwaite, C. Warren, 6:2821–2822
Berkeley School and, 1:192
culture and technology work of, 1:432, 1:467, 6:2822
climatic water budget work of, 4:1871
climatology work of, 6:2821–2822
human ecology views of, 3:1455
potential evapotranspiration (PE), 6:2821–2822
service work of, 6:2822
water balance methods of, 6:2821
Thorpe, Harry, 3:1402
Three-dimensional data models, 6:2822–2825
digital elevation model for Greene County, Missouri, 6:2823 (fig.)
digital terrain model (DTM) and, 2:753–756
geological and seismic velocity model of Santa Clara Valley area, 6:2824 (fig.)
GIScience and, 3:1284–1289
Mei-Po Kwan’s work in, 4:1674
quasi-3D data modeling and, 6:2822–2823
true-3D data modeling and, 6:2825
Three Mile Island nuclear accident, 6:2825–2827
event description and, 6:2825–2826
government warnings during, 6:2826
nuclear energy and, 4:2050–2052
nuclear regulation impact of, 6:2825
Three Mile Island nuclear power plant, 6:2827 (photo)
Thrift, Nigel, 6:2827–2830
academic career of, 6:2827
culture and technology work of, 6:2829
economic geography of Australia and, 6:2827
emotional geographies and, 2:892
Torsten Hägerstrand and, 3:1398
human geography work of, 6:2827–2828
international financial system work of, 6:2828–2829
multifield contributions of, 6:2827
new urbanism work of, 5:2268
nonrepresentational theory and, 1:290
nonrepresentational theory work of, 1:290, 4:2042
postmodernism and, 6:2827
poststructuralism and, 6:2827
publications of, 6:2827–2828
questions of time and, 6:2827
radical geography and, 5:2352
regional effects of globalization and, 6:2828
time geography work of, 6:2836
urban geography work of, 6:2828
Thucydides, 4:1896

Thunderstorms, 6:2830–2832
air mass thunderstorms term and, 6:2830
approaching thunderstorm with lead gust front and, 6:2831 (photo)
atmospheric circulation explanation of, 1:135
derechos term and, 6:2830
Intertropical Convergence Zone (ITCZ) location factor in, 6:2832
lightning and, 4:1779–1783
Mesoscale Convective Complexes (MCCs) and, 6:2831
as mesoscale system, 6:2830
in midlatitudes, 6:2832
multicell thunderstorms and, 6:2830–2831
ordinary cell thunderstorms and, 6:2830
supercell thunderstorms and, 6:2831
supercell tornadoes and, 6:2851

Thünen model, 6:2832–2834
agricultural land use and, 6:2832–2834
bid-rent curve and, 5:2328, 6:2833–2834, 6:2833 (fig.)
concentric farm-land use model and, 4:1728, 5:2236
economic rent, location rent concept and, 6:2832
as first model of land markets, 4:1798
food geographies and, 3:1144
location theory and, 3:1628, 4:1798, 4:1799 (fig.), 5:2393, 5:2433, 6:2832–2834
August Lösch and, 3:1628, 4:1805
modern human settlement patterns and, 4:1728
Tibet
bovine domestication in, 2:783
human rights atrocities in, 3:1480, 3:1481

Tickell, Adam, 4:2014
Till, Karen, 3:1202

Timber plantations, 6:2834–2836
benefits from, 6:2834
casuarinas in dunes, Zululand, South Africa, 6:2881 (photo)
costs associated with, 6:2834–2835
nontimber forest products (NTPPs) and, 6:2834
slash pine plantation, Georgia (U.S.), 6:2835 (photo)

Time, geographies of, 6:2836–2837
Anne Buttimer and, 6:2836
cycles and timetables, 6:2836
demarcation of time for activities and, 6:2836
Torsten Hägerstrand and, 6:2837–2838
Julian calendar of AD 1020 and, 6:2836
lived time and, 6:2837
Jon May and, 6:2836
nonlinear and chaotic characteristics of time and, 6:2836
social time: the geographies of rhythms and, 6:2836–2837
Nigel Thrift, 6:2836
time-space and, 6:2836, 6:2837
tools and technologies related to, 6:2836
See also Time-geography; Time-space compression

Time-geography, 6:2837–2840
authority constraints and, 6:2838
capability constraints and, 6:2838
co coupling constraints, 6:2838
environmental issues and, 6:2839
everyday life geographies and, 2:1042–1045
Derek Gregory’s work and, 3:1380
Mei-Po Kwan’s work in, 4:1674
Harvey Miller and, 4:1905
notational systems and, 6:2838–2839, 6:2839 (fig.)
Allan Pred and, 5:2289–2290
time-space compression and, 6:2838
See also Time, geographies of; Time-space compression

Time-space compression, 6:2840–2844
air transportation example of, 6:2842
automobility and, 1:171–175
aviation and, 1:179–182
capitalism and, 4:1936
communication times and, 6:2844
compression term and, 6:2840
derechos term and, 6:2840–2842
contemporary view in, 6:2843–2844
cost-space compression and, 6:2842
distanciation (Giddens) and, 6:2840
evolution of, 6:2842–2843
friction of distance, 6:2841
globalization and technology advances and, 6:2843
inequities in, 6:2843
Internet element in, 6:2844
mobility and, 4:1918–1921
neovisual geographies and, 4:2043
popular culture and, 5:2229–2230
postindustrial perspective on, 6:2843
production of space and, 5:2297–2298
relative/relational space and, 5:2404–2405
space of flows and, 5:2600–2601
spatial and temporal scales of, 6:2840–2842
technocratic views of communication and, 6:2843
transportation speeds example of, 6:2840
urban accessibility and, 6:2843
velocities of transportation and, 6:2841 (fig.)
See also Globalization; Time, geographies of; Time-geography

TIN. See Triangulated Irregular Network (TIN) data model

T-in-O maps, 6:2844–2846
antiquity origins of, 6:2843–2846
biblical mapping and, 1:347, 1:349 (fig.), 3:1461
definition of, 6:2844–2845
Hereford mappa mundi and, 6:2845
model of, 6:2845, 6:2845 (fig.)
symbolism element in, 6:2845
zonal map and, 6:2845
Toal, Gerard, 3:1232
Tobago, 3:1190 (table)
Tobin, James, 4:1805

Tobler, Waldo, 6:2846–2847
academic career of, 6:2846
cartograms and, 1:338
distance decay work of, 2:774
fields of interest of, 6:2846
map animation by, 4:1826, 6:2846–2847
mapping work of, 6:2846
migration work of, 6:2846
Newton’s law and, 4:1802
quantitative revolution and, 6:2846
Tobler, Walter, 1:192, 4:1945
Tornadoes, 6:2848–2849
definition of, 6:2848
eigenhofer and herring's nine-intersection scheme and, 6:2848–2849
examples of, 6:2848, 6:2848 (fig.)
GIS systems accessibility calculations and, 1:5
werner kuhn's work in, 4:1672–1673
projective relationships and, 6:2848
self-organizing maps and, 5:2526–2628
triangulated irregular network (TIN) data model and, 6:2833–2834
Toponymy, 6:2849–2850
disciplines linked to, 6:2850
etymological origins of names research and, 6:2849
Eurocentrism and, 2:1102
Gazetteer and, 3:1185–1186
goecoding and, 3:1208–1209
geography linked to, 6:2849–2850
new applications for, 6:2850
proper names focus of, 6:2849
see also Place names
Topophilia, 6:2850–2851
biophilia and biophobia and, 6:2850
cognitive challenge element in, 6:2851
ecological diversity element in, 6:2850–2851
familiarity element in, 6:2851
geography and environmental psychology intersection and, 6:2850
love of space meaning of, 2:637
spectrum of responses of, 6:2830
synesthetic tendency element in, 6:2851
yi-fu tuan and, 6:2890–2891
Tornadoes, 6:2851–2854
atmospheric circulation explanation of, 1:135–136
conditions for formation of, 6:2852
counter-clockwise rotation of, 6:2852
damage and casualties from, 6:2852–2854
deadliest tornadoes examples and, 6:2854
definition of, 6:2851
eye-warning systems and, 2:760, 6:2854
Enhanced Fujita Scale to rank scale of, 6:2853
first tornado captured by NSSL Doppler radar, Union City, Oklahoma (1973), 6:2853 (photo)
gustnadoes and landspouts nonsupercell tornadoes, 6:2852
mechanisms of, 6:2852
middle latitudes location of, 6:2851
outer-region vs. inner-region tornadoes, 6:2852
regional occurrences and frequencies of, 6:2851
seasonal patterns of, 6:2851
suction vortices and, 6:2852
supercell tornadoes within supercell thunderstorms, 6:2852
three-dimensional numerical studies of, 2:760
urban areas affected by, 2:762
"watch" vs. "warning" notification of, 2:761
waterspout and, 6:2852
Tourism, 6:2854–2860
Stephen Britton and, 6:2857–2859
conceptual models of, 6:2855
consumption geographies and, 2:575
coral reefs and, 2:582–583
Detroit's electronic music festival and, 6:2858 (photo), 6:2859 (photo)
environmental impacts of, 2:953–955
migration, labor market factors and, 6:2959
neo- and post-Fordist tourism, 6:2960
resort morphology model (Pearce) of, 6:2855
Swiss alpine and lake landscapes and, 6:2856
in Switzerland, Hotel Wetterhorn, 6:2855 (photo)
Tourism Geographies journal and, 6:2960
tourism research and, 6:2857–2859
tourist area cycle model (Butler) of, 6:2856–2857
tourist area cycle model of, 6:2857 (fig.)
tourist-historic city model of, 6:2855–2856
See also Ecotourism
Township and range system, 6:2861–2862
cadastral systems and, 1:311–318, 6:2861
elements of, 6:2862 (fig.)
influence of, 6:2862
Thomas Jefferson and, 6:2861
Northwest Ordinance of 1787 and, 6:2861
public domain and, 6:2861
spatial regularity of, 6:2861–2862
township, sections, quarter sections units and, 6:2861
U.S. Public Land Survey System and, 6:2861
Toxic Substance Control Act (1976), 3:1948
Tourism, 6:2863–2866
APEC and, 1:121–122
ASEAN and, 1:126–131
comparative advantage and, 2:556–558
competitive advantage and, 2:558–559
carrier terminal, Victoria Harbor, Hong Kong, 6:2864 (photo)
exchange rates and, 6:2865
export-led development and, 2:1063–1066
export processing zones and, 6:2865
government direct investment (FDI) and, 3:1153–1156
generational effects of, 6:2865–2866
generational patterns in, 6:2863–2864
import substitution industrialization and, 3:1549–1551
most favored nation status and, 4:1948
NAFTA and, 4:2044–2046
newly industrializing countries and, 4:2021–2024
Organization of the Petroleum Exporting Countries (OPEC) and, 4:2097–2100
policy and customs in, 6:2864–2865
quotas and, 6:2865
prices in, 6:2865
trading agreements and, 6:2865
traded materials and, 6:2863
typical gravity model of, 6:2864
See also European Union (EU)
Tragedy of the Commons. See Commons, tragedy of the
Transnational corporation (TNC), 6:2866–2870
benefits of, 3:1154
classic global organizational model and, 6:2868
definition and measurement of, 6:2866–2867
economic autonomy threatened by, 3:1154
evolution of, 6:2867–2868
export processing zones (EPZ) and, 2:1067, 2:1068
factors influencing geography of, 6:2868–2869
foreign direct investment and, 3:1153–1156
impacts of, 6:2869
information technology revolution and, 3:1154
market-oriented production and, 6:2867
NAFTA and, 4:2044
national context factor and, 6:2868
negative influences of, 3:1154
neocolonialism perpetuated by, 4:2004
neoliberal environmental policy and, 4:2008
new international division of labor, 4:2020–2021
organizational structure changes and, 6:2867–2868
outsourcing and, 4:2108–2110
ownership structure factor and, 6:2869
related terms and, 6:2866
sector factor and, 6:2868
supply or cost-oriented production and, 6:2867

Transnationalism, 6:2870–2872
APEC and, 1:121–122
borderlands and, 1:291–292
cosmopolitanism and, 2:591–592
cross-border cooperation and, 2:630–631
definition of, 6:2870
denationalization and, 3:1339
deterriorization and, 3:1340–1341
diaproa and, 2:735
extent and intensity of, 6:2870–2871
globalization process of, 3:1338
globalized networks and, 3:1339–1340
hypermobile migrants and, 6:2871
identity geographies and, 3:1527–1531
immigration and, 3:1542–1545
September 11, 2001, attacks and, 6:2871
terms related to, 6:2870
transnational elites and, 6:2871
“transnationalism from below” and, 6:2870
See also European Union (EU)

Transportation geography, 6:2872–2877
accessibility/mobility distinctions in, 6:2873–2874
aggregate vs. disaggregate approaches to, 6:2874
air transportation studies and, 6:2876
automobile studies and, 6:2875–2876
automobility and, 1:171–175
aviation and, 1:179–182
commuting and, 2:553–555
Corinth Canal, Greece, 6:2873 (photo)
economy, environment and sustainability issues in, 6:2875
environmental impacts of roads and, 2:951–953
freight industry studies and, 6:2876
geographical patterns of economic activity and, 2:851
information and communication technologies and, 2:539
Mei-Po Kwan’s work in, 4:1674
Harvey Miller and, 4:1905
mobility and, 4:1918–1921
mobility vs. mobilities and, 6:2874
modes and intermodalism focus in, 6:2873–2876
network analysis and, 4:2016–2018
network data model and, 4:2018–2019
Panama Canal, 5:2254
passenger and freight movement and, 6:2872–2873
public vs. private dimensions of, 6:2874–2875
railroads and, 6:2876
shipping industry, containerization and, 6:2876
Suez Canal, 5:2254
time-space compression and, 2:539
See also GIS in transportation

Trap streets, 6:2877–2878
Alexandria Drafting Co. v. Amsterdam and, 6:2877
copyright infringement lawsuits and, 6:2877
definition of, 6:2877
“editing the competition” concept and, 6:2877

Travel writing, geography of, 6:2878–2880
al-Idrisi, medieval geographer and, 1:66–67, 4:2179
“contact zones” and, 6:2879
“empty” spaces, 6:2879
Alexander von Humboldt, 3:1462, 3:1482, 3:1484
Ibn Khaldún, 3:1520–1521, 4:2179
Marco Polo, 6:2878 (image)
George Perkins Marsh, 4:1859
Tom L. Mc Knight, 4:1873
Pictures From Italy (Chares Dickens, 1846) and, 6:2879 (image)

Tree farming, 6:2880–2882
benefits of, 6:2881
boreal forest biome and, 1:214–217
casuarinas in dunes, Zululand, South Africa, 6:2881 (photo)
commercial timber industry and, 6:2880
debates and controversies, 6:2882
functions of, 6:2880
history of, 6:2880–2881
plantation forestry term and, 6:2880
slash pine plantation, Georgia (U.S.), 6:2835 (photo)

Trewartha, Glenn, 6:2882–2883
population geography work of, 5:2245–2246, 5:2247, 6:2882–2883
regional geography of Japan work of, 6:2883
settlement geography work of, 5:2536, 5:2537
weather and climate work of, 6:2882–2883

Triangulated Irregular Network (TIN) data model, 6:2883–2884
functions of, 6:2884
implementation of, 6:2883–2884
linear referencing and dynamic segmentation and, 4:1784–1785
terrain surfaces and, 6:2883
topology structures and, 6:2883
triangles element in, 6:2883

Tricart, Jean, 2:617
Trinidad, 3:1190 (table)

Troll, Carl, 6:2884–2885
accomplishments of, 6:2884–2885
high-mountain geography work of, 6:2884
landscape ecology term and, 3:1458, 4:1705, 4:1714, 6:2884–2885
service work of, 6:2885

Tsunami, 6:2885–2888
earthquakes and, 2:812–813
geography of and warning systems for, 6:2886–2887
mechanics of, 6:2885–2886
Pacific Tsunami Warning Center and, 6:2886
prehistoric tsunamis and, 6:2887
tsunami deposits, Maggie Kettle’s Loch, Sullom Voe, Shetland Isles, 6:2888 (photo)
tsunami early warning buoy and, 2:760 (photo)
word derivation and, 6:2885
See also Tsunami of 2004, Indian Ocean

Tsunami of 2004, Indian Ocean, 6:2888–2890
death toll of, 2:743, 2:813, 6:2888
devastation caused by, 2:813
differential vulnerabilities and, 2:743
earthquake epicenter and, 6:2890
efforts to avoid devastation and, 1:497
subaltern uneven development and, 6:2902
subnational regional scales and, 6:2901
world-systems theory and, 6:2900
See also Gross domestic product/gross national product
(GDP/GNP)
Uniformitarianism, 3:1245, 4:2179–2180
Union Carbide, 1:194–195
See also Bhopal, India, chemical disaster
Union of Concerned Scientists, 1:196
Union of Soviet Socialist Republics (USSR). See Russia; Soviet Union
United Arab Emirates
economically active females in, 3:1190 (table)
OPEC membership of, 4:2099, 4:2100 (fig.)
United Kingdom
acid rain in, 1:7
agglomeration economies in, 1:32
AGILE membership of, 1:125 (table)
Anglocentrism of, 1:2030 (table)
as archipelago island formation, 1:105
automobile industry in, 1:169, 1:171
automobility in, 1:172
biotechnology industry in, 1:280
British Association for the Advancement of Science (BA), 3:1601
British National Grid coordinate system and, 2:579
brownfield redevelopment in, 1:298
brownfields redevelopment in, 1:298
business geography university departments in, 1:305
carbon or climate change taxes in, 4:1857
Changing Urban and Regional System (CURS) program in, 4:1790–1791
coastal dead zones and, 1:488
commuting studies in, 2:554
competitive advantage areas in, 2:558
critical human geography in, 2:620
deindustrialization in, 2:700
designer drug use in, 2:799
digital ground model and, 2:753
drug substitution programs in, 2:799
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
Economics and Social Research Council and, 4:1790
energy policies in, 2:902
environmental issues in, 2:1034
European Union (EU) membership of, 2:1035
GDP of, 3:1382, 3:1383 (fig.)
GIS pioneering in, 3:1283
greenbelts in, 3:1363–1364, 3:1365 (fig.)
green building programs in, 3:1368–1369, 3:1371
Green Party in, 2:1034
hate groups in, 3:1407
health inequities in, 3:1411
herbicide-tolerant crops in, 1:279
heroin parks in, 2:799
housing policy in, 3:1447, 3:1448
hydroelectricity installed in, 3:1506
incubator zones in, 3:1552
industrial studies in, clusters and, 1:480
Kyoto Protocol of 1997 and, 1:463
London, airline networks, 1:179
London, cholera distribution in, 1:355, 1:401–402
London, command and control economy in, 1:304
London, crime studies, 2:607
London, Kensal House modernist architecture, 1:108
London, “killer smog” in, 1:69, 1:70
London, Mayday Monopoly protests and, 1:100
London, St. Paul’s Cathedral and, 1:107
military expenditures in, 4:1898, 4:1899 (table)
mixed farming in, 4:1915, 4:1917
mobile phone-based location services standards in, 3:1256
Network of GMO Free Regions in, 3:1610
Ordnance Survey map, England, 1:354, 1:354 (fig.)
protests, Catholic and Protestant neighborhoods, Belfast, Ireland, 5:2525 (photo)
public-private partnerships in, 5:2312
public urban water systems in, 5:2316
redistricting in, 5:2376–2377
regional environmental planning in, 5:2384
regional governance in, 5:2390–2391
social class studies in, 1:418
soil erosion in, 5:2585
Sustainable Livelihoods Framework, of environmental entitlements in, 2:924
total factor productivity (TFP) of, 6:2780 (table)
2008 financial crisis and, 2:691
UK Woodlands Assurance Scheme and, 4:2024
U.S. cultural geography
urban village movement (Prince Charles) in,
UK Woodlands Assurance Scheme and,
Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries and, 3:1165
Conference on the Human Environment and, 2:1003, 3:1604, 62747
Conference on the Law of the Non-Navigational Uses of International Watercourses and, 3:1619
Conference on the Law of the Sea and, 4:2069
Conference on the Prevention and Punishment of the Crime of Genocide and, 3:1199
counter-Eurocentrist movement and, 2:1029
“Declaration on the Granting of Independence to Colonial Countries and Peoples of 1960” and, 3:1534
Declaration on the Rights of Indigenous Peoples and, 3:1544, 3:1569
desertification conferences of, 2:718–719, 2:972–973, 3:1335
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
Economics and Social Research Council and, 4:1790
energy policies in, 2:902
environmental issues in, 2:1034
European Union (EU) membership of, 2:1035
GDP of, 3:1382, 3:1383 (fig.)
GIS pioneering in, 3:1283
greenbelts in, 3:1363–1364, 3:1365 (fig.)
green building programs in, 3:1368–1369, 3:1371
Green Party in, 2:1034
hate groups in, 3:1407
health inequities in, 3:1411
herbicide-tolerant crops in, 1:279
heroin parks in, 2:799
housing policy in, 3:1447, 3:1448
hydroelectricity installed in, 3:1506
incubator zones in, 3:1552
industrial studies in, clusters and, 1:480
Kyoto Protocol of 1997 and, 1:463
London, airline networks, 1:179
London, cholera distribution in, 1:355, 1:401–402
London, command and control economy in, 1:304
London, crime studies, 2:607
London, Kensal House modernist architecture, 1:108
London, “killer smog” in, 1:69, 1:70
London, Mayday Monopoly protests and, 1:100
London, St. Paul’s Cathedral and, 1:107
military expenditures in, 4:1898, 4:1899 (table)
mixed farming in, 4:1915, 4:1917
mobile phone-based location services standards in, 3:1256
Network of GMO Free Regions in, 3:1610
Ordnance Survey map, England, 1:354, 1:354 (fig.)
protests, Catholic and Protestant neighborhoods, Belfast, Ireland, 5:2525 (photo)
public-private partnerships in, 5:2312
public urban water systems in, 5:2316
redistricting in, 5:2376–2377
regional environmental planning in, 5:2384
regional governance in, 5:2390–2391
social class studies in, 1:418
soil erosion in, 5:2585
Sustainable Livelihoods Framework, of environmental entitlements in, 2:924
total factor productivity (TFP) of, 6:2780 (table)
2008 financial crisis and, 2:691
UK Woodlands Assurance Scheme and, 4:2024
U.S. cultural geography
urban village movement (Prince Charles) in,
human right to water, legal contributions supporting, 2:995 (table)
Hyogo Framework of Action (HFA) of, 4:1987
illegal drugs trade and, 2:796
indigenous peoples policy and actions of, 3:1554
intergovernmental organizations and initiatives overseen by, 3:1604
international environmental movements and, 3:1611
international framework for disaster risk reduction and, 4:1987
International Panel on Climate Change of, 2:943–944
Land Cover Classification System (LCCS) of, 4:1740
League of Nations and, 6:2903
Martinez-Cobo Study by, 3:1554
Millennium Ecosystem Assessment and, 2:862–863
Millennium Ecosystem Assessment project (UN) and, 2:1001
narcotics production regulated by, 2:796
New York City headquarters of, 6:2904 (photo)
Office for the Co-ordination of Humanitarian Affairs (UN-OCHA), 2:814
organizations of, 6:2903–2904
peace and security as primary goal of, 6:2904
Peace Palace, The Hague, Netherlands, and, 6:3130 (photo)
Permanent Forum on Indigenous Issues of, 3:1554, 3:1564
political refugees, political asylum and, 3:1545
population growth estimates of, 5:2241
public-private partnerships supported by, 5:2312
recycling of municipal solid waste issue and, 5:2373
technology advances and, 6:2904
UNAIDS and, 3:1436–1437, 3:1437 (fig.)
UN Charter and, 6:2903
UN Convention to Combat Desertification (UNCCD) and, 5:2232, 5:2234
UNESCO World Heritage sites and, 1:216, 4:1705, 4:1716, 5:2406 (photo)
UN Framework Convention on Climate Change (UNFCCC) and, 1:9, 1:462, 2:945, 3:1374, 5:2220, 5:2245, 6:2748–2749
UN Group of Experts on Geographical Names (UNGEGN) and, 5:2189
UN Human Poverty Index (HPI) of, 5:2274
UN International Strategy for Disaster Reduction (UNISDR) and, 4:1987
United Nations High Commissioner for Refugees and, 5:2378–2379
Universal Declaration of Human Rights and, 3:1480
Working Group on Indigenous People of, 3:1554
World Commission on Environment and Development and, 3:1604, 5:2220
world hydroelectricity maps and, 3:1508 (figs.)
World Intellectual Property Organization and, 4:1771
World Summit on Sustainable Development and, 2:1005, 3:1102, 3:1604, 6:2738, 6:2750
world undernutrition and malnutrition estimates of, 3:1487
See also Food and Agriculture Organization (FAO); United Nations Conference on Environment and Development (UNCED); United Nations Educational and Cultural Organization (UNESCO); United Nations Environment Programme (UNEP); World Summit on Sustainable Development
achievements of, 6:2906
Agenda 21, global sustainable development action plan and, 2:914, 2:1004–1005, 6:2737–2738, 6:2746, 6:2747, 6:2748
Agenda 21 action plan of, 6:2906
Brundtland Commission and, 6:2905–2906
criticism of, 6:2749–2750
deresertification issue and, 2:973
Earth Summit term of, 2:981, 2:1004, 6:2747, 6:2748, 6:2907
ecosystem approach to environmental planning and, 2:981
environmental impact statements and, 2:958
global management approach of, 6:2749
Rio Declaration on Environment and Development (the Earth Charter) and, 2:1004
sustainable cities and, 6:2746
sustainable use of natural resources focus of, 6:2905–2906
UN Conference on the Human Environment and, 2:1003, 3:1604, 6:2747
UN Framework Convention on Climate Change (UNFCCC) and, 1:9, 1:462, 2:945, 3:1374, 5:2220, 5:2245, 6:2748–2749
United Nations Educational, Scientific and Cultural Organization (UNESCO)
biosphere reserves recognized by, 1:256
endangered species and, 1:216
Seville Strategy of 1995 and, 1:256
soil classification system of, 5:2592
soil conservation and, 5:2580
World Heritage sites of, 1:216, 4:1705, 4:1716, 5:2406 (photo)
United Nations environmental summits, 6:2906–2907
Earth Summit and, 6:2907
first summit and, 6:2906–2907
functions of, 6:2906
Our Common Future Brundtland Commission report and, 6:2907
World Summit on Sustainable Development (WSSD) and, 2:1005, 6:2738, 6:2750, 6:2907
United Nations Environment Programme (UNEP), 6:2907–2909
accomplishments of, 6:2909
bilateral or multilateral environmental treaties and, 2:967
climate policy and, 1:462
contributors to, 6:2908
creation of, 6:2907–2908
deresertification conferences and, 2:718–719, 2:973
environmental governance role of, 3:1604
environmental policy mandate of, 6:2908
environmental secretariats of, 6:2908–2909
establishment of, 2:1003
funding of, 6:2908
Global Environment Facility (GEF) and, 6:2908
Intergovernment Panel on Climate Change (IPCC) and, 1:82
Millennium Ecosystem Assessment project and, 2:1001
mission of, 3:1604
pesticide deaths data of, 1:53
postwar environmental assessment by, 2:957
regional seas program of, 3:1604
soil conservation focus of, 5:2580
Vienna Convention for the Protection of Stratospheric Ozone and, 1:462
World Conservation Strategy and, 2:1003
World Meteorological Organization and, 1:462
See also Intergovernmental Panel on Climate Change (IPCC)
United States
academic cartography programs in, 1:342
acid rain in, 1:6–7
airline deregulation in, 1:180
airline networks in, 1:179–181
air masses of, 1:63
anthropogeography, Kentucky Appalachians and, 1:93
anticolonialism, antiglobalization and, 1:94–95
antiglobalization, anticollonialism in, 1:97
ANZUS treaty and, 1:505
APEC membership of, 1:121
applied geography academic programs in, 1:101
arms trade in, 4:1902
art tourism in, 1:119, 1:119 (photo)
atmospheric energy variations in, 1:164
automobile industry in, 1:169, 1:170 (fig.)
amobility in, 1:172–174, 1:174 (fig.)
basin and range topography in, 1:186
biofuels produced in, 1:202–203
biotechnology industry in, 1:280–281
brownfield redevelopment in, 1:298
cadastral systems, land ownership and, 1:315
cancer studies of southern-born African Americans and, 1:336
carbon trading and, 3:1486
common resources (water) management with Mexico and,
1:526, 1:527 (fig.)
commuting studies in, 2:554
competitive advantage areas in, 2:558
countering terrorism, human rights violations and, 3:1481
critical human geography in, 2:620
digital divide in, 2:750–751
digital elevation model and, 2:753
drought prone region in, 2:787, 2:791 (photo)
dry climates in, 1:429, 1:430 (fig.)
Eastern Utah desert in, 1:115 (photo)
ecological footprint and biocapacity of, 2:827 (table)
economically active females in, 3:1190 (table)
elderly care and services environments in, 2:878
energy policy of, 2:899–901
environmental history studies in, 2:929
environmental privatization in, 4:2009
ethanol production in, 202
feng shui geomancy in, 3:1239
fixed vs. flexible exchange rates and, 4:1936
foreign direct investment in China from, 3:1155
gated communities in, 3:1181
GDP/GNP of, 3:1382, 3:1383 (fig.)
genetically modified foods in, 3:1198
geocoding methods in, 1:1208
geographical ignorance in, 3:1219, 3:1219 (image)
geopolitics in, 3:1250
geothermal areas in, 3:1273
geothermal energy use in, 1:1267
ghettos in, 3:1275–1277
Great Salt Lake regional basin lowpoint in, 1:114
greenbelts in, 3:1364
house gas emissions of, 1:464, 3:1376 (fig.), 3:1377, 5:2220
“Gunbelt” region of, 4:1902
hardiness zones in, 1:319 (fig.)
hate groups in, 1:1406–1407
health inequities in, 1:1411
heavy industry development in, 3:1584
hegemony in, 3:1420
housing policy in, 3:1447, 3:1448
humid continental climate of, 1:439, 1:440
hunger conceptual debates and, 3:1486
hurricane losses in, 4:1984
hydroelectrical power in, 3:1506, 3:1507
immigration laws of, 3:1545
immigration studies of (W. Clark) and, 1:418
incubator zones in, 3:1552
indigenous reserves and reservations in, 3:1570
industrialization in, 3:1583
industrialized agriculture in, 1:43–47
international criminal court objects of, 3:1606
Internet penetration rates in, 2:750, 2:750 (table)
Kyoto Protocol of 1997 and, 1:463
labor force decline, deindustrialization and, 2:700–710, 2:701 (fig.)
land covers, 1987 census of agriculture, 2:796
manifest destiny, ethnocentrism of, 2:1027
manifest destiny policies of, 3:1222–1223, 3:1223 (fig.)
manufacturing regional areas in, 4:1821–1822
midlatitude deciduous forest in, 1:223–226, 1:224–226
midlatitude grasslands and grasses in, 1:227–228, 1:228 (fig.)
military expenditures in, 4:1898, 4:1899 (table)
“military-industrial complex in, 4:1900
monsoons in (southwestern), 1:134
NAFTA and, 1:121, 1:129, 4:2044–2046
Native American reservations, ethnic segregation and, 2:1022
neocolonialism and, 4:2004–2005
neoliberalist policies in global South and, 4:2012–2013
New Historical Atlas of Religion in America (Gausstad and
Barlow) and, 5:2407
New Urbanism movement in, 2:555
oil imports of, 4:2073
organic product certification in, 3:1081
particulate matter pollution in, 1:151
PC user statistics in, 2:750
playas arid topography in, 1:115
political map of, 6:3163
population growth in, 5:2241
population migration and mobility studies in, 1:417–418
population pyramid for, 5:2250 (fig.)
poverty threshold measure in, 5:2274
public land management in, 2:552
public urban water systems in, 5:2316
racialized landscapes in, 5:2342
railroads in, 5:2338–2339, 5:2360 (photo), 5:2361 (fig.)
redistricting in, 5:2375–2376
regional environmental planning in, 5:2386
regional governance in, 5:2391–2392
religious right in, 1:97
social class studies in, 1:418
soil classification system of, 5:2592
soil erosion in, 5:2585
spatial adjustment for river basin conflict resolution with
Mexico and, 1:527 (fig.)
State Plan Coordinate Systems of, 2:579
sustainable forests in, 3:1164
textile exports from, 6:2815 (fig.), 6:2816 (fig.)
time zones established in, 5:2363
total factor productivity (TFP) of, 6:2780 (table)
transnational corporations in, 3:1154
2008 financial crisis and, 2:691
U.K. cultural geography vs., 2:635–636
undernourishment in, 3:1488
university business geography programs in, 1:305, 1:306
university regional science programs in, 1:81
urbanization in, 3:1585–1586
U.S. Agency for International Development (USAID) and, 2:871
U.S./Canada borderlands and, 1:292
U.S. Census decennial map (1870), 1:356, 1:358 (fig.)
Utah’s desert arid topography and, 1:111 (photo)
watershed management in, 6:3072–3073
water stress ratio in, 3:1516
“working poverty” in, 5:2276
Yellowstone National Park in, 3:1273
zero-tolerance zones in, 2:800
See also Foreign aid; United States: maps
United States: maps
average annual rate of domestic net migration by county (2000–2004), 4:1892 (fig.)
bioengineering, centers, 1:281 (fig.)
cropland and free-standing shifts in, 1982–1997, 1:38 (fig.)
developed land increase in, 1992–1997, 1:42 (fig.)
housing ownership, 1900–2000, 4:1965 (fig.)
interstate highway system in, 1:174 (fig.)
kriskogram of interstate migration in, 3:1140 (fig.)
land covers, 1987 census of agriculture, 1:40 (fig.)
land use in, 1:37 (fig.)
large U.S. metropolitan areas and, 4:1887 (fig.)
live-fuel moisture stress, fire potential, 5:2320 (images)
metropolitan segregation levels, 2000, 2:1024 (fig.)
Midwest hub-and-spoke airline network, 1:180 (fig.)
murder rates, possible factors and, 4:1964 (fig.)
murder rates and families in poverty, 4:1965 (fig.)
NATO membership of, 4:2048 (fig.)
net regional U.S. migration (2007), 4:1891 (fig.)
Omaha, Nebraska, African Americans in, 2000, 2:1025 (fig.)
Omaha, Nebraska, poverty in, 2:1026 (fig.)
Omaha, Nebraska, Whites in, 2000, 2:1025 (fig.)
population sizes, Eastern U.S. cities, 2000, 6:2982 (fig.)
radar-estimated accumulated precipitation, 5:2283 (fig.)
railroad network, 5:361
shares of land in major uses, 2002, 1:41 (fig.)
spatial resolution and vector data, counties in the U.S., 5:2661 (fig.)
Sunbelt, 5:2724 (fig.)
2004 presidential election, 2:870 (fig.)
urban geography of carbon footprints, 3:1379 (fig.)
U.S. federal government outlays per capita, 2005, 5:2231 (fig.)
U.S. Gunbelt (2008), 4:1903 (fig.)
visualization of high-risk clusters of cervical cancer in U.S. and, 2:1062 (fig.)
United States Census Bureau, 6:2909–2911
address list update, 2009, 6:2910 (photo)
census tracts and, 1:374
counting racial groups and, 5:2343
decennial Census of Population and Housing (U.S. Census Bureau) and, 1:371–373
digital data files technology of, 3:1283
dual Independent Map Encoding (DIME) GIS data format and, 2:674
GIS automated address matching and, 1:1282
kriskogram of U.S. interstate migration and, 3:1140 (fig.)
largest U.S. metropolitan areas, 2007, 4:1888 (table)
large U.S. metropolitan areas, 2007, 4:1887 (fig.)
metropolitan districts, term, 4:1886
multi-racial census responses and, 5:2343
reference map classification and, 1:340 (fig.)
self-identification and, 5:2343
TIGER data files, geocoding by street address and, 3:1208, 3:1312
urbanized area defined by, 5:2239
U.S. metropolitan population (2000) and, 4:1886 (table)
United States Environmental Protection Agency (EPA). See Environmental Protection Agency (EPA)
United States Geological Survey (USGS), 6:2912–2913
aerial photographs for mapping and, 1:15
digital spectral library of, 4:1954
fumarole, Spirit Lake, Klamath County, Washington, 3:1271 (photo)
Geographic Names Information System (GNIS) digital gazetteer and, 3:1185
Grove Karl Gilbert’s service to, 3:1279
Grand Canyon publications of, 3:1245
Ferdinand Hayden’s survey work for, 3:1409
Landsat satellites co-developed by, 3:1283, 4:1974
landslide data of, 4:1722–1723
mining data from, 4:1911
mudflow damage measurement, Upper Muddy River, Skamania County, Washington, 6:2912 (photo)
National Elevation Dataset and National Hydrography Dataset developed by, 3:1317
nationwide inventory of land cover and land use of, 3:1302
John Wesley Powell’s service to, 3:1409, 5:2277
United States National Climatic Data Center, 3:1125
University Consortium for Geographic Information Science (UCGIS), 6:2913–2914
GISScience research and education priorities of, 3:1286, 3:1287–1288, 3:1288 (table, 4:2165
David M. Mark’s service to, 4:1856
membership of, 3:1286
mission and goals of, 3:1286
Timothy Nyerges’ service to, 4:2055–2056
Donna Pequen’s service to, 4:2165
Unsupervised classification, 6:2914–2915
advantages of, 6:2915
algorithms used by, 6:2915
classifiers of, 6:2914–2915
digital image classification and, 6:2914
digital image classification and, 6:2914
function of, 6:2914
supervised classification and, 5:2725, 6:2914
Unwin, David, 6:2915–2916
academic career of, 6:2915
computing/GIS work of, 6:2915–2916
quantitative geography work of, 6:2915–2916
teaching work of, 6:2915
Unwin, Raymond, 3:1363
Urban and regional development, 6:2916–2921
built environment and, 1:298–300
"economies of speed," 5:2362
future directions, 6:2920–2921
growth machine politics and, 3:1390
growth poles and, 3:1391–1392
inequality geographies and, 3:1589
informal economy and, 3:1590–1592
interregional commerce affected by, 5:2362
Interstate Commerce Act (1887) and, 5:2362
land grants and, 5:2362
markets expansion and, 5:2362
origins of, 6:2916–2918
railroads and, 5:2362
regeneration of urban landscapes and, 1:420, 1:422
urban governance and growth machine, urban regimes and regulation theory in, 6:2919–2920
urban population densities and, 5:2239–2240
Urban and regional planning, 6:2922–2925
Cities and Complexity (Batty) and, 1:187
history of, 6:2922
landscape architecture and, 4:1698–1701
participatory planning and, 4:2126–2129
process of, 6:2924
regional planning and, 6:2923–2924
Urban Modeling (Batty) and, 1:187
urban planning and, 6:2922–2923
Urban ecology, 6:2925–2927
eyearly developments in, 6:2925
future trends in, 6:2927
human ecology role in, 6:2925–2926
urban environmental services and, 6:2926
Urban environmental studies, 6:2927–2933
atmospheric pollution and, 1:151, 1:152, 1:153
photochemical smog and, 4:2171–2173
urban air pollution and, 6:2931
urban climate and air quality in, 6:2929–2930
urban environmental sustainability and, 6:2932
urban landscapes and, 6:2928–2929
urban population density and, 5:2239–2240
urban vegetation and, 6:2932
urban water and, 6:2931
Urban gardens, 6:2933–2935
above-ground park, Tokyo, Japan, 6:2934 (photo)
beneﬁts of, 6:2933
careeristics of, 6:2933
definition of, 6:2933
human well-being and, 6:2933–2934
lack of information on, 6:2934
landscape design and, 4:1703–1705
neighbor mimicry effect and, 6:2934
threats to, 6:2934–2935
variations in, 6:2933
Urban geography, 6:2935–2942
aerial view of Chicago, 6:2937 (photo)
behavior and humanist perspectives on, 6:2938
Brian Berry’s work and, 1:193, 3:1466
closed-circuit television systems in cities and, 2:541
gated communities and, 3:1181–1183
gentrification and, 3:1203–1208
ghettos and, 3:1275–1277
Jean Gottmann’s work in, 3:1355–1357
Homer Hoyt’s work and, 3:1448–1450
information and communication technologies and, 2:539
law geographies and, 4:1766
megacities (Gottmann) and, 3:1355–1356
metropolitan areas and, 4:1886–1888
new urbanism and, 4:2024–2027
origins and growth of, 6:2935–2938
“post-al” encounters in, 6:2939–2941
radical turn in, 6:2938–2939
rank-size rule and, 5:2365
regeneration of urban landscapes and, 1:420, 1:422
social justice geographies and, 4:1644
urban density and, 5:2239–2240
urban migration and, 5:2232
urban green space, 6:2942–2946
in Auckland, New Zealand, 6:2943 (photo)
ecology in and of cities and, 6:2942–2943
engineered urban green space, 6:2944–2945
environmental services and, 6:2944
future of, 6:2946
greenbelts and, 3:1363–1367
health and well-being and, 6:2945
landscape design and, 4:1703–1705
negative perceptions, 6:2945–2946
social and cultural services and, 6:2945
wildlife corridors in Wandsworth, southwest London and Central Park, 6:2944 (photo)
Urban heat island (UHI), 6:2946–2949
air, surface, and underground locations of, 6:2946
construction materials factor in, 6:2948
description of, 6:2946
global warming and, 6:2948
hot rooftops, Baton Rouge, Louisiana, 6:2947 (image)
human and natural systems affected by, 6:2947–2948
latent heat exchange element in, 6:2948
nocturnal UHIs and, 6:2948
in small towns, 6:2948
urban climatology advances and, 6:2948
Urban Heat Island Pilot Project and, 6:2947 (image)
Urban hierarchy, 6:2949–2951
Brian Berry’s work and, 1:193
central place theory and, 1:380–382
challenges faced by, 6:2951
Walter Christaller’s central place theory and, 1:409–410, 5:2393
degree of primacy and, 6:2950–2951, 6:2951 (fig.)
economic development and, 6:2950, 6:2950 (fig.)
globalization and, 6:2951
Atsuyuki Okabe and, 4:2076–2077
population, settlements, and services in, 6:2949–2950, 6:2949 (fig.)
primate cities, 5:2290–2291
rank-size rule and, 5:2365
urban population sizes and, 6:2949
Urbanization, 6:2952–2958
future trends in, 6:2956–2957
global trends in, 6:2954–2956, 6:2955 (fig.), 6:2956 (table)
Jean Gottmann’s work in, 3:1355–1357
Industrial Revolution and, 3:1582–1586
measurement of, 6:2953–2954
megacities and, 6:2957 (table)
megacities (Gottmann) and, 3:1355–1356
selected size group of cities and, 6:2956 (table)
uneven growth between more- and less developed regions and, 6:2955 (fig.)
urban evolution and, 6:2952–2953
urban migration and, 5:2232
Urban land use, 6:2958–2963
application of models in, 6:2961–2963
central business districts (CBDs) and, 1:379–380
commuting and, 2:553–555
concentric zone model in, 6:2959, 6:2960 (fig.)
economic competition and accessibility and, 6:2958, 6:2958 (fig.)
global environmental change and, 3:1336
models of, 6:2959–2961
monocentric model of urban form and, 5:2236–2237
multiple-nuclei, 6:2960 (fig.), 6:2961
peripheral model of, 6:2961, 6:2962 (fig.)
regeneration of urban landscapes and, 1:420, 1:422
sector model in, 6:2959–2961, 6:2960 (fig.)
urban heat island effect and, 3:1336
urban land use regulation and, 4:1727
urban population densities and, 5:2239–2240
Urban metabolism, 6:2963–2967
environmental impacts of cities and, 2:940, 2:941
factors influencing, 6:2966
Hong Kong, 6:2964 (table)
indicator of sustainability in, 6:2964–2966
linear and circular patterns of, 6:2965 (fig.)
Urban planning and geography, 6:2967–2972
cellular automata used in, 1:370, 1:371 (fig.)
growth machine politics and, 3:1390
information and communication technologies and, 2:539
integration of, 6:2971
multiple dimensions of, 6:2970 (fig.)
new urbanism and, 4:2024–2027
participatory planning and, 4:2126–2129
planning in, 6:2970–2971
population of major world cities and, 6:2969 (fig.)
regeneration of urban landscapes and, 1:420, 1:422
UN estimates, total world and urban population, 1990–2030,
6:2967 (table), 6:2968 (fig.)
urban geography and, 6:2967–2970
urban political ecology and, 1:425
urban population densities and, 5:2239–2240
See also Architecture and geography
Urban policy, 6:2972–2977
developing world approaches to, 6:2976–2977
growth machine politics and, 3:1390
Keynesian influence on, 6:2973–2974
law geographies and, 4:1766
national differences in, 6:2972–2973
neoliberal influence on, 6:2974–2976, 6:2976
public housing and, 5:2303–2304
Urban solid waste management, 6:2978–2981
environmental impacts of, 2:941–942
facilities of, 6:2980
informal sector in, 6:2979–2980
landfills and, 4:1684–1686
locally unwanted land uses (LULUs) and, 4:1792
policy tools of, 6:2980–2981
recycling of municipal solid waste and, 5:2372–2375
waste generation and composition in, 6:2978–2979
waste hierarchy and integrated waste management in, 6:2979
waste incineration and, 6:3048–3049
Urban spatial structure, 6:2981–2987
automobility and, 1:172–175
Brian Berry’s work and, 1:193
central business districts (CBDs) and, 1:379–380
Chicago School models of, 6:2985 (fig.)
Cities and Complexity (Batty) and, 1:187
concentric zone model of, 6:2984, 6:2985 (fig.)
diversity, spatial specialization, and urban futures of, 6:2986–2987
economic functions in, 6:2981–2982
environmental settings impact in, 6:2982–2983
filtering process and, 3:1110–1111
gentrification and, 3:1203–1208
ghettos and, 3:1275–1277
Homer Hoyt’s work and, 3:1448–1450
information and communication technologies and, 2:539
intra-urban spatial structure models of, 6:2983–2986
metropolitan areas and, 4:1886–1888
multiple-nuclei model of, 6:2985 (fig.), 6:2986
new urbanism and, 4:2024–2027
patterns of interurban spatial structure and, 6:2981–2983
patterns of intra-urban spatial structure and, 6:2983
population sizes of Eastern U.S. cities, 2000 and, 6:2982 (fig.)
regeneration of urban landscapes and, 1:420, 1:422
sector model of, 6:2984–2986, 6:2985 (fig.)
urbanization in the United States and, 6:2983
Urban Modeling (Batty) and, 1:187
urban population densities and, 5:2239–2240
Urban sprawl, 6:2987–2990
automobility and, 1:172–175
central business districts (CBDs) and, 1:379–380
commuting and, 2:553–555
counterurbanization and, 2:596–597
drums and, 2:1074–1076
Jean Gottmann’s work in, 3:1355–1357
greenbelts and, 3:1363–1367
megapolis (Gottmann) and, 3:1355–1356
metropolitan areas and, 4:1886–1888
monocentric model of urban form and, 5:2236–2237
new urbanism and, 4:2024–2027
in San Gabriel mountains, Los Angeles County, California,
6:2989 (photo)
San Jose, California, 6:2988 (photo)
smart growth and, 5:2250–2251
Urban storm water management, 6:2990–2993
best management approaches to, 6:2991
combined sewer overflow (CSO) and, 6:2991
current approaches of, 6:2991–2992
in developing countries, 6:2992
drains in Pierene, Turkey, 6:2991 (photo)
early examples of, 6:2990
failure factors in, 6:2990
flood risk management and, 6:2990
green roof example of, 6:2991
integrated approach to, 6:2992–2993
unpredictability of surface water flows and, 6:2990
varying precipitation levels factor in, 6:2990–2991
Urban sustainability, 6:2993–2997
agenda in, 6:2993–2994
practice of, 6:2995
research perspective on, 6:2996–2997
U.S. Postal Service green roof, New York City, 6:2995 (photo)
Urban underclass, 6:2997–2999
culture of poverty and, 6:2998
definition of, 6:2997
ghettos and, 3:1275–1277
David Harvey and, 6:2998
increase in, 6:2997–2998
informal economy and, 3:1590–1592
level and intensity issues, 6:2998
Gunner Myrdal and, 6:2997
neoliberalization and globalization causes of, 6:2998
as neutral descriptor, 6:2997
racial and class associations of, 6:2997
service jobs factor and, 6:2997–2998
as stigmatization term, 6:2997
term controversy and, 6:2997
underclass behavior and, 6:2998
welfare system dysfunction and, 6:2998
William Julius Wilson and, 6:2997
Urban water supply, 6:2999–3002
contemporary political economies of water and, 6:3001–3002
environmental impacts of, 2:942
public water services and, 5:2315–2319
technology, engineering, and urbanization of, 6:2999–3000
water delivery organization in, 6:3000–3001
See also Groundwater
Urlrich, Roger, 4:1716
Uruguay, economically active females in, 3:1190 (table)
Usability of geospatial information, 6:3002–3004
legal aspects of geospatial information and, 4:1770–1772
metadata and, 4:1885
See also Geospatial industry; Geospatial semantic web; Legal aspects of geospatial information; Privacy and security of geospatial information
U.S. Board of Geographic Names, Geographic Names Information System (GNIS) digital gazetteer and, 3:1185
USDA. See U.S. Department of Agriculture (USDA)
U.S. Department of Agriculture (USDA)
agricultural biotechnology regulated by, 1:34
agricultural land protected by, 1:42–43
cropland and forestland shifts, 1:37 (fig.)
developed land increases and, 1:42 (fig.)
Economic Research Service of, 1:37–38 (figs., table)
Natural Resources Conservation Service (NRCS) and, 3:1303, 3:1303 (photo)
soil survey digitization and, 3:1303, 3:1303 (photo)
U.S. Department of Transportation, 3:1312
U.S. Environmental Protection Agency (EPA).
See Environmental Protection Agency (EPA)
U.S. General Accounting Office, 2:986
USGS. See United States Geological Survey (USGS)
USSR. See Russia; Soviet Union
Utah
Bingham Canyon copper mine and, 4:2086
fluvial erosion, Canyonlands National Park, 4:1691
Great Salt Lake and Bonneville Salt Flats in, 3:1549
Lake Bonneville, Bonneville Salt Flats in, 1:186
normal fault, Basin and Range Province in, 3:1086
Promontory Point, Union Pacific and Central Pacific lines and, 5:2338
Uzbekistan
Collective Security Treaty Organization (CSTO) membership of, 2:536
Commonwealth of Independent States (CIS) membership of, 2:536 (table)
economically active females in, 3:1190 (table)
GUAM Organization for Democracy and Economic Development co-founded by, 2:538
HIV/AIDS in, 3:1438

Vagueness in spatial data, 6:3005–3007
core and boundary problem in, 6:3005
fuzzy minimum bounding rectangle (FMBR) and, 6:3006
fuzzy sets and, 6:3005
geometrical orientation relationships and, 6:3006
indiscernibility relation and, 6:3006–3007
spatial database definition and, 6:3005
spatially related properties and, 6:3006
spatial region descriptions and, 6:3005
spatial relationships and, 6:3006–3007
topological relationships and, 6:3006
uncertainty and, 6:3005
Van Agtmael, Antoine, 2:890
Vance, James, 6:3007–3008
academic career of, 6:3007
central place theory and, 6:3008
“the city of the realms” spatial model of, 6:3008
geography theory contributions of, 6:3007
mercantile model of, 6:3008
textbooks written by, 6:3007
urban, historical, and transportation work of, 6:3007–3008
Vandermeer, John, 1:54
Varenius, 6:3008–3009
chorology and, 1:404, 3:1461–1462
Geographia Generalis written by, 1:404, 3:1461–1462, 4:2179, 5:2387
graphy subdivisions views of, 4:2179
physical geography term and, 4:2179
specific vs. general geography and, 3:1462, 4:2179, 5:2387
Varnes, D. J., 4:1720
Vectorization, 6:3009–3010
definition of, 6:3009
GIS software programs and, 6:3009
line modeling, spaghetti modeling and, 6:3009
raster data processed using, 6:3009–3010
terms related to, 6:3009
vectorization terms and, 6:3009
Venables, Anthony, 5:2395
Venezuela
economically active females in, 3:1190 (table)
oil sources in, 4:2163
OPEC membership of, 4:2099, 4:2100 (fig.)
tropical deciduous forest in, 1:231
tropical rain forest of, 1:234
tropical savanna in, 1:239, 1:241
U.S. foreign aid to, 3:1151
Venturi, Robert, 5:2264
Vernacular landscapes as expressions of environmental ideas, 6:3010–3012
examples of, 6:3011–3012
landscape architecture and, 4:1698–1701
landscape interpretation and, 4:1713–1715
tulip field, typical Dutch setting and, 6:3011 (photo)
Vernon, Raymond, 3:1154, 5:2296
Via Campesina (International Farmers’ Movement), 6:3013–3014
agrarian reform activism of, 6:3014
alternatives developed by, 6:3014
dramatic anticorporate actions of, 6:3013
GM campaign of, 6:3013
human rights campaigns of, 6:3014
International Federation of Agricultural Producers (IFAP) and, 6:3013
issues addressed by, 6:3013
as land reform example, 4:1695
Movimento Sem Terra (MST) and, 4:1948
nongovernmental organizations and, 6:3013
peasant movements and, 6:3013
rural social movements and, 6:3013
transnational regional agrarian coalitions and, 6:3013
Victoria Falls, Africa, 2:1057
Vidal de la Blache, Paul, 6:3014–3015
chorology work of, 1:404, 3:1465
Henry Clifford Darby influenced by, 2:664
environmental determinism views of, 1:404, 3:1464, 5:2387
environmental possibilism and, 3:1464, 5:2387
as father of French Geography, 3:1465
Lucien Febvre and, 3:1090, 3:1465
French Annales School of history and, 1:79–80, 3:1465
Jean Gottmann and, 3:1335
Alfred Hettner influenced by, 3:1423, 3:1465
human ecology in geography work of, 3:1458
John Brinkerhoff Jackson influenced by, 4:1641
natural and human landscapes as inseparable view of, 2:640, 4:1989, 5:2387
organic analogies of the Earth views of, 2:667
Élisée Reclus and, 5:2372
society and nature as focus of geographic study and, 2:640
spatial theory work of, 3:1355
Video games, geography and, 6:3015–3016
controversy, 6:3016
early games and, 6:3016
video game industry geography and, 6:3016
Web-based games and, 6:3016
“world-hood” or “spatiality” features of, 6:3015
World War II flight simulators origin of, 6:3016
Vietnam
  anticolonialism in, 1:194
  APEC membership of, 1:121
  ASEAN membership of, 1:128 (table), 1:129 (table)
  Cambodian incursion by, 1:130
  clothing exports from, 6:2186 (fig.)
  Cold War and, 1:504, 1:505
  collectivized farming in, 2:543
  COMECON membership of, 2:593 (table)
  domino theory and, 2:787, 3:1224
  economically active females in, 3:1190 (table)
  economic restructuring in, 5:2460
  French colonization of, 1:515, 1:516
  guerrilla conflicts in, 2:692
  HIV/AIDS in, 3:1438
  independence of, 1:517
  Japanese electronics industry in, 2:885–886
  marine aquaculture in, 4:1854, 4:1854 (fig.)
  peasant farmer carrying straw, Hoi An, 4:2138 (photo)
  textile exports from, 6:2816 (fig.)

Viewshed analysis, 6:3016–3018
  calculation and analysis techniques and, 6:3017–3018
  definition of, 6:3016
  as form of geographical analysis, 6:3016–3017
  raster-based GIS operation and, 6:3017
  sample of, 6:3017 (fig.)
  structure of calculated viewsheds and, 6:3017–3018
  visibility analysis and, 6:3016
  Viking exploration, 2:1051–1053, 2:1052 (fig.)
  Virgil, 5:2584

Virilio, Paul, 6:3018–3019
  culture of speed and, 6:3018
  geography as product of warfare views of, 6:3018
  military technology and, 6:3018
  postmodern capitalism, time-space compression and, 6:3019
  social and spatial change theory and, 6:3018
  state as “means of destruction” and, 6:3018
  telecommunications and, 6:3018–3019
  tyranny of constant speed views of, 6:3019

Virtual and immersive environments, 6:3019–3021
  authenticity of virtual worlds and, 6:3019–3020
  cyberspace and, 2:646–648
  examples of, 6:3019, 6:3020
  Google Earth and, 3:1332–1335
  massively multiplayer online role-playing games and, 6:3020
  meaning of geography in, 6:3021
  Second Life example of, 6:3019, 6:3020–3021
  universities and, 6:3021
  virtual environment definition and, 6:3019
  virtual worlds and, 6:3020–3021

Virtual geographies, 6:3022–3023
  collaborative virtual worlds and, 6:3022
  communication technology advances and, 6:3022
  computer and video games and, 6:3022
  cybergeography term and, 6:3022
  cyberspace term and, 6:3022
  definition of, 6:3022
  digital landscapes and, 6:3022
  individual Web sites and, 6:3022
  information and communication technologies (ICTs) and, 6:3022
  networked virtual geographies and, 6:3022
  new notions of space and place, 6:3022
  Second Life example of, 6:3022
  sense of immersion of, 6:3022

virtual term and, 2:540
  Web-mapping applications and, 6:3022–3023
  Virtual globes, 6:3023–3025
  client-server architecture and, 1:426
  examples of, 6:3023–3024
  geobrowsers and, 6:3023
  geospatial content in, 6:3024–3025
  global representation of data sets type of, 6:3024
  Google Earth and, 3:1332–1335, 6:3024
  history and popularization of, 6:3023–3024
  mirror of the real world type of, 6:3024
  NASA World Wind and, 6:3024
  Snow Crash and, 6:3023
  types of, 6:3024
  Virtual Reality Modeling Language (VRML) and, 6:3023
  WebEarth open-source VRML application and, 6:3023

See also Google Earth

Vision and geography, 6:3025–3027
  art and geography, 1:118–120
  blindness and geography and, 1:286–287
  Dennis Cosgrove and, 6:3025
  Michel Foucault and, 6:3026
  gaze and, 6:3026
  iconography and, 6:3025–3026
  Lacanian film theory and, 6:3026
  ontology and, 6:3025
  photography and, 4:2176–2178
  poststructuralist theory and, 6:3026
  Gillian Rose and, 5:2484–2485, 6:3026
  social construction of landscape and, 6:3025
  technology advances and, 6:3026
  Vogel, Hermann Carl, 4:2113

Volcanic eruptions as risk and hazard, 6:3027–3029
  assessment of, 6:3027
  atmospheric hazards and, 6:3027–3028
  hazard maps of volcanoes and, 6:3027
  holistic volcano assessments and, 6:3028
  Mount Pinatubo’s eruption, Philippines, 1991 and, 6:3028 (photo)
  sulfur dioxide hazardous material and, 6:3028
  topography of areas near volcanoes and, 6:3027
  volcanoes’ functions and, 6:3027
  volcanoes near large cities and, 6:3028

See also Volcanoes

Volcanoes, 6:3029–3033
  aa lavas and, 6:3029
  aseismic creep and, 2:605
  barrier reefs and, 2:583
  Big Island of Hawai‘i, 4:1688
  bennocks and, 6:3029
  caldera, 6:3030–3031
  carbon cycle and, 1:327, 1:328
  cinder cones, 6:3029
  climate change factor of, 1:461
  composite volcanoes and, 4:1687
  fall deposits and, 6:3029
  fringing reefs and, 2:583
  global sea-level rise and, 3:1345
  Great Rift Valley, East Africa, 6:3029
  Hawaiian island volcanic chain and, 4:1688–1689
  hazards of, 6:3032
  hot spot volcanoes, 4:1687–1688
  igneous rocks classification and, 6:3029
  landforms formed by, 4:1687–1689
  lava domes, 6:3029
  Long Valley Caldera, California, 4:1688
low islands and atoll structures and, 3:1635–1638, 3:1636 (photo), 3:1637 (photo)
magma and, 6:3029
magma intrusion and, 6:3029
mass wasting processes on Hawaiian Islands and, 4:1689
monitoring networks and, 6:3032
morphology of, 6:3030–3032
natural resources from, 6:3032
Pacific Ring of Fire and, 3:1273
pahoehoe morphological features and, 6:3029
paleoclimatology and, 1:471–472
teleteconics and, 5:2195–2199
rift zone volcanism and, 4:1688
scenic landscapes of, 6:3032
shield volcanoes, 6:3029–3030
solar radiation affected by, 1:163
stratovolcanoes, 6:3030
subtle volcanoes, 4:1688
thermal features and, 3:1273
tephra fragmented material and, 6:3029
types of eruptions and, 6:3029–3030
Volcanic Explosivity Index (VEI) and, 6:3029
volcanism and, 6:3029
wasting processes and, 4:1689
Yellowstone caldera and, 4:1688 (fig.)
See also Volcanic eruptions as risk and hazard

Volcanoes: specific eruptions
El Chichon (1982), 3:1345
Mt. Etna, 2:605
Mt. Krakatau (1883), 1:163, 3:1345
Mt. Mazama (6800 BC), 6:3032
Mt. Tambora (1815), 1:461, 3:1345
Voltaire, 4:1928
Von Bertallanfy, Ludwig
general systems theory of, 1:403, 2:560
Vonder Haar, T. H., 1:160
von Herder, Johann Gottfried, 3:1143
von Thünen, Johann, 3:1144, 3:1628, 4:1728, 5:2433
See also Thünen model

Voronoi diagrams, 6:3033–3035
applications of, 6:3034–3035, 6:3034 (fig.), 6:3035 (fig.)
cellular automata use and, 1:370
coordinate transformations and, 2:580–581
Delunay triangulation and, 6:3033, 6:3033 (fig.), 6:3034, 6:3034 (figs.)
Encyclopedia of Voronoi Diagrams (Okabe) and, 4:2076
example of, 6:3033 (fig.)
map generalization and, 4:1837, 4:1839, 4:1840 (fig.)
Atsuyuki Okabe and, 4:2076–2077
properties of, 6:3033–3034

Vulnerability, risks, and hazards, 6:3036–3039
differential vulnerability and, 2:742–744
gender and environmental hazards, 3:1186–1188
hazards and, 6:3036
hazards and vulnerabilities of megacities and, 6:3038–3039
hazards and vulnerabilities of place, 6:3038–3039
landslides and, 4:1720–1723
lightning and, 4:1779–1783
natural and technological hazards and, 6:3036–3037
natural hazards and risk analysis and, 4:1983–1989
remote sensing in disaster response and, 5:2424–2428
resilience and, 6:3038
risks and, 6:3037
social vulnerability and, 6:3038
vulnerability and, 6:3038
wildfires, Southern California, 2007 and, 6:2037 (photo)
See also Disaster preparedness

Wackernagel, Mathis, 2:828
Walby, Sylvia, 4:2136
Wald, L., 3:1533
Waldorf, Brigitte, 5:2393

Waldseemüller, Martin, 6:3041–3043
American on map of, 6:3041, 6:3042 (fig.)
Carta Marina of, 6:3043
human geography work of, 3:1461
Ptolemy’s maps and, 6:3041
Matthias Ringmann and, 6:3041
“Terra Nova” term and, 6:3043
Amerigo Vespucci’s discoveries and, 6:3041

Wales
coal energy source in, 3:1582
solid waste collection in, 5:2373
Walker, Gilbert, Sir, 2:887, 2:888

Walker, Richard, 6:3043–3044
American suburbanization work of, 6:3043
books written by, 6:3043–3044
economic geography work of, 6:3043–3044
David Harvey and, 6:3043
historic development of California work of, 6:3044
Marxist geographies and, 3:1467, 6:3043
urban division of labor work of, 4:1863

Wallace, Alfred Russell, 1:199
lattitudinal biodiversity gradient explained by, 1:198
Malay Archipelago and, 1:106, 1:107
social Darwinism and, 5:2211
social justice advocacy of, 5:2211
theory of evolution via natural selection and, 1:199, 2:916, 5:2211
Wallerstein, Immanuel, 3:1419

Walsh, Edmund, Fr., 3:1250

War, geography of, 6:3044–3048
analytical approaches to, 6:3046–3047
environmental impacts of war and, 2:955–957
environmental matrix and, 6:3045
environmental matrix of, 6:3045, 6:3046 (fig.)
evolution of, 6:3047–3048
framework defined for, 6:3044
genocide geographies and, 3:1199–1202
military geography and, 4:1896–1897
military operations environment and, 6:3044–3045
military spending and, 4:1898–1905
scales of analysis in, 6:3045–3046

Warren, D. Michael, 3:1557
Warren, Stephen, I:479

Washington, D.C.
carbon footprint of, 3:1377–1378
megacities element of, 3:1355–1356
Washington (state)
Easton Glacier in, 3:1331 (photo)
erosion in wheat field, 5:2584 (photo)
fumarole, Spirit Lake, Kamania County, 3:1271 (photo)
Lyman Glacier in, 3:1329 (photo)
mass wasting, Mount Rainier National Park, 4:1870 (photo)
nuclear weapons site in, 5:2469
USGS mudflow damage measurement, Upper Muddy River, Skamania County, 6:2912 (photo)
Water degradation, 6:3048–3049
anti-incinerator arguments and, 6:3049
benefits of, 6:3048
definition of, 6:3048
first incinerator and, 6:3048
first waste-to-energy plant and, 6:3048
incinerator technology advances and, 6:3048
landfills and, 4:1684–1686
“locally unwanted land uses” (LULUs) and, 6:3049
“not in anyone’s backyard” ((NIABY) and, 6:3049
“not in my backyard” (NIMBY) and, 6:3049
recycling of municipal solid waste and, 5:2372–2375
social and environmental justice issues, 6:3049
Wastewater management, 6:3049–3052
brief history of, 6:3050–3051
diagram of, 6:3051 (fig.)
flocculation and, 3:1127–1128
flow of, 3:1138
modern approaches to, 6:3051
wastewater constituents and, 6:3050
wastewater sources and, 6:3050
wastewater treatment and, 6:3052
Water degradation, 6:3052–3056
biological pollution and, 6:3054
chemical water pollution and, 6:3053–3054
eutrophication and, 6:3054
indicators and assessment of, 6:3055
manufacturing and, 2:945
physical factors in, 6:3054
plastic and trash pollution, Bicaz Lake, Romania, 6:3053 (photo)
pollution measures of, 6:3055
sources, distribution, and freshwater uses and, 6:3052–3053
thermal pollution and, 6:3055
water crises adaptation measures and, 1:11
water stress and, 6:3053–3055
See also Water management and treatment; Water needs; Water pollution; Watershed management; Watershed yield; Water supply siting and management
Water management and treatment, 6:3056–3062
background of, 6:3056
drylands environmental management and, 2:971–973
environmental markets of, 4:2009
future problems in, 6:3060
GIS in water management and, 3:1316–1318
hydrology and, 3:1513–1518
potable water treatment process and, 6:3060 (fig.)
potential water availability, 2007, 2050, 6:3059 (fig.)
renewable water resources and availability by continents and, 6:3057 (table)
surface water diversion for agricultural needs and, 2:939
timeline of international efforts in, 6:3060–3061
total renewable freshwater resources per capita and, 6:3058 (fig.)
water crises adaptation measures and, 1:11
water needs and, 6:3056–3058
water resources and, 6:3056
wastewater treatment and, 6:3038–3060
See also Water degradation; Water needs; Water pollution; Watershed management; Watershed yield; Water supply siting and management
Water needs, 6:3062–3066
agriculture and, 6:3064
biota needs and, 1:238
cities, 2:943
clean water rights case sample of, 2:995–997, 2:996 (table), 2:997 (fig.)
drylands environmental management and, 2:971–973
Earth’s ecosystems and, 6:3062–3063
energy and, 6:3064
free trade agreements on local governance of water and, 2:995
human right to water, legal contributions supporting, 2:995 (table)
lack of reliable information on use and, 6:3064–3065
photosynthesis process and, 1:258
public water services and, 5:2315–2319
society and, 6:3064
surface water diversion for agricultural needs and, 2:939
water crises adaptation measures and, 1:11
water quality and, 6:3063–3064
water rate conceptual model with incline block rates and, 2:995, 2:997 (fig.)
water use and, 6:3063
wetlands at land-sea margin and, 6:3064
World Commission on Dams and, 2:995
See also Groundwater; Water degradation; Water management and treatment; Water pollution; Watershed management; Watershed yield; Water supply siting and management
Water pollution, 6:3066–3070
anthropogenic sources of, 3:1387–1388
anticlockwise loop and, 6:3069, 6:3070 (fig.)
chlorinated hydrocarbons (CHCs) and, 1:396–400
Clean Water Act and, 2:925, 2:966, 5:2476
groundwater pollution and, 3:1387–1388
hysterisis analysis and, 6:3069
hysteresis loop and, 6:3069
manufacturing and, 2:945
National Primary and Secondary Drinking Water Regulations and, 2:984
nonpoint sources of pollution and, 4:2039–2040
oil spills and, 4:2073–2076
sediment-rating curve and, 6:3068–3069, 6:3068 (fig.)
urban polluting factors and, 2:943, 3:1335
water crises adaptation measures and, 1:11
water filtration and, 3:1115
See also Coastal dead zones; Coastal zone and marine pollution;
Water degradation; Water management and treatment;
Water needs; Watershed management; Watershed yield;
Water supply siting and management
Watershed management, 6:3070–3074
ecoshed and, 2:857
flood protection and, 6:3074
GIS in water management and, 3:1316–1318
good governance and, 6:3074
indigenous methods of, 3:1375
indigenous water management and, 3:1573–1576
international watershed management and, 3:1618–1620
minimum flows and levels in, 6:3072–3073
prior appropriation method and, 6:3072
right to use doctrine and, 6:3072
Union Grove Lake, Tama County, Iowa, 6:3073 (photo)
U.S. philosophies of, 6:3072–3073
water quality and, 6:3073
water quantity and, 6:3071
See also Water degradation; Water management and treatment;
Water needs; Water pollution; Watershed yield; Water supply siting and management
Watershed yield, 6:3074–3076
factors affecting, 6:3075
measurement importance and, 6:3074–3075
regional context of, 6:3075–3076
sediment yield definition and, 6:3075
soil erosion models and, 6:3075
spatial variability factor in, 6:3075–3076
watershed definition and, 6:3075
watershed size factor in, 6:3075
See also Groundwater; Water degradation; Water management
and treatment; Water needs; Water pollution; Watershed
management; Water supply siting and management
Water supply siting and management, 6:3076–3078
GIS in water management and, 3:1316–1318
global environmental change and, 3:1335–1336
irrigation effects on, 3:1335
public water services and, 5:2315–2319
spillway at Broken Bow Reservoir, Mountain Fork River,
McCurtain County, Oklahoma, 6:3077 (photo)
water crises adaptation measures and, 1:11
See also Water degradation; Water management and treatment;
Water needs; Water pollution; Watershed management;
Watershed yield
Watt-Cloutier, Sheila, 3:1525
Watts, Michael, 6:3078–3079
African families work of, 4:1863
contract farming and, 4:2139
environmental entitlements work of, 2:924
environmental imaginaries and, 2:933, 4:1863
Marxist geography work of, 4:1863, 4:1996, 4:2139
nature-society theory and, 4:1996
Richard Peet and, 4:2144
political ecology work of, 2:622, 4:1996, 5:2213
spatial imaginaries and, 2:932
Wæver, Ole, 2:1037
Wayfinding, 6:3079–3081
blindness and geography and, 1:286–287
conceptual—conceptual nature of, 6:3080
definition of, 6:3079
interactions in, 6:3080 (fig.)
knowledge of one’s environment element of, 6:3080, 6:3081
landmarks research and, 6:3080
location and navigation vs., 6:3080
mental maps and, 4:1881–1883
multimodal environment features of, 6:3081
route finding and planning and, 6:3080
strategies of, 6:3081
WCED. See World Commission on Environment and
Development (WCED)
Weather and climate controls, 6:3082–3085
climatic and, 1:476–480
localized controls in, 6:3084
major controls in, 6:3082–3084
oceanic circulation and, 4:2058–2064
seasonal changes on climate and, 6:3082
See also Albedo
Weber, Alfred, 6:3085–3087
corporate location model of, 6:3085, 6:3085 (fig.)
impact of, 6:3085
location theory and, 3:1628, 4:1798, 5:2393
model criticism and, 6:3086
transportation costs and, 6:3085–3086, 6:3086 (fig.)
Weber, Max
capitalism origins views of, 4:1931–1932
classic social theory of, 3:1277
criticism of, 4:1932
culture definition and, 2:634
commodity and commodification relationship and, 4:1936
Protestant work ethic, 2:1028–1029, 4:1931
qualitative methodology and, 5:2323
rationalization views of, 4:1931–1932
social sciences vs. natural sciences and, 5:2513
Web geoprocessing workflows, 6:3087–3089
architectural patterns for service chains and, 6:3088
description of, 6:3088
flexibility benefit of, 6:3088
gioprocessing definition and, 6:3087
potential of, 6:3088
spatial data infrastructures (SDIs) and, 6:3086
Web-based workflows definition and, 6:3087–3088
Web service orchestration and, 6:3088
workflow definition and, 6:3087
Web service architectures for GIS, 6:3089–3092
business models for GIS and, 1:306–308
data compression methods and, 2:679–680
descriptions of, 6:3090–3092
diagram of, 6:3091 (fig.)
service-oriented architecture and, 6:3089–3090
See also GIS software; GIS Web services
Weeks, John, 5:2247
Wegener, Alfred, 4:1665
Weigert, Hans, 3:1250
Weimer, Arthur, 3:1449
Weiner, Daniel, 5:2304
West Africa
agrobiodiversity in, 1:50
bush fallow farming in, 1:302
carbon dioxide disaster, Cameroon, 1:68–69
drought, famine in, 2:622, 2:727, 4:1996
drug trafficking and, 2:798
El Niño–Southern Oscillation (ENSO) and, 2:889
food security in, 4:1996
forest fragmentation in, 3:1159
French colonies in, 1:509
groundwater usage in, 3:1386
HIV/AIDS in, 3:1438
HIV-2 in, 3:1436
Ibn Battuta exploration of, 2:1054, 3:1519
indigenous agriculture in, 3:1556–1557
indigenous cartographies in, 3:1562
Niger famine, 2005 and, 4:1986
nomadic Tuareg herders and camels, Sahara Desert, Mali,
4:2034 (photo)
peanut farming in, 1:61 (photo)
population growth of, 5:2233 (fig.)
Sahel drought and, 2:717–718, 2:972, 2:989
sewage entering coastal zones of, 1:301
timber from, 1:238
tropical rain forest of, 1:234
tropical savanna climate in, 1:455
tropical savanna in, 1:240
Western Europe
political map of, 6:3160
Western Hemisphere
AGS library maps of, 1:71
mining frontier in, 4:1911
Wetlands, 6:3092–3094
characteristics of, 6:3092–3093
definition of, 6:3092
gleying process and, 6:3092
hydric soils and, 6:3093
hydrophytic vegetation and, 6:3093–3094
interior wetland classifications and, 6:3092
marine aquaculture and, 4:1853–1855
mottles and, 6:3092
muck and peat soil of, 6:3092

pothole wetland, South Dakota, 6:3093 (photo)
saltwater interior wetlands and, 6:3092
topography and water salinity classification
of, 6:3092
wetland hydrology and, 6:3092–3093
Whatmore, Sarah
animal geographies work of, 2:831, 2:832
Hybrid Geographies, 2:469–650
Whitbeck, Ray, 2:848–849
White, Denis,
Whitbeck, Ray,
White, Gilbert, 6:3094–3095
Harlan Barrows and, 6:3094
donors water use in East Africa, model of, 6:3095
ergy and human ecology work of, 2:894
as father of floodplain management, 6:3094
government service work of, 6:3095
Robert Kates influenced by, 4:1654
natural hazards paradigm of, 6:3095
practical applied research views of, 6:3094
service work of, 6:3095
water policy issues and, 5:2307
White, Langdon, 4:1873
White, Lynn, 2:925, 5:2409
White, S. H., 5:2609
“White man’s burden,” 2:1021, 2:1027
Whiteness, 6:3096–3097
color blindness myth and, 6:3096
discourses, 6:3096
environmental justice/injustice and, 2:962, 6:3096
ethnocentrism and, 2:1027
institutional racism and, 6:3096
modern racial whiteness construct and, 6:3096
national identities and, 6:3096
racilized landscapes and, 6:3096
terms associated with, 6:3096
“white flight” and, 1:420, 2:962, 2:986
white privilege and, 2:962, 6:3096
Whittlesey, Derwent, 6:3097–3098
academic career of, 6:3097
Isaiah Bowman and, 6:3097–3098
Harvard’s geology department closing and, 6:3097
historical geography work of, 3:1429
sequent occupance work of, 5:2534–2535, 6:3097
service work of, 6:3097
theory of sequent occupance and, 3:1429, 4:2111
WHO. See World Health Organization (WHO)
Whorl, Benjamin, 4:1754
Wikipedia, 3:1257
Wilderness, 6:3098–3099
Arctic National Wildlife Refuge, 6:3093 (photo)
definition of, 6:3098
parks and reserves and, 4:2117–2120
preservationists and, 6:3098
protected lands and, 6:3098
settlement era and, 6:3098
social constructed nature of, 6:3098–3099
as a therapeutic space, 6:3098
Wildfires: risk and hazard, 6:3099–3102
at-risk term and, 6:3100
fire behavior models and, 6:3100, 6:3101 (fig.)
hazard term and, 6:3100
pyrogeography and, 5:2319–2322
risk analysis and, 6:3100
risk assessment map for Whiskeytown Fire, Redding, California, 2008 and, 6:3101 (fig.)
terrain factors in, 6:3100
threat term and, 6:3099, 6:3100
value of resources at risk and, 6:3100–3101
vegetationor fuel factor in, 6:3100
weather factors and, 6:3100
wildfires as a spatial problem, 6:3099
Willhite, Donald, 2:787–788
Wilkes, R., 5:2345
Williams, Raymond, 1:118, 4:1787
cultural geography work of, 3:1142
fish farming research of, 2:1120
“militant particularism,” 5:2574
social construction of space work of, 5:2297, 5:2574
Williamson, Hugh, 4:1642
Wilson, Alan, 5:2393, 5:2395–2396
Wilson, E. O., theory of island biogeography and, 1:199, 3:1635, 4:1696, 5:2672
Wilson, Edward, 2:992
Wilson, J., 2:1075
Wilson, John, 6:3102–3103
academic career of, 6:3102–3103
awards and honors received by, 6:3103
books written by, 6:3103
GIS work of, 6:3102
journal work of, 6:3103
service work of, 6:3103
spatial analysis and environmental modeling work of, 6:3103
Winchester, Simon, 4:1884
Wind, 6:3103–3107
atmospheric circulation explanation of, 1:131–136
chinook/foehn winds and, 1:394–395
Coriolis force and, 2:586–587
derechos and, 2:714–715
differential heating and, 2:740–742
formation of, 6:3104–3105
Hadley cell model of, 3:1395–1397, 6:3105 (fig.)
idealized global circulation and, 6:3105 (fig.)
importance of, 6:3106–3107
measurement of, 6:3106
types of, 6:3105–3106
Wind energy, 6:3108–3110
advantages of, 6:3108–3109
chinook/foehn winds and, 1:394–395
drawbacks in use of, 6:3109
generating electricity from, 6:3108
national energy policies and, 2:900
natural phenomenon of, 6:3108
wind turbines, Royd Moore, South Yorkshire, England, 6:3109
Wind erosion, 6:3110–3115
abrasion forms from, 6:3114–3115
abrasion process in, 6:3110–3111
chinook/foehn winds and, 1:394–395
deflation forms from, 6:3111–3114
deflation process in, 6:3110
dunes and, 2:800–803
erosion processes of, 6:3110–3111
hazards from, 6:3115
landforms of, 6:3111–3115
pan field, Western Australia, 6:3113 (photo)
transport processes and, 6:3111
trough blowouts, foredune system, Guadalupe, California, 6:3112 (photo)
yardang field on Mars and, 6:3114 (photo)
Wine, geography of, 6:3115–3117
ancient geographies and, 6:3115–3116
books written about, 6:3117
history and diffusion of wine grape and, 6:3115–3116
physical variables in wine production and, 6:3116
socioeconomic factors and, 6:3116
*territor* concept and, 6:3116, 6:3117–3119
vineyard, Constantia region, Cape Winelands, South Africa, 6:3118 (photo)
vineyards, Chianti region, Tuscany, Italy, 6:3116 (photo)
wine influence on environment and, 6:3117
wine labels and, 6:3116
See also Wine *terroir*

**Wine terroir**, 6:3117–3119
climate factors and, 6:3119
definition of, 6:3117–3118
importance of, 6:3118
physical geography and wine growing effects on, 6:3118–3119
soil factors and, 6:3119
vineyard, Constantia region, Cape Winelands, South Africa, 6:3118 (photo)
vineyard geography factors and, 6:3118–3119
See also Wine, geography of

Winters, Harold, 4:1897

Wirth, Louis, 3:1103, 4:1936
Wisconsin
Milwaukee brownfields in, 1:297 (photo)
prairie restoration in, 5:2278

**Wise use movement**, 6:3119–3120
ambiguity of, 6:3120
anti-environmental and antifederal organizations features of, 6:3119
decline of, 6:3120
federal lobbying effort and, 6:3120
Progressive-era conservation origins of, 6:3119
property rights movement, 6:3120
rural West location of, 6:3120
social movements in global South and, 6:3120
Wisner, Ben, 2:618

Withers, Charles, 2:910, 2:911, 4:1789

Wittfogel, Karl, 6:3120–3121
Asian civilization studied by, 6:3121
Frankfurt School and, 2:617
humanity's relationship with nature work of, 6:3120
“hydraulic empires” theory of, 5:2215, 6:3121
*Oriental Despotism* written by, 5:2215

Wittgenstein, Ludwig, 4:1754

Wojcik, Dariusz, 3:1118

Wolf, Jennifer, 2:831

Wolf, Eric, 5:2212, 5:2711–2712

Wolfram, S., 1:369

Wolman, Leopold, 3:1128, 3:1130

Wood, Denis, 6:3121–3122
critical cartography and, 6:3121–3122
maps, mapping, and mapmaking processes focus of, 6:3121–3122
maps as narrative texts and, 6:3121
maps as sign systems and, 6:3121–3122
politics embedded within maps and, 6:3121–3122

Woodfuel, 6:3122–3124
for cooking, Maharashtra, India, 6:3123 (photo)
in developing countries, 6:3122, 6:3123–3124
global climate change and, 6:3122–3123
limitations of, 6:3124
sustainable development and, 6:3122–3123

Woodward, David, 3:1402
Woodward, Rachel, 4:1897

World Bank, 6:3124–3126
antiglobalization issues and, 1:96
colonial powers domination of, 5:2261
demonstration against, West Berlin, 1988, 5:2443 (photo)
etcotourism supported by, 2:871
emerging markets and, 2:890
Global Environment Facility (GEF) and, 6:2748
diffuse network of, 3:1548
Heavily Indebted Poor Countries initiative of, 2:690
international environmental movements and, 3:1611
International Monetary Fund (IMF) and, 3:1615–1618
land reform policies of, 4:1695
neocolonialism policies of, 4:2003
neoliberal economic policies of, 5:2220, 5:2459, 6:2750, 6:3014
neoliberal environmental policy and, 4:2008
NIC export-led development and, 2:1065
population growth estimates of, 5:2241
poverty definitions of, 5:2274
Poverty Reduction Strategy Papers and, 4:2014
public-private partnerships supported by, 5:2312
structural adjustment of economies role of, 5:2703
Structural Adjustment Programs (SAPs) of, 2:1065, 4:1694, 4:2012
supranational economic activity, glocalization and, 3:1347

**World cities**, 6:3126–3129
aviation and, 1:179–182
critique of the concept, 6:3128–3129
finance geographies and, 3:1115–1118
historical development of term and, 6:3126–3128
internal structure of, 6:3128–3129
Los Angeles School of urban economy and, 4:1803–1805
map of, 6:3127 (fig.)
networking of, 6:3128
primate cities and, 5:2290–2291
telecommunication technology and, 6:2786
urban telecommunications infrastructures and, 6:2788–2789

World Commission on Environment and Development (WCED), 1:256, 2:835, 3:1604
environmental impact statements and, 2:938, 2:958
*Our Common Future* (Brundtland Report) environmental security publication of, 1:256, 2:998, 2:1003, 6:2747, 6:2748
sustainable development, 2:870, 2:1003–1004, 5:2220, 6:2737–2738, 6:2747

**World Court**, 6:3129–3131
accomplishments of, 6:3131
early roots of, 6:3130
functions of, 6:3130–3131
International Court of Justice (ICJ) and, 6:3129
judges and their terms and, 6:3130
Peace Palace, The Hague, Netherlands, and, 6:3130 (photo)
United Nations and, 6:3129

World Economic Forum, 1:415

**World Health Organization (WHO)**, 6:3131–3132
carcinogen lists maintained by, 1:335
disaster preparedness and response program of, 2:763
Global Malaria Eradication Program of, 4:1817
global public health initiatives function of, 6:3131
primary health care contribution of, 6:3131
standards of atmospheric particulates and, 1:151
standards of pollutant thresholds and, 1:68
United Nations creation of, 6:3131

World maps
adults and children living with HIV in 1007, 3:1437 (fig.)
Wright, Dawn, 6:3137
  academic career of, 6:3137
  ArcGIS Marine Data Model developed by, 6:3137
  awards and honors received by, 6:3137
  GIScience contributions of, 6:3137
  service work of, 6:3137
Wright, Don, 1:488
Wright, John Kirtland, 6:3138–3139
  AGS work of, 6:3138
  daseymetric maps and, 2:670
  exploration and mapping by, 6:3138
  history and geography relationship views of, 6:3138
  phenomenology and, 4:2167
  publications of, 6:3138
Wright, Melissa, 3:1192
Writing, 6:3139–3141
  academic writing and, 6:3140
  context of knowledge about places and, 6:3139
  experiential knowledge with linguistic implications and, 6:3139
  human geography fieldwork and, 3:1103–1005
  language role in constructing places and, 6:3139–3140
  literature geographies and, 4:1785–1788
  “objective” discourse and, 6:3140
  quality of writing and, 6:3140
  quantitative methods and, 6:3139
  symbol systems and, 6:3139
  understandings of places and spaces and, 6:3139
  writer qualities and self-awareness and, 6:3140
  writing as a tool and, 6:3139
See also Languages, geography of

WSSE. See World Summit on Sustainable Development (WSSD)
Wu, P., 2:1042
Wycoff, William, 5:2536, 5:2537
Wylie, John, 4:2042
Wynne, Brian, 5:2517, 5:2518
Wyoming
  coal supply in, 1:483, 1:484 (fig.)
  Grand Teton National Park, 4:2119 (fig.)
  Gros Ventre Slide, Grand Teton National Park in, 4:1721 (photo), 4:1723

Xeriscaping, 6:3143–3145
  environmental benefits from, 6:3144
  geography of, in North America, 6:3145
  landscape management practices and, 6:3143–3144
  social dimensions of, 6:3145
  Tempe Women’s Club Park, Demonstration Garden, Arizona, 6:3144 (photo)
Yamasaki, Minoru, 5:2303

Yemen, 3:1190 (table)
Young, Iris, 4:1644
Yugoslavia
  collapse of, 4:1978
  COMECON membership of, 2:593 (table)
  ethnic cleansing, ethnicity of place and, 2:1020
Yukon Territory
  tundra of, 1:247
  wet tundra of, 1:249

Zaire, 6:2780 (table)
Zambia, 3:1190 (table)
Zanzibar, 2:1054
Zelinsky, Wilbur, 6:3147–3148
  academic career of, 6:3147
  awards and honors received by, 6:3147–3148
  cultural landscape work of, 2:642
  fieldwork views of, 3:1103
  multidisciplinary work of, 6:3147
  population geography work of, 5:2247
  publications of, 6:3147
  religious geography work of, 5:2407
  service work of, 6:3147
  topics studied by, 6:3147
Zielonka, Jan, 2:1038
Zimbabwe
  CAMPFIRE ecotourism program, Zimbabwe, 2:871
  Communal Areas Management Programme for Indigenous Resources in, 2:549, 2:550
  communally owned forests and wildlife in, 1:526
  economically active females in, 3:1190 (table)
  game ranching in, 3:1180
  Zimmerer, Karl, 2:633, 5:2213
Zimmerman, Erich, 5:2428
Zoning, 6:3148–3150
  cadastral systems and, 1:311–318
  conservation zones and, 2:571–572
  criticisms, 6:3150
  economic functions of, 6:3150
  land segregation and, 6:3148
  legal functions of, 6:3150
  “negative” tool of, 6:3148
  “order” and “separation” functions of, 6:3148
  original function of, 6:3148
  political and economic functions of, 6:3148
  power relations and social inequities and, 6:3148, 6:3150
  in San Leandro, California, 6:3149 (fig.)
  social control functions of, 6:3150
  social disorganization discourse and, 6:3148
  spatial disorganization of populations and, 6:3148
Zukin, Sharon, 3:1207