

Color Maps and Figures

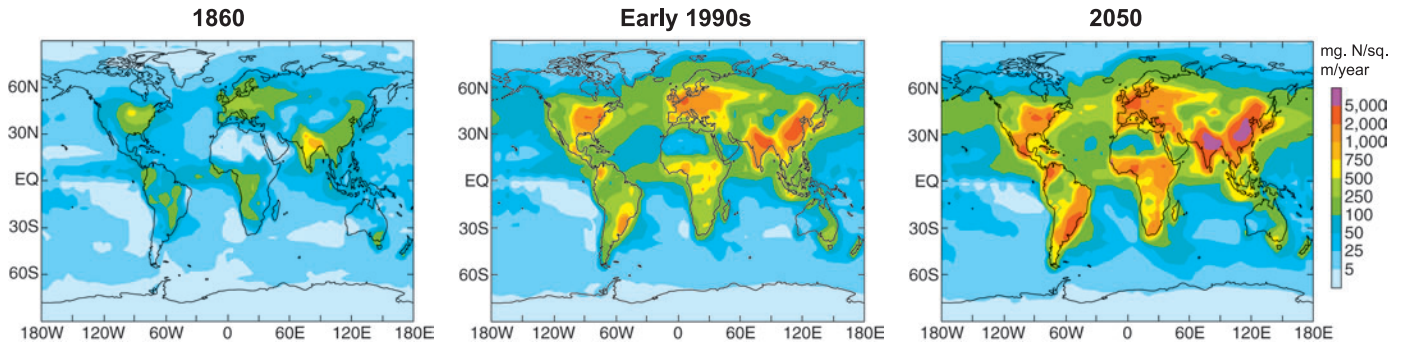


Figure 9.2. Estimated Total Inorganic Nitrogen Deposition, Wet and Dry, in 1860, Early 1990s, and Projected for 2050 (milligrams of nitrogen per square meter per year) (Galloway et al. 2004)

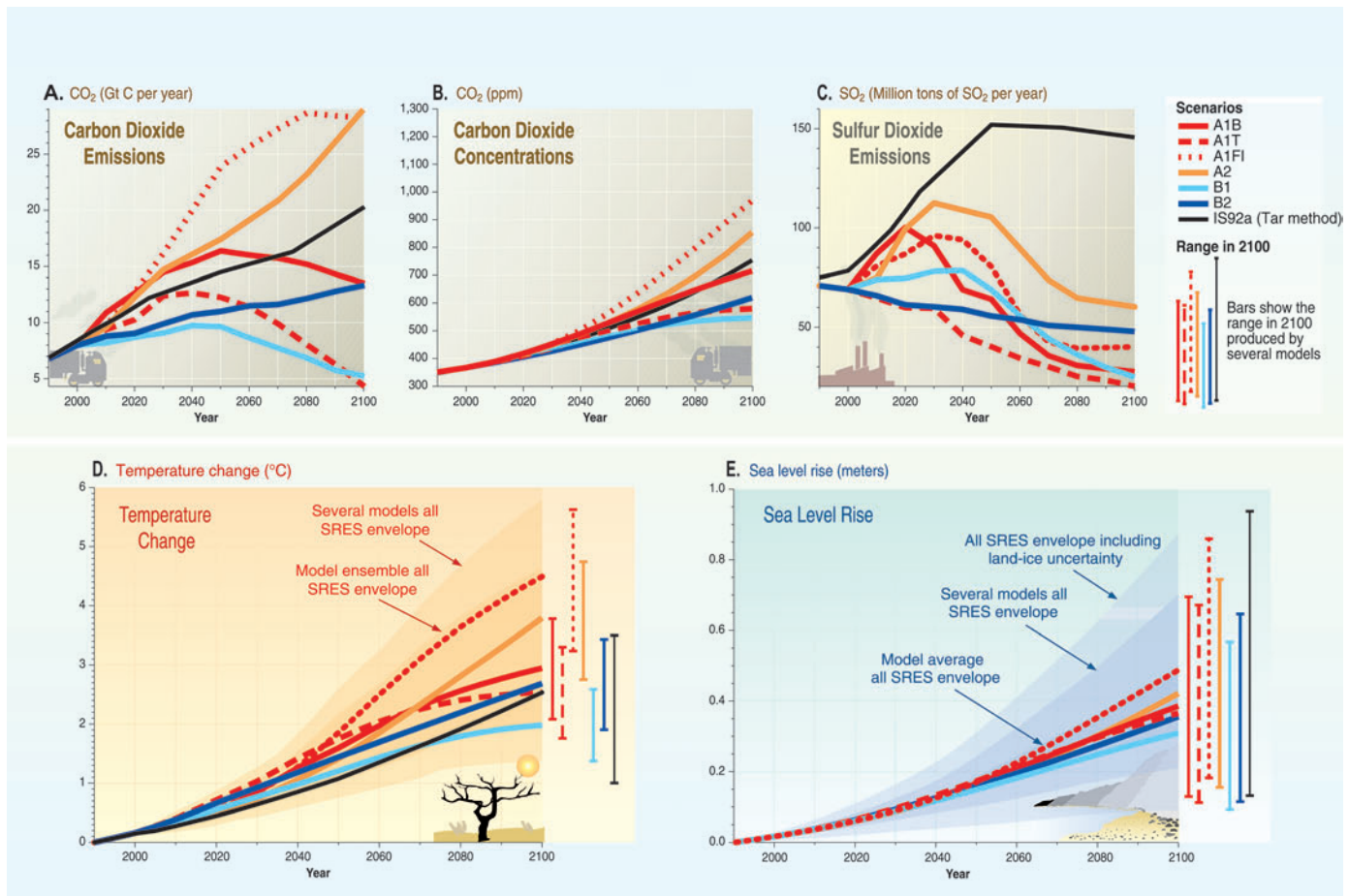


Figure 13.1. The Global Climate Models for the Twenty-first Century. The global climate in this century will depend on natural changes and the response of the climate system to human activities. Climate models project the response of many variables—such as increases in global surface temperature and sea level—to various scenarios of greenhouse gases and other human-related emissions. Graph A shows the carbon dioxide emissions of the six illustrative SRES scenarios; B shows the projected carbon dioxide concentrations; C shows anthropogenic sulfur dioxide emissions. Emissions of other greenhouse gases and aerosols were included in the model but are not shown in the figures. D and E show the temperature and sea level responses, respectively.

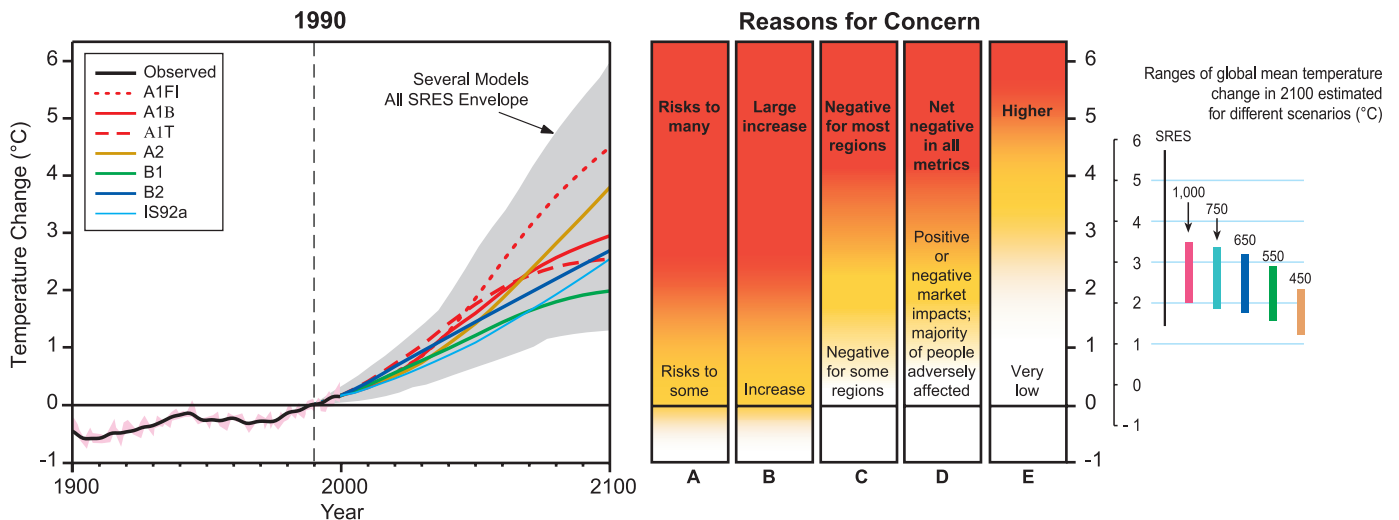
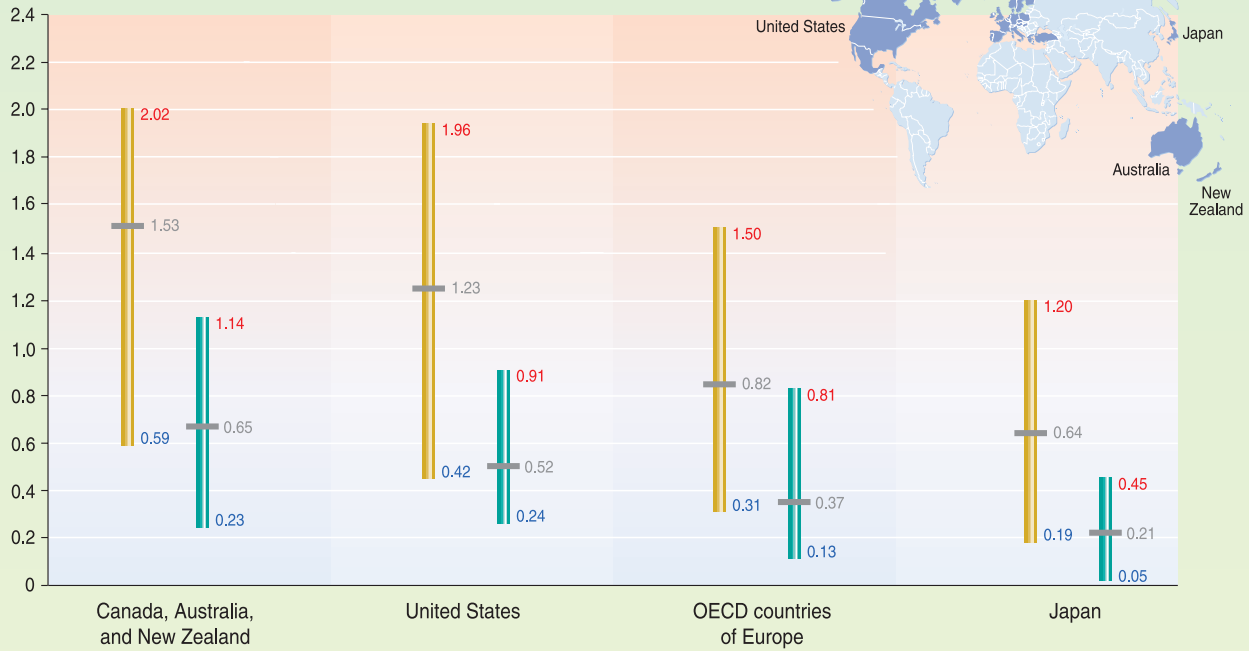


Figure 13.2. Reasons for Concern about Projected Climate Change Impacts. The risks of adverse impacts from climate change increase with the magnitude of climate change. The left part of the figure displays the observed temperature increase relative to 1990 and the range of projected temperature increase after 1990 as estimated by Working Group I of the IPCC for scenarios from the *Special Report on Emissions Scenarios*. The middle panel displays conceptualizations of five reasons for concern regarding climate change risks evolving through 2100. White indicates neutral or small negative or positive impacts or risks, yellow indicates negative impacts for some systems or low risks, and red means negative impacts or risks that are more widespread and/or greater in magnitude. The assessment of impacts or risks takes into account only the magnitude of change and not the rate of change. Global mean annual temperature change is used in the figure as a proxy for the magnitude of climate change, but projected impacts will be the function of, among other factors, the magnitude and rate of global and regional changes in mean climate, climate variability and extreme climate phenomena, social land economic conditions, and adaptations. The right panel shows estimates of global mean temperature change by 2100 relative to 1990 for scenarios that would lead to stabilization of the atmospheric concentration of carbon dioxide, as well as the full set of SRES projections, which are shown in the left panel. As shown in Table 13.1, the equilibrium changes in temperature associated with each of these stabilization levels is significantly higher than the projected increase by 2100, for example, stabilization at 750 ppm is projected to result in an increase of 2.8–7.0°C, compared to an increase of 1.9–3.4°C by 2100. Reasons for Concern: A. Risks to Unique and Threatened Systems: Extinction of species, loss of unique habitats and coastal wetlands, and bleaching and death of coral; B. Risks from Extreme Climate Events: Health, property, and environmental impacts from increased frequency and intensity of some climate extremes; C. Distribution of Impacts: Cereal crop yield changes that vary from increases to decreases across regions but that are estimated to decrease in most tropical and sub-tropical regions; decrease in water availability in some water-stressed countries, increase in others; greater risks to health in developing countries than in industrial countries; net market sector losses estimated for many developing countries; mixed effects estimated for industrial countries up to a few degrees warming and negative effects for greater warming; D. Aggregate Impacts: Estimates of globally aggregated net market sector impacts are positive and negative up to few degrees warming and negative for greater warming. More people adversely affected than beneficially affected even for warming of less than a few degrees; E. Risks from Future Large-Scale Discontinuities: Significant slowing of thermohaline circulation possible by 2100; melting and collapse of ice sheets adding substantially to sea level rise (very low probability before 2100; likelihood higher on multi-century time scale).

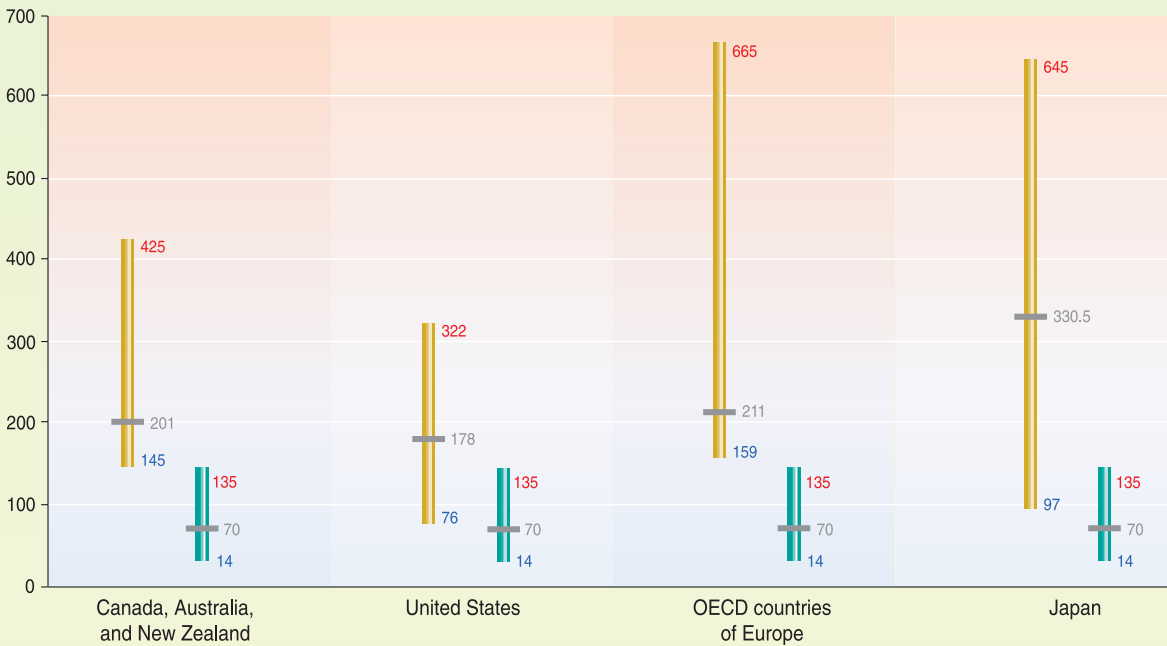
(a) GDP losses

Percentage of GDP loss in the year 2010



(b) Marginal cost

1990 US dollars per t C



Range of outcomes for two scenarios

Absence in international trade in carbon emissions rights: each region must take the prescribed reduction

Full Annex B trading of carbon emissions rights permitted

The three numbers on each bar represent the highest, mean, and lowest projections from the set of models.

Figure 13.5. Projections of GDP Losses and Marginal Costs in Industrial Countries in 2010. The reductions in projected GDP are for 2010 relative to the models' reference case GDP. These estimates are based on results from nine modeling teams that participated in the Energy Modeling Forum study. The models examined two scenarios. In the first, each region makes the prescribed reduction with only domestic trading in carbon emissions. In the second, Annex B trading (i.e., includes countries with economies in transition) is permitted, and thereby marginal costs are equal across regions.

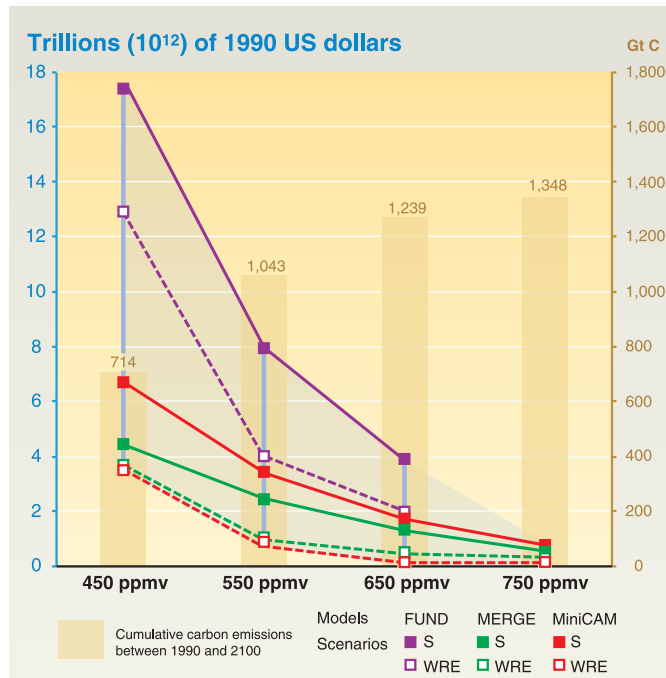


Figure 13.6. Projected Costs of Stabilizing Carbon Dioxide Concentrations. The mitigation costs (1990 US dollars, present value discounted at 5% per year for the period 1990–2100) of stabilizing carbon dioxide concentrations at 450 to 750 ppmv are calculated using three global models, based on different model-dependent baselines. Avoided impacts of climate change are not included. In each instance, costs were calculated based on two emissions pathways for achieving the prescribed target (S and WRE). The bars show cumulative carbon emissions between the years 1990 and 2100. Cumulative future emissions until the carbon budget ceiling is reached are reported above the bars in Gt C.

Appendix B

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Appendix C

Abbreviations and Acronyms

AI	aridity index	CIFOR	Center for International Forestry Research
AKRSP	Aga Khan Rural Support Programme	CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
AMF	arbuscular mycorrhizal fungi	CMS	Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
ASB	alternatives to slash-and-burn	CONICET	Consejo de Investigaciones Científicas y Técnicas (Argentina)
ASOMPH	Asian Symposium on Medicinal Plants, Spices and Other Natural Products	COP	Conference of the Parties (of treaties)
AVHRR	advanced very high resolution radiometer	CPF	Collaborative Partnership on Forests
BCA	benefit-cost analysis	CSIR	Council for Scientific and Industrial Research (South Africa)
BGP	Biogeochemical Province	CV	contingent valuation
BII	Biodiversity Intactness Index	CVM	contingent valuation method
BMI	body mass index	DAF	decision analytical framework
BNF	biological nitrogen fixation	DALY	disability-adjusted life year
BOOT	build-own-operate-transfer	DDT	dichloro diphenyl trichloroethane
BRT	Bus Rapid Transit (Brazil)	DES	dietary energy supply
BSE	bovine spongiform encephalopathy	DHF	dengue hemorrhagic fever
Bt	<i>Bacillus thuringiensis</i>	DHS	demographic and health surveys
C&I	criteria and indicators	DMS	dimethyl sulfide
CAFO	concentrated animal feeding operations	DPSEEA	driving forces-pressure-state-exposure-effect-action
CAP	Common Agricultural Policy (of the European Union)	DPSIR	driver-pressure-state-impact-response
CAREC	Central Asia Regional Environment Centre	DSF	dust storm frequency
CBA	cost-benefit analysis	DU	Dobson Units
CBD	Convention on Biological Diversity	EEA	European Environment Agency
CBO	community-based organization	EEZ	exclusive economic zone
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources	EGS	ecosystem global scenario
CCN	cloud condensation nuclei	EHI	environmental health indicator
CCS	CO ₂ capture and storage	EIA	environmental impact assessment
CDM	Clean Development Mechanism	EID	emerging infectious disease
CEA	cost-effectiveness analysis	EKC	Environmental Kuznets Curve
CENICAFE	Centro Nacional de Investigaciones de Café (Colombia)	EMF	ectomycorrhizal fungi
CFCs	chlorofluorocarbons		
CGIAR	Consultative Group on International Agricultural Research		

E/MSY	extinctions per million species per year	HWB	human well-being
ENSO	El Niño/Southern Oscillation	IAA	integrated agriculture-aquaculture
EPA	Environmental Protection Agency (United States)	IAM	integrated assessment model
EPI	environmental policy integration	IBI	Index of Biotic Integrity
EU	European Union	ICBG	International Cooperative Biodiversity Groups
EU ETS	European Union Emissions Trading System	ICDP	integrated conservation and development project
FAO	Food and Agriculture Organization (United Nations)	ICJ	International Court of Justice
FAPRI	Food and Agriculture Policy Research Institute	ICRAF	International Center for Research in Agroforestry
FLEGT	Forest Law Enforcement, Governance, and Trade	ICRW	International Convention for the Regulation of Whaling
FRA	Forest Resources Assessment	ICSU	International Council for Science
FSC	Forest Stewardship Council	ICZM	integrated coastal zone management
GATS	General Agreement on Trade and Services	IDRC	International Development Research Centre (Canada)
GATT	General Agreement on Tariffs and Trade	IEA	International Energy Agency
GCM	general circulation model	IEG	international environmental governance
GDI	Gender-related Development Index	IEK	indigenous ecological knowledge
GDP	gross domestic product	IFPRI	International Food Policy Research Institute
GEF	Global Environment Facility	IGBP	International Geosphere-Biosphere Program
GEO	<i>Global Environment Outlook</i>	IIASA	International Institute for Applied Systems Analysis
GHG	greenhouse gases	IK	indigenous knowledge
GIS	geographic information system	ILO	International Labour Organization
GIWA	Global International Waters Assessment	IMF	International Monetary Fund
GLASOD	Global Assessment of Soil Degradation	IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
GLC	Global Land Cover	IMR	infant mortality rate
GLOF	Glacier Lake Outburst Flood	INESI	International Network of Sustainability Initiatives (hypothetical, in <i>Scenarios</i>)
GM	genetic modification	INTA	Instituto Nacional de Tecnología Agropecuaria (Argentina)
GMO	genetically modified organism	IPAT	impact of population, affluence, technology
GNI	gross national income	IPCC	Intergovernmental Panel on Climate Change
GNP	gross national product	IPM	integrated pest management
GPS	Global Positioning System	IPR	intellectual property rights
GRoWI	<i>Global Review of Wetland Resources and Priorities for Wetland Inventory</i>	IRBM	integrated river basin management
GSG	Global Scenarios Group	ISEH	International Society for Ecosystem Health
GSPC	Global Strategy for Plant Conservation	ISO	International Organization for Standardization
GtC-eq	gigatons of carbon equivalent	ITPGR	International Treaty on Plant Genetic Resources for Food and Agriculture
GWP	global warming potential	ITQs	individual transferable quotas
HDI	Human Development Index	ITTO	International Tropical Timber Organization
HIA	health impact assessment	IUCN	World Conservation Union
HIPC	heavily indebted poor countries	IUU	illegal, unregulated, and unreported (fishing)
HPI	Human Poverty Index	IVM	integrated vector management
HPS	hantavirus pulmonary syndrome		

IWMI	International Water Management Institute	NFP	national forest programs
IWRM	integrated water resources management	NGO	nongovernmental organization
JDS	Johannesburg Declaration on Sustainable Development	NIH	National Institutes of Health (United States)
JI	joint implementation	NMHC	non-methane hydrocarbons
JMP	Joint Monitoring Program	NOAA	National Oceanographic and Atmospheric Administration (United States)
LAC	Latin America and the Caribbean	NPP	net primary productivity
LAI	leaf area index	NSSD	national strategies for sustainable development
LARD	livelihood approaches to rural development	NUE	nitrogen use efficiency
LDC	least developed country	NWFP	non-wood forest product
LEK	local ecological knowledge	ODA	official development assistance
LME	large marine ecosystems	OECD	Organisation for Economic Co-operation and Development
LPI	Living Planet Index	OSB	oriented strand board
LSMS	Living Standards Measurement Study	OWL	other wooded land
LULUCF	land use, land use change, and forestry	PA	protected area
MA	Millennium Ecosystem Assessment	PAH	polycyclic aromatic hydrocarbons
MAI	mean annual increments	PCBs	polychlorinated biphenyls
MBI	market-based instruments	PEM	protein energy malnutrition
MCA	multicriteria analysis	PES	payment for environmental (or ecosystem) services
MDG	Millennium Development Goal	PFT	plant functional type
MEA	multilateral environmental agreement	PNG	Papua New Guinea
MENA	Middle East and North Africa	POPs	persistent organic pollutants
MER	market exchange rate	PPA	participatory poverty assessment
MHC	major histocompatibility complex	ppb	parts per billion
MICS	multiple indicator cluster surveys	PPI	potential Pareto improvement
MIT	Massachusetts Institute of Technology	ppm	parts per million
MPA	marine protected area	ppmv	parts per million by volume
MSVPA	multispecies virtual population analysis	PPP	purchasing power parity; also public-private partnership
NAP	National Action Program (of desertification convention)	ppt	parts per thousand
NBP	net biome productivity	PQLI	Physical Quality of Life Index
NCD	noncommunicable disease	PRA	participatory rural appraisal
NCS	National Conservation Strategy	PRSP	Poverty Reduction Strategy Paper
NCSD	national council for sustainable development	PSE	producer support estimate
NDVI	normalized difference vegetation index	PVA	population viability analysis
NE	effective size of a population	RANWA	Research and Action in Natural Wealth Administration
NEAP	national environmental action plan	RBO	river basin organization
NEP	new ecological paradigm; also net ecosystem productivity	RIDES	Recursos e Investigación para el Desarrollo Sustentable (Chile)
NEPAD	New Partnership for Africa's Development	RIL	reduced impact logging
NFAP	National Forestry Action Plan	RLI	Red List Index
		RO	reverse osmosis

RRA	rapid rural appraisal	TSU	Technical Support Unit
RUE	rain use efficiency	TW	terawatt
SADC	Southern African Development Community	UMD	University of Maryland
SADCC	Southern African Development Coordination Conference	UNCCD	United Nations Convention to Combat Desertification
SAfMA	Southern African Millennium Ecosystem Assessment	UNCED	United Nations Conference on Environment and Development
SAP	structural adjustment program	UNCLOS	United Nations Convention on the Law of the Sea
SAR	species-area relationship	UNDP	United Nations Development Programme
SARS	severe acute respiratory syndrome	UNECE	United Nations Economic Commission for Europe
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice (of CBD)	UNEP	United Nations Environment Programme
SEA	strategic environmental assessment	UNESCO	United Nations Educational, Scientific and Cultural Organization
SEME	simple empirical models for eutrophication	UNFCCC	United Nations Framework Convention on Climate Change
SES	social-ecological system	UNIDO	United Nations Industrial Development Organization
SFM	sustainable forest management	UNRO	United Nations Regional Organization (hypothetical body, in <i>Scenarios</i>)
SIDS	small island developing states	UNSO	UNDP's Office to Combat Desertification and Drought
SMS	safe minimum standard	USAID	U.S. Agency for International Development
SOM	soil organic matter	USDA	U.S. Department of Agriculture
SRES	Special Report on Emissions Scenarios (of the IPCC)	VOC	volatile organic compound
SSC	Species Survival Commission (of IUCN)	VW	virtual water
SWAP	sector-wide approach	WBCSD	World Business Council for Sustainable Development
TAC	total allowable catch	WCD	World Commission on Dams
TBT	tributyltin	WCED	World Commission on Environment and Development
TC	travel cost	WCMC	World Conservation Monitoring Centre (of UNEP)
TCM	travel cost method	WFP	World Food Programme
TDR	tradable development rights	WHO	World Health Organization
TDS	total dissolved solids	WIPO	World Intellectual Property Organization
TEIA	transboundary environmental impact assessment	WISP	weighted index of social progress
TEK	traditional ecological knowledge	WMO	World Meteorological Organization
TEM	terrestrial ecosystem model	WPI	Water Poverty Index
TESEO	Treaty Enforcement Services Using Earth Observation	WRF	white rot fungi
TEV	total economic value	WSSD	World Summit on Sustainable Development
TFAP	Tropical Forests Action Plan	wta	withdrawals-to-availability ratio (of water)
TFP	total factor productivity	WTA	willingness to accept compensation
TFR	total fertility rate	WTO	World Trade Organization
Tg	teragram (10 ¹² grams)	WTP	willingness to pay
TK	traditional knowledge	WWAP	World Water Assessment Programme
TMDL	total maximum daily load	WWF	World Wide Fund for Nature
TOF	trees outside of forests	WWV	World Water Vision
TRIPS	Trade-Related Aspects of Intellectual Property Rights		

Glossary

Abatement cost: See *Marginal abatement cost*.

Abundance: The total number of individuals of a taxon or taxa in an area, population, or community. Relative abundance refers to the total number of individuals of one taxon compared with the total number of individuals of all other taxa in an area, volume, or community.

Active adaptive management: See *Adaptive management*.

Adaptation: Adjustment in natural or human systems to a new or changing environment. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptive capacity: The general ability of institutions, systems, and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences.

Adaptive management: A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning.

Afforestation: Planting of forests on land that has historically not contained forests. (Compare *Reforestation*.)

Agrobiodiversity: The diversity of plants, insects, and soil biota found in cultivated systems.

Agroforestry systems: Mixed systems of crops and trees providing wood, non-wood forest products, food, fuel, fodder, and shelter.

Albedo: A measure of the degree to which a surface or object reflects solar radiation.

Alien species: Species introduced outside its normal distribution.

Alien invasive species: See *Invasive alien species*.

Aquaculture: Breeding and rearing of fish, shellfish, or plants in ponds, enclosures, or other forms of confinement in fresh or marine waters for the direct harvest of the product.

Benefits transfer approach: Economic valuation approach in which estimates obtained (by whatever method) in one context are used to estimate values in a different context.

Binding constraints: Political, social, economic, institutional, or ecological factors that rule out a particular response.

Biodiversity (a contraction of biological diversity): The variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes diversity within species, between species, and between ecosystems.

Biodiversity regulation: The regulation of ecosystem processes and services by the different components of biodiversity.

Biogeographic realm: A large spatial region, within which ecosystems share a broadly similar biota. Eight terrestrial biogeographic realms are typically recognized, corresponding roughly to continents (e.g., Afrotropical realm).

Biological diversity: See *Biodiversity*.

Biomass: The mass of tissues in living organisms in a population, ecosystem, or spatial unit.

Biome: The largest unit of ecological classification that is convenient to recognize below the entire globe. Terrestrial biomes are typically based on dominant vegetation structure (e.g., forest, grassland). Ecosystems within a biome function in a broadly similar way, although

they may have very different species composition. For example, all forests share certain properties regarding nutrient cycling, disturbance, and biomass that are different from the properties of grasslands. Marine biomes are typically based on biogeochemical properties. The WWF biome classification is used in the MA.

Bioprospecting: The exploration of biodiversity for genetic and biochemical resources of social or commercial value.

Biotechnology: Any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use.

Biotic homogenization: Process by which the differences between biotic communities in different areas are on average reduced.

Blueprint approaches: Approaches that are designed to be applicable in a wider set of circumstances and that are not context-specific or sensitive to local conditions.

Boundary organizations: Public or private organizations that synthesize and translate scientific research and explore its policy implications to help bridge the gap between science and decision-making.

Bridging organizations: Organizations that facilitate, and offer an arena for, stakeholder collaboration, trust-building, and conflict resolution.

Capability: The combinations of doings and beings from which people can choose to lead the kind of life they value. Basic capability is the capability to meet a basic need.

Capacity building: A process of strengthening or developing human resources, institutions, organizations, or networks. Also referred to as capacity development or capacity enhancement.

Capital value (of an ecosystem): The present value of the stream of ecosystem services that an ecosystem will generate under a particular management or institutional regime.

Capture fisheries: See *Fishery*.

Carbon sequestration: The process of increasing the carbon content of a reservoir other than the atmosphere.

Cascading interaction: See *Trophic cascade*.

Catch: The number or weight of all fish caught by fishing operations, whether the fish are landed or not.

Coastal system: Systems containing terrestrial areas dominated by ocean influences of tides and marine aerosols, plus nearshore marine areas. The inland extent of coastal ecosystems is the line where land-based influences dominate, up to a maximum of 100 kilometers from the coastline or 100-meter elevation (whichever is closer to the sea), and the outward extent is the 50-meter-depth contour. See also *System*.

Collaborative (or joint) forest management: Community-based management of forests, where resource tenure by local communities is secured.

Common pool resource: A valued natural or human-made resource or facility in which one person's use subtracts from another's use and where it is often necessary but difficult to exclude potential users from the resource. (Compare *Common property resource*.)

Common property management system: The institutions (i.e., sets of rules) that define and regulate the use rights for common pool resources. Not the same as an open access system.

Common property resource: A good or service shared by a well-defined community. (Compare *Common pool resource*.)

- Community (ecological):** An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.
- Community (human, local):** A collection of human beings who have something in common. A local community is a fairly small group of people who share a common place of residence and a set of institutions based on this fact, but the word 'community' is also used to refer to larger collections of people who have something else in common (e.g., national community, donor community).
- Condition of an ecosystem:** The capacity of an ecosystem to yield services, relative to its potential capacity.
- Condition of an ecosystem service:** The capacity of an ecosystem service to yield benefits to people, relative to its potential capacity.
- Constituents of well-being:** The experiential aspects of well-being, such as health, happiness, and freedom to be and do, and, more broadly, basic liberties.
- Consumptive use:** The reduction in the quantity or quality of a good available for other users due to consumption.
- Contingent valuation:** Economic valuation technique based on a survey of how much respondents would be willing to pay for specified benefits.
- Core dataset:** Data sets designated to have wide potential application throughout the Millennium Ecosystem Assessment process. They include land use, land cover, climate, and population data sets.
- Cost-benefit analysis:** A technique designed to determine the feasibility of a project or plan by quantifying its costs and benefits.
- Cost-effectiveness analysis:** Analysis to identify the least cost option that meets a particular goal.
- Critically endangered species:** Species that face an extremely high risk of extinction in the wild. See also *Threatened species*.
- Cross-scale feedback:** A process in which effects of some action are transmitted from a smaller spatial extent to a larger one, or vice versa. For example, a global policy may constrain the flexibility of a local region to use certain response options to environmental change, or a local agricultural pest outbreak may affect regional food supply.
- Cultivar** (a contraction of cultivated variety): A variety of a plant developed from a natural species and maintained under cultivation.
- Cultivated system:** Areas of landscape or seascape actively managed for the production of food, feed, fiber, or biofuels.
- Cultural landscape:** See *Landscape*.
- Cultural services:** The nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values.
- Decision analytical framework:** A coherent set of concepts and procedures aimed at synthesizing available information to help policy-makers assess consequences of various decision options. DAFs organize the relevant information in a suitable framework, apply decision criteria (both based on some paradigms or theories), and thus identify options that are better than others under the assumptions characterizing the analytical framework and the application at hand.
- Decision-maker:** A person whose decisions, and the actions that follow from them, can influence a condition, process, or issue under consideration.
- Decomposition:** The ecological process carried out primarily by microbes that leads to a transformation of dead organic matter into inorganic matter.
- Deforestation:** Conversion of forest to non-forest.
- Degradation of an ecosystem service:** For *provisioning services*, decreased production of the service through changes in area over which the services is provided, or decreased production per unit area. For *regulating and supporting services*, a reduction in the benefits obtained from the service, either through a change in the service or through human pressures on the service exceeding its limits. For *cultural services*, a change in the ecosystem features that decreases the cultural benefits provided by the ecosystem.
- Degradation of ecosystems:** A persistent reduction in the capacity to provide ecosystem services.
- Desertification:** land degradation in drylands resulting from various factors, including climatic variations and human activities.
- Determinants of well-being:** Inputs into the production of well-being, such as food, clothing, potable water, and access to knowledge and information.
- Direct use value** (of ecosystems): The benefits derived from the services provided by an ecosystem that are used directly by an economic agent. These include consumptive uses (e.g., harvesting goods) and nonconsumptive uses (e.g., enjoyment of scenic beauty). Agents are often physically present in an ecosystem to receive direct use value. (Compare *Indirect use value*.)
- Disability-adjusted life years:** The sum of years of life lost due to premature death and illness, taking into account the age of death compared with natural life expectancy and the number of years of life lived with a disability. The measure of number of years lived with the disability considers the duration of the disease, weighted by a measure of the severity of the disease.
- Diversity:** The variety and relative abundance of different entities in a sample.
- Driver:** Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.
- Driver, direct:** A driver that unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy. (Compare *Driver, indirect*.)
- Driver, endogenous:** A driver whose magnitude can be influenced by the decision-maker. Whether a driver is exogenous or endogenous depends on the organizational scale. Some drivers (e.g., prices) are exogenous to a decision-maker at one level (a farmer) but endogenous at other levels (the nation-state). (Compare *Driver, exogenous*.)
- Driver, exogenous:** A driver that cannot be altered by the decision-maker. (Compare *Driver, endogenous*.)
- Driver, indirect:** A driver that operates by altering the level or rate of change of one or more direct drivers. (Compare *Driver, direct*.)
- Drylands:** See *Dryland system*.
- Dryland system:** Areas characterized by lack of water, which constrains the two major interlinked services of the system: primary production and nutrient cycling. Four dryland subtypes are widely recognized: dry sub-humid, semiarid, arid, and hyperarid, showing an increasing level of aridity or moisture deficit. See also *System*.
- Ecological character:** See *Ecosystem properties*.
- Ecological degradation:** See *Degradation of ecosystems*.
- Ecological footprint:** An index of the area of productive land and aquatic ecosystems required to produce the resources used and to assimilate the wastes produced by a defined population at a specified material standard of living, wherever on Earth that land may be located.
- Ecological security:** A condition of ecological safety that ensures access to a sustainable flow of provisioning, regulating, and cultural services needed by local communities to meet their basic capabilities.
- Ecological surprises:** unexpected—and often disproportionately large—consequence of changes in the abiotic (e.g., climate, disturbance) or biotic (e.g., invasions, pathogens) environment.
- Ecosystem:** A dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit.
- Ecosystem approach:** A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. An ecosystem approach is based on the application of appropriate scientific methods focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.
- Ecosystem assessment:** A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers.
- Ecosystem boundary:** The spatial delimitation of an ecosystem, typically based on discontinuities in the distribution of organisms, the biophysical environment (soil types, drainage basins, depth in a

water body), and spatial interactions (home ranges, migration patterns, fluxes of matter).

Ecosystem change: Any variation in the state, outputs, or structure of an ecosystem.

Ecosystem function: See *Ecosystem process*.

Ecosystem interactions: Exchanges of materials, energy, and information within and among ecosystems.

Ecosystem management: An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

Ecosystem process: An intrinsic ecosystem characteristic whereby an ecosystem maintains its integrity. Ecosystem processes include decomposition, production, nutrient cycling, and fluxes of nutrients and energy.

Ecosystem properties: The size, biodiversity, stability, degree of organization, internal exchanges of materials, energy, and information among different pools, and other properties that characterize an ecosystem. Includes ecosystem functions and processes.

Ecosystem resilience: See *Resilience*.

Ecosystem resistance: See *Resistance*.

Ecosystem robustness: See *Ecosystem stability*.

Ecosystem services: The benefits people obtain from ecosystems.

These include *provisioning services* such as food and water; *regulating services* such as flood and disease control; *cultural services* such as spiritual, recreational, and cultural benefits; and *supporting services* such as nutrient cycling that maintain the conditions for life on Earth. The concept “ecosystem goods and services” is synonymous with ecosystem services.

Ecosystem stability (or ecosystem robustness): A description of the dynamic properties of an ecosystem. An ecosystem is considered stable or robust if it returns to its original state after a perturbation, exhibits low temporal variability, or does not change dramatically in the face of a perturbation.

Elasticity: A measure of responsiveness of one variable to a change in another, usually defined in terms of percentage change. For example, own-price elasticity of demand is the percentage change in the quantity demanded of a good for a 1% change in the price of that good. Other common elasticity measures include supply and income elasticity.

Emergent disease: Diseases that have recently increased in incidence, impact, or geographic range; that are caused by pathogens that have recently evolved; that are newly discovered; or that have recently changed their clinical presentation.

Emergent property: A phenomenon that is not evident in the constituent parts of a system but that appears when they interact in the system as a whole.

Enabling conditions: Critical preconditions for success of responses, including political, institutional, social, economic, and ecological factors.

Endangered species: Species that face a very high risk of extinction in the wild. See also *Threatened species*.

Endemic (in ecology): A species or higher taxonomic unit found only within a specific area.

Endemic (in health): The constant presence of a disease or infectious agent within a given geographic area or population group; may also refer to the usual prevalence of a given disease within such area or group.

Endemism: The fraction of species that is endemic relative to the total number of species found in a specific area.

Epistemology: The theory of knowledge, or a “way of knowing.”

Equity: Fairness of rights, distribution, and access. Depending on context, this can refer to resources, services, or power.

Eutrophication: The increase in additions of nutrients to freshwater or marine systems, which leads to increases in plant growth and often to undesirable changes in ecosystem structure and function.

Evapotranspiration: See *Transpiration*.

Existence value: The value that individuals place on knowing that a resource exists, even if they never use that resource (also sometimes known as conservation value or passive use value).

Exotic species: See *Alien species*.

Externality: A consequence of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized through the markets. Externalities can be positive or negative.

Feedback: See *Negative feedback*, *Positive feedback*, and *Cross-scale feedback*.

Fishery: A particular kind of fishing activity, e.g., a trawl fishery, or a particular species targeted, e.g., a cod fishery or salmon fishery.

Fish stock: See *Stock*.

Fixed nitrogen: See *Reactive nitrogen*.

Flyway: Areas of the world used by migratory birds in moving between breeding and wintering grounds.

Forest systems: Systems in which trees are the predominant life forms. Statistics reported in this assessment are based on areas that are dominated by trees (perennial woody plants taller than five meters at maturity), where the tree crown cover exceeds 10%, and where the area is more than 0.5 hectares. “Open forests” have a canopy cover between 10% and 40%, and “closed forests” a canopy cover of more than 40%. “Fragmented forests” refer to mosaics of forest patches and non-forest land. See also *System*.

Freedom: The range of options a person has in deciding the kind of life to lead.

Functional diversity: The value, range, and relative abundance of traits present in the organisms in an ecological community.

Functional redundancy (= functional compensation): A characteristic of ecosystems in which more than one species in the system can carry out a particular process. Redundancy may be total or partial—that is, a species may not be able to completely replace the other species or it may compensate only some of the processes in which the other species are involved.

Functional types (= functional groups = guilds): Groups of organisms that respond to the environment or affect ecosystem processes in a similar way. Examples of plant functional types include nitrogen-fixer versus non-fixer, stress-tolerant versus ruderal versus competitor, resprouter versus seeder, deciduous versus evergreen. Examples of animal functional types include granivorous versus fleshy-fruit eater, nocturnal versus diurnal predator, browser versus grazer.

Geographic information system: A computerized system organizing data sets through a geographical referencing of all data included in its collections.

Globalization: The increasing integration of economies and societies around the world, particularly through trade and financial flows, and the transfer of culture and technology.

Global scale: The geographical realm encompassing all of Earth.

Governance: The process of regulating human behavior in accordance with shared objectives. The term includes both governmental and nongovernmental mechanisms.

Health, human: A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. The health of a whole community or population is reflected in measurements of disease incidence and prevalence, age-specific death rates, and life expectancy.

High seas: The area outside of national jurisdiction, i.e., beyond each nation’s Exclusive Economic Zone or other territorial waters.

Human well-being: See *Well-being*.

Income poverty: See *Poverty*.

Indicator: Information based on measured data used to represent a particular attribute, characteristic, or property of a system.

Indigenous knowledge (or local knowledge): The knowledge that is unique to a given culture or society.

Indirect interaction: Those interactions among species in which a species, through direct interaction with another species or modification of resources, alters the abundance of a third species with which it is not directly interacting. Indirect interactions can be trophic or nontrophic in nature.

- Indirect use value:** The benefits derived from the goods and services provided by an ecosystem that are used indirectly by an economic agent. For example, an agent at some distance from an ecosystem may derive benefits from drinking water that has been purified as it passed through the ecosystem. (Compare *Direct use value*.)
- Infant mortality rate:** Number of deaths of infants aged 0–12 months divided by the number of live births.
- Inland water systems:** Permanent water bodies other than salt-water systems on the coast, seas and oceans. Includes rivers, lakes, reservoirs wetlands and inland saline lakes and marshes. See also *System*.
- Institutions:** The rules that guide how people within societies live, work, and interact with each other. Formal institutions are written or codified rules. Examples of formal institutions would be the constitution, the judiciary laws, the organized market, and property rights. Informal institutions are rules governed by social and behavioral norms of the society, family, or community. Also referred to as organizations.
- Integrated coastal zone management:** Approaches that integrate economic, social, and ecological perspectives for the management of coastal resources and areas.
- Integrated conservation and development projects:** Initiatives that aim to link biodiversity conservation and development.
- Integrated pest management:** Any practices that attempt to capitalize on natural processes that reduce pest abundance. Sometimes used to refer to monitoring programs where farmers apply pesticides to improve economic efficiency (reducing application rates and improving profitability).
- Integrated responses:** Responses that address degradation of ecosystem services across a number of systems simultaneously or that also explicitly include objectives to enhance human well-being.
- Integrated river basin management:** Integration of water planning and management with environmental, social, and economic development concerns, with an explicit objective of improving human welfare.
- Interventions:** See *Responses*.
- Intrinsic value:** The value of someone or something in and for itself, irrespective of its utility for people.
- Invasibility:** Intrinsic susceptibility of an ecosystem to be invaded by an alien species.
- Invasive alien species:** An alien species whose establishment and spread modifies ecosystems, habitats, or species.
- Irreversibility:** The quality of being impossible or difficult to return to, or to restore to, a former condition. See also *Option value*, *Precautionary principle*, *Resilience*, and *Threshold*.
- Island systems:** Lands isolated by surrounding water, with a high proportion of coast to hinterland. The degree of isolation from the mainland in both natural and social aspects is accounted by the *isola effect*. See also *System*.
- Isola effect:** Environmental issues that are unique to island systems. This uniqueness takes into account the physical seclusion of islands as isolated pieces of land exposed to marine or climatic disturbances with a more limited access to space, products, and services when compared with most continental areas, but also includes subjective issues such as the perceptions and attitudes of islanders themselves.
- Keystone species:** A species whose impact on the community is disproportionately large relative to its abundance. Effects can be produced by consumption (trophic interactions), competition, mutualism, dispersal, pollination, disease, or habitat modification (nontrophic interactions).
- Land cover:** The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Related to, but not synonymous with, *land use*.
- Landscape:** An area of land that contains a mosaic of ecosystems, including human-dominated ecosystems. The term cultural landscape is often used when referring to landscapes containing significant human populations or in which there has been significant human influence on the land.
- Landscape unit:** A portion of relatively homogenous land cover within the local-to-regional landscape.
- Land use:** The human use of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by, but not synonymous with, *land cover*.
- Length of growing period:** The total number of days in a year during which rainfall exceeds one half of potential evapotranspiration. For boreal and temperate zone, growing season is usually defined as a number of days with the average daily temperature that exceeds a definite threshold, such as 10° Celsius.
- Local knowledge:** See *Indigenous knowledge*.
- Mainstreaming:** Incorporating a specific concern, e.g. sustainable use of ecosystems, into policies and actions.
- Malnutrition:** A state of bad nourishment. Malnutrition refers both to undernutrition and overnutrition, as well as to conditions arising from dietary imbalances leading to diet-related noncommunicable diseases.
- Marginal abatement cost:** The cost of abating an incremental unit of, for instance, a pollutant.
- Marine system:** Marine waters from the low-water mark to the high seas that support marine capture fisheries, as well as deepwater (>50 meters) habitats. Four sub-divisions (marine biomes) are recognized: the coastal boundary zone; trade-winds; westerlies; and polar.
- Market-based instruments:** Mechanisms that create a market for ecosystem services in order to improving the efficiency in the way the service is used. The term is used for mechanisms that create new markets, but also for responses such as taxes, subsidies, or regulations that affect existing markets.
- Market failure:** The inability of a market to capture the correct values of ecosystem services.
- Mitigation:** An anthropogenic intervention to reduce negative or unsustainable uses of ecosystems or to enhance sustainable practices.
- Mountain system:** High-altitude (greater than 2,500 meters) areas and steep mid-altitude (1,000 meters at the equator, decreasing to sea level where alpine life zones meet polar life zones at high latitudes) areas, excluding large plateaus.
- Negative feedback:** Feedback that has a net effect of dampening perturbation.
- Net primary productivity:** See *Production, biological*.
- Non-linearity:** A relationship or process in which a small change in the value of a driver (i.e., an independent variable) produces an disproportionate change in the outcome (i.e., the dependent variable). Relationships where there is a sudden discontinuity or change in rate are sometimes referred to as abrupt and often form the basis of thresholds. In loose terms, they may lead to unexpected outcomes or “surprises.”
- Nutrient cycling:** The processes by which elements are extracted from their mineral, aquatic, or atmospheric sources or recycled from their organic forms, converting them to the ionic form in which biotic uptake occurs and ultimately returning them to the atmosphere, water, or soil.
- Nutrients:** The approximately 20 chemical elements known to be essential for the growth of living organisms, including nitrogen, sulfur, phosphorus, and carbon.
- Open access resource:** A good or service over which no property rights are recognized.
- Opportunity cost:** The benefits forgone by undertaking one activity instead of another.
- Option value:** The value of preserving the option to use services in the future either by oneself (option value) or by others or heirs (bequest value). Quasi-option value represents the value of avoiding irreversible decisions until new information reveals whether certain ecosystem services have values society is not currently aware of.
- Organic farming:** Crop and livestock production systems that do not make use of synthetic fertilizers, pesticides, or herbicides. May also include restrictions on the use of transgenic crops (genetically modified organisms).
- Pastoralism, pastoral system:** The use of domestic animals as a primary means for obtaining resources from habitats.
- Perturbation:** An imposed movement of a system away from its current state.

- Polar system:** Treeless lands at high latitudes. Includes Arctic and Antarctic areas, where the polar system merges with the northern boreal forest and the Southern Ocean respectively. See also *System*.
- Policy failure:** A situation in which government policies create inefficiencies in the use of goods and services.
- Policy-maker:** A person with power to influence or determine policies and practices at an international, national, regional, or local level.
- Pollination:** A process in the sexual phase of reproduction in some plants caused by the transportation of pollen. In the context of ecosystem services, pollination generally refers to animal-assisted pollination, such as that done by bees, rather than wind pollination.
- Population, biological:** A group of individuals of the same species, occupying a defined area, and usually isolated to some degree from other similar groups. Populations can be relatively reproductively isolated and adapted to local environments.
- Population, human:** A collection of living people in a given area. (Compare *Community (human, local)*.)
- Positive feedback:** Feedback that has a net effect of amplifying perturbation.
- Poverty:** The pronounced deprivation of well-being. Income poverty refers to a particular formulation expressed solely in terms of per capita or household income.
- Precautionary principle:** The management concept stating that in cases “where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation,” as defined in the Rio Declaration.
- Prediction (or forecast):** The result of an attempt to produce a most likely description or estimate of the actual evolution of a variable or system in the future. See also *Projection* and *Scenario*.
- Primary production:** See *Production, biological*.
- Private costs and benefits:** Costs and benefits directly felt by individual economic agents or groups as seen from their perspective. (Externalities imposed on others are ignored.) Costs and benefits are valued at the prices actually paid or received by the group, even if these prices are highly distorted. Sometimes termed “financial” costs and benefits. (Compare *Social costs and benefits*.)
- Probability distribution:** A distribution that shows all the values that a random variable can take and the likelihood that each will occur.
- Production, biological:** Rate of biomass produced by an ecosystem, generally expressed as biomass produced per unit of time per unit of surface or volume. Net primary productivity is defined as the energy fixed by plants minus their respiration.
- Production, economic:** Output of a system.
- Productivity, biological:** See *Production, biological*.
- Productivity, economic:** Capacity of a system to produce high levels of output or responsiveness of the output of a system to inputs.
- Projection:** A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from “predictions” in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized; they are therefore subject to substantial uncertainty.
- Property rights:** The right to specific uses, perhaps including exchange in a market, of ecosystems and their services.
- Provisioning services:** The products obtained from ecosystems, including, for example, genetic resources, food and fiber, and fresh water.
- Public good:** A good or service in which the benefit received by any one party does not diminish the availability of the benefits to others, and where access to the good cannot be restricted.
- Reactive nitrogen (or fixed nitrogen):** The forms of nitrogen that are generally available to organisms, such as ammonia, nitrate, and organic nitrogen. Nitrogen gas (or dinitrogen), which is the major component of the atmosphere, is inert to most organisms.
- Realm:** Used to describe the three major types of ecosystems on earth: terrestrial, freshwater, and marine. Differs fundamentally from *biogeographic realm*.
- Reforestation:** Planting of forests on lands that have previously contained forest but have since been converted to some other use. (Compare *Afforestation*.)
- Regime shift:** A rapid reorganization of an ecosystem from one relatively stable state to another.
- Regulating services:** The benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases.
- Relative abundance:** See *Abundance*.
- Reporting unit:** The spatial or temporal unit at which assessment or analysis findings are reported. In an assessment, these units are chosen to maximize policy relevance or relevance to the public and thus may differ from those upon which the analyses were conducted (e.g., analyses conducted on mapped ecosystems can be reported on administrative units). See also *System*.
- Resilience:** The level of disturbance that an ecosystem can undergo without crossing a threshold to a situation with different structure or outputs. Resilience depends on ecological dynamics as well as the organizational and institutional capacity to understand, manage, and respond to these dynamics.
- Resistance:** The capacity of an ecosystem to withstand the impacts of drivers without displacement from its present state.
- Responses:** Human actions, including policies, strategies, and interventions, to address specific issues, needs, opportunities, or problems. In the context of ecosystem management, responses may be of legal, technical, institutional, economic, and behavioral nature and may operate at various spatial and time scales.
- Riparian:** Something related to, living on, or located at the banks of a watercourse, usually a river or stream.
- Safe minimum standard:** A decision analytical framework in which the benefits of ecosystem services are assumed to be incalculable and should be preserved unless the costs of doing so rise to an intolerable level, thus shifting the burden of proof to those who would convert them.
- Salinization:** The buildup of salts in soils.
- Scale:** The measurable dimensions of phenomena or observations. Expressed in physical units, such as meters, years, population size, or quantities moved or exchanged. In observation, scale determines the relative fineness and coarseness of different detail and the selectivity among patterns these data may form.
- Scenario:** A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technology change, prices) and relationships. Scenarios are neither predictions nor projections and sometimes may be based on a “narrative storyline.” Scenarios may include projections but are often based on additional information from other sources.
- Security:** Access to resources, safety, and the ability to live in a predictable and controllable environment.
- Service:** See *Ecosystem services*.
- Social costs and benefits:** Costs and benefits as seen from the perspective of society as a whole. These differ from private costs and benefits in being more inclusive (all costs and benefits borne by some member of society are taken into account) and in being valued at social opportunity cost rather than market prices, where these differ. Sometimes termed “economic” costs and benefits. (Compare *Private costs and benefits*.)
- Social incentives:** Measures that lower transaction costs by facilitating trust-building and learning as well as rewarding collaboration and conflict resolution. Social incentives are often provided by bridging organizations.
- Socioecological system:** An ecosystem, the management of this ecosystem by actors and organizations, and the rules, social norms, and conventions underlying this management. (Compare *System*.)
- Soft law:** Non-legally binding instruments, such as guidelines, standards, criteria, codes of practice, resolutions, and principles or declarations, that states establish to implement national laws.
- Soil fertility:** The potential of the soil to supply nutrient elements in the quantity, form, and proportion required to support optimum plant growth. See also *Nutrients*.

Speciation: The formation of new species.

Species: An interbreeding group of organisms that is reproductively isolated from all other organisms, although there are many partial exceptions to this rule in particular taxa. Operationally, the term *species* is a generally agreed fundamental taxonomic unit, based on morphological or genetic similarity, that once described and accepted is associated with a unique scientific name.

Species diversity: Biodiversity at the species level, often combining aspects of species richness, their relative abundance, and their dissimilarity.

Species richness: The number of species within a given sample, community, or area.

Statistical variation: Variability in data due to error in measurement, error in sampling, or variation in the measured quantity itself.

Stock (in fisheries): The population or biomass of a fishery resource. Such stocks are usually identified by their location. They can be, but are not always, genetically discrete from other stocks.

Stoichiometry, ecological: The relatively constant proportions of the different nutrients in plant or animal biomass that set constraints on production. Nutrients only available in lower proportions are likely to limit growth.

Storyline: A narrative description of a scenario, which highlights its main features and the relationships between the scenario's driving forces and its main features.

Strategies: See *Responses*.

Streamflow: The quantity of water flowing in a watercourse.

Subsidiarity, principle of: The notion of devolving decision-making authority to the lowest appropriate level.

Subsidy: Transfer of resources to an entity, which either reduces the operating costs or increases the revenues of such entity for the purpose of achieving some objective.

Subsistence: An activity in which the output is mostly for the use of the individual person doing it, or their family, and which is a significant component of their livelihood.

Subspecies: A population that is distinct from, and partially reproductively isolated from, other populations of a species but that has not yet diverged sufficiently that interbreeding is impossible.

Supporting services: Ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.

Sustainability: A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Sustainable use (of an ecosystem): Human use of an ecosystem so that it may yield a continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.

Symbiosis: Close and usually obligatory relationship between two organisms of different species, not necessarily to their mutual benefit.

Synergy: When the combined effect of several forces operating is greater than the sum of the separate effects of the forces.

System: In the Millennium Ecosystem Assessment, reporting units that are ecosystem-based but at a level of aggregation far higher than that usually applied to ecosystems. Thus the system includes many component ecosystems, some of which may not strongly interact with each other, that may be spatially separate, or that may be of a different type to the ecosystems that constitute the majority, or matrix, of the system overall. The system includes the social and economic systems that have an impact on and are affected by the ecosystems included within it. For example, the Condition and Trend Working Group refers to "forest systems," "cultivated systems," "mountain systems," and so on. Systems thus defined are not mutually exclusive, and are permitted to overlap spatially or conceptually. For instance, the "cultivated system" may include areas of "dryland system" and vice versa.

Taxon (pl. taxa): The named classification unit to which individuals or sets of species are assigned. Higher taxa are those above the species

level. For example, the common mouse, *Mus musculus*, belongs to the Genus *Mus*, the Family Muridae, and the Class Mammalia.

Taxonomy: A system of nested categories (*taxa*) reflecting evolutionary relationships or morphological similarity.

Tenure: See *Property rights*, although also sometimes used more specifically in reference to the temporal dimensions and security of property rights.

Threatened species: Species that face a high (*vulnerable species*), very high (*endangered species*), or extremely high (*critically endangered species*) risk of extinction in the wild.

Threshold: A point or level at which new properties emerge in an ecological, economic, or other system, invalidating predictions based on mathematical relationships that apply at lower levels. For example, species diversity of a landscape may decline steadily with increasing habitat degradation to a certain point, then fall sharply after a critical threshold of degradation is reached. Human behavior, especially at group levels, sometimes exhibits threshold effects.

Thresholds at which irreversible changes occur are especially of concern to decision-makers. (Compare *Non-linearity*.)

Time series data: A set of data that expresses a particular variable measured over time.

Total economic value framework: A widely used framework to disaggregate the components of utilitarian value, including *direct use value*, *indirect use value*, *option value*, *quasi-option value*, and *existence value*.

Total factor productivity: A measure of the aggregate increase in efficiency of use of inputs. TFP is the ratio of the quantity of output divided by an index of the amount of inputs used. A common input index uses as weights the share of the input in the total cost of production.

Total fertility rate: The number of children a woman would give birth to if through her lifetime she experienced the set of age-specific fertility rates currently observed. Since age-specific rates generally change over time, TFR does not in general give the actual number of births a woman alive today can be expected to have. Rather, it is a synthetic index meant to measure age-specific birth rates in a given year.

Trade-off: Management choices that intentionally or otherwise change the type, magnitude, and relative mix of services provided by ecosystems.

Traditional ecological knowledge: The cumulative body of knowledge, practices, and beliefs evolved by adaptive processes and handed down through generations. TEK may or may not be indigenous or local, but it is distinguished by the way in which it is acquired and used, through the social process of learning and sharing knowledge. (Compare *Indigenous knowledge*.)

Traditional knowledge: See *Traditional ecological knowledge*.

Traditional use: Exploitation of natural resources by indigenous users or by nonindigenous residents using traditional methods. Local use refers to exploitation by local residents.

Transpiration: The process by which water is drawn through plants and returned to the air as water vapor. Evapotranspiration is combined loss of water to the atmosphere via the processes of evaporation and transpiration.

Travel cost methods: Economic valuation techniques that use observed costs to travel to a destination to derive demand functions for that destination.

Trend: A pattern of change over time, over and above short-term fluctuations.

Trophic cascade: A chain reaction of top-down interactions across multiple trophic levels. These occur when changes in the presence or absence (or shifts in abundance) of a top predator alter the production at several lower trophic levels. Such positive indirect effects of top predators on lower trophic levels are mediated by the consumption of mid-level consumers (generally herbivores).

Trophic level: The average level of an organism within a food web, with plants having a trophic level of 1, herbivores 2, first-order carnivores 3, and so on.

Umbrella species: Species that have either large habitat needs or other requirements whose conservation results in many other species being conserved at the ecosystem or landscape level.

- Uncertainty:** An expression of the degree to which a future condition (e.g., of an ecosystem) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined terminology or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgment of a team of experts).
- Urbanization:** An increase in the proportion of the population living in urban areas.
- Urban systems:** Built environments with a high human population density. Operationally defined as human settlements with a minimum population density commonly in the range of 400 to 1,000 persons per square kilometer, minimum size of typically between 1,000 and 5,000 people, and maximum agricultural employment usually in the vicinity of 50–75%. See also *System*.
- Utility:** In economics, the measure of the degree of satisfaction or happiness of a person.
- Valuation:** The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on). See also *Value*.
- Value:** The contribution of an action or object to user-specified goals, objectives, or conditions. (Compare *Valuation*.)
- Value systems:** Norms and precepts that guide human judgment and action.
- Voluntary measures:** Measures that are adopted by firms or other actors in the absence of government mandates.
- Vulnerability:** Exposure to contingencies and stress, and the difficulty in coping with them. Three major dimensions of vulnerability are involved: exposure to stresses, perturbations, and shocks; the sensitivity of people, places, ecosystems, and species to the stress or perturbation, including their capacity to anticipate and cope with the stress; and the resilience of the exposed people, places, ecosystems, and species in terms of their capacity to absorb shocks and perturbations while maintaining function.
- Vulnerable species:** Species that face a high risk of extinction in the wild. See also *Threatened species*.
- Water scarcity:** A water supply that limits food production, human health, and economic development. Severe scarcity is taken to be equivalent to 1,000 cubic meters per year per person or greater than 40% use relative to supply.
- Watershed** (also catchment basin): The land area that drains into a particular watercourse or body of water. Sometimes used to describe the dividing line of high ground between two catchment basins.
- Water stress:** See *Water scarcity*.
- Well-being:** A context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience.
- Wetlands:** Areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. May incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies of marine water deeper than six meters at low tide laying within the wetlands.
- Wise use** (of an ecosystem): Sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem

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