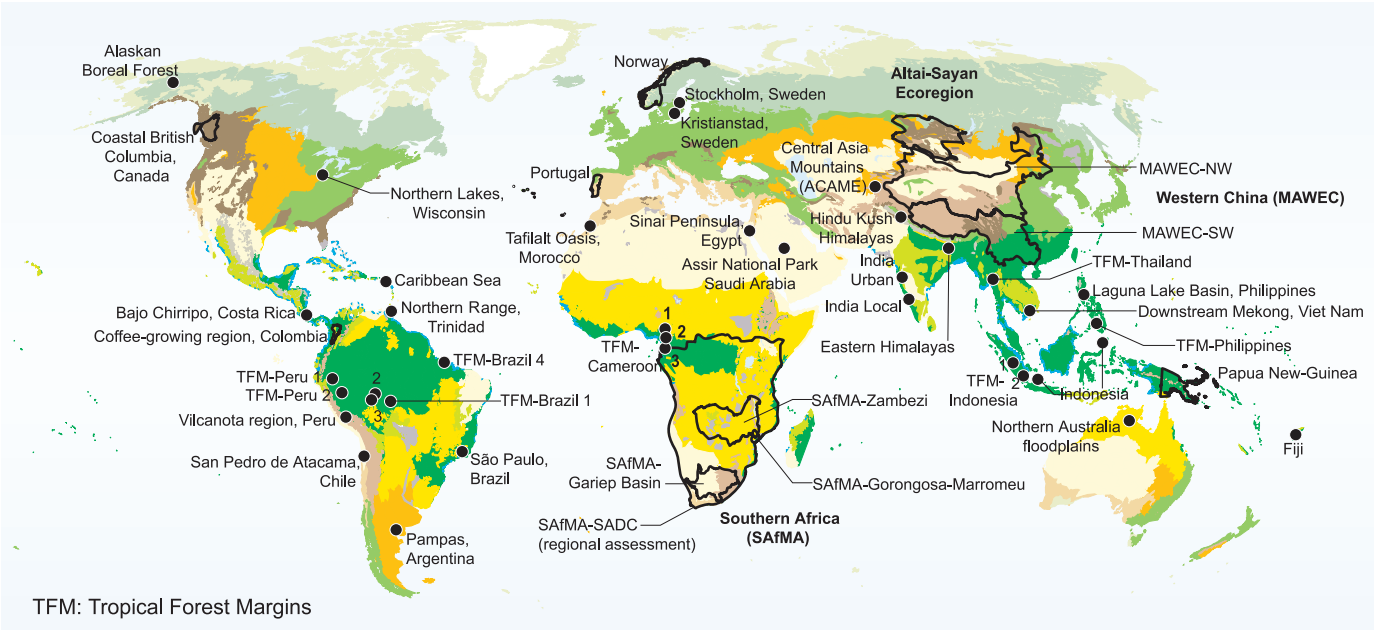
Appendix A

Color Maps and Figures



Biomes

- Tropical and sub-tropical moist broadleaf forests
- Tropical and sub-tropical dry broadleaf forests
- Tropical and sub-tropical coniferous forests
- Temperate broadleaf and mixed forests
- Temperate coniferous forests
- Boreal forest/taiga
- Tundra
- Mediterranean forests, woodland, and scrub
- Tropical and sub-tropical grasslands, savannas, and shrublands
- Temperate grasslands, savannas, and shrublands
- Montane grasslands and shrublands
- Flooded grasslands and savannas
- Mangroves
- Deserts and xeric shrublands
- Rock and ice

Figure 2.2. Locations of MA Sub-global Assessments. The map shows the locations of the MA sub-global assessments, with areas of coverage where geographical coordinates were available, in relation to the WWF ecoregions.

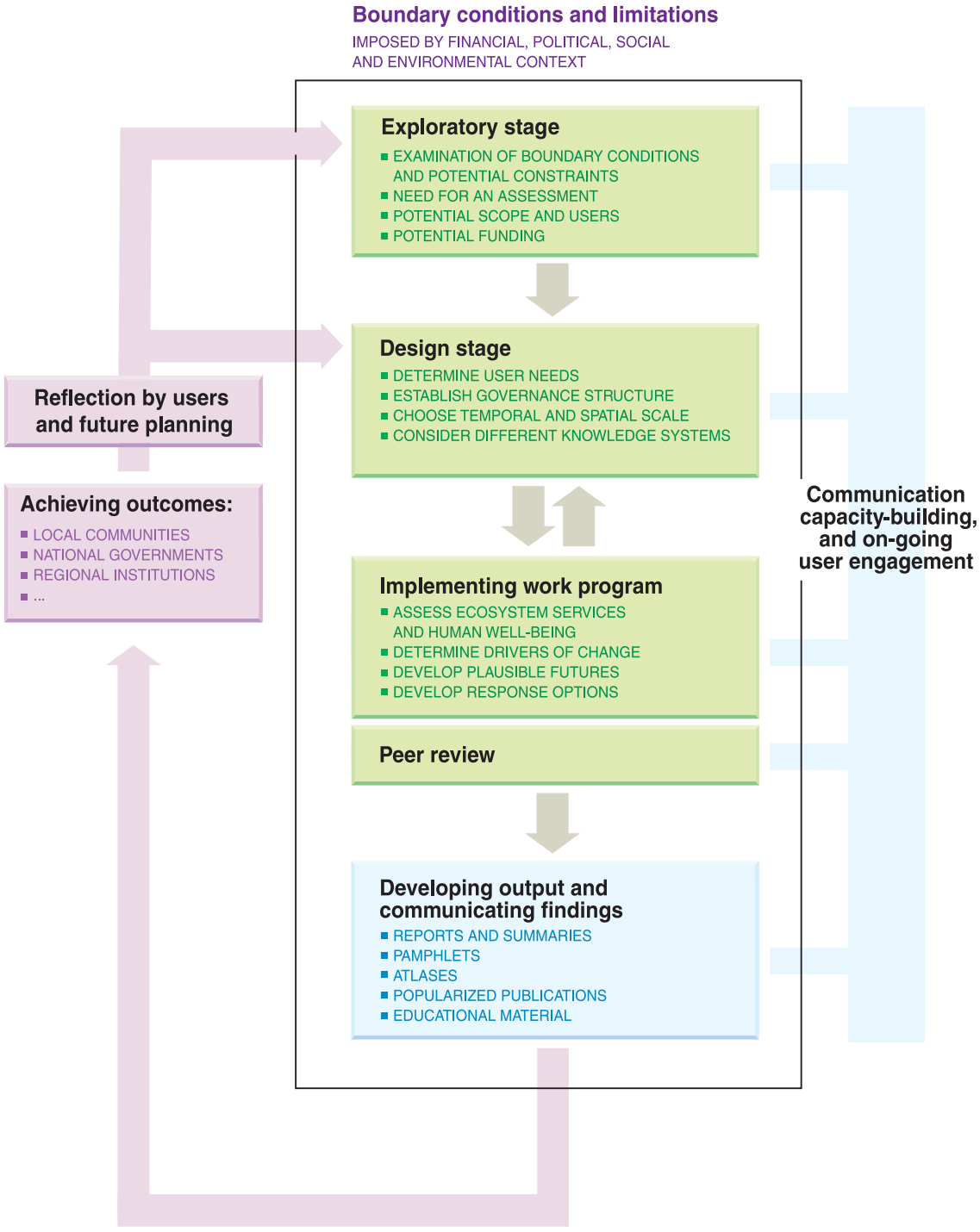


Figure 6.1. Overview of Assessment Process. The sub-global assessment process has three stages that are generally sequential, but often overlapping and iterative: (1) the exploratory stage, (2) the design stage, and (3) implementation of the workplan. The exploratory stage includes an examination of the social, political, and environmental contexts in the areas to be assessed (external boundary conditions), and the resource and human capacity of the assessment team (internal boundary conditions). A fourth set of activities, which includes ongoing user engagement and communication, occurs throughout the entire process. User engagement begins when the assessment is initiated, but communication with users is ongoing in order to maintain user interest, adjust the process to evolving needs, and ensure uptake of the findings. A review process is strongly linked to the implementation of the workplan, and contributes both to the robustness and credibility of assessment findings, and to communication with the users. Final assessment findings are communicated to the intended users and wider audience through the development of appropriate outputs. An assessment should not be seen as an isolated activity; users and technical teams should reflect on the process once it is over, suggest improvements, and determine future assessment needs.

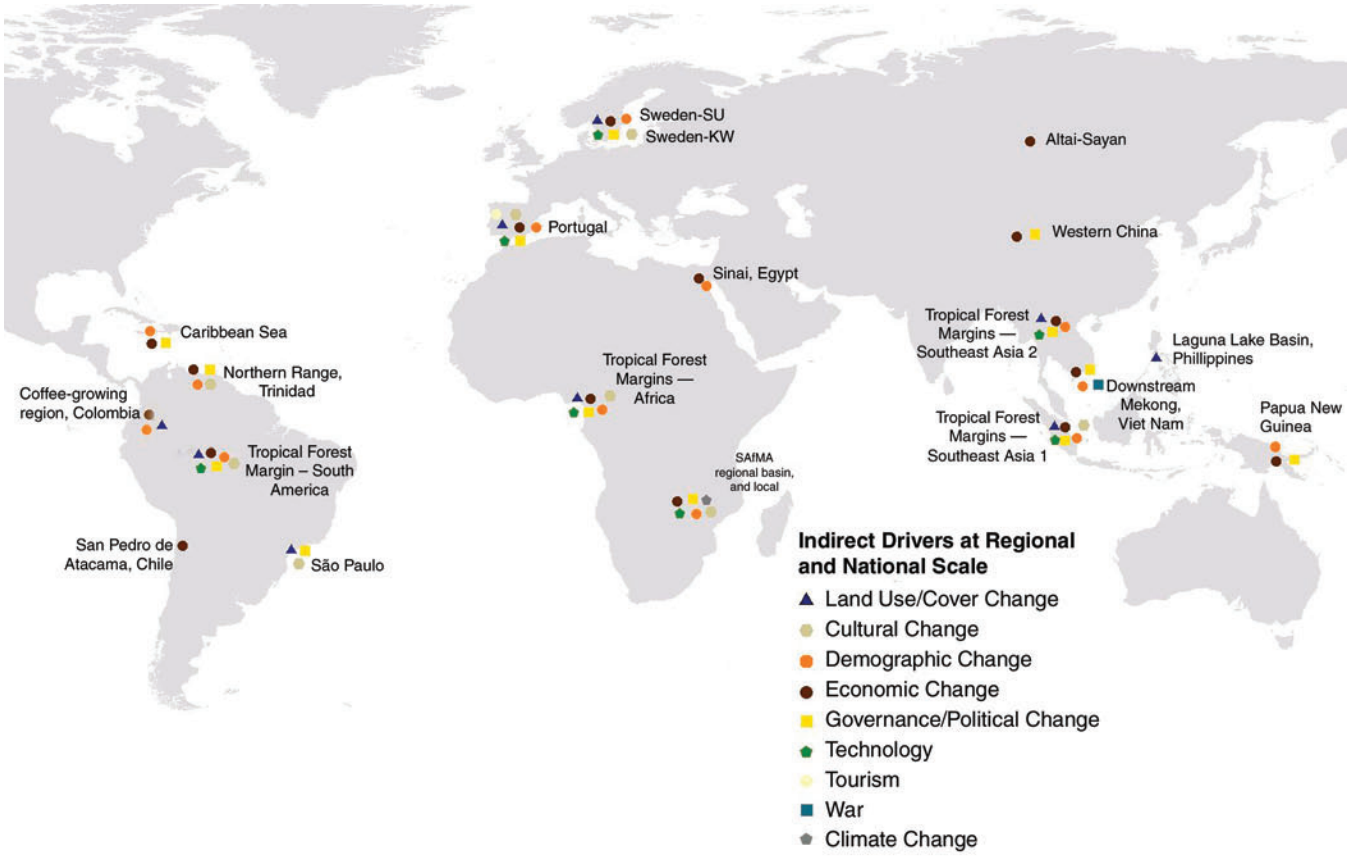


Figure 7.1. Indirect Drivers of Ecosystem Change at Regional and National Scales Identified by the Sub-global Assessments. Land use and land cover change include transformation, ownership, tenure, and regulations that affect terrestrial or freshwater systems. Cultural change includes environmental awareness and attitudes and social capacity. Demographic change includes economic growth, markets, and trade. Governance and political change includes policies, institutions, and legislation. Technology includes innovations in science and technological applications to ecosystem services. Assessments that identified a single driver (San Pedro Atacama, Chile, Altai-Sayan, and Laguna Lake Basin) did not indicate that this was the sole driver of change influencing ecosystem services, but rather that it was the only driver that was assessed, either because of a lack of information about other drivers or because of the particular focus of the assessment. Other assessments concentrated on a wide range of drivers (e.g., Tropical Forest Margins, SAfMA, Portugal, Sweden SU and Sweden KW).

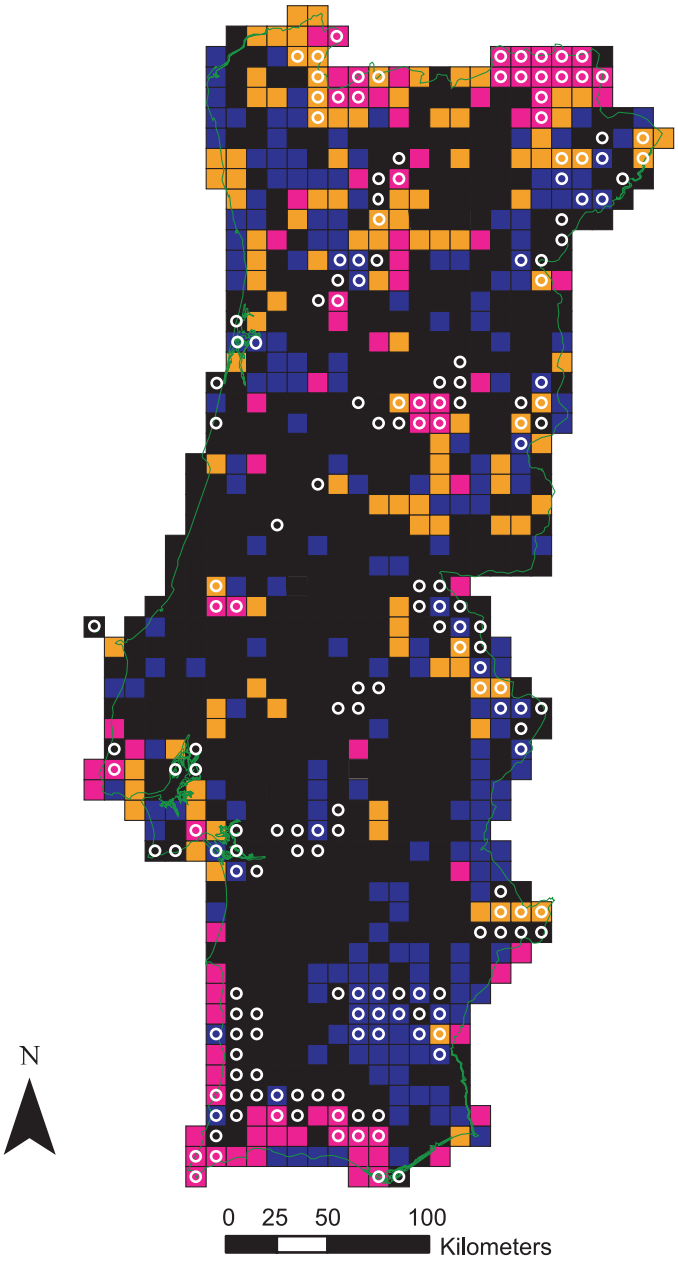


Figure 8.3. Biodiversity Irreplaceability Values in Portugal per 10x10 Kilometer Cell. Biodiversity irreplaceability is a measure of conservation options lost if the site were to be converted or further degraded (Pressey et al. 1993). The irreplaceability value is not an indicator of biodiversity condition, but can be useful in prioritizing areas for conservation. Cell colors indicate decreasing levels of biodiversity irreplaceability in the following order: red, yellow, blue, and black. White circles denote cells belonging to the Natura 2000 network of protected areas.

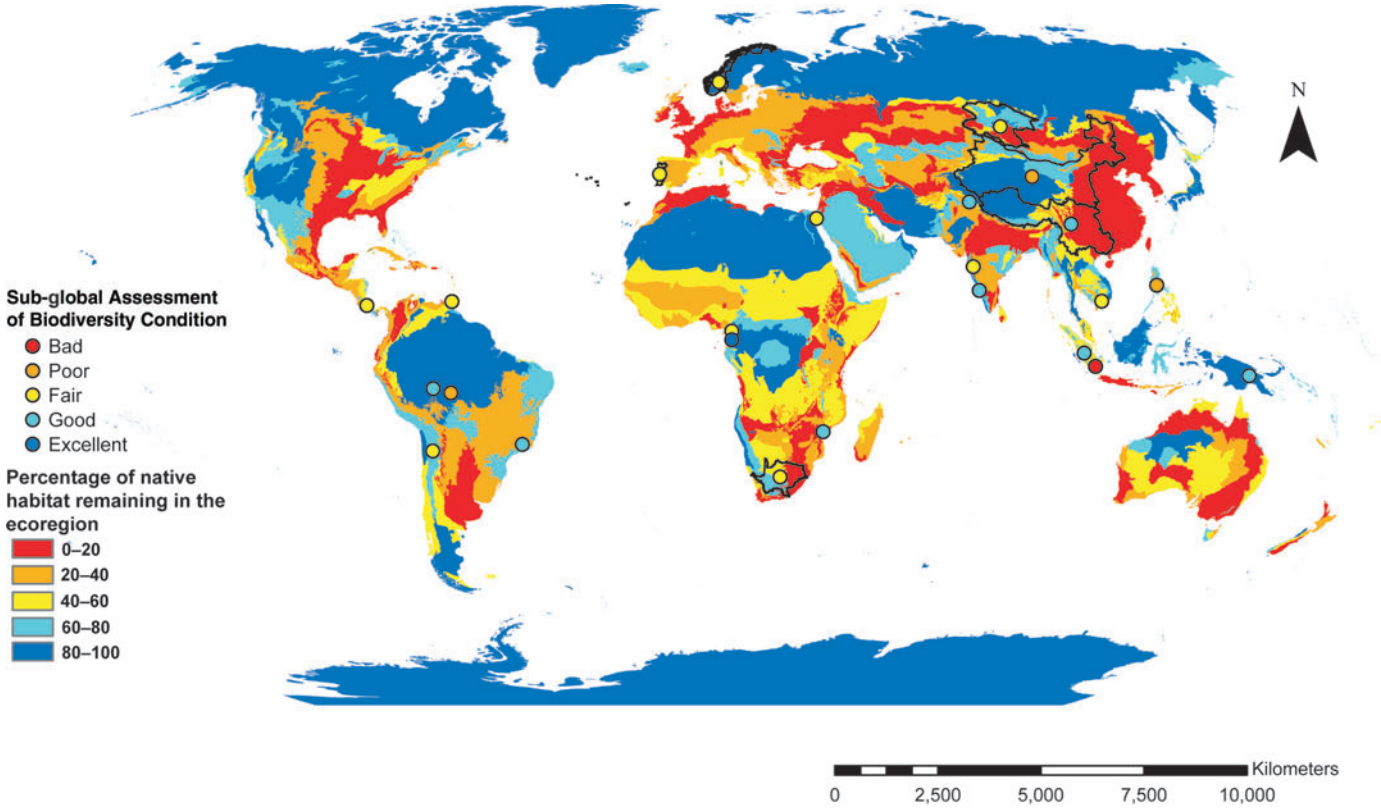


Figure 8.4. Comparison between the Sub-global Assessments of Biodiversity Condition and the Amount of Native Habitat Remaining in the Ecoregions of the World. The percentage of land converted to human-dominated uses (i.e., cropland and pasture) for each ecoregion was calculated with data from the MA Scenarios Working Group, using the land-cover map for the *Global Orchestration* Scenario in the year 2000 (Olson 2001). Sub-global assessments that assess large areas have the boundaries plotted in black (note that the Western China assessment area is divided into two sub-regions).

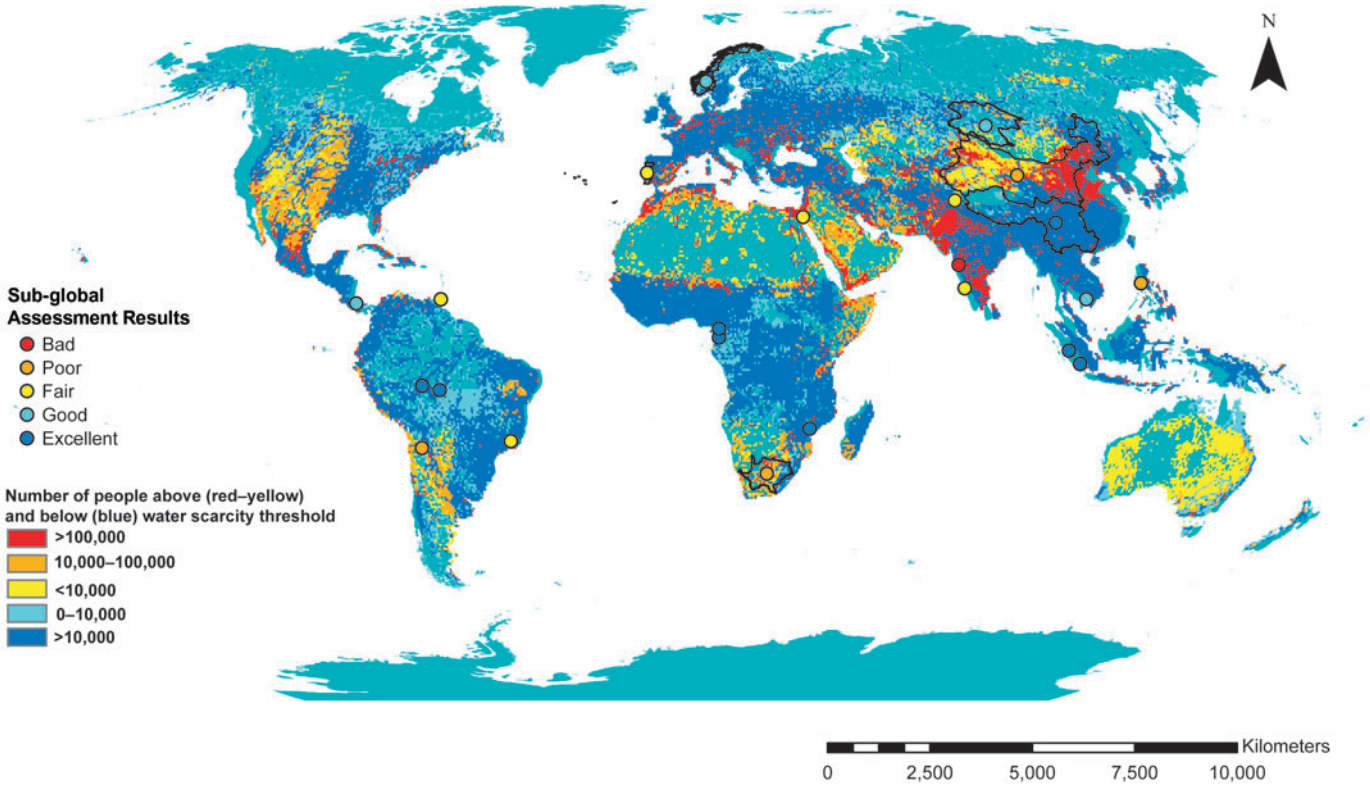


Figure 8.5. Comparison between Freshwater Condition in the Sub-global Assessments and the Global Distribution of Human Population in 1995 Relative to a Threshold of Severe Water Scarcity. This map shows the distribution of the human population which has severe water limitations (i.e., which is above the water scarcity threshold). The threshold corresponds to a ratio of 40% of water use or withdrawal to discharge (Vörösmarty et al. 2000). Boundaries of sub-global assessments that assess large areas are plotted in black.

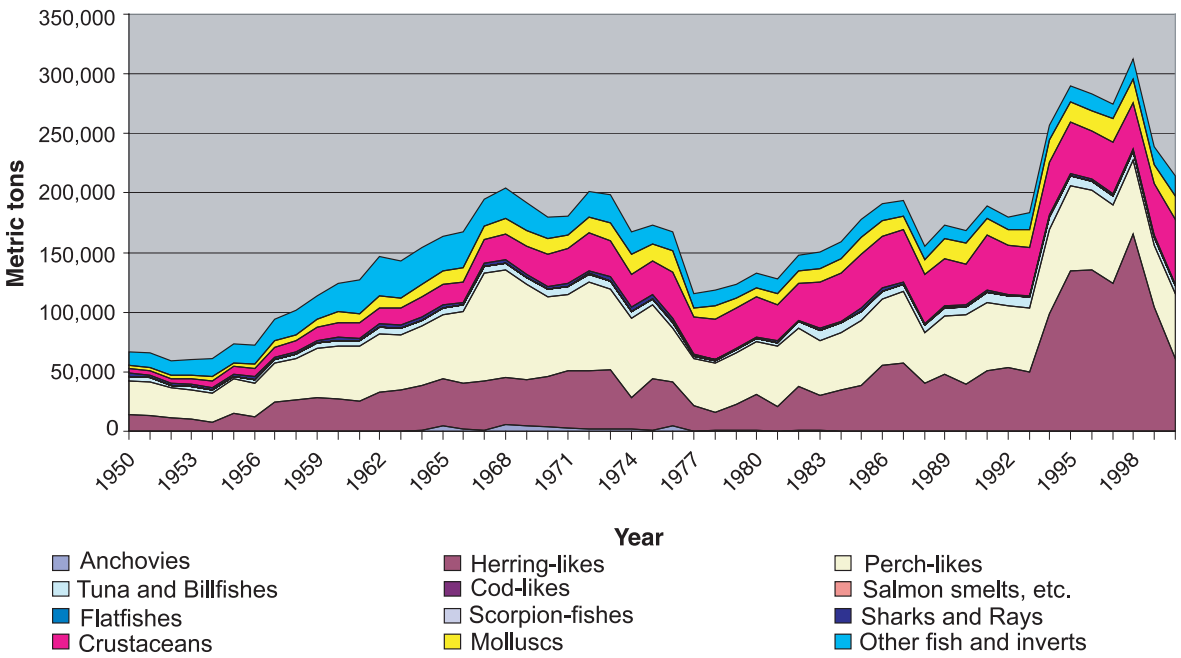


Figure 8.6. Marine Animal Catches by Animal Type in the Caribbean Sea

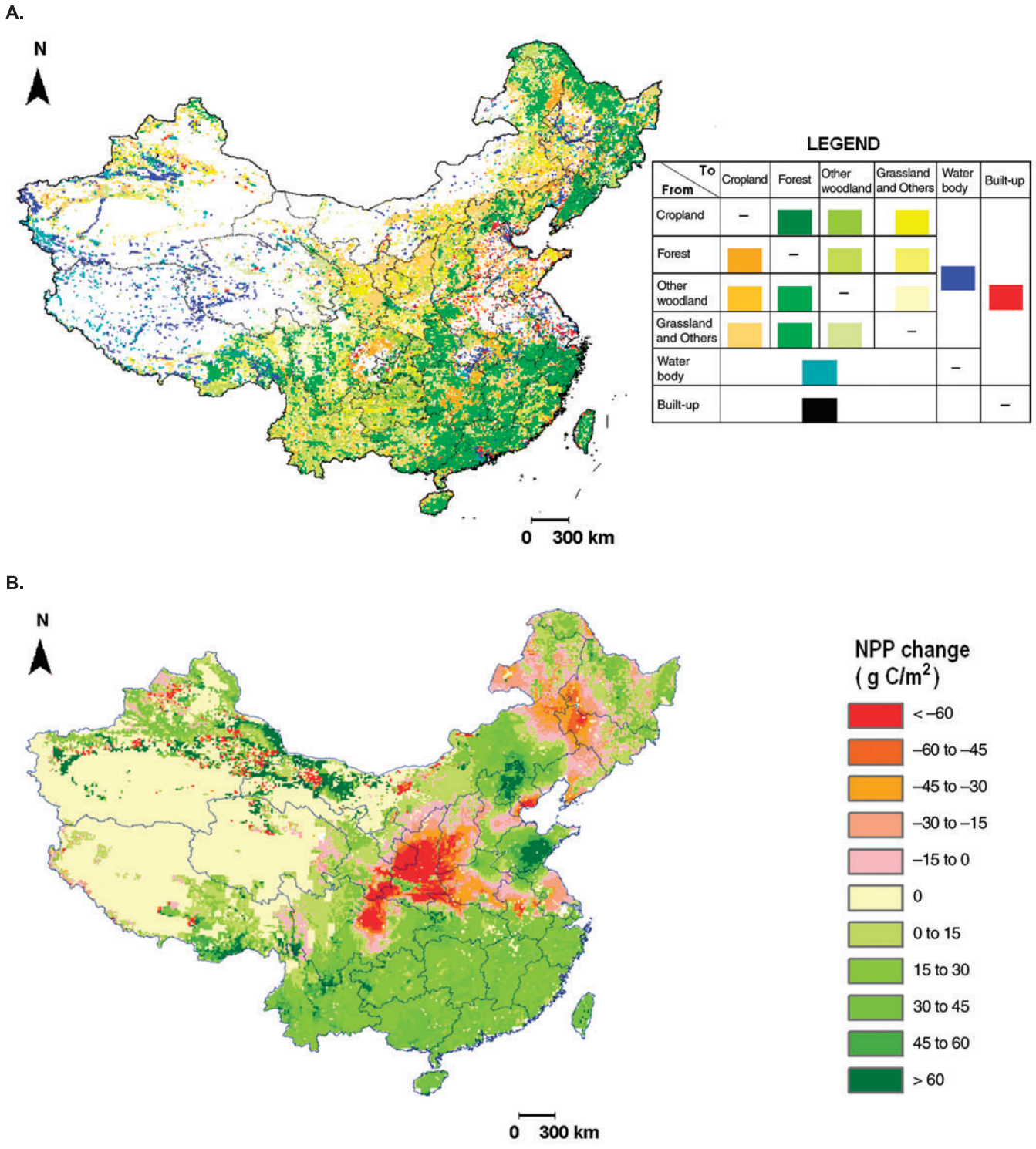
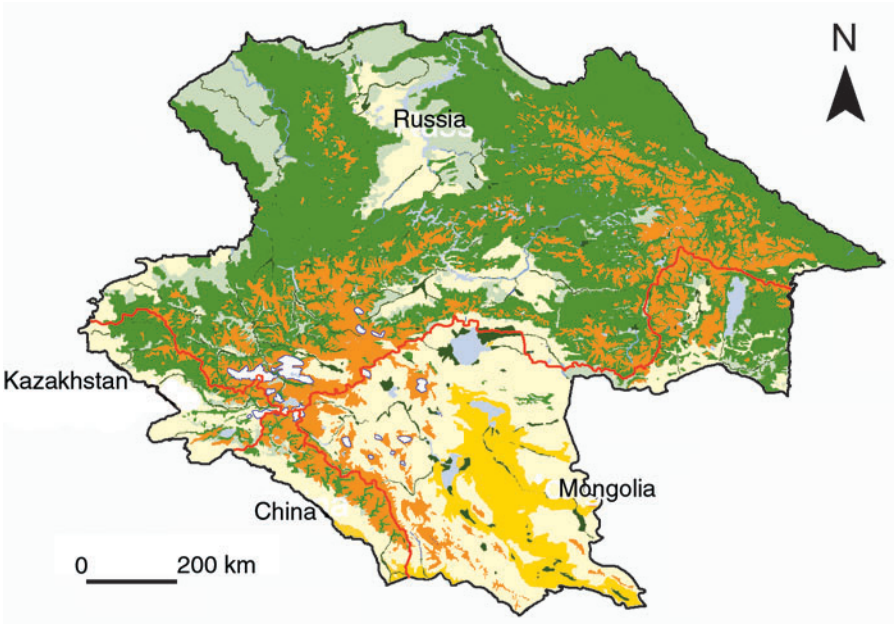
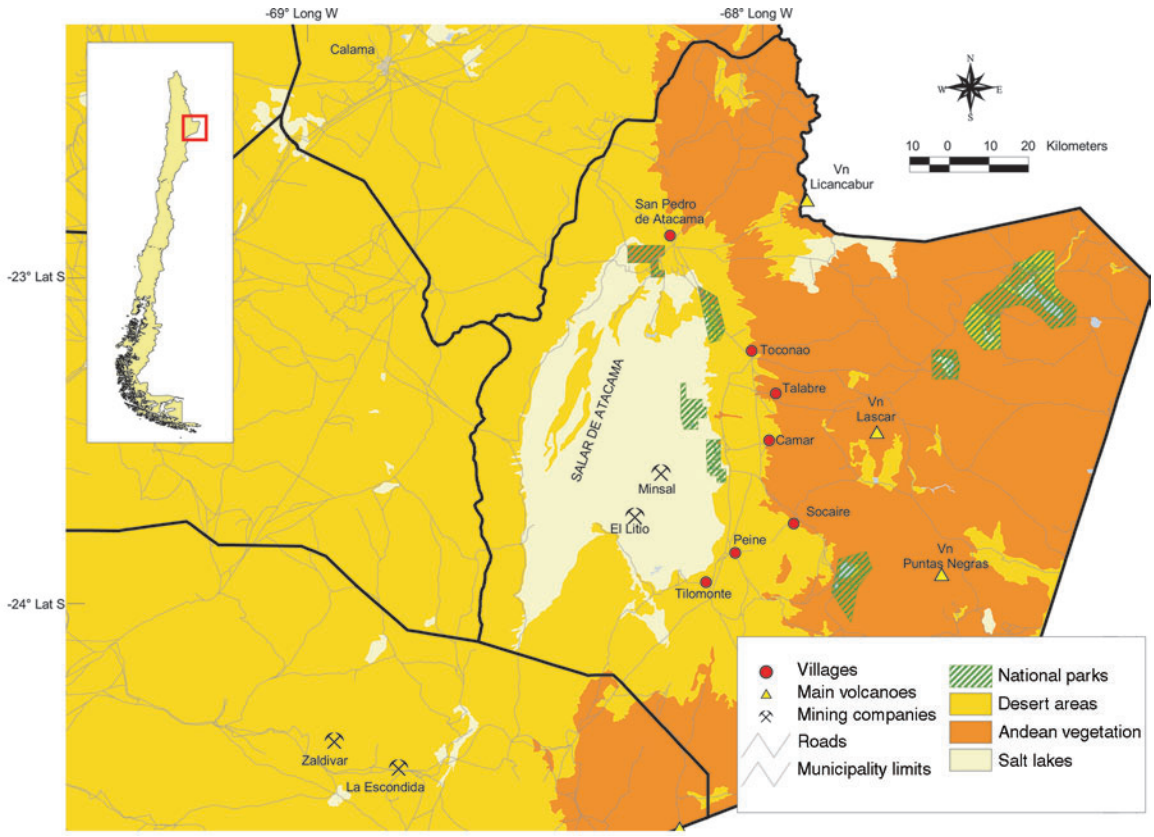


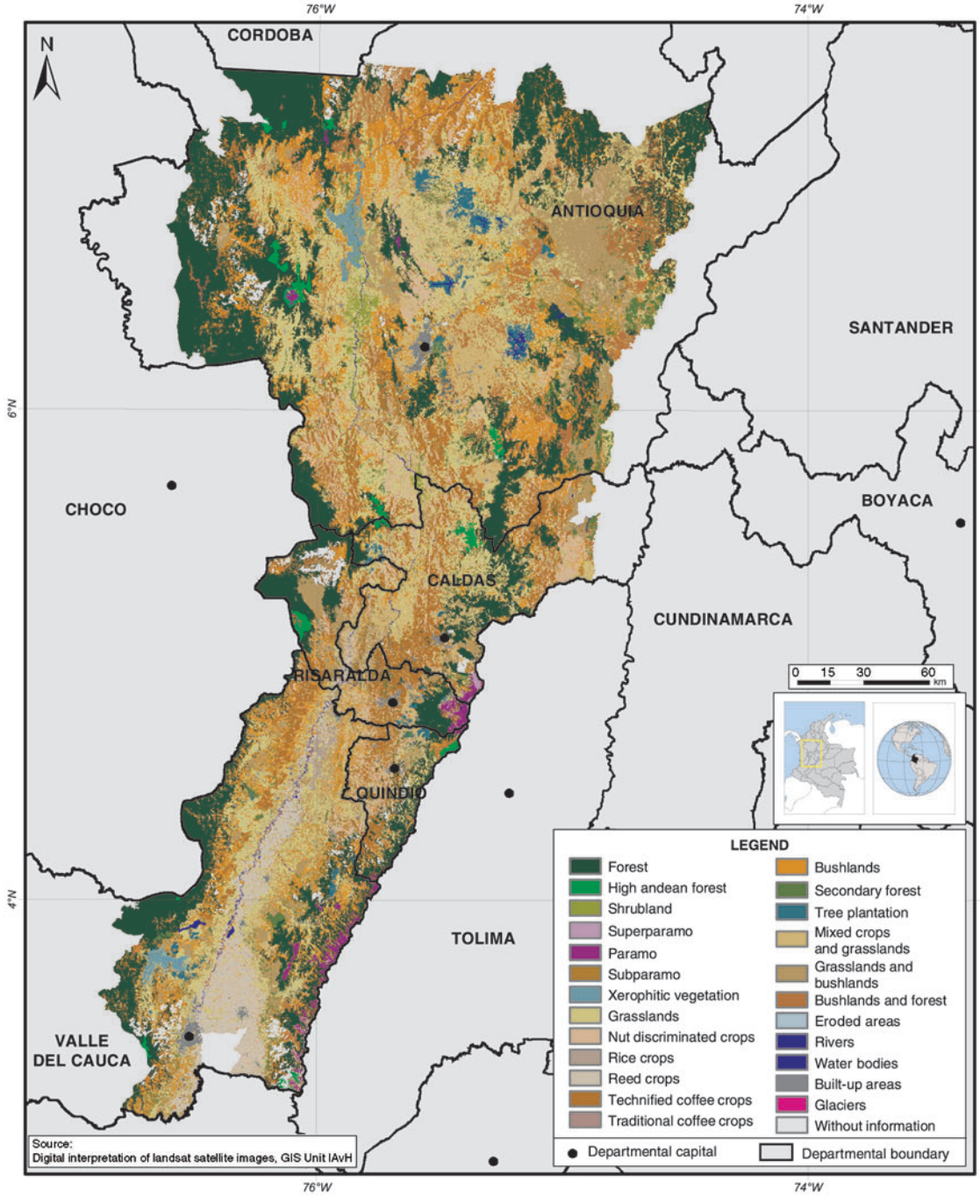
Figure for Box 8.8. Land Use Change from 1981 to 2000 (A) and Its Impact on Net Primary Productivity of Ecosystems (B).



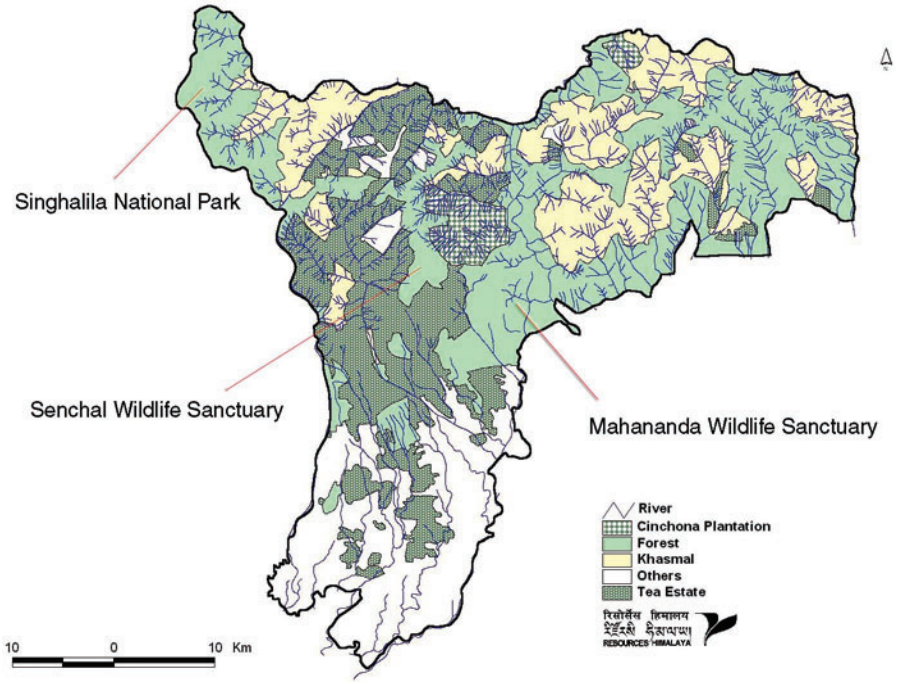
Altai-Sayan Ecoregion



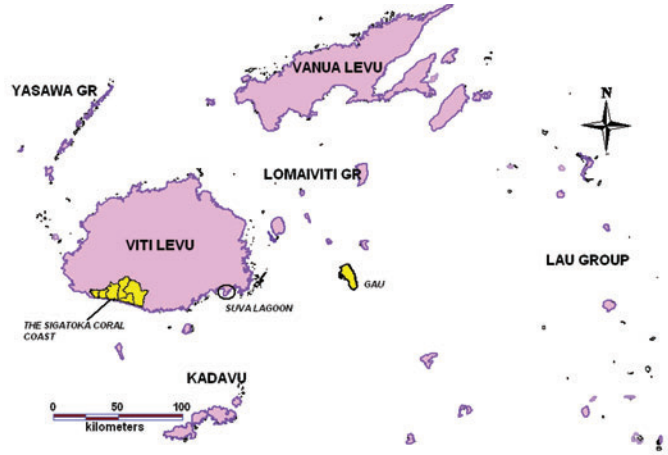
Study Area of the San Pedro de Atacama, Chile MA Sub-global Assessment



Ecological Function Assessment, Colombian Andean Coffee Growing Region

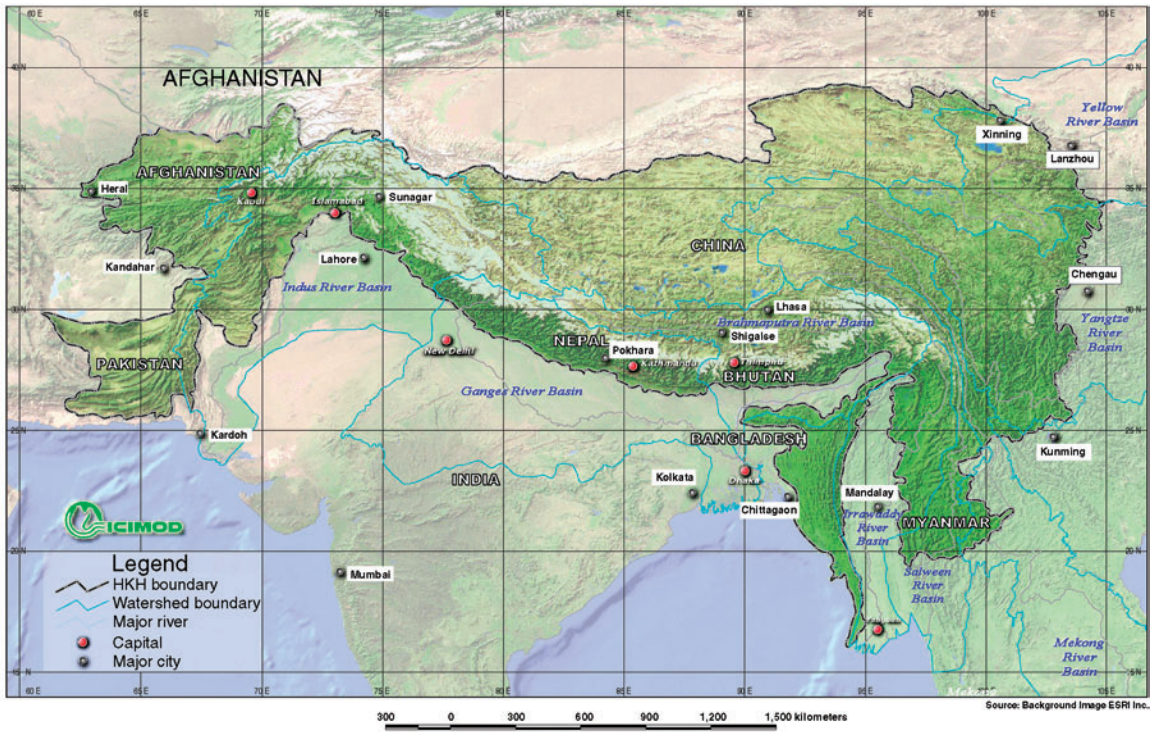


Eastern Himalayas Assessment

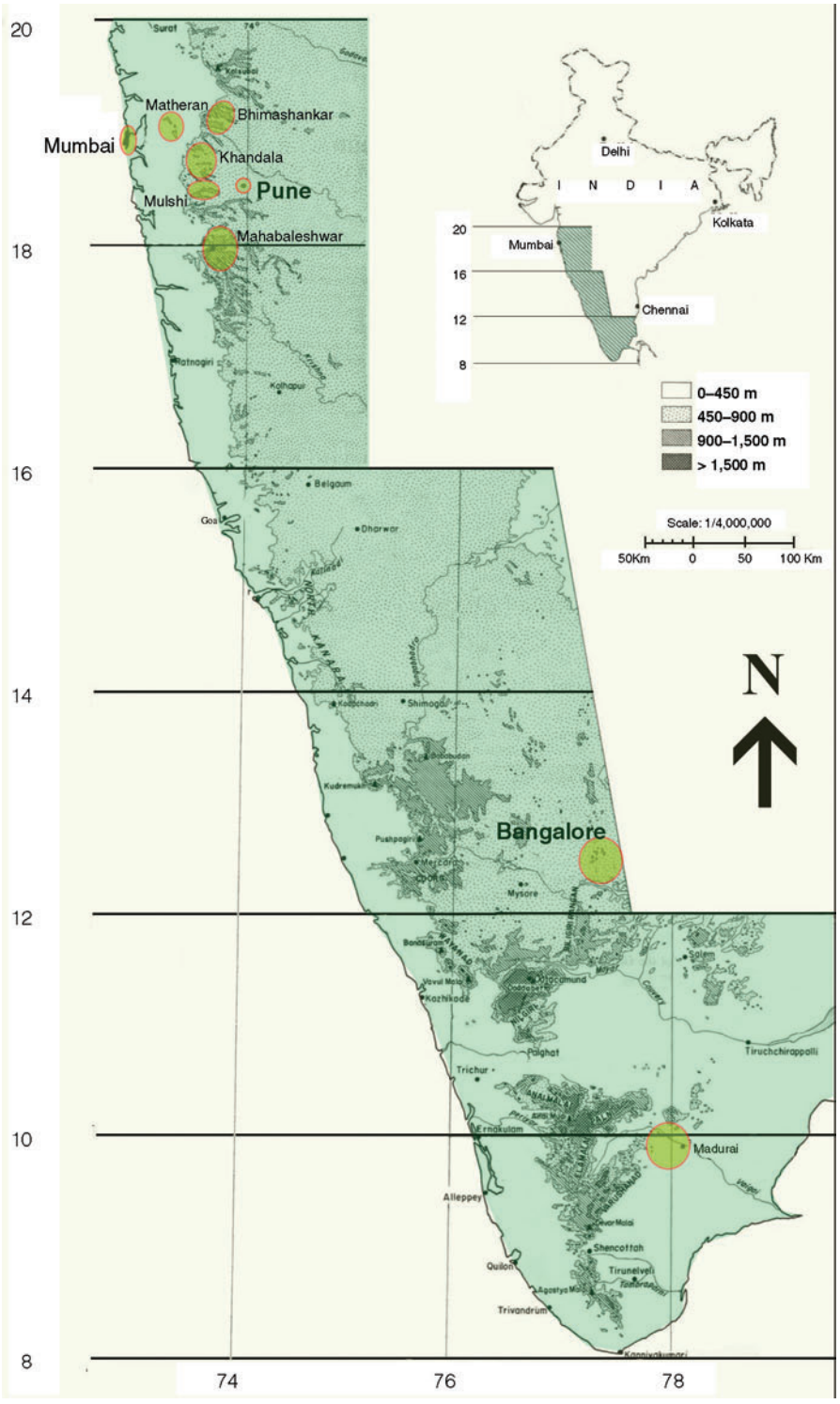


Fijian Assessment

Map of Caribbean Sea with Exclusive Economic Zones of Surrounding Countries (The Nature Conservancy)

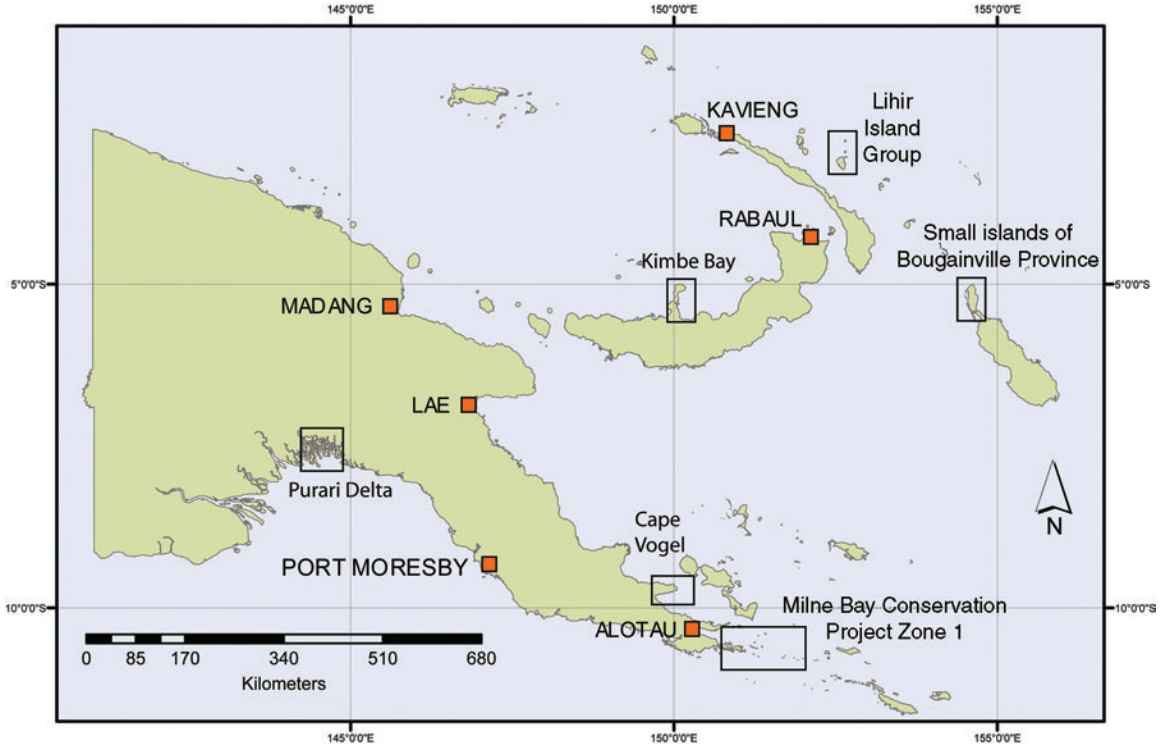


Hindu-Kush Himalayas

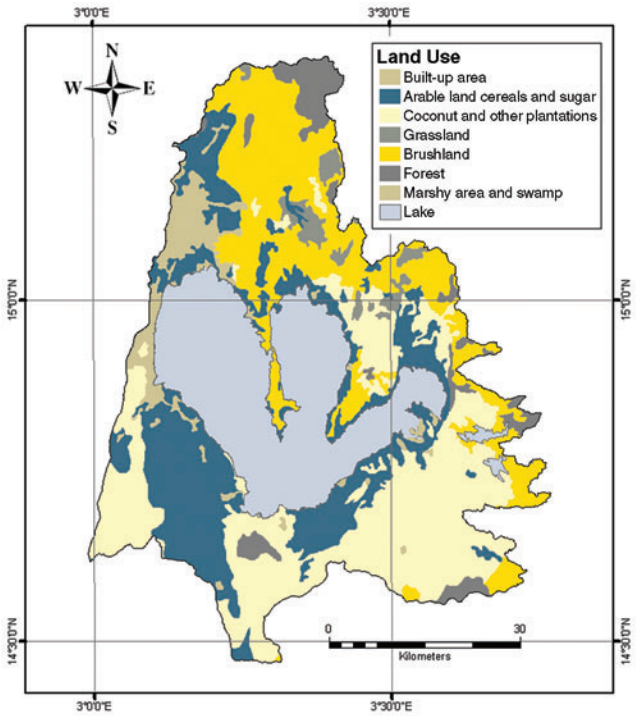


Indian Urban Resource Millennium Assessment

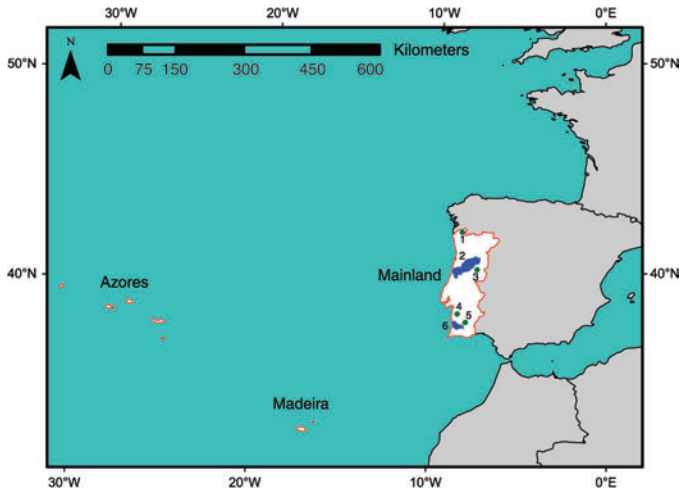
Glomma and Lägen River Basins



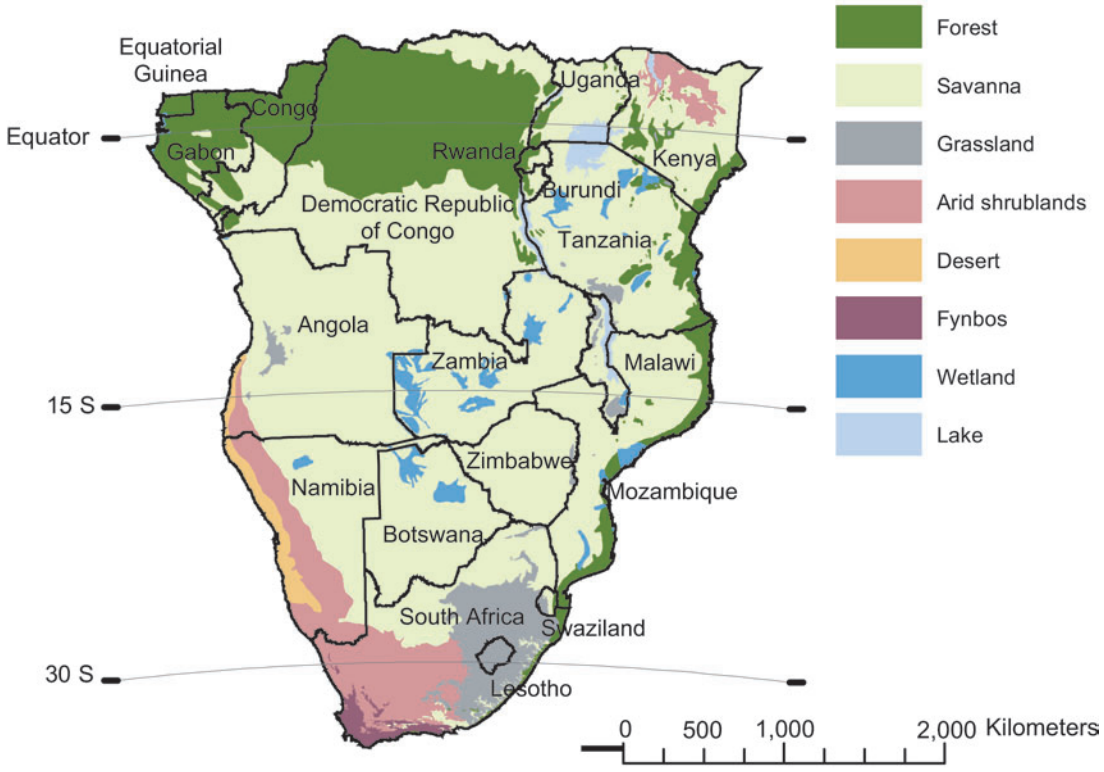
Papua New Guinea Coastal, Small Island, and Coral Reef Ecosystems



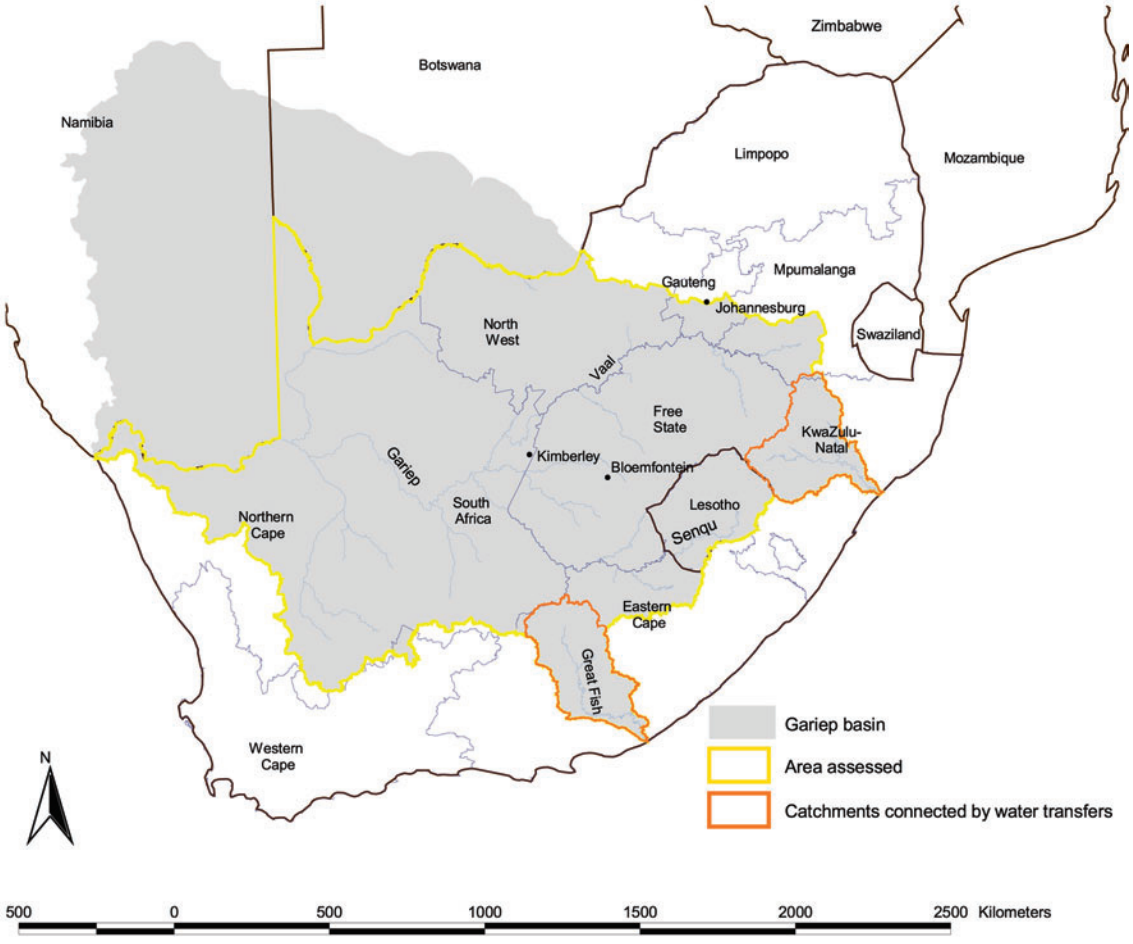
Laguna Lake Basin, Philippines



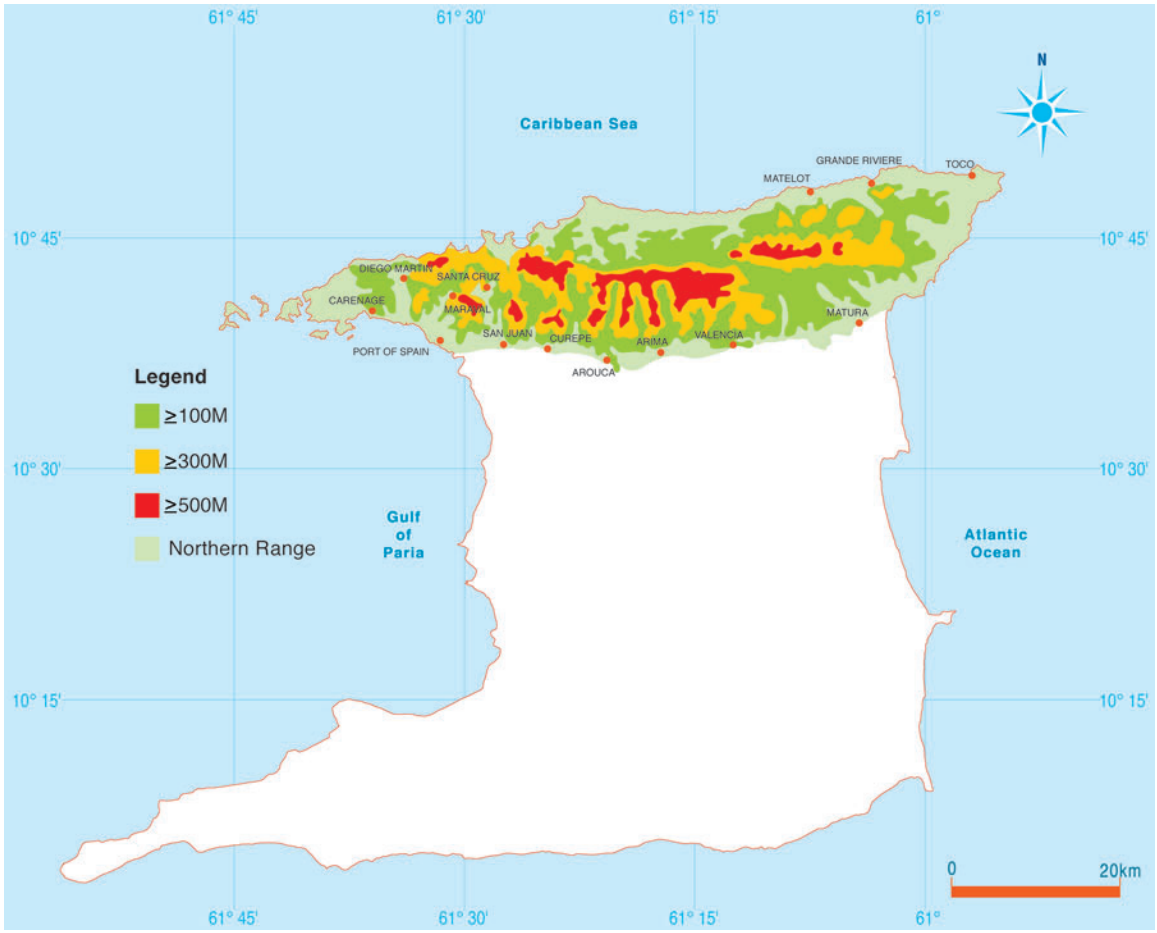
Portugal



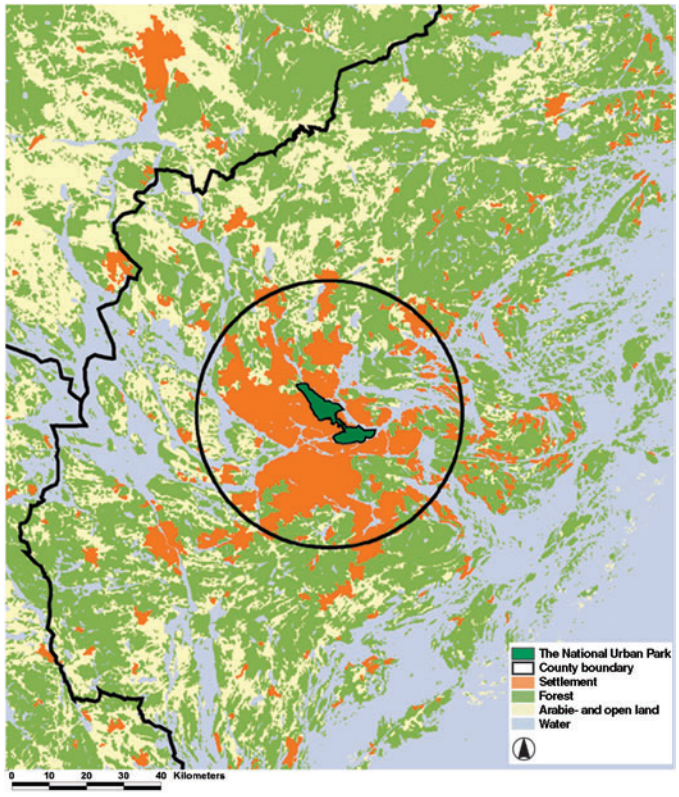
Southern African Regional Assessment. This covered 19 countries in mainland Africa south of the equator, and eight major biome types. (Scholes and Biggs 2004)



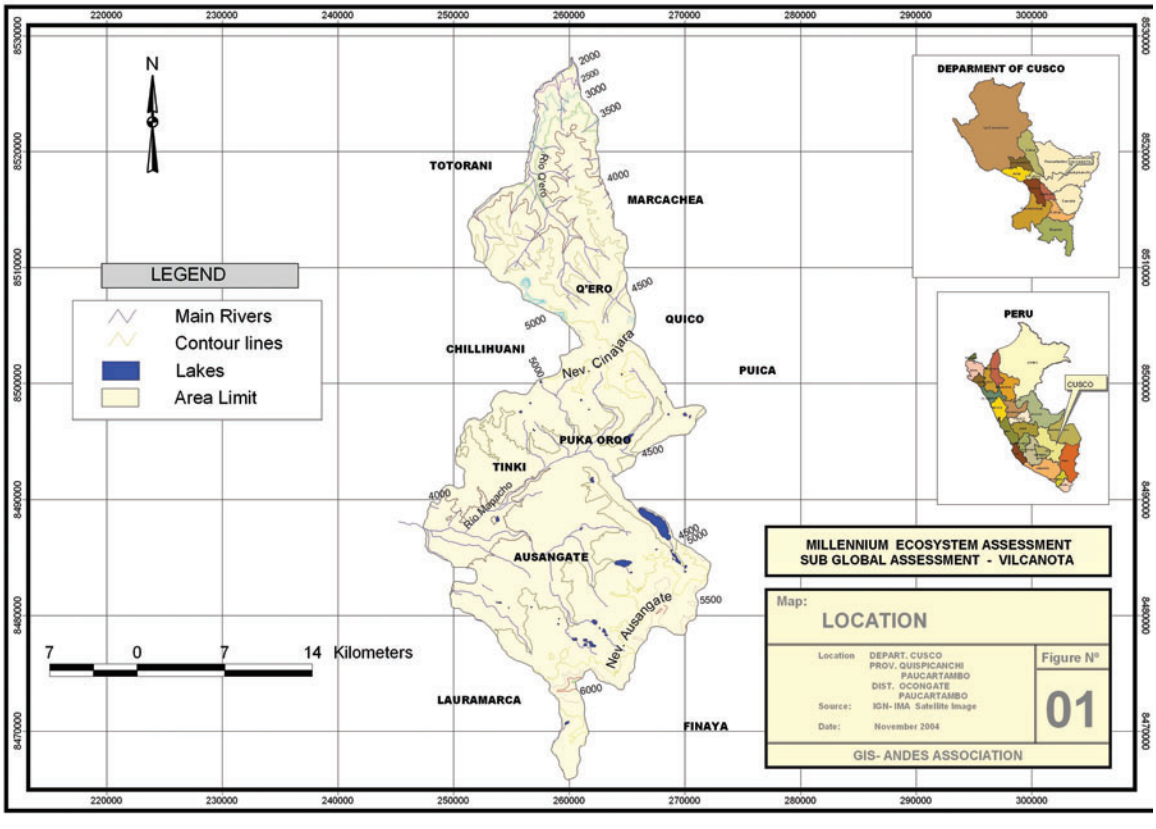
Location of the Gariep Basin, International Boundaries, South African Provincial Boundaries, Major Rivers, and Major Cities. Note that the actual Gariep basin extends beyond the area assessed. (Bohensky et al. 2004)



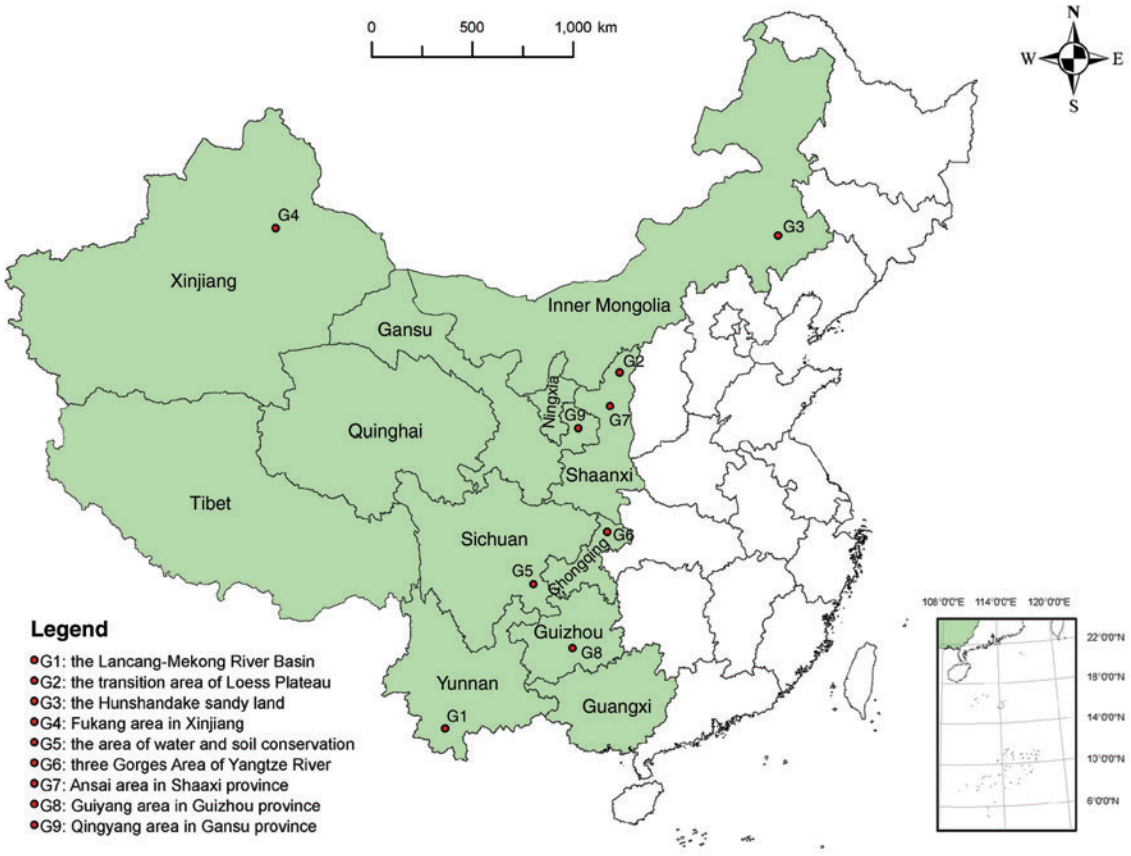
Map of Trinidad, Highlighting Topography and Major Towns of the Northern Range (Kenny 2000)



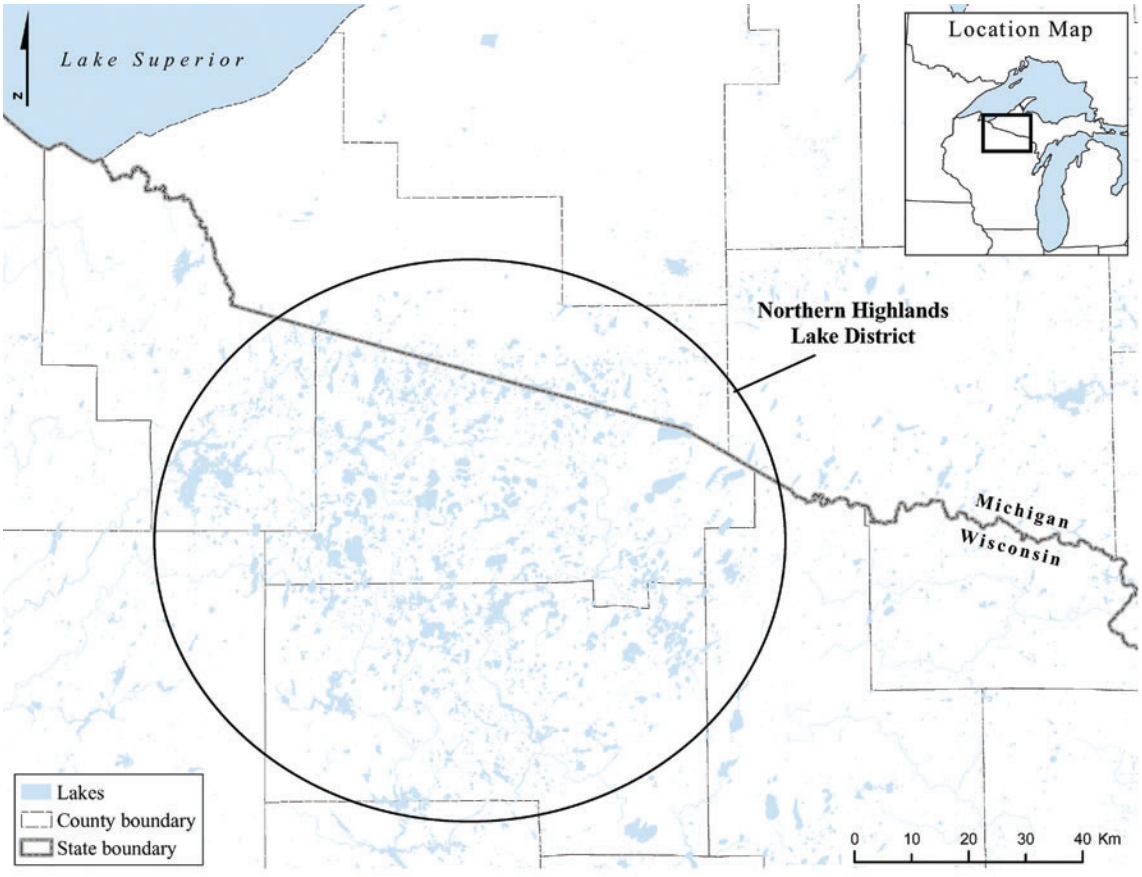
The Stockholm Urban Assessment. This assessment is located within a circle with a radius of 20 km surrounding the most central parts of the city. The National Urban Park is located in the center of this circle.



Vilcanota, Peru



The Western Region of China. The red points represent typical areas at local scale.



Northern Highlands Lake District, Wisconsin

Appendix B

Brief Summaries of the Sub-global Assessments

Alaska

Fire-mediated changes in the Alaskan Boreal Forest: Interactions of changing climate and human activities

Contact person:
Stuart Chapin
Institute of Arctic Biology, University of Alaska
Fairbanks, AK 99775, USA
E-mail: terry.chapin@uaf.edu

Project team and institutions:
Stuart Chapin (team leader, ecosystem ecologist), University of Alaska
Dave McGuire (ecosystem modeler), University of Alaska
Scott Rupp (landscape modeler), University of Alaska
Tony Starfield (conservation modeler), University of Minnesota
Erica Zavaleta (ecologist/anthropologist), University of California, Santa Cruz
Henry Huntington (anthropologist), private consultant, Alaska
David Natcher (anthropologist), Memorial University of Newfoundland, Canada
Amy Lovecraft (political scientist), University of Alaska
Sarah Trainor (political scientist), University of Alaska
Roz Naylor (resource economist), Stanford University
Paul Baer (resource economist), Stanford University
Orville Huntington, resident of Huslia; Vice-Chair, Alaska Native Science Commission
La'ona DeWilde, resident of Huslia

Location: Yukon River drainage of interior Alaska and western Canada (63.5–68°N; 130–160°W).

Time period:
Year range for assessment: 1800–present (detailed analysis since 1950)
Year range for scenarios: 2000–2100 (detailed projections through 2050)
Project time frame: Phase 1: September 2007; Phase II: September 2010

Project summary:
Recent economic and climatic changes in interior Alaska have interacted to reduce the well-being of rural residents and reduce the resilience of the region to projected future changes. The goal of this assessment is to document the changing role of fire, particularly as affected by human activities, on the Boreal system and its human residents and to explore alternative scenarios of future changes that might enhance or further reduce human well-being. Our study design is spatially hierarchical: the boreal forest of western North America, which contains two countries (Yukon Territory in Canada; Alaska in the United States), within which we study smaller regions centered on two communities in each country. Our study also has a temporal hierarchy of long-term trends (1800–2100), within which we study most intensively the period 1950–2050, where we have greatest confidence in past records and future projections. We focus primarily on two bundles of ecosystem services that are strongly affected by changes in climate and fire regime and on a set of management policies that alter the relationships among fire, ecosystem services, and human well-being.

Fire and climate warming alter climate regulation at large spatial scales by changing vegetation composition, energy exchange with the atmosphere, and carbon balance. We study how these ecological changes either amplify or buffer the rate of climatic warming. These climate feedbacks also influence the consequences of state/territory and national policies of carbon sequestration and fire suppression. Human effects on, and responses to, fire at this scale are currently small. Ecosystem modeling (the Terrestrial Ecosystem Model or TEM) and policy analysis are the primary tools used to study these large-scale processes.

Fire and climatic warming modify provisioning and cultural services such as subsistence foods (for example, game, berries, firewood), economic opportunities and risks (for example, wages, property risk), and cultural ties to the land (as reflected in altered subsistence activities, rural-urban migration, and forest harvest). We document changes in subsistence foods based on ecological observations and interviews with subsistence users. We then use a landscape model of climate-fire-vegetation interactions (the Alaska Frame Based Ecosystem Code or ALFRESCO) to explore how future changes in climate and fire policy might alter fire regime and ecosystem services. The landscape pattern of these changes determines the consequences for use by local communities. We use records of fires, employment, and community income to assess the positive and negative economic effects of fire on communities. We assess conditions and trends through stand-age reconstructions, maps of fires since 1950, and interviews with elders. We explore scenarios through landscape modeling.

Policy and management influence the ways in which climate and fire affect ecosystem services through policy effects on fire pattern and extent and on the wages available to support subsistence. Fire policies respond to both national and local pressures for change. Game management policies influence both the availability and harvest of ecosystem goods by local communities.

References:
Web page: http://www.hfi.uaf.edu/
System overview: **Chapin,** F.S., III, et al., 2003: Planning for resilience: Modeling change in human-fire interactions in the Alaskan boreal forest. *Frontiers in Ecology and the Environment* 1, 255–261.

Funding: U.S. National Science Foundation (September 2003–2006; $1.14 million).

Altai-Sayan Ecoregion

(See color version of locator map in Appendix A.)

Contact person:
Dr. A.S. Shestakov
WWF Russia
19–3, Nikoloyamskaya str.
109240, Moscow, Russia
E-mail: AShestakov@wwf.ru
www.wwf.ru

Technical team: Chimed-Ochir Bazarsad, Alexander Bondarev, Anatoliy Mandych, Yuri Plusnin, Veniamin Semenov, Alexander Shestakov, Vladimir Sokolov, and Svetlana Surazakova.

Time period: 2003–ongoing.

Intended audience: local, national and regional decision-makers.

Issues addressed:

Biodiversity. The high value of ecosystems and biodiversity of the Altai-Sayan ecoregion is fundamental in considering it one of the key Global 200 Ecoregions identified by the WWF and recognized by the United Nations and World Bank (3,726 species of vascular plants are registered in the region including 700 threatened or rare species, 317 of which are endemic; fauna consists of 680 species, 6% of which are endemic). The ecoregion is the northern range of the natural habitat of the snow leopard (*Uncia uncia*) and Altai mountain sheep argali (*Ovis ammon ammon*). Poverty, widespread unemployment, and a lack of alternative economic activities are serious socioeconomic drivers that could negatively impact the biodiversity of the Altai-Sayan. Exploitation and strain on natural resources are increasing rapidly in the ecoregion. Protection of biodiversity in the region also depends on the ability of the local communities to maintain traditional land use patterns and practices.

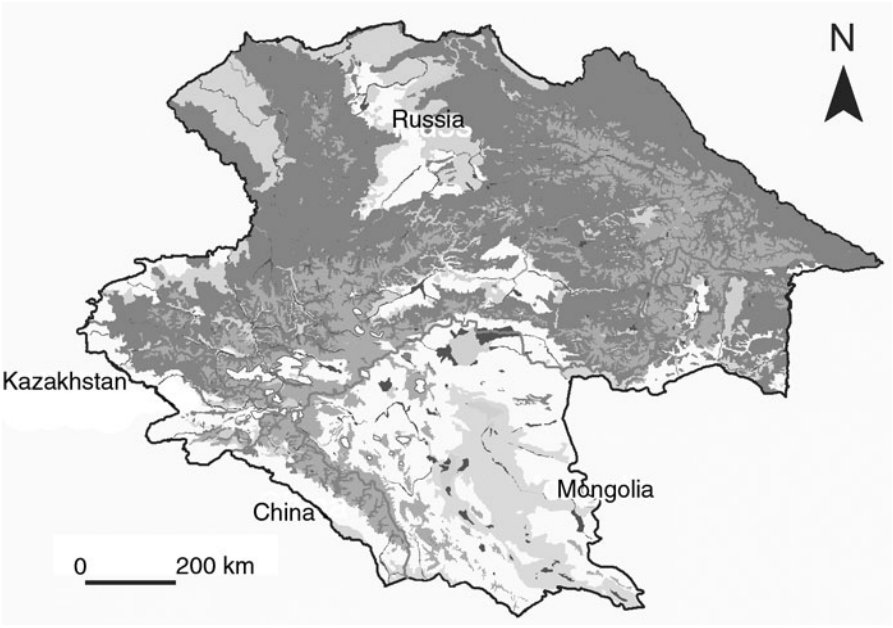
Natural forests. The present-day condition of the main provisioning goods—timber and firewood—of forest ecosystems in the Altai-Sayan ecoregion overall is estimated to be good. However, the condition is reduced to fair or even poor in some localities that are under human pressure or where unsustainable use, including illegal logging, is practiced. In the foreseeable future, forest ecosystems of the region will continue to provide people with the resources they demand, while also continuing to provide other supporting and regulating services. However, this will be sustainable in the long-term only if the state controls the use of forest services at current levels.

The existing data and modeling outputs are not sufficient to address questions about the impact of climate change on forest ecosystems and related consequences for human well-being. New studies on the impact of climate change on forest ecosystems of the Altai-Sayan ecoregion are urgently required. In the recent decades, the leading drivers of change in the region's forest ecosystems have been commercial logging and fire. Fire impact will increase in the future, owing to human activity, economic change, climate change, and pests.

Grazing lands of Western Mongolia. Overgrazing and overharvesting of biological resources (timber, wildlife) in western Mongolia is a result of the impoverishment of the country's population, who have few livelihood options and who depend almost entirely on natural resources. Mongolia's transition to a market economy caused some adverse effects on the state of the environment and grazing ecosystems. One of the effects related to changes in grazing lands was caused by the cessation of seasonal grazing, which has been practiced by Mongolian nomads for millennia. Seasonal herding led to a distributed impact on all grazing lands of the region. The abandonment of traditional herding practices was accompanied by an increase of livestock concentrated close to settlements and water sources. This caused overgrazing and even complete degradation of grazing lands in some places.

Based on the assessment of the current state and trends of grazing ecosystems, it is possible to define priorities for social responses to the current situation and future developments, including elements of a social strategy related to the use of natural resources and sustainable resource management.

Regional waters and climate change. Pronounced climate warming has been observed in the region in recent decades, and has resulted in the Altai glaciers receding and shrinking. In the case of the Katun River,



Altai-Sayan Ecoregion

which drains the northern slope of the Altai high mountains, there was no increasing trend in the river's runoff from 1950 to 2000. However, there was a noticeable trend of decreasing differences between seasonal runoff in the high and low mountains of the Katun basin. This is explained by the different responses of the rivers, with runoff forming in different elevation zones according to seasonal changes in precipitation. Currently the population and the economy have a much more significant impact on the water quality of rivers and lakes than does climate change. An increase in population and growth of the economy will likely cause rapid changes in the condition of regional waters, especially through surface water pollution.

Environmental consciousness of rural populations. The rural population in Altai-Sayan is slowly moving from the utilitarian and negative environmental paradigm of "extraction and utilization" towards new ethical principles regarding the environment. People have become aware of the need for environment protection and conservation. This is reflected in public behavior (environmental protests, establishment of new environment NGOs), although it is still rare. It has also been observed in new economic behavior and in the establishment of environmentally friendly businesses, related to the sustainable use and regeneration of local resources. This has taken place without the assistance and initiative of central authorities or the mass media.

Arafura and Timor Seas

Contact person:
Kishan Khoday
Deputy Programme Coordinator
Environment, UNDP Indonesia
Jl. M.H. Thamrin 14,
PO Box 2338
Jakarta 10240
E-mail: kishan.khoday@undp.org

Location: The Arafura and Timor seas are contiguous, semi-enclosed seas bordered by Indonesia and Timor-Leste to the north, Papua New Guinea to the west, and Australia to the south. The Pacific flows into the Arafura and Timor seas through the Torres Strait.

Lead institution: The Arafura and Timor Seas Forum (ATSEF) is a non-binding forum for collaboration between Indonesia, Timor-Leste, Papua New Guinea, and Australia for the sustainable use of the living resources of the Arafura and Timor seas.

Focal issues: The sub-global assessment focuses on four sets of institutional, biophysical, and systems dynamics priorities:

- institutional: impact of illegal, unreported, and unregulated (IUU) fishing in the Arafura and Timor Seas;
- institutional: assessment of sustainable and/or alternative livelihoods for coastal and indigenous communities;
- biophysical: assessment of fish stocks, marine habitats, and coastal and marine biodiversity; and
- systems dynamics of the seas.

Ecosystem services assessed: Fish stocks, marine habitats, coastal and marine biodiversity, wetlands, and carbon sequestration.

Key features of assessment area: These semi-enclosed seas are the global maximum for marine biodiversity. The seas have a carbon sequestration capacity that markedly exceeds other marine regions, despite containing the richest known hydrocarbon deposits. They are among the few seas where stocks depletion has been minimal, though that status is deteriorating rapidly. The near coast of much of the region consists of wetlands/floodplains that are critical to migratory bird species. Despite this abundance, 50% of the population of the coastal communities and the littoral states live below the absolute poverty line.

Argentine Pampas
The provision of ecosystem services and human well-being in the Pampas of Argentina

Contact person:
Dr. Ernesto F. Viglizzo
INTA Centro Regional La Pampa
Av. Spinetto 785 (C.C. 302), 6300 Santa Rosa
La Pampa, Argentina.
E-mail: evigliz@cpenet.com.ar

Project team and institutions: Ernesto F. Viglizzo (INTA Argentina), Emilio Satorre (Buenos Aires University), Otto T. Solbrig (Harvard University, USA), Filemón Torres (CEO Consultants) and Jorge Ingaramo (Cereals Board of Buenos Aires).

Time period: the assessment of condition and trends extends from 1880 to 2000, but detailed information is provided only for the period 1960–2000. Scenarios are projected to the year 2025.

Relevant findings: The assessment looks at four increasing geographical scales (farm, major agroecosystems, the whole Pampas, and the Del Plata basin) and time periods (from one year to four decades). Some relevant findings in relation to the supply of ecosystem services and their impact on human well-being in the Pampas are the following:

Food production. Since the beginning of colonization (1879), the Pampas of Argentina have shown their ecological potential for food production at a commercial scale. Crop and beef productivity have been growing steadily at increasing rates, and this has resulted in increased surpluses to fulfill domestic and export needs. Today, the dynamics of Argentina's economy strongly depend on the Pampas' provisioning and underlying ecosystem services. Current production is still far from the biophysical potential of ecosystems, and there is enough room to increase productivity through (1) the conversion of natural and cultivated grazing lands into croplands, and (2) increased use of external inputs. We expect that the profile of the Argentine Pampas as an international food supplier will be confirmed in coming decades and the Pampas will have an increasing economic impact at the regional, the national, and the Del Plata basin scales.

Soil erosion control and carbon sequestration capacity. Since the end of the nineteenth century, land use conversion for increasing food production has deteriorated the capacity of ecosystems to control soil erosion and sequester atmospheric carbon in soil and vegetation. Considering that these ecosystem services are coupled, they have been affected by similar changing factors. The persistent conversion of natural grasslands into cultivated lands, the extensive use of fire for managing rangelands and grasslands, the introduction of ruminant grazing cattle, and the spreading of non-conservative tillage operations for more than 80 years, have triggered frequent soil erosion episodes and transformed a carbon-sequestering region into a carbon-emitting one. Soil erosion has a broader scale, off-site impact (water sedimentation) on the Del Plata basin mouth. Carbon emission from the Pampas has, on the other hand, impact on atmospheric warming at a global scale but which has not been fully assessed. In recent times, declines in both these services have stopped and even been slightly reversed due to the extensive application of no-till practices. These practices are driving both a re-accumulation of soil organic carbon and a drastic reduction in fossil fuel consumption.

Freshwater provision. In quantitative terms, freshwater provision is not a limiting factor for human well-being in the Pampas. However, the increasing utilization of chemical inputs (especially pesticides and fertilizers) due to the expansion of the cropping area is probably affecting water quality in various areas of the region. Our regional scale studies using models tend to demonstrate that the risk of water contamination is increasing in areas where continuous cropping predominates. These estimations are confirmed by non-point field measurements over recently converted lands. Because of multiple surface and groundwater connections, contamination at the farm scale spreads to broader scales.

Habitat provision. All over the region, the expansion of cultivation is causing rapid simplification of the rural landscape, especially in continuously cropped lands. Although the systematic assessment of biodiversity is still uncommon in the Pampas, the fragmentation of landscapes, the utilization of conventional tillage, and the application of pesticides have all been consistent causes of decline in habitat provisioning. Thus we can presume that wildlife biodiversity is persistently declining over the whole region, but particularly in the more intensively impacted ecosystems.

Nutrient cycling. The replacement of rangelands and cultivated grasslands by croplands is deeply modifying the nutrient cycling in ecosystems. Our studies have revealed an increasing weakness of organic compartments in nitrogen (N) and phosphorus (P) cycles. The retention of N and P in strong organic compartments has maintained a robust functioning of nutrient cycles when rangelands and legume-based cultivated grasslands have predominated over croplands. The expansion of croplands during the last 20 years has caused rapid depletion of the soil nutrient endowment and a growing use of inorganic fertilizers (especially N) to compensate for this. Increased leakage of nutrients and the risk of water contamination were unavoidable results. On-site actions affecting nutrient cycles have off-site effects at wider scales. Thus the disruption of nutrient cycles not only affects the on-site maintenance of soil fertility, but also puts at risk the off-site provisioning of good-quality fresh water.

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Viglizzo, E.F., A.J. Pordomingo, M.G. Castro, and F.A. Lértora, 2003: Environmental assessment of agriculture at a regional scale in the Pampas of Argentina. *Environmental Monitoring and Assessment* 87, 169–195.

Funding: National Institute for Agricultural Technology (INTA) of Argentina.

San Pedro de Atacama, Chile
Human well-being and sustainable management of the Salar de Atacama ecosystem

(See color version of locator map in Appendix A.)

Contact person:
Hernán Blanco
Executive Director
Recursos e Investigación para el Desarrollo Sustentable
Andrés de Fuenzalida 22, Oficina 801
Providencia, Santiago, Chile
E-mail: hblanco@rides.cl

Project coordinating institutions: RIDES, *Recursos e Investigación para el Desarrollo Sustentable*. RIDES is a research center—an NGO based in Santiago, Chile. Its mission is to develop applied research to contribute to public and private policies for sustainable development in Chile and in the South American region.

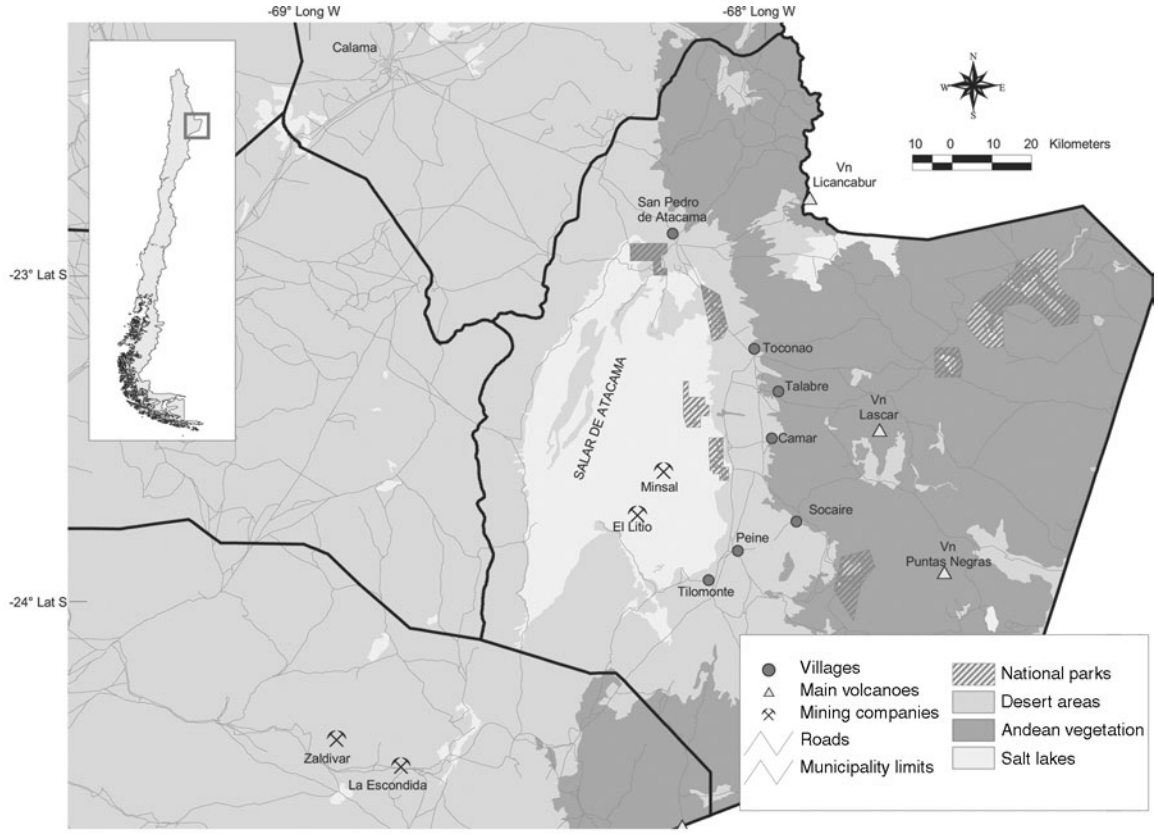
Project time frame:
Range for which the condition and trend assessment applies: last 10–15 years.
Range for which the scenario projections apply: 5–20 years.
Work time frame: June 2003–February 2005

Summary of important findings and methodologies used: The table summarizes the links between the ecosystem services studied in the project and human well-being.

References: RIDES Web site: www.rides.cl.

Funding: The project received $95,000 from the MA; approximately $4,000 from mining companies; approximately $7,000 from public sector agencies (final figure to be confirmed); and in in-kind cooperation from various agencies (private and public) on the order of $2,000.

Acknowledgments: The following institutions/programs have actively collaborated with the project: interdisciplinary studies on biodiversity program, *Programa Interdisciplinario de Estudios en Biodiversidad,* Universidad de Chile (www.biodiversidad.uchile.cl); Forestry Agency, CONAF (www.conaf.cl); indigenous people's development area, *Área de Desarrollo Indígena Atacama la Grande*; San Pedro de Atacama municipality; and two mining companies—Compañía Minera Zaldívar (www.cmz.cl) and Minera Escondida Limitada (www.mel.cl).



Study Area of the San Pedro de Atacama, Chile MA Sub-global Assessment

Ecosystem Service	Link to Human Well-being	Indicators
Water	A scarce resource fundamental for human life and ecosystem support. Economic activities such as mining, agriculture and tourism depend upon water availability. Water scarcity has generated conflicts between the main users. Water quality is another issue: high levels of arsenic are naturally present.	In Chile there is a water market, ruled by the Mining and Water Law. Indigenous communities and related public institutions do not have enough resources to buy water rights, compared to the mining companies. Distribution of water rights and requests (requests exceed available volume) **Potable Water.** Rights: 817 l/s (13%); Requests: 288 l/s **Irrigation.** Rights: 3,008 l/s (47%); Requests: 5,049 l/s **Mining.** Rights: 2,600 l/s (40%); Requests: 5,518 l/s **Brine exploitation.** No information yet. **Recreational.** 20 l/s (<1%) ; Requests: 0 l/s 68% of the population does not have access to treated water. Only in San Pedro is water potable. Mining improvements: MEL imposed itself the goal of recycling 38% of water consumed in operations; CMZ reduced its annual consumption of water by about 800 cubic meters between 1995 and 2002.
Tourism	Source of employment and income to local communities (indigenous and non-indigenous). For indigenous people, it is an opportunity to revalue their culture and landscape. Tourism, on the other hand, affects the traditional lifestyle of local communities and might contribute to pollution (waste, noise, etc.).	The two main sources of local employment are: construction (17.7%) and hotels and restaurants (15%). For the year 2000, tourism income in San Pedro de Atacama was about $5,381,000 Local population: 4,696 Visitors: around 3,800 monthly visitors in high season and 1,800 in low season.
Minerals	Source of employment and income to local communities (indigenous and non-indigenous). At the regional and national level it is a major source of revenues and a main contributor to GDP. Mining is the main water user and is also a source of waste and risks.	Mining is the third largest source of local employment (11.4%). Mining represents 4.8% of national GDP and 66.21% of regional GDP (1999). Mining consumes more than 65% of available water in the region.
Biodiversity	Supports the life cycle of basic elements (water, nutrients, etc.), providing elements and resources (like bogs(for animals (birds, llamas, foxes, etc.) and human life (seeds, wood fuel, vegetables, and fruits). Biodiversity is a constitutive element of the Atacameños' culture; expressions of this are, for example, the use of flamingo feathers in religious ceremonies and the use of herbs in traditional medicine.	Bogs represent 0.07% (1,697 ha) of the municipality's total area. Three species of flamingos: F. Chileno (*Phoenicopterus chilensis)*, F. Andino (*Phoenicoparrus andinus)*, F. de James (*Phoenicoparrus jamesi)*. The Salar is the world's largest nesting site of flamingos, and the only area in which the F. Andino is found. 3% (73,983 ha) of the whole area is protected by the state.
Agriculture and livestock	Historically, agriculture was a main economic (and also cultural) activity; it fostered the development of the Atacameños' traditional water management techniques. At present, local communities still practice agriculture but for household consumption. One current risk (to human well-being and ecosystem health) is mono-cropping.	Cropland distribution: Hay: 73.4% (alfalfa) Vegetables: 13.7% Fruits: 6.7% Cereals: 4.2% Domestic crops: 0.6% Forest: 1.4%
Observatories	The pristine air, extremely low humidity, and the geographical features of the area create excellent conditions for astronomical observations. Observatories generate knowledge (particularly at a global level) and employment, and recent agreements between developers and communities include opportunities for local development. On the negative side, observatories alter the landscape, generate waste, increase access to previously isolated areas, and impose limits on the amount of surrounding light.	ALMA Project, total investment: $555 million over 8 years Social contributions: $700,000 annually for local and regional development projects, and national scientific projects. Locally: about $183,000 for health and education projects in San Pedro de Atacama and for productive development for the indigenous community of Toconao.

Caribbean Sea

(See color version of locator map in Appendix A.)

Contact person:
John Agard
Department of Life Sciences
University of the West Indies, St. Augustine,
Trinidad and Tobago
E-mail: jagard@fsa.uwi.tt

Lead institutions: University of the West Indies (UWI), The Cropper Foundation (TCF), The Institute of Marine Affairs (IMA), Caribbean Conservation Association (CCA), UNEP Regional Office for Latin America and the Caribbean (UNEP ROLAC), Caribbean Agricultural Research and Development Institute (CARDI), Island Resources Foundation (IRF).

The Advisory Committee of potential users of the assessment includes the Secretariats of the Association of Caribbean States (ACS), CARICOM, the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), and the Caribbean Conservation Association.

Time period: The time frame evaluated for key ecosystem services were the following: fish production (1950–2000); desalinated water (1992–2000); coral reef cover (1977–2002); amenity value (1990–2003); and climate regulation 1910–2000).

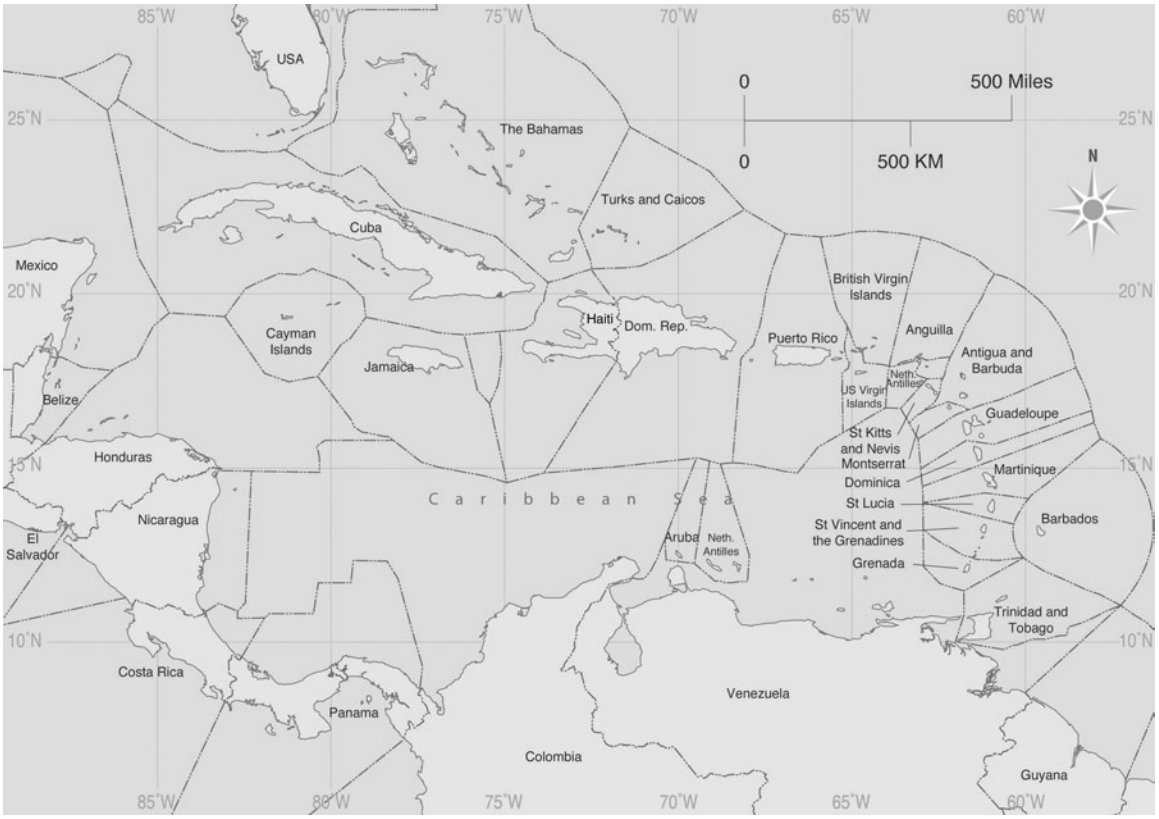
Four scenarios were developed to the year 2050: Neo-plantation Economy, Quality over Quantity, Diversify Together, and Growing Asymmetries.

Summary of important findings:

Fish production. It is moderately uncertain whether increasing efficiency of fish capture through the increasingly widespread use of gill-netting, purse-seining, long-lining and trawling involving local fishers inshore and foreign fleets offshore may have been the cause of major fluctuations in fish catches since the 1980s and of a change in the trophic structure of the Caribbean Sea ecosystem. In Central America and the insular Caribbean the number of people actively fishing increased from 194,278 in the 1970s to 504,913 in the 1990s. Per capita consumption of fish in the region is approximately 15 kilograms, but is highest in the insular states where the average per capita consumption is 19 kilograms, which is well above the world average. The export value of fish and fisheries products increased from $400.6 million in 1976 to $1.6 billion in 2000. The U.S. market is the major destination of most exports from the Caribbean. Export products are dominated by high-value commodities such as shrimp, spiny lobster, tunas, snappers and groupers, and queen conch, which command premium prices in the international market.

Desalinated water. About 3% of the world total of desalinated water is produced from the Caribbean Sea; 92.5% of this desalinated water is utilized by the insular Caribbean countries mainly to solve distribution problems and satisfy tourist demand. The value of the water produced is conservatively estimated at about $317 million per annum. This is an indicator of the replacement cost of this ecosystem service, which is normally sourced from terrestrial watersheds.

Coral reef cover. From 1977 to 2001, typical live coral cover has with high certainty declined from more than 50% in 1977 to about 10–15% in many shallow Caribbean Sea reefs. Studies in 2004 suggest that reefs in waters deeper than about 10 meters and also far from land or next to small populations are much healthier.



Map of Caribbean Sea with Exclusive Economic Zones of Surrounding Countries (The Nature Conservancy)

Amenity value. With high certainty, data from the World Tourism and Travel Council show that relative to its size, the Caribbean scores highest in several key categories when its dependence on tourism is compared with other regions on a global scale. Thus the Caribbean may be the region in the world most dependent on tourism for jobs and income. In 2003, the Caribbean's travel and tourism economy accounted directly and indirectly for: 1,857,000 jobs representing 12.0% of total employment; $23.1 billion of GDP, equivalent to 13.0% of total GDP; $16.2 billion of exports services and merchandise, or 16.5% of total exports; and $7.6 billion of capital investment, or 22.3% of total investment

Climate regulation. Elevated sea temperature episodes in the last decade are the most likely cause of increasingly frequent occurrences of coral reef bleaching in the Caribbean. Since 1998, it is known with high certainty that the region has seen a trend of increasing frequency of tropical cyclones. Deaths and damage to property and ecosystems have also increased incrementally due to interaction with rapid urbanization on the coast.

Major funding: MA, IDRC, UNEP ROLAC.

Central Asia Mountain Ecosystems

Contact person:
Bulat Yessekin
Executive Director, Regional Environmental Centre for Central Asia
40, Orbita-1, Almaty, 480043
Republic of Kazakhstan
E-mail: BYessekin@carec.kz
Web site: http://www.carec.kz

Lead institution: Regional Environmental Center for Central Asia

Time period: The period assessed is 1999–2004. Scenarios are projected to 2030. The project completion date is planned for December 2006.

Intended audience: Governments of the Central Asian states; international and national public organizations; nature users and persons using ecosystem recreational and aesthetic services; population of mountainous areas; mass media; educational, scientific, cultural, and health institutions; local governments; environmental organizations.

Goal: To ensure conservation of mountain ecosystems and sustainable development of the Central Asian sub-region on the basis of continuous effective regional policy efforts designed to improve the interaction of society with ecosystems. Project tasks include the following:

- analyzing the current status and magnitude of human-caused transformation of the Central Asia mountain ecosystems at the local, national, and regional levels;
- identifying causes and effects;
- assessing the capacity of mountain ecosystems to provide goods and services;
- developing and approving a toolbox for an ecological assessment and examination of actions designed to reduce negative influences on ecosystems;
- developing scenarios of possible ecosystem changes depending on adopted decisions;
- developing recommendations for decision-making and planning related to conservation and restoration of mountain ecosystems in Central Asia.

Project components:

- Northern part of Western Tien Shan, near Almaty city (Republic of Kazakhstan)
- Catchment basin of Talass (Kyrgyz Republic)
- Vorzob gorge, Southern slope of Gissar mountains (Republic of Tajikistan)
- Kopet-Dag reservation and surroundings (Turkmenistan)
- Gissarskiy reservation and surroundings, Western Pamir-Alay (Republic of Uzbekistan)

Condition of ecosystem services in the Central Asian mountains:

Genetic resources. The mountains of Central Asia, due to their geographic location in the heart of the sub-region and a comprehensive range of altitude belts, are characterized by high biological diversity at the ecosystem, population, and species levels. Mountain ecosystems serve as the place of origin for many cultivated plants and animal breeds, refugia of plants and animal species, and a gene pool for a number of globally important species.

Water. The mountains of Central Asia are a unique source of fresh water. Runoff of the large rivers in the regions, such as the Ili, Shu, Talas, Syrdarya, Amudarya, Zeravshan, Atrek, Karatal, Aksu, Lepsa, etc., is formed in the high altitude mountains. A cascade of water reservoirs used for irrigation and power generation controls the runoff. Many small rivers start in the foothills as a result of underground runoff discharge. Their water is used to irrigate agricultural land in the piedmont valleys.

Forestry resources. The main forestry resources of the region are concentrated in the mountains of Central Asia. They are the source of timber and fuel wood, fruits, berries, and medicinal plants, and the habitat of various wild animals. The Tien Shan Mountains have a unique spruce forest belt formed by the relic species of Tien Shan spruce. The Western Tien Shan still has a lot of Zeravshan juniper open woodlands. Considerable areas are under wild fruit-bearing forests and represent the genetic centers of origin for cultivated varieties of apple, pear, pomegranate, apricot, etc. Mountainous forests play an important role in water regulation, landscape control, oxygen production and carbon dioxide absorption.

The Central Asia mountains are surrounded by a desert zone. Foothills and low altitude areas are overpopulated due to more favorable climatic conditions and a better supply of water, land, pasture, forest, and other resources. The mountain ecosystems play a leading role in sustaining the livelihood of populations in the mountains and adjacent valleys (providing water, fuel, feed for domestic animals, treatment and recreational facilities, etc.)

Mountain ecosystems appear to be highly vulnerable and sensitive to human pressures due to the high rate of substance and energy transfers from higher to lower altitudes, which contributes to the threat of natural and human-caused disasters. Increasing exploitation of mountain ecosystems and degradation of biota result in the disruption of ecosystem linkages and the consequent reduction of the regulating functions of ecosystems. The negative effects of human activities in the mountains are demonstrated by an increased occurrence of natural disasters (mudflows, landslides, floods), extremely fast biodiversity losses, water resource reduction, and soil degradation. This, in turn, makes the mountains less appealing in terms of tourism and recreation, negatively affects the revenues of the people populating both the mountains and surrounding valleys (deserts), and promotes the processes of ecosystem destruction. Low living standards and population growth often force the Central Asia governments and populations to compromise, accepting progressive environmental degradation to satisfy the urgent needs of life. Resource depletion ultimately results in further impoverishment of the population.

Coastal British Columbia, Canada (Coastal BC)

Contact person:
Robert Prescott-Allen
627 Aquarius Road
Victoria, BC
V9C 4G5 Canada
E-mail: rpa@padata.com

Project team and institutions: The assessment was conducted by the Coast Information Team (CIT), consisting of a management committee of representatives of the British Columbia Provincial Government (David Johns, Ken Baker [Co-Chair], Gary Reay), First Nations (Art Sterritt [Co-Chair], Dallas Smith), environmental NGOs (Dr. Jody Holmes, Ivan Thompson, Tom Green), forest products companies (Rick Jeffery, Corby Lamb, Patrick Armstrong, Linda Coady, Hans Granander), and the community at-large (Graem Wells, Bill Beldessi), a secretariat (executive director Robert Prescott-Allen, program manager Melissa Hadley), and ten project teams: Ecosystem-based Management (EBM) Framework (led by Alex Grzybowski), EBM Planning Handbook (Dan Cardinall), Hydroriparian Planning Guide (Dr. Mike Church, Karen Price), Scientific Basis of EBM (Dr. Andy MacKinnon), Ecosystem Spatial Analysis (Dr. Reed Noss and Chuck Rumsey), Ecosystem Trends Risk Assessment (Dr. Rachel Holt), Cultural Spatial Analysis (Dr. Bob Lee), Economic Gains Spatial Analysis (Dr. Doug Williams, David Hall), Well-being Assessment (Robert Prescott-Allen), and Policy and Institutional Analysis (Dr. George Hoberg). The peer review chair was Dr. Rod Dobell, Emeritus Professor of Public Policy, University of Victoria.

Time period: The period assessed is 1990–2000. The project timeframe was January 2002–March 2004.

Intended users: Sub-regional and First Nations planning processes; provincial and First Nations governments.

Products: The CIT produced four EBM guides and six regional and sub-regional analyses. The former consisted of EBM Framework, EBM Planning Handbook, Hydroriparian Planning Guide, and Scientific Basis of EBM; the latter included Ecosystem Spatial Analysis, Ecosystem Trends Risk Assessment, Cultural Spatial Analysis, Economic Gains Spatial Analysis, Well-being Assessment, and Policy and Institutional Analysis.

Main findings:

Ecosystem services and human well-being. The region's ecosystems provide supporting and regulating services that are essential for human well-being. In rural societies, major provisioning and cultural services—notably those required for sustenance—are identical. However, the assessment distinguished *economic services* (sources of income and employment with a direct monetary value) and *cultural services* (all other material and nonmaterial contributions to human well-being, including the provision of food). The main economic services are provision of resources for fisheries and food production, logging and wood production, and tourism, contributing from 17% to 56% of employment income (depending on sub-region)—lower than it was in 1990, except in Upper Mid Coast, where the contribution to employment income has risen. The largest source of employment income is logging and wood production, apart from fisheries and food production in the Outer Central Coast. The main cultural services are provision of land and marine plants and animals that are major sources of sustenance for First Nations and nonaboriginal communities (fishing, hunting, and plant gathering have both nutritional and cultural value in local cuisines and as activities that express and affirm aboriginal and rural lifestyles); raw materials for traditional arts, crafts, and medicines; the sites of origin stories, crests, dances, legends, and names, as well as traditional fishing, hunting, gathering, and dwelling places; and places of artistic heritage and aesthetic and recreational value.

Conditions and trends: ecological integrity and ecosystem services. The supply of ecosystem services depends on maintaining the ecological integrity of land, fresh water, and marine ecosystems and the atmosphere. Ecological integrity is medium poor, based on scores for ecosystem diversity, species and genetic diversity, environmental quality, and provisioning and cultural services. Declining populations of resource species and increasing risk to rare ecosystems and species are the main signs of impaired ecological integrity. Although the protected area system is already substantial, it does a poor job of representing the region's land and marine diversity, and in two subregions is entirely inadequate. Declines in resource species have a direct impact on economic and cultural services. Increasing risk to rare ecosystems and species is evidence of damage to ecological integrity that may not affect economic and cultural services but could impair supporting and regulating services.

Conditions and trends: human well-being. Human well-being is medium, based on scores for population and health, wealth, knowledge and culture, and community. The main reasons are: excessive population fluctuations, inadequate employment income, high proportions of low-income households, weak economic foundations (poor access to resources and limited business diversity), mediocre knowledge and education, insecure access to cultural places, lack of power over decisions that affect local livelihoods, low expectations of local governance, and social problems manifested by a high proportion of deaths from self-destructive behavior (drugs, alcohol, suicide) and high rates of domestic violence. Over the past decade, most of these factors have worsened (notably population fluctuations, employment income, low-income households, economic foundations), although other conditions have improved (education levels and crime rates).

Drivers of change. The main human impacts on the ecosystem are uses of provisioning and cultural services through harvest pressure and the introduction of exotic species. These are driven by needs for sustenance and to earn a living, a desire to make money, provincial revenue demands, and the pursuit of recreational enjoyment—or, in general terms, people's needs and wants. In turn, the needs and wants which count the most depend on market powers and access to local resources. Metropolitan populations dominate access to, and decisions on, local resources. Local populations have a small share of the benefits from local resources compared with the large share flowing to corporations outside the region. Local populations do not drive change; change drives populations—into or out of the region, depending on whether the change is for good or bad. The impacts of human drivers on the ecosystem may be dampened or intensified by ecosystem drivers—the dynamics of populations and species, biogeoclimatic processes, and disturbance regimes.

Responses. Six sets of responses are proposed:

- increased ecological protection;
- providing cultural security by guaranteeing access to places needed for sustenance and protecting places needed for other values (such as heritage and nonconsumptive recreation);
- improving economic development by concentrating on areas with the highest potential for economic gain from timber, tourism, nonwood forest products, fisheries, and minerals;
- combining ecosystem and cultural conservation and economic development through ecosystem-based management planning;
- regular monitoring and periodic assessment of plan implementation, together with a research program to fill major knowledge gaps and reduce uncertainty; and

- better governance through new institutions and policy instruments, including sub-regional decision-making bodies, an independent regional science body, making EBM objectives legally binding, public and private conservation financing, and an independent dispute resolution body.

For further information: Full information on the assessment, together with the four EBM guides and six regional and sub-regional analyses, are available from http://www.citbc.org

Budget: CA$3.3 million, funded by the Province of British Columbia (58%), environmental groups (18%), forest products companies (18%), and the Federal Government of Canada (6%).

Colombia

Ecological Function Assessment in the Colombian Andean Coffee-growing Region

(See color version of locator map in Appendix A.)

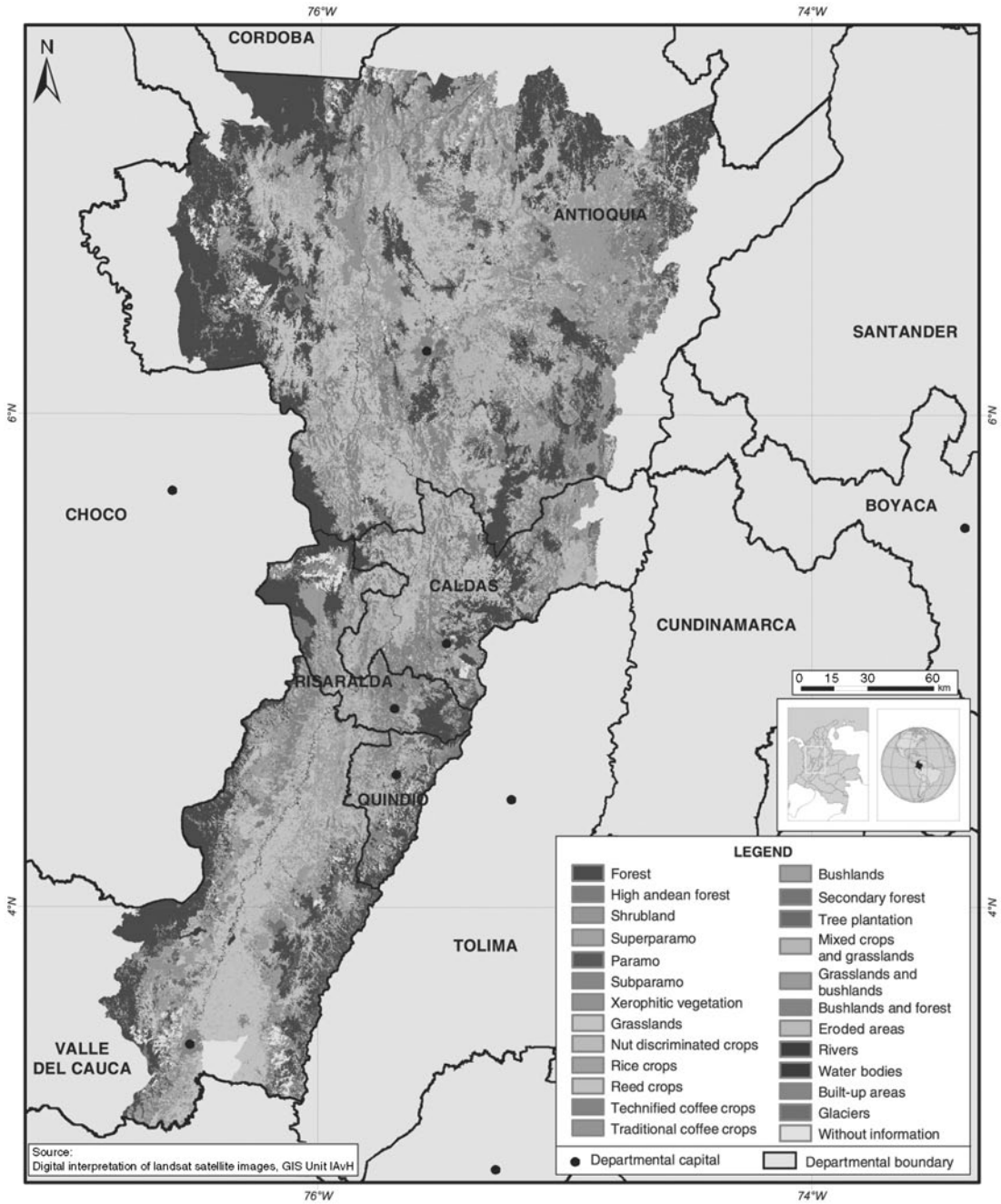
Contact person:
Dolors Armenteras
Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
Carrera 7 #35–20
Bogotá, Colombia.
E-mail: darmenteras@humboldt.org.co

Project team: Dolors Armenteras, Nestor Ortiz, Alexander Rincón, Nestor Ricardo Bernal, Edersson Cabrera, Diana Patricia Ramírez, and Nelly Rodríguez of the Humboldt Institute, and Margarita Jaramillo of Cenicafe with the collaboration of several Cenicafe researchers.

Time period: The period assessed is 1985–2003. Scenarios are projected until 2025. Completion of the assessment is uncertain, dependent on funding.

Intended audience: Sub-national and local decision-makers.

Issues addressed:
This ecological function assessment of the coffee-growing region of Colombia was undertaken as a spatial-temporal comparative study of several social, economic, demographic, and environmental variables at different scales. The relationships between drivers of ecosystem changes, ecosystem services, and human well-being have been identified for the



Ecological Function Assessment, Colombian Andean Coffee Growing Region

Colombian situation and include coffee-related factors as well as others that might have an important effect on human well-being.

Drivers of change. Ecosystem services significantly contribute to the well-being of the human population in coffee-growing regions and to their economic productivity. This assessment identifies indirect drivers that can have an effect on those factors that directly influence ecosystem processes (direct drivers) in the region, such as economic activity and the population which themselves become the main factors of changes in natural and seminatural cover, greater use of pesticides and fertilizers, introduction of new species, etc. *Indirect* drivers studied include total population, population density, economic activity indicators, national gross domestic product, environmental NGOs, and other associations. *Direct* drivers studied were land cover change and phytosanitary aspects related to coffee production.

Human well-being was addressed by looking at the population quality of life, percentage of households with unsatisfied basic needs, poverty line, mortality rates per cause of death, and educational issues such as illiteracy rate and education levels.

Ecosystem services. Ecosystems and their services have traditionally been undervalued, and they are often ignored in regional decision-making processes. The extent, location, and trends in transformation to and from ecosystems were studied, as well as the location of rapid changes in the area. Supporting and provisioning services such as biodiversity and coffee production were also analyzed. In 2002, Colombia was the third largest coffee producing country (out of 79), with 9% of world production, representing around 805,000 hectares, with an average production of 820 kilograms per hectare.

Correlation analysis and important findings. This assessment attempts to offer region-specific information to support decision-making in the area and to summarize possible current conditions and some trends in the coffee region. It focuses on quantifying ecosystem and population changes and analyzing changes in the structure of ecosystems that have taken place over time in the area, pointing out how they might be related to changes in the area's demographic and economic structure. The smallest spatial unit for which most socioeconomic and demographic data are available is the *municipio,* a purely administrative frontier. In order to analyze the impact of human pressures on natural ecosystems and the possible determinants of ecosystem changes we undertook correlation analysis (Pearson correlation coefficient) of 57 environmental, demographic and socioeconomic variables.

For further information: Part of this study is published as: Rincón, A. Armenteras, D., Ortiz, N., Ramírez, D y Cabrera, E. (2004). Indicadores de Seguimiento y Evaluación de la Política Nacional de Biodiversidad en la zona cafetera occidental: avances metodológicos y resultados.'' Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Serie: Indicadores de Seguimiento y Evaluación de la Política de Biodiversidad. 86 pages. ISBN: 958-8151-29-5

Funding: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt.

Eastern Himalayas

(See color version of locator map in Appendix A.)

Contact person:
Ankila Hiremath
ATREE
659, 5th A Main Road, Hebbal
Bangalore 560024
India
E-mail: hiremath@atree.org

Location: The Darjeeling district, covering an area of 3,149 square kilometers.

Lead institution: Ashoka Trust for Research in Ecology and the Environment (ATREE).

Indirect drivers of change:

Population growth. Population increase over the years has been one of the main problems in the Darjeeling hills, resulting from a number of factors such as uncontrolled family expansion, immigration from other regions of India as well as other nearby countries due to the establishment of the tea plantations, and Darjeeling being a prominent tourist destination.

Family fragmentation. The village communities have started moving toward nuclear-type families, resulting in land that is more fragmented and less suitable for the practice of subsistence agriculture. In 1956, Karmat village had 24 houses; in 2003, as a result of families splitting up, the number of houses in the village had increased to 65, with an average size of 6 family members.

Economic status. Economic self-sufficiency and alternative livelihood options are severely lacking in the hills due to the lack of resources and the absence of alternative job opportunities. Villagers located in mountainous terrain at altitudes of between 1,800 and 3,600 meters have to purchase basic necessities including staple foods such as rice and dal (pulses) from the nearest urban centers. Price fluctuations of these staples, along with transportation costs, encourage villagers to sell fuelwood to cope with the situation.

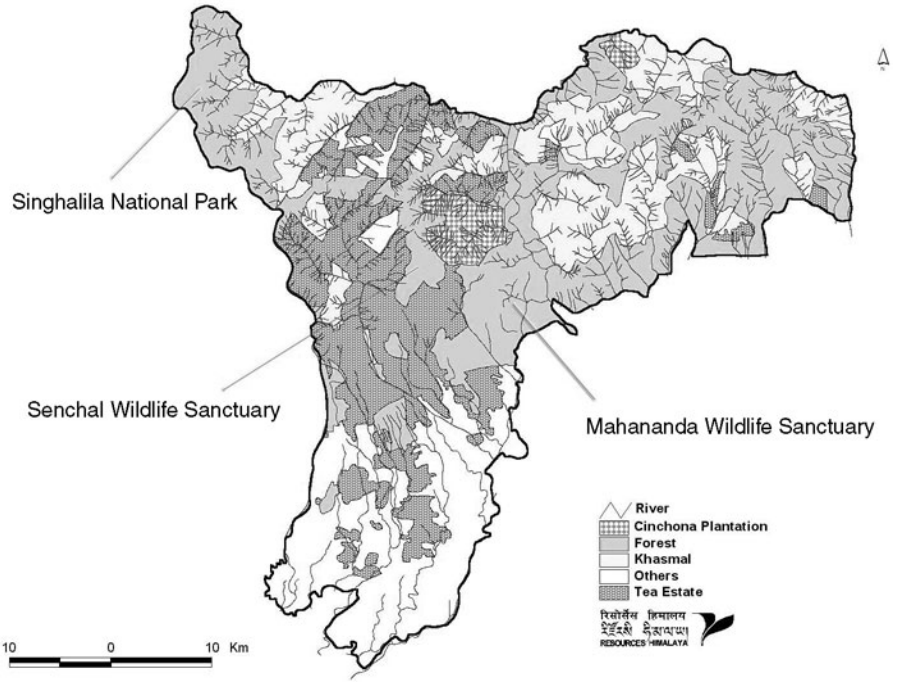
Policies, institutions, and processes. Despite implementation of a wide range of policies, institutions, and processes, the government's capacity-building measures have not achieved significant diversification of livelihood patterns in the villages. Often the secretaries of various committees are nominated by the government, and villagers are not made aware of the activities underway and the budget allocated.

Change in local land use pattern. Family fragmentation has resulted in fragmentation of agricultural land and clearing of forest land for settlement. This land use pattern has also played a major role in the degradation of ecosystems and in causing land slides and flooding. The recent proposed sites of Teesta Dam Stage IV and Ramam Hydel Project and Nuclear Laboratory will result in the submergence of villages and the fragmentation of habitats for flora and fauna. The Kalikhola mini hydel project will lead to the loss of faunal habitat, which can accentuate the conflict between humans and animals in the villages and lead to loss in agricultural production.

Ecosystem services:

Non-wood forest products (fruits, vegetables, and medicinal plants). The village communities in the protected areas extract NWFPs at subsistence level. Woody and fibrous construction materials are required for agriculture implements, cattle sheds, and repair of houses. Various studies have shown that there has been an overextraction and exploitation of medicinal plants such as *Aconitum bisma, Aconitum spicatum, Dactylorhiza hatagirea, Heracluem wallichii, Neopicrorhiza scrophulariiflora, Panax pseudoginseng subsp himalacus, Podophyllum sikkimense,* etc.

Water. Water-related problems are faced by the village communities of the three protected areas in the assessment. The village communities are aware that the problem is due to the felling of trees and clearing of forest in the catchments. Two lakes built inside the Sepahijala Wildlife Sanctuary at the turn of the twentieth century demarcated 447.4 hect-



ares as catchment areas for drinking water supply to Darjeeling town. The catchments were securely protected by construction of barbed wire fencing. Today, the fence is as good as nonexistent. At least 81% of the catchments presently lie denuded. As long as protection was provided to the catchments, nearly 26 streams regularly supplied water to the lake. Today, only 14 of those streams are still flowing, which has resulted in an acute water crisis in Darjeeling.

Soil. Soil fertility has been affected by the use of chemicals like urea and diammonium phosphate; in addition, faulty agricultural practices such as tilling of land during monsoon season have caused the erosion of topsoil. The villages located in the hilly region have not adopted contour bunding in the terraces where vegetables are grown, resulting in landslides and soil erosion.

Responses undertaken: The northern region of West Bengal has a long-standing tradition of symbiotic relationships between the local communities and the forests, but since independence, the government's approach to the local people was mainly confrontational thus leading to severe negative impacts in terms of conflicts between the local communities and the forest departments. This conflict also led to the proliferation of the illegal trade in timber and other ecosystem products. The importance of involving the local people in protected area management was realized in the early 1970s when UNESCO's Man and the Biosphere Reserve Program began to promote the creation of buffer zones between the strictly preserved areas and human settlements. India's Department of Environment created a Board of Ecodevelopment in 1982–83, after the World Congress on National Parks in Bali gave impetus to the objective of linking protected area management with economic activities of the local people by advocating the implementation of joint management between the communities which traditionally managed these forests and the protected area authorities. Following this, the Joint Forest Management Program was initiated through the National Forest Policy of 1988. This concept extended the ''ecodevelopment'' program to protected areas, not only reducing the impact of people on protected areas but also fostering better communication between local communities and the management authorities of protected areas

Scenarios: The ecosystem in the Darjeeling Himalayas has been under tremendous human pressure over the years. Even though some remedial measures have been initiated involving the communities and the government agencies, success has been only partial. The consequences of the continuing exploitation of ecosystem services, if unchecked, will have a major impact on the state of the environment. The assessment developed four plausible scenarios for the region, calling them ''No Action,'' ''Varied Experiments,'' ''Technological Fix,'' and ''Development Fix.''

Time frame: The assessment was initiated in 2002 and is on-going.

Sinai, Egypt
Local knowledge, biodiversity, and poverty alleviation

Contact person:
Professor Mohamed Tawfic Ahmed
Environmental Impact Assessment Unit
Faculty of Agriculture, Suez Canal University
PO Box 41522, Ismailia, Egypt.
E-mail: motawfic@tedata.net.eg

Coordinating institution: Suez Canal University, Ismailia, Egypt.

Ecosystem services:

Cultural services. The survival of local, indigenous knowledge is one of the main factors that enables Bedouins to withstand the harsh environment of Sinai. Management of agricultural systems, conservation of valuable native plants, and small handicrafts are illustrative examples of the utilization of vital knowledge about the environment that contributes to the well-being of local populations. Local people utilize intercropping systems to gain maximum yield, to ensure the sustainable exploitation of natural resources (water and land), to protect themselves against environmental risks such as unexpected drought or disease. In particular, Bedouins may bring some distant species to their local areas to increase the diversity of plants and to use them in a variety of ways, including for medicine and fodder.

Grazing. Grazing contributes to the well-being of Bedouins and supports their existence in Sinai's unusually arid ecosystem. Related ecosystem goods include meat and milk, which supply Bedouins with their protein needs. Transport is partially dependent on camels; organic manure is one of the grazed livestock products that is often used as a source of heat and cooking, and animal skin is used for the construction of shelters. Animal wool is used as the primary material to produce a variety of household and farming tools. Wool is also the backbone of some handicraft industries such as rugs, and can be used in bedding and clothing.

Condition and trends: Condition and trends of ecosystem services are assessed over the past 10 years. The lack of available data on led to the use of information from the local Bedouin inhabitants. The long periods of drought that Sinai has had during the last 7 years had a significant impact on ecosystem conditions. Natural flora provide a source of provisioning services that are crucial to local populations, in the form of food, fodder and medicine. Some of the most well-known plants have almost disappeared due to overharvesting as well as drought. Grazing has declined due to low levels of rainfall, as a result of the decrease in populations of local plants normally eaten by the grazing animals. The role of local knowledge to support human life in the Sinai desert is declining to some extent due to changes in lifestyle. Drivers include education, immigration, employment, and changing sources of income.

Scenarios: Scenario development will be based on public participation to allow users to have a say in developing scenarios.

Responses: The analysis of responses will entail the participation of stakeholders and decision-makers, including Bedouins. Responses will be designed to maintain various components of human well-being including health, food security, economic security, and equity. The main strategies that will be undertaken to achieve these goals include the promotion of awareness of the local people at selected sites with the need and importance of nurturing biodiversity, training courses and capacity-building, rehabilitation of some wild species, formation of a Bedouin biodiversity association, and crop biodiversity and management.

Funding: Ford Foundation, $150,000; UNEP, West Asia Office, $75,000.

Fiji

(See color version of locator map in Appendix A.)

Contact person:
Joeli Veitayaki
Marine Studies Programme
University of the South Pacific
Suva, Fiji
E-mail: veitayaki_j@usp.ac.fj

Location: Three sites are included in the assessment: Gau, the fifth largest island in the country with pristine natural ecosystems; the Greater Suva Harbor, the lagoon surrounding a large urban center; and the Coral Coast, a region in transition with extensive tourist development.

Lead institutions: Marine Studies Programme (MSP), Institute of Applied Science, and the International Ocean Institute-Pacific Islands (IOI-PI) at the University of the South Pacific.

Focal issues: The assessment in Fiji will allow the exploration of existing resource-use practices, the examination of the changes and trends affecting ecological conditions, and the formulation of the various response options. Involvement of local communities is a major challenge.

Key features of the assessment: Fiji is a developing country where the main economic activities include agricultural production, tourism, and the exploitation of natural resources. The population of Fiji is growing at the rate of 2.3% annually and this has led to serious environmental problems that threaten the ecological integrity of local ecosystems. The assessment sites represent areas of different levels of economic development. Some threats include destructive fishing, coastal erosion, logging, industrial pollution and waste disposal.

Fijian Assessment

Bajo Chirripó, Costa Rica
Local ecosystem assessment of the higher and middle Chirripó river sub-basins, Cabécar Indigenous Territory

Contact person:
Esther Cámac
Association Ixacavaa de Desarrollo e Información Indígena
San Jose, Costa Rica
E-mail: ixacavaa@racsa.co.cr

Project team: The assessment was conducted by: Abraham García, Flor Morales, Elizabeth Sanabria, Otilio Mora, Roger Espinoza, Carlos Artavia—members of the Cabecar indigenous community; and Carlos Sevilla, Esther Cámac, and Fabricio Carbonell—consultants.

Project time frame: Planning began in January 2003 and the project was formally launched in June 2003.

Ecosystem services assessed: Culture and biodiversity in holistic integration

This is a user-driven assessment conducted in large part using the traditional knowledge of the inhabitants of the assessment areas. The area is part of the La Amistad Biosphere Reserve of Costa Rica, established in 1982 and declared a World Heritage site one year later. It is located in the buffer zone of the Caribbean basin, in the sub-basin of the Chirripó River. It is also a part of the Mesoamerican Biological Corridor due to its important ecosystems, with six life zones and species diversity of high conservation value.

Traditionally this population conserves deeply-rooted ancestral knowledge on the uses of ecosystems, and lives in a tropical humid forest with dense cover. Their territory contains 48,000 hectares of pristine forest that is currently threatened by timber activities, poaching, pollution, and ecosystem fragmentation due to the unsustainable agricultural practices of non-indigenous people.

We started by recovering the stories and histories from the elders about the habitat, its creation, and the norms that regulate its use. We then complemented this knowledge with scientific literature and produced a first interpretation of the relation of ecosystems and human well-being from the Cabécar perspective. We then validated the information in community gatherings convened by elders in other Cabécar communities.

What we came up with first was a description of the broad cosmovision of the Cabécar people. Some elements of it are: (1) Earth is a circle surrounded by sea; there is a balance between upper and lower worlds; (2) habitat as a conic house; (3) special areas and places are protected by guardians that regulate access and use of resources; and (4) each living entity is a seed that deserves respect. Human beings are maize seeds.

Given this cosmovision, the relationship between ecosystems and human well-being needs to be understood as taking one of three possible forms: (1) Interrelation—human beings are part of habitat and habitat is part of human beings; (2) *reciprocity*—among human beings (men-women, children-elders) and with the environment; and (3) *respect*—codes, norms, myths, beliefs, dreams.

One of the main qualities of ecosystems is ''abundance''—these are places full of life, places of generation of life. Access to this abundance is regulated by ''guardians'', which are not human. So the norms that control access are within the ecosystem itself. Also, among the constituents of human well-being, the main ones identified are cultural security (identity, spiritual, health, knowledge), food, territorial security, social and environmental reciprocity.

Funding: The MA, SwedBio, and Ixacavaa Association are providing financial support.

Forest and Agroecosystem Tradeoffs in the Humid Tropics (Tropical Forest Margins)

Contact person:
Thomas P. Tomich
Principal Economist and Global Coordinator
Alternatives to Slash-and-Burn Programme (ASB)
c/o World Agroforestry Centre (ICRAF)
PO Box 30677, 00100 GPO, Nairobi, Kenya
E-mail: t.tomich@cgiar.org

Co-coordinating lead author: Cheryl A. Palm, Earth Institute at Columbia University, New York, NY, USA.

This cross-cutting assessment focuses on the landscape mosaics (comprising both forests and agriculture) where global environmental problems and poverty coincide at the margins of the remaining humid tropical forests. Deforestation often is blamed on the slash-and-burn practices of migrant smallholders, millions of whom do clear and cultivate small areas of forest by this method. However, other groups also are involved, including plantation owners, other medium- and large-scale farmers, ranchers, loggers, and state-run enterprises and projects.

Assessment domain: tropical forest margins in ecoregions mapped by the World Wide Fund for Nature that contain benchmark sites of the Alternatives to Slash-and-Burn Program in the Peruvian Amazon, the Western Amazon of Brazil, an associated site in the Eastern Amazon of Brazil, the Congo Basin of Cameroon, Northern Thailand in Montane Mainland Southeast Asia, and the islands of Sumatra in Indonesia and Mindanao in the Philippines. ASB benchmark sites are areas (roughly ranging from one hundred to one thousand square kilometers) of long-term study and engagement by ASB partners with households, communities, and policy-makers at various levels. Human population of the specific benchmark sites ranges from ten thousand to one hundred thousand and, comparing across sites, densities range from less than 20 to over 170 persons per square kilometer. All the ASB benchmark sites and corresponding WWF ecoregions are in the humid tropical broadleaf forest biome.

In a class by themselves as the richest terrestrial vegetation by far, conversion of these forests leads to the greatest species loss per unit area of any type of land cover change. Preliminary estimates indicate more than 500 million people live within this humid tropical forest biome; ongoing refinements based on newly released data likely will increase that figure substantially. Most are poor households directly dependent on forest resources and agriculture for their livelihoods. Other poor households suffer indirectly from waste of these resources and environmental degradation.

Key users of the assessment: national and regional policy-makers, rural communities, national research organizations, and universities.

Driving forces of land use and land cover change: Deforestation has no single cause but is the outcome of a complex web of factors whose mix varies greatly in time and space. Shifting cultivation for subsistence food production is seldom the main cause of tropical deforestation. Other forms of agricultural expansion—practiced by smallholders and large landowners alike—tend to be much more important. But the most significant determinant of all is how these land uses interact with and are affected by macroeconomic forces, access to markets, and a host of other policy and institutional factors. Changes in land use and land cover are, in turn, major drivers of changes in ecosystem services in the tropical forest margins. Assessment of driving forces arising from human activities, institutions, and policies is largely complete and *these findings are well-established*.

Ecosystem services and human well-being: Conditions and trends

Assessment topics include provisioning services, of which food supply received particular emphasis from users; the regulating of services carbon storage, water supply, and soil nutrient supply; and biological diversity. Specific assessment questions have been developed further through stakeholder consultations that have been completed in Brazil, Indonesia, and Cameroon and that are nearly complete in Peru and Thailand. Because the assessment of conditions and trends is ongoing, the following summary of *preliminary findings on specific conditions and trends are established* (for ASB sites) *but not yet complete* (regarding synthesis of other scientific results).

Food and other provisioning services. The relative importance to local livelihoods of the food, timber, fodder, and other goods produced in mosaics of land uses at the forests margins differs dramatically among sites in South America, Central Africa, and Southeast Asia. Analysis of yields of the main products from representative land uses and the profitability of those land use alternatives are complete for ASB benchmark sites in five countries spanning the humid tropics. Work is underway to scale up these results to assess the relative importance of the tropical forest margins as suppliers of these key goods to regional and national economies and to international markets.

Water. There are trade-offs between total water supply and the seasonal pattern of river flows (including flooding risks) because forests use more water than other types of vegetation in the humid tropics. It is important to disentangle watershed issues when considering how land use change affects them. New tools and data sets exist that can eliminate some of the uncertainty about cause and effect at meaningful scales for policy-makers. ASB partners have employed a nested set of models (from sub-catchment to basin to pantropic scales) to apply the best available data and tools to assessment of these relationships. See http://www.asb.cgiar.org/BNPP/phase2/bnpp_phase2_general.htm.

Carbon stocks and biological diversity. No forest-derived land use can match the carbon storage or biological diversity of natural forests, but the agricultural uses that follow forest conversion differ significantly with respect to delivering these ecosystem services. The rubber agroforests of Sumatra and cocoa agroforests in Cameroon are examples of systems with levels of biodiversity far higher than those in monocrop tree plantations or annual cropping systems, though not as high as natural forests. These agroforests also store substantial levels of carbon relative to the other systems, yet less than half that of natural forest. In contrast, the pasture-livestock systems that dominate land-use in deforested areas in the Brazilian Amazon have much starker trade-offs, providing attractive opportunities for smallholders but large losses of carbon storage and biodiversity. See http://www.asb.cgiar.org/publications.shtm #WGReports.

Trade-offs between ecosystem services and human well-being. Striking an equitable balance between the legitimate interests of development and equally legitimate global concerns over the environmental consequences of tropical deforestation is difficult. ASB has developed a tool, called the ASB Matrix, for assessing these trade-offs, and has applied it at five benchmark sites. Poverty reduction in most of the tropics depends on finding ways to raise productivity of labor and land through intensification of smallholder production systems. Although there may be opportunities to alleviate poverty while conserving tropical rainforests, it is naïve to expect that productivity increases necessarily slow forest conversion or improve the environment. See http://www.asb.cgiar.org//PDFwebdocs/Policybrief5..pdf.

Responses: The challenge of ASB, and of this assessment, is to identify innovative technologies, institutions, and policies that can reconcile

two great issues of our time: tropical forest conservation and poverty reduction. The assessment focuses on responses aimed at balancing these tradeoffs between ecosystem services and human well-being that characterize the tropical forest margins, including land and tree tenure reform (http://www.asb.cgiar.org/PDFwebdocs/PolicyBrief2.pdf); incentive schemes for environmental services that target benefits to the rural poor, such as payments for environmental services (http://www.worldagroforestrycentre.org/sea/Networks/RUPES); negotiation support systems to better link science with social and political processes, thereby accelerating learning and discovery of workable options (http://www.consecol.org/vol5/iss2/art21); and landscape restoration (http://www.unep-wcmc.org/forest/restoration/globalpartnership) to revive habitats and restore ecosystem functions while reducing poverty by creating valuable assets for the rural poor. This work will follow on the assessment of conditions and trends and likely will continue in 2005.

Scenarios capacity building: ASB partners have limited experience with participatory formulation and use of scenarios. To fill this gap, a workshop was held in late 2004 to train ASB facilitators. Planned follow-up to the workshop includes local and national scenarios activities at ASB sites and a ''virtual'' on-line event to compare results and distill lessons learned in 2005.

Time frame: Pilot assessment: 2003. Main assessment: 2004. Review and outreach: 2005.

Key references:

http://www.asb.cgiar.org. This website includes ASB *Policybriefs,* technical reports, country synthesis reports and a searchable database of over 500 ASB publications.

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- Tomich, D.E. Thomas, and M. van Noordwijk (eds.), *Environmental Services and Land Use Change: Bridging the Gap between Policy and Research in Southeast Asia*. Elsevier Science (in press). Available at http://www.asb.cgiar.org/PDFwebdocs/Environmental_Services.pdf

Funding: This work has been funded by grants from the Millennium Ecosystem Assessment and the World Bank Netherlands Partnership Programme; funding was also provided by the government of the Netherlands and core support was provided by CGIAR, the World Agroforestry Center, and the Earth Institute at Columbia University. ASB partners provided in-kind contributions.

Hindu Kush–Himalayas

(See color version of locator map in Appendix A.)

Contact person:
Prof. Xu Jianchu
Program Manager, Water Hazard and Environmental Management
International Centre for Integrated Mountain Development
P.O. Box 3226, Kathmandu, Nepal
E-mail: jxu@icimod.org.np

Location: The Hindu Kush–Himalayas (HKH) region, stretching 3,500 kilometers over eight countries, from Afghanistan in the west to Mynamar in the east, is home to more than 150 million people and affects the lives of three times as many in the plains and river basins below. The region is not only the world's highest mountain region, but also its most populous.

Lead institution: International Centre for Integrated Mountain Development (ICIMOD).

Objectives: The overall objective is to provide scientifically credible information of ecosystem services to facilitate trade-off and incentive (compensation) mechanisms for poverty alleviation and environmental enhancement in the HKH mountains. Specific objectives include:

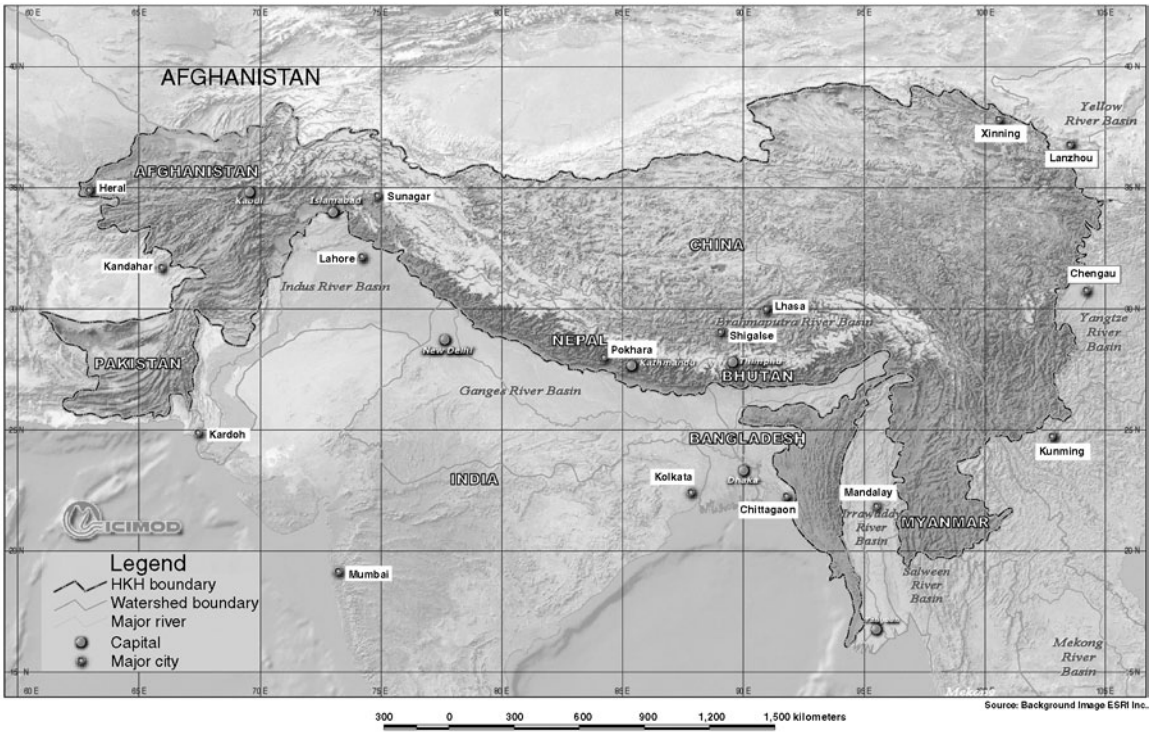
- providing credible information on ecosystem services in terms of provisioning, regulating, and supporting services, and cultural heritage;
- measuring the pace of environmental change and the consequences to local, regional, and global beneficiaries;
- identifying the dominant driving forces for environmental change and explore future trends;
- developing scenarios of the future on ecosystem services;
- identifying policy responses in general, trade-off options at the local level, and incentives (compensation) at national, regional, and global levels;
- catalyzing international negotiations on environmental incentives;
- synthesizing existing knowledge and bridging knowledge gaps;
- building capacity among institutions of the HKH region, particularly on the science-policy interface for the effective use of research findings.

Key features of assessment: The HKH mountains ecosystems provide goods and services that sustain 150 million people living within the region and some 500 million people living downstream. In addition, this mountainous region is vital to sustaining the earth through the following ecosystem services:

- cold source and carbon sink to respond to the threats of climate change;
- sources of water as the birthplace of many large rivers such as Indus, Ganges, Yangtze, Mekong, Yellow and Yaluzanbu;
- genetic resources to the rest of the world and future generations from its rich biodiversity;
- indigenous knowledge of best practices for managing fragile mountain environments;
- cultural and spiritual assets derived from the local geography and history; and
- recreational sites for people from all over the world.

The inherited environmental fragility and social economic vulnerability have put the Hindu Kush–Himalayas on the top of sustainable development agendas. The rapid change of the ecosystem, driven by both natural and anthropogenic determinants, poses unprecedented threats not only to the livelihoods of the local people, wildlife and culture, but also to the global environment.

Budget, time frame: Approximately $2.0 million, of which $0.5 million in-kind is from ICIMOD and member countries and $1.5 million is from donors such as the Italian government and other donor agencies. The assessment is expected to take 3 years.



Hindu-Kush Himalayas

India Local Villages (India Local)

Contact person:
Madhav Gadgil
Centre for Ecological Sciences, Indian Institute of Science
Bangalore, India – 560012
E-mail: madhav@ces.iisc.ernet.in

Project team and institutions:
Madhav Gadgil, CES, IISC, Bangalore, Karnataka; Yogesh Gokhale, CES; K. P. Achar, CES; Shrikant Gunaga, CES; M. B. Naik, CES; Shridhar Patgar, CES; Nagarik Seva Trust, Guruvayankere, Karnataka; Nilesh Heda, CES,; Mohan H. H., Vrikshamitra, Chandrapur, Maharashtra; Yogini Dolke, Srujan, Pandharkavada, Maharashtra; Kaustubh Pandharipande, Karanja, Maharashtra; Shubhada Deshmukh, AAA, Kurkheda, Maharashtra; Vijay Edlabadkar, Ballarpur, Maharashtra.

Time period: The condition and trend assessment is for a 10-year period. The project time frame is 2000–2004.

Ecosystem goods and services assessed:

Study area	Goods and services	Bads and Disservices	Ecosystem Types	Management Context
Southern Karnataka	availability of economically important NWFP species; provisioning of food, water, fuel, fiber; aesthetic and spiritual services	reduction in cultivation area of traditional cultivars; scarcity of fuel and fodder; menace of wild boars, gaurs, and monkeys for agriculture; health problems to people and livestock due to weed plants; drinking water scarcity; vectors like ticks; crop and livestock diseases; siltation of waterbodies; soil erosion	evergreen forests; semi-evergreen forests; scrub forests; plantations; grasslands; orchards; flowing waterbodies; wells, borewells; lakes; ocean; sea shores	presence of National Park; no official rights of local people over forests; existence of private management systems like leaf manure forests
Vidarbha	availability of economically important NWFP species; provisioning of food, water, fuel, fiber, medicinal plants; aesthetic and spiritual services	menace of wild boars for agriculture; reducing wild food	moist deciduous forests, scrub forests	NISTAR—usufruct rights over forests; ownership over "minor forest produce"

Summary of important findings and methodologies used in the assessment:
The recently enacted Biological Diversity Act (2002) has made the preparation of a "People's Biodiversity Register" (PBR) mandatory for village councils all over India. The India Local assessment provides a methodology for preparation of PBRs. Through model PBRs consistent with the MA framework, the following conclusions were derived for the changes taking place in ecosystems and their impacts on human livelihoods at the local scale in the assessment areas.

Land use changes and driving forces. In the Western Ghats, excessive levels of conversion of paddy fields to areca nut orchards has been undesirable, as this has increased irrigation water demands to an unsustainable level. The conversion of former village common lands used as grazing grounds to habitation or *Casuarina equisetifolia and Acacia* sp. plantations have led to a reduction in livestock holdings and a decline in organic manure resources. In Vidarbha, the availability of usufruct rights (Nistar rights) and awareness about it in recent years are important drivers for motivating people to think about resource management. Joint Forest Management initiated by the State Forest Department has also been an important driver and has led to several villages successfully implementing resource micro planning.

Soil and water. There is a widespread perception that a decline in the use of organic manure accompanied by an increase in the application of chemical fertilizers and insecticides has led to a serious loss in soil fertility as well as affected the quality of water and aquatic life. The traditional gravity flow irrigation method has been replaced by drips and sprinklers, which greatly reduce the water going back into streams or percolating to underground water tables—ultimately reducing the stock of underground water.

Agriculture and tree crops. The patterns and practices of agriculture, that is, the land under cultivation of seasonal / annual crops and tree crops have changed over time, thereby affecting ecosystem services.

Forests and forestry plantations. Original forests have disappeared due to deforestation in coastal villages in the Western Ghats of Karnataka. Overexploitation of forest resources has led to the opening up of the canopy, which coincided with the invasion of the exotic weed *Eupatonum odoratum (Chromolaena odorata)*. Forest plantations such as *Casuarina equisetifolia* and *Acacia auriculiformis* have largely come upon lands that were earlier maintained as community grazing lands.

Grasslands. People attribute the following causes for the degradation of grasslands and related ecosystem services in recent decades: (1) rapid depletion of common resources and (2) apathy of forest authorities towards cattle and fire.

Domestic animals. The introduction of high milk yielding breeds of domestic cattle in Karnataka villages has resulted in the loss of traditional breeds of cattle such as *Malnad Gidda*.

Fish. Fishing during the breeding season in the sea has resulted in the loss of fish diversity and density and also decline in the availability of fishes. Fishery resources are neither abundant nor diverse in other water bodies. Destructive fishing methods such as the use of dynamite and fish poisons have led to fish depletion.

Selected response options: In Koyyur village, the following responses have begun to be implemented:

- The forest department was compelled to form Village Forest Committees as a part of the JFPM so that people can participate collectively in natural resource management. The villagers are providing vital information to the Forest Department regarding timber smuggling.
- In Koyyur village, five farmers have come forward to dig the percolation pits in their plots.
- Three sacred groves have been identified and the process started for planting medicinal plants and endangered species.
- Morante (*Channa striatus*) fish breeding has been initiated.
- About 15 individuals were selected for developing kitchen herbal gardens and seed banks at the household level.

Scenarios: Three state-level and two national-level scenarios were developed. The state-level scenarios include:

Bioresource database. Indian states gear up to implement the National Biological Diversity Act, 2002. State-level documentation of bioresources in the state is undertaken to create a database. This will help to ensure better, more-informed decision-making. Such database building efforts will be taken up by states within a few years.

Strengthening the IPR regime and validation. States will be establishing a system of safeguarding people's knowledge related to bioresources and steps for adding value. There are examples which include initiatives taken by Government of India through the National Innovation Foundation. States will have such organizations at levels accessible to local people. Special efforts with the help of scientific institutions will be required to validate the knowledge. There has been an increasing demand to explore traditional knowledge for commercial use by blending it with modern technology. This will have to be done in parallel with knowledge documentation processes. Norms of benefit sharing need to be evolved. There is enough technical expertise available within the country in terms of information technology for safeguarding intellectual property.

Sustainability in strategies. States will have to take measures for devising strategies as per the Biological Diversity Act 2002, by declaring sites as biodiversity heritage sites, banning the extraction of particular species, etc. as suggested by documentation done at village level. These strategies will supplement the existing legal provisions like protected areas, etc.

The national-level scenarios developed by the project include the following:

Network of databases. As a follow up to National Biological Diversity Act, there will be a national database of bioresources in India. This process is likely to be initiated soon. By 2015 there could be networked information system available all over the country. The data mining from this system along with validation of knowledge will create opportunities for jobs all over the country.

Strengthen state and local functioning. Central government will have to strengthen various systems operating at state and local levels which include strategies for sustainable utilization, IPR protection and benefit sharing, and evolving systems of positive incentives.

For further information: http://144.16.65.194/hpg/cesmg/pbr_nov212002A.htm.

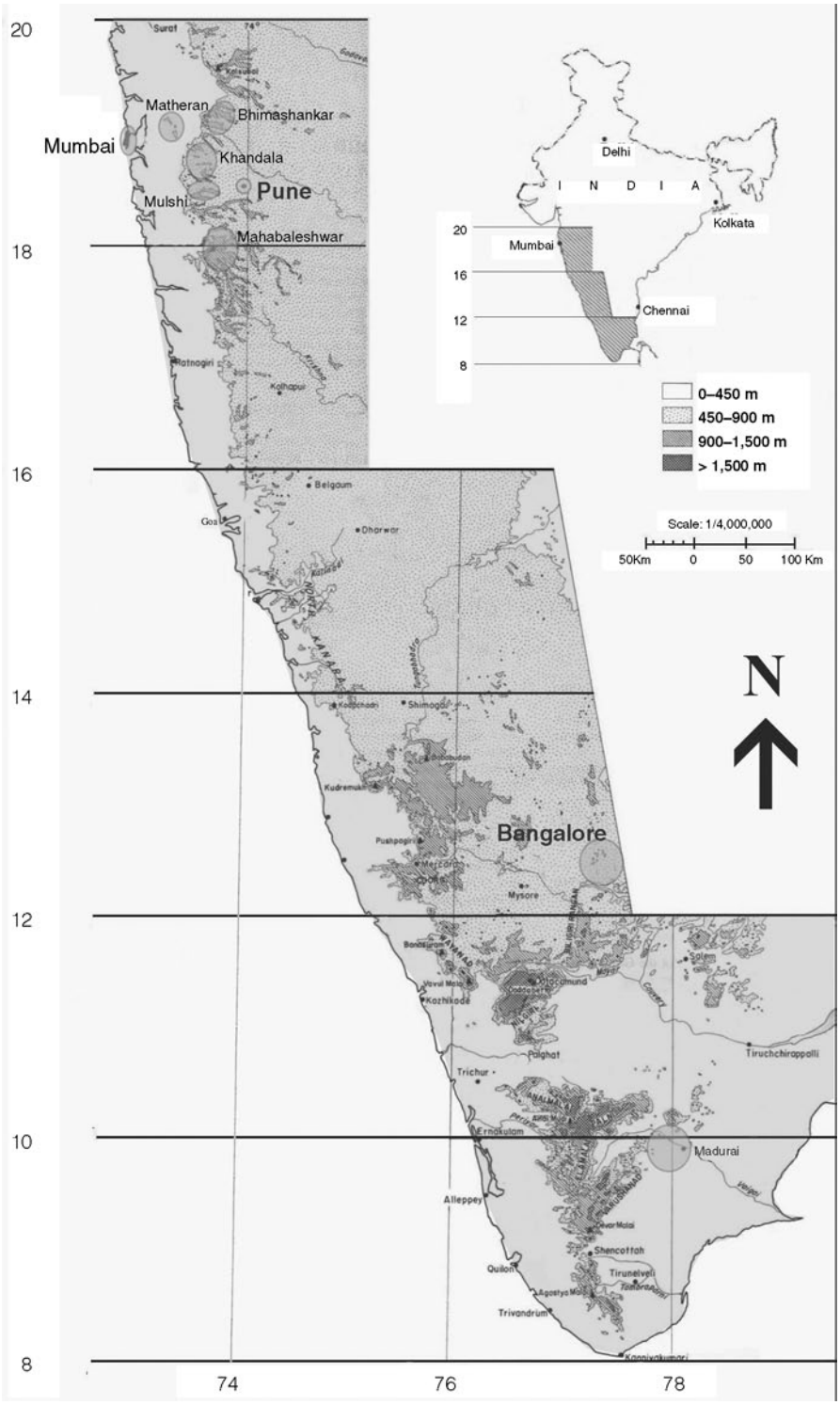
Funding: Ministry of Environment and Forests, Government of India ($40,000); Millennium Ecosystem Assessment ($10,000).

India Urban Resource (India Urban)

(See color version of locator map in Appendix A.)

Contact person:
Ankur Patwardhan
RANWA, C-26/1
Ketan Heights, Kothrud
Pune, 411038, India.
E-mail: ranwa@pn3.vsnl.net.in
Web site: www.ranwa.org/mea.htm

Introduction: The Indian Urban Resource Millennium Assessment by Naturalists is a nested national level assessment completed during 2000–04, with a focus on Pune, Bangalore, and Madurai cities at the local level. The focal issues are food, fuel, water, and health care; in addition, fiber, culture (including human well-being), biodiversity, climate, and waste recycling were studied opportunistically. The stakeholders consulted include traders, farmers, government officials, scientists, citizens, teachers, and students. Research and Action in Natural Wealth Administration (RANWA), an NGO, facilitated the India Urban assessment. Its partner Community Enterprise Forum of India



Indian Urban Resource Millennium Assessment

(CEFI), Madurai, focused on health care, and the Sustainable Rural Transformation (SuTRA) unit of the Indian Institute of Science (IISc) assessed fuel scenarios.

Methodology: Literature was surveyed during 2000–02 to document condition and trends. Response options and future scenarios were inferred from the proceedings of the 17 workshops regarding biodiversity, farming, fuel, water, and health care. These involved 3,000 stakeholders and were funded by various government agencies and private donors for their business planning. Data and projections include the past 50 and future 25 years, respectively, including negative feedback. Ecosystem product or process and response options were assessed with regard to input, process, output, and feedback over their ''life cycle.'' Experts from the stakeholder groups reviewed broadly the inferences drawn, when personally consulted.

Condition and trends: Urban population has grown two times and food consumption three times in the past five decades, and prices are low while farmers are paid poorly. Quality is deteriorating with growing chemical inputs, and reduced forest and pasture nutrients. Growing meat, milk, and sugar production, as well as 200 liters of daily direct water consumption (and pollution), has also reduced water resources and polluted the remaining surface and ground pools, bringing villagers in conflict. Fossil fuel imports have grown four times in the past 20 years with a five-fold rise in costs of private transport. Electricity and natural gas usage has grown three times, due to the use of electronic goods and fuelwood replacement, respectively. Air pollution—including approximately 0.5 kilograms of carbon per person per day—has exceeded safety levels by 20–40%. Health disorders per capita more than doubled despite growing medical facilities and costs, as 10% of citizens, especially children, have become obese, due to changes in diet, sedentary lifestyles, and a low diversity, low nutrition diet. Natural fiber for clothing, furnishing, packing, paper, etc., has been replaced mostly by synthetics, which generate daily 0.3 kilograms of waste per person, thus exhausting landfills around cities. The remaining 0.2 kilograms of waste per person is organic (kitchen waste and drainage), but not recycled, which is hampering farm, river, and costal productivity. Pollution has wiped out about 10% of fish species and overharvest another 5%, while narrow niche bird and plant species have suffered over 50% population loss, despite growth in exotic species. Culture of nature worship and celebration has eroded in the last three decades, as has its safety and savings orientation, using local handicrafts from biological products—grains, vegetables, milk, clothing, footwear, mats, furniture, gifts, etc.

Drivers: Direct endogenous drivers of declining ecosystem health and human well-being include: (1) land use changes such as reducing tree cover and open areas, while increasing built-up area density due to unplanned growth, hampering biodiversity, air, and water circulation, (2) rising private transport and air pollution, (3) consumerist lifestyle with enhanced (processed) food, mechanical tools, electricity, and water consumption (and wastage). Indirect exogenous drivers (mostly global/national) include (1) technological—mechanization or using handicrafts (2) economic—pricing, taxes, or concessions, (3) political—law and policy. Culture (education, media, religion) is a two-way driver.

Response options: Response options to gradually reduce pollution or (local) extinction, while generating rural employment (to reverse urban immigration) include (in increasing order of difficulty): (1) reviving traditional organic farming and diet (including diversity and balance); (2) low intensity handloom, recycled paper, and jute packing; (3) low transport using public modes and local biodiesel (from leguminous trees along avenues, wastelands, and farm bunds, to recycle carbon and nitrogen); (4) recycling kitchen waste and drainage to generate biogas and farm manure respectively; (5) rationing piped water supply to 50 liters, in addition to encouraging rainwater harvesting; (6) enhanced taxes on private vehicles/gadgets and high emission technology.

Scenarios: Two scenarios were developed.

Business-as-usual. The BAU techno-commercial scenario is a ''pleasure fuels violence'' story with the following components:

- National food imports (already begun with sugar and cotton) rise to 20% of the national demand in 2015, due to greater climatic uncertainty; reduced soil fertility and water availability; enhanced meat, milk product industry, and addictions (tea, coffee, tobacco).
- Fiber imports and fossil fuel imports as well as air and water pollution may double by 2025. Abrupt climate change, volcanic eruptions, flooding due to snow melting, earthquakes, and terrorism or war cutting fuel supplies, could occur. Biodiesel can hardly meet 5% of the excessive transport demand.
- Urban solid and water waste recycling may increase 20% and 30%, respectively, as a lucrative business, but increased concrete waste treatment could be difficult even with advances in nano-technology.
- Rising air, noise, water, and food pollution and growing assets could reduce human well-being as families and communities weaken. Crime, health problems, violence (including gender) and suicide grow. Food, water and fuel scarcity could trigger conflict.

Low External Input Sustainable Activities. This scenario is a ''contented local cultures'' community story, in which adaptive management is driven less by hi-tech education, profit, and pleasure motives, and more by traditional wisdom, ethical trading, and recycling jobs in cities and farm skills in villages. It employs an ''ecosystem approach'' (reuse, recycle and reduce or refuse) and the ''precautionary principle'' based on ''eco-religion,'' where uncertainty is minimized to climate alone. If realized, it can stabilize or reduce fiber and fossil fuel imports, while reducing mining and large dams. It can equitably provide 300 grams of diverse food and 50 liters of water daily, and three pairs of handloom clothes annually to all. Human well-being will be enhanced as personal creativity and choice grow along with local community interdependence and local governance.

Lessons: The following lessons were learned: (1) technology and economic growth require prior and periodic multidimensional and long-term environmental and cultural impact assessment; (2) science needs to be promoted as logical thinking for all people; and (3) lifestyle choices must be informed ones, for conserving natural and cultural diversity and stability. The results of the India Urban assessment will also be disseminated as children's stories.

Indonesia
Jakarta Bay and Bunaken ecosystems

Contact person:
Ministry of Environment
Mr. Heru Waluyo
Assistant Deputy for Coastal and Marine Affairs
Jl. DI Panjaitan, Kebon Nanas, Jakarta 13410
Indonesia
E-mail: pkepl@menlh.go.id

The assessment was conducted by Zainal Arifin, as chief scientist, with the assistance of members of the Jakarta Bay Working Group (for the Jakarta Bay site), and by Reihart Patt, chief scientist, with the assistance of the Bunaken National Park Management Council (for the Bunaken site). At the current stage, the exercise is focused on providing condition and trends of the ecosystem.

First site: The Greater Jakarta Bay Ecosystem (GJBE)
The period of assessment is 1992–2002. Scenarios are projected to 2020. Assessment completion is scheduled for end 2005.

GJBE consists of two distinct ecosystems: Jakarta Bay, which is strongly influenced by land-based activities, and Seribu island complex (*Kepulauan Seribu*), which is dominated by 110 small islands. The assessment of GJBE is intended to assist decision-makers at the national and local/regional levels in making decisions about managing the area. The main stakeholders in the area are national and local governments, as well as NGOs and private enterprises.

Marine biodiversity. GJBE is rich with marine biodiversity, especially in the National Marine Park of Kepulauan Seribu, including183 species of stony corals, 166 species of fishes, 101 species of seaweeds, 6 species of seagrasses, and 4 species of mangroves.

Food sources. Fish production from capture fisheries declined at an average of 11% annually during the last six years (1997–2002). Mariculture, especially green mussel and seaweed cultures, increasingly play a significant role in contributing to economic activities for local fishers.

Recreation. The Kepulauan Seribu National Park is one of the major attractions for tourist activities in the GJBE. The number of both local and foreign tourists continued to grow during the last 15 years, bringing benefits not only to the local government but also to local communities.

Pollution. Thirteen rivers flow into Jakarta Bay, which thus receives many pollutants. The inland area is considered the primary source of waste and pollutants, mainly due to untreated wastewater from the population of 20 million people of the Jakarta metropolitan areas and its industry.

Second site: The Bunaken Ecosystem
The period assessed is 1993–2002. Scenarios cover the period until 2020. Assessment completion is scheduled for end 2005.

The assessment, which covered the Bunaken National Park of North Sulawesi and its surrounding areas, is intended to assist decision-makers at the local level in making management decisions about the area. The main stakeholders are local government, NGOs, and private enterprises, which together established the Bunaken National Park Management Council.

Marine biodiversity. Bunaken has a high diversity of species of corals, fish, mollusks, algae and other marine biota, as well as mangroves. At least seven species of giant clam and endangered species of turtle and dugong can be found in the area.

Fisheries production. In the last several years, fisheries production from the area increased as a consequence of increasing numbers of fishers both in capture fisheries and mariculture (for example, seaweed). This increasing number of fisheries activities brings better income to the fishers.

Tourism. The number of tourists both domestic and foreign tended to increase in the last five years resulted in the growing of economic sector of the area. However, a concern has been raised in relation to the carrying capacity of the ecosystem for tourism activities, in particular for diving.

Funding: The first phase of the sub-global assessment (identifying condition and trends) was funded by GEF (seed funding) and supported by the Ministry of Environment (in-kind contribution). Therefore, fund-raising is needed in order to continue the next phase of the assessment (that is, preparing scenarios and responses).

For further information: The full report of the condition and trends of the Jakarta Bay and Bunaken ecosystems as the first phase of the sub-global assessment will be available at www.menlh.go.id.

Morocco, Saudi Arabia, Sinai: Arab Region Assessment

Overall project management:
Director and Regional Representative
Regional Office for West Asia
United Nations Environment Programme
P.O. Box 10880, Manama, Bahrain

Technical and regional coordination:
Adel Farid Abdel-Kader
Programme Officer
Regional Office for West Asia
United Nations Environment Programme
P.O. Box 10880, Manama, Bahrain
E-mail: Adel.Abdelkader@unep.org.bh

Location: Three sites have been selected from across the region to be the focal sites for this study:

- Assir National Park, Kingdom of Saudi Arabia; located in the Assir Mountains, which contain one of the most important ecological hotspots in the Arab region. Encompasses three main habitat types: sandy desert, high altitude habitats, and marine habitat of the Red Sea.
- Sinai Peninsula, Egypt; one of the main heritage sites of humanity, embracing a unique collection of sacred shrines and ecologically valuable landmarks. Includes the following ecosystems: desert, mountains, wetlands, coastal, agricultural, and marine.
- Tafilalt Oasis, Morocco; located in the Sahara in southeast Morocco, with an area of about 1,370 square kilometers. It contains date groves, palm trees, and small trading settlements.

Lead institutions: The UNEP Regional Office for West Asia is the lead organization to coordinate the regional assessment, in partnership with the following lead national institutions: Presidency of Meteorology and Protection of the Environment, Saudi Arabia; the Suez Canal University, Egypt; and the Moroccan National Observatory for the Environment.

Focal issues: The main goal of the project is to promote the adoption of integrated assessment approaches in the Arab region at the local, national, and regional levels. This will be accomplished by conducting a pilot study that will serve to develop the framework for a coordinated and integrated regional collaborative multiscale assessment effort. An integrated assessment approach will provide the information to decision-makers for designing a comprehensive and sustainable management plan for the environment.

Ecosystem services: The ecosystems to be addressed in this study are diverse, including desert, mountain, coastal, cultivated, freshwater, and rangeland ecosystems. These systems provide a wide range of services, including food, drinking water, water for agriculture and industry, medicinal services, aesthetic and recreational services, and other socioeconomically important products and services.

Project outputs: The outputs will include regional and site-specific assessment reports, web portals and national and regional information systems, capacity building strategies, regional conceptual framework and harmonized methodology, specialized in-depth modules of the training package, a series of workshops for both the producers and users, and an institutional network of partner institutions and expertise.

Key features of the assessment: The unique and highly vulnerable ecosystems of the Arab region are at serious risk from increasing human populations and their associated activities. The concept of this study is to select strategic sites of importance in the region that represent regional ecosystems and can be linked hierarchically with national and global ecosystems. The study is designed to provide the scientific information base to support decision-making and policy formulation in order to protect and promote sustainable management of the ecosystems in the selected sites and related areas. There is a movement to concentrate on increasingly decentralized governance in order to sustain ecosystem services at a local level. The study intends to provide the scientific information and knowledge for sound management of these resources.

Budget: The estimated funding for this project is $1,040,000. Some of the funding has already been secured while the various partners will raise the rest. Saudi Arabia pledged $400,000 for the study.

Northern Australian Floodplains, Australia

Contact person:
Max Finlayson
International Water Management Institute
PO Box 2075
Colombo, Sri Lanka
E-mail: m.finlayson@cgiar.org

Lead institution: Environmental Research Institute of the Supervising Scientist (ERISS). The Institute is a part of Environment Australia and a component of the Australian federal Department of Environment and Heritage.

Project objectives: To provide information on the floodplain and coastal ecosystems and their services of the tropical floodplains to the east of Darwin, Australia (including the Mary and Alligator rivers, which encompass the World Heritage and Ramsar Convention listed Kakadu National Park, and the Blythe-Liverpool rivers in Arnhem Land), noting information needs and analyses at multiple scales and taking into account multiple pressures on these ecosystems.

Methods:
The landscape analyses comprise sub-projects that address mapping at scales from the regional (biogeographical region; 1:500,000), catchment (East Alligator river: 1:250,000), sub-catchment (Magela creek and floodplain; 1:50,000) to individual reaches of streams (parts of Magela creek; 1:10,000). The Alligator Rivers Region covers about 2.8 million hectares and includes the entire catchments of two major rivers. The region will also be placed within a spatial biogeographical context, although analyses of major pressures will not be undertaken at this scale. Landscape analyses will be undertaken using appropriate imagery and all data contained within a GIS platform. The mapping approach will be based on the principles outlined in the Ramsar Convention Framework for Wetland Inventory and the Ramsar-endorsed Asian Wetland Inventory.

The analyses of pressures on floodplain and coastal ecosystems and their services will be undertaken using the Ramsar Convention framework for Wetland Risk Assessment. This encompasses an assessment of the extent and effect of the particular pressure(s) being considered, the extent of risk of adverse change occurring, and risk reduction and monitoring steps. In this manner, the three basics components of the MA process (condition/trends, scenarios, and responses) will be addressed. Information from across the region will be collated and assessed through this framework and, where necessary, complemented with information from specific research activities. Collating this information will involve collaboration with other research and governmental agencies responsible for particular sectors of the environment. The pressures that will initially be addressed include: feral animals and alien weeds (invasive alien species); infrastructure development and transport routes (including those linked with tourism and other developments); mining and milling activities; burning and fire regimes; and global climate change. Services that will be primarily addressed include provisioning services for local people, supporting services for biodiversity and ecosystem processes, and enriching services for the local indigenous and other resident populations.

The ecosystem services on the floodplains will be addressed through a framework based on that provided by the MA and adapted for local conditions. An initial framework has been developed after consultation; this will be expanded and information will added as it is collected and made available from stakeholders. This framework will sit alongside other ecological and economic investigations and developments within the regions. As these are being undertaken through different processes linked with local organizations, there is no intent to link them—the differences between the resource management structures and the likely outcomes provide comparative responses and options for management interventions.

Products: The primary purpose of the landscape-scale analyses is to provide information for managing the aquatic ecosystems within the region, noting that the responsibility for management decisions is shared between local landholders, governmental agencies, and resource managers. As the Institute does not directly manage ecosystems or their services it is necessary to present research/assessment outcomes in formats suitable for ready access by all stakeholders and decision-makers. The Institute already operates a transparent system for access to data and reports and specifically provides information to major stakeholders through formal and informal reporting procedures. This includes but is not limited to the Alligators Rivers Region Technical Committee. As a publicly-funded institution, all information collected by the Institute is made available. An annual report is presented and where possible information is published in the scientific literature.

Norway

(See color version of locator map in Appendix A.)

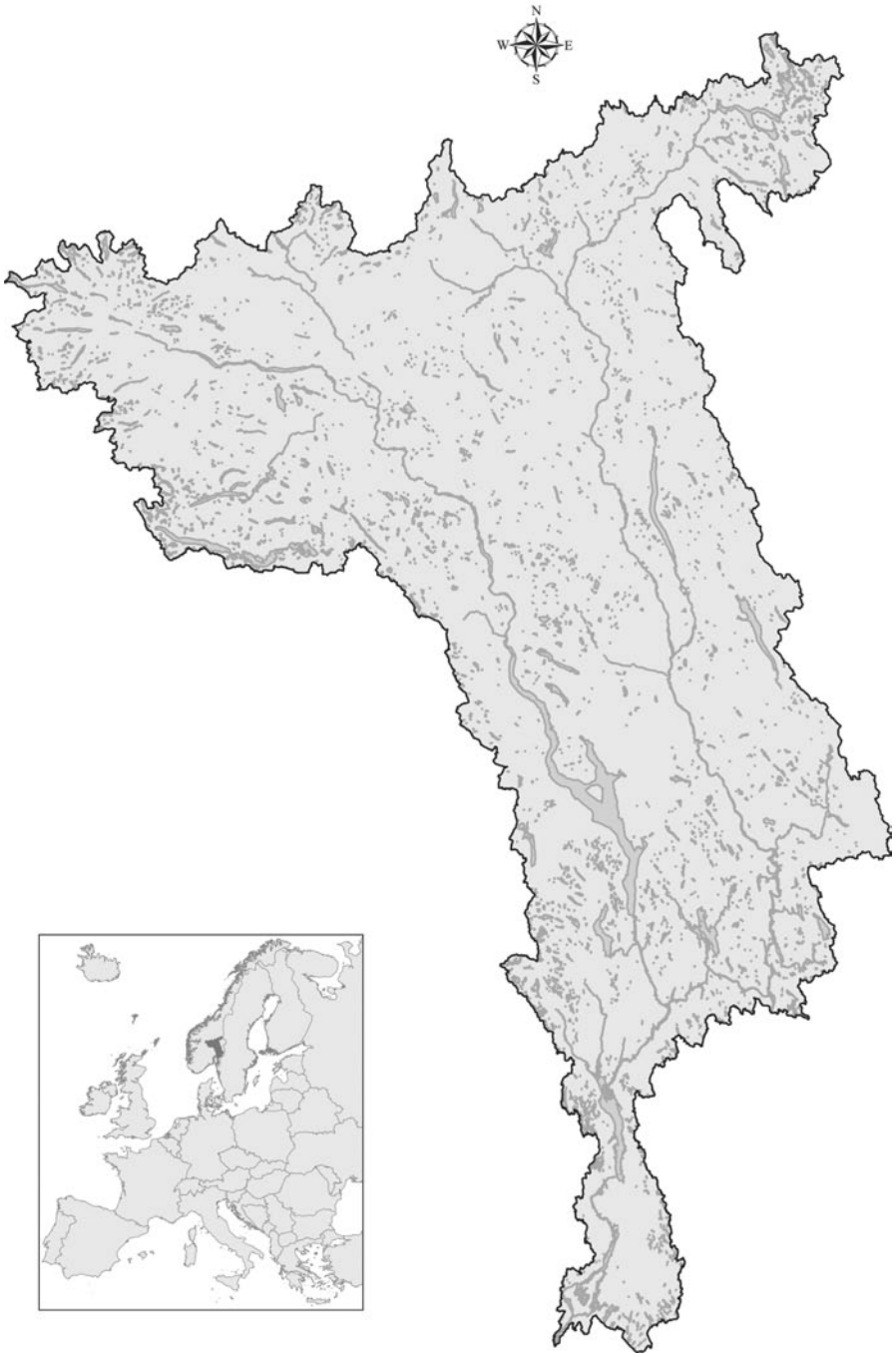
Contact persons:
Signe Nybø
Directorate for Nature Management
Tungasletta 2
N-7485 Trondheim
Norway

Odd Terje Sandlund
Norwegian Institute for Nature Research
Tungasletta 2
N-7485 Trondheim
Norway

Project team and institutions: The pilot study was conducted by Signe Nybø of the Directorate for Nature Management and Odd Terje Sandlund of the Norwegian Institute for Nature Research. The scenario project on Østfold was conducted by Bjørn Åge Tømmerås and Hanne Svarstad of the Norwegian Institute for Nature Research.

Time period: Conditions and trends was assessed from 1900–2000, with time scales differing among services investigated. The scenarios were projected until 2025. The conditions and trends assessment was completed February 2002, while the scenario project was completed in September 2004.

Intended audience: national and regional decision-makers.



Glomma and Lägen River Basins

Summary of findings:
The pilot study prepared the decision for undertaking a full-scale study. The pilot study consisted of three main parts: (1) proposals for the content and organization of a full scale study, (2) a survey of Norway's natural environment and its ecosystem services, and (3) a case study from the Glomma river basin. Glomma is the largest river in Norway.

The pilot study concluded that Norway both had the data and the capacity to do the full-scale study, and also that several sectors had an interest in doing it. However, the full-scale study never got funded; reported here are the results of parts 2 and 3.

Survey of Norway's natural environment and ecosystem services. This part of the pilot study comprises a simplified analysis of the condition of, and trends within, values and services associated with Norway's natural environment. The study compares the current status with the situation as it was about a hundred years ago.

The Glomma river basin study. The Glomma case study demonstrates how data series from diverse social sectors and activities can be used to analyze the way in which the extraction of products and services from ecosystems simultaneously depends upon, and exerts influence on, the condition of the ecosystems. The demands of one sector for extraction of services can influence the potential for extraction desired by other sectors. The Glomma river basin exemplifies many of the opposing interests, conflicts and necessary compromises faced by those involved in nature management. Some examples are:

- The construction of infrastructure leads to the fragmentation of the landscape. We know this has a negative effect on species such as wild reindeer, but we lack much information on the other effects of such fragmentation. In the Glomma river basin, the areas south of the line Trysil—Elverum—Hamar—Gjøvik are today devoid of encroachment-free areas, and in the areas north of this line the encroachment-free areas largely coincide with existing or planned conservation areas.
- The areas of old-growth forest have diminished, while at the same time the forests contain a larger volume of timber and have a different structure than they had fifty years ago. This efficient management of forest resources aimed at lumber production has probably led to the loss of biological diversity at the species or ecosystem level.
- Economic and political conditions at national and international levels promote changes in farming methods. Larger areas of uninterrupted fields and fewer field boundaries and groves provide for more efficient food production. Changes in the cultural landscape have consequences for tourism and outdoor pursuits in terms of experience and enjoyment value. The homogenization of the landscape can be detrimental to the tourist industry.
- Along the coast, conflicts of interest continually arise between the construction of holiday cottages or other infrastructure and the public's rights of access to land and sea. This problem also arises along the coast near the mouth of the Glomma.
- The watercourse today supplies diverse services and products such as hydro-electricity, supply of water to households and irrigation, cleansing of drainage water and recreation. Future conflict between different user interests on the watercourse will probably occur in different combinations in each individual case.

Scenarios: Three scenarios were developed for the Glomma river outlets. The *bush encroachment scenario* and the *urban growth scenario* are trend scenarios in which two present tendencies are imagined as being dominant toward the year 2025. The third scenario provides a contrast in which both of the two sets of trends have been avoided by various political actions. The study was carried out as a cross-disciplinary collaboration based on ecology and sociology.

Funding: The pilot study was funded by the Ministry of Environment of Norway, while the scenario project was funded by the Nordic Council of Ministers.

For further information: The two reports may be found at www.maweb.org.

Papua New Guinea (PNG)

Coastal, small island, and coral reef ecosystems

(See color version of locator map in Appendix A.)

Contact person:
Colin Filer
Resource Management in Asia-Pacific
Research School of Pacific and Asian Studies
Australian National University
Canberra ACT 0200
Australia
E-mail: colin.filer@anu.edu.au

Project team and institutions: This assessment is undertaken by a team of scientists coordinated by staff at the Australian National University and the University of Papua New Guinea. The first phase of the assessment (due for completion in 2005) is a nationwide survey of the relationship between coastal communities and coastal ecosystems, with a number of local-level case studies of this relationship. The second phase (due for completion in 2007) will focus on community-based assessments in one of the case study areas. This second phase is an integral component of the Milne Bay Community-Based Coastal and Marine Conservation Project (MBCP), which is being implemented by UNDP and executed by Conservation International. This project has its own Steering Committee with representation from a variety of stakeholders.

Time period: The period assessed is 1975–2000. Scenarios are projected until 2020. The assessment is scheduled for completion in March 2007.

Intended audience: national and provincial decision-makers, conservation organizations, university students, and local communities.

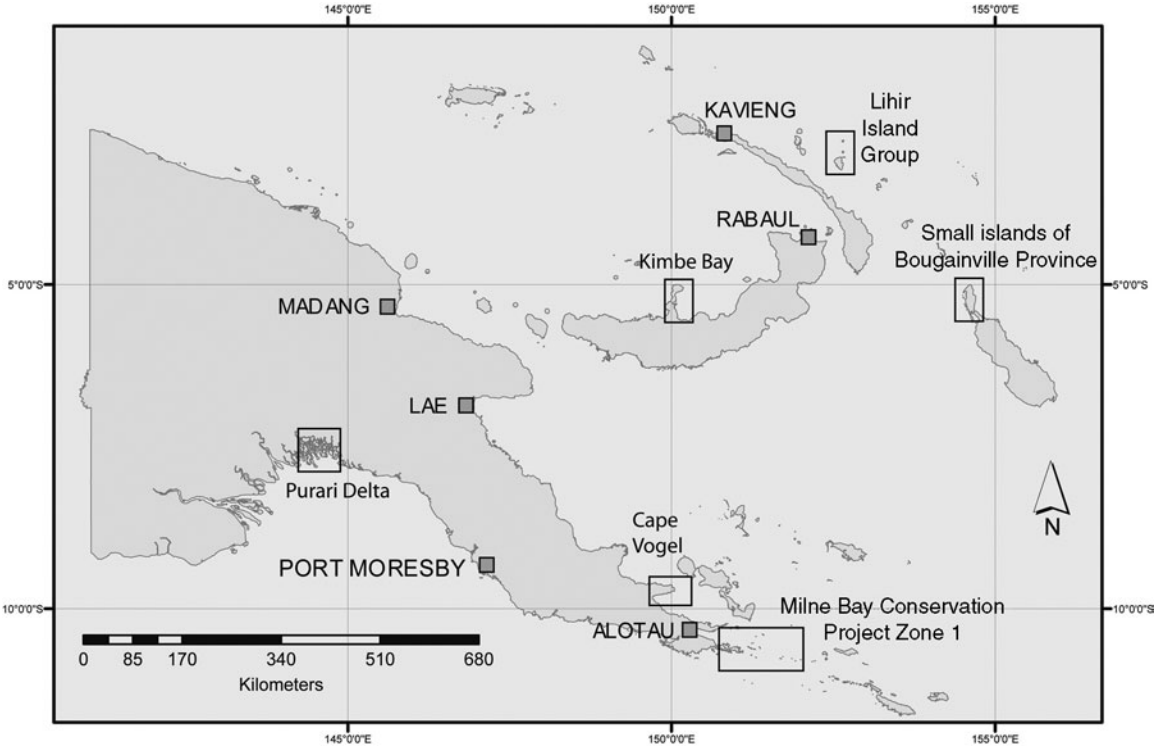
Focus: The main focus of this assessment is population pressure as a driver of ecosystem change in coastal and small island communities. Other significant drivers of change in PNG's coastal ecosystems are climate change, tectonic disturbances, the industrial exploitation of inshore marine resources, and the discharge of industrial and domestic waste material. The areas selected for local-level case studies in the first phase of the assessment are intended to reflect the extent of local variation in the relative significance of different drivers.

Within the coastal zone, both terrestrial and marine communities are assessed. Terrestrial communities include ''uncultivated'' forest (including sago groves); cultivated land (including bush fallows and orchards); other ''natural'' communities (such as grasslands and wetlands); and towns, villages, and other ''built-up environments.'' Marine communities include mangrove swamps; coral reefs; seagrass beds; and unvegetated bottoms. At the national scale, information about the supply of ecosystem services is primarily arranged by reference to indigenous food-cropping systems, which are treated as the core component of local resource management regimes in rural areas. Human well-being is measured by cash income, access to government services, and indicators of health, nutrition, and life expectancy.

The two scales of analysis and interpretation in the first phase of the assessment are the national and local scales, where each of the local case studies encompasses an area roughly equivalent in size and population to that of a single local level government in PNG. A preliminary assessment of the relationship between people and ecosystems in the area designated as ''Zone 1'' by the MBCP will count as one of five local case studies documented in the report of the first phase.

In the second phase, the national and local scales will be replaced by the provincial and community scales, because the assessment will focus on the coastal ecosystems of Milne Bay Province (one of 19 provinces in PNG) and on a number of coastal and small island communities within Zone 1. This phase is known as the Small Islands in Peril Program (SMIP) because of the preponderance of small island communities in this area.

As a sub-global assessment within the MA process, the Milne Bay SMIP has four objectives—to:



Papua New Guinea Coastal, Small Island, and Coral Reef Ecosystems

- build a credible and feasible framework for the collection, analysis, and synthesis of ecosystem-wide data for decision-making at the level of the local community and the province as a whole;
- test this framework in community-based assessments of ecosystem services in the area(s) of interest to the MBCP;
- address decision-making information needs at the provincial level by means of scientific analysis, scenario construction, and policy advice; and
- build capacity to undertake integrated assessments of the relationship between ecosystems and socioeconomic systems at local, provincial, and national scales.

For further information: To learn more about the design, progress, and outputs of the PNG assessment, see www.maweb.org.

Funding: The MA provided financial support for the first phase of this assessment, including production and dissemination of the national report. The second phase is funded by UNDP as part of the co-financing of a grant from the Global Environment Facility.

Laguna Lake Basin, Philippines

(See color version of locator map in Appendix A.)

Contact person:
Rodel D. Lasco
Chair, Philippine MA Technical Working Group
Environmental Forestry Programme
College of Forestry and Natural Resources
University of the Philippines Los Baños
College, Laguna 4031
The Philippines

Project team and institutions: The assessment is conducted by a panel of 25 scientists from the University of the Philippines (UP), Laguna Lake Development Authority (LLDA), Department of Science and Technology (DOST), Department of Environment and Natural Resources (DENR), Madecor Environmental Management System, Inc. (MEMSI), the SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), and Haribon Foundation. They are headed by the Coordinating Lead Authors, namely, Rodel D. Lasco, Ma. Victoria O. Espaldon, Adelina Santos-Borja, Macrina Zafaralla, Leonardo Liongson, Adelaida Palma, Benito Vergara, and Edwino Fernando. The advisory committee is composed of heads and representatives of various research and development institutions and an NGO; its members are DENR Secretary Elisea G. Gozun, Victor Ella, LLDA General Manager Casimiro Ynares III, Laguna Governor Teresita Lazaro, Rizal Governor Rebecca Ynares, Ramon Razal, Enrique Pacardo, Patricio Faylon, Rafael Guerrero, and Emerson Jacinto.

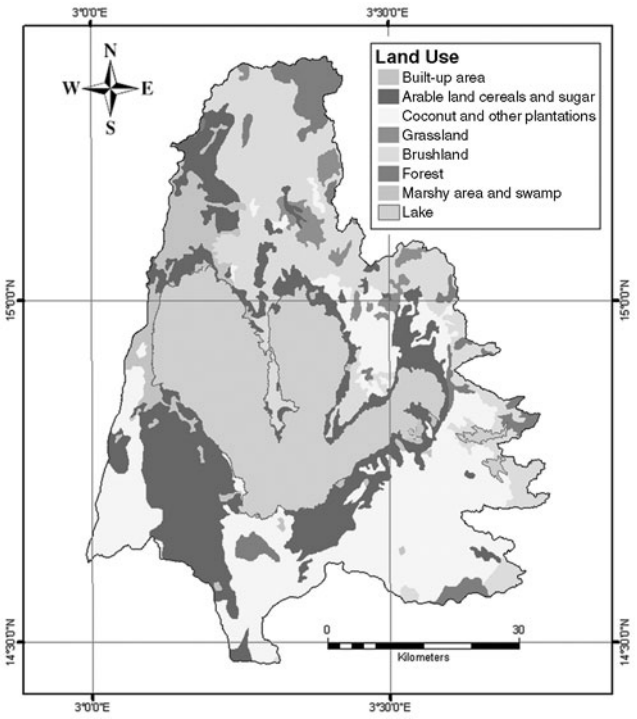
Time period: The period assessed is 1990–2000. Scenarios are projected to 2050. Assessment completion planned for mid-2005.

Intended audience: decision-makers at various scales: farm/village, basin/watershed, and national, especially the LLDA and DENR.

Ecosystem services assessed:
The following ecosystem services were assessed: water resources, fish resources, rice, biodiversity, and climate change in the Laguna Lake Basin. The scale of the assessment was nested from the local (farm/village) to the basin/watershed to the national policy implications of the findings. Major stakeholders include: farmers and fisherfolks, depending on the services provided by the lake, local government units, LLDA and DENR.

Water resources. The biological and chemical analyses of the water coming from the lake and its tributary rivers showed that many water quality parameters have already either exceeded or fallen below the criteria for Class "C" (suitable for fishery) waters, indicating the worsening condition of the lake. This has affected the productivity of the lake, particularly fish production. Hence, Laguna de Bay is in need of rehabilitation, of restoration to a past state that is more acceptable.

Fish resources. The fisheries of Laguna de Bay have been affected by human, industrial, and environmental factors which resulted in a 64% decline in production levels between 1980 and 1996. Species diversity has also significantly declined, with exotic aquaculture species dominating the catch. Although the number of fishermen operating in the lake has been reduced by 50.4%, they have remained in marginalized condition and there is a need for a viable alternative/supplemental livelihood.



Laguna Lake Basin, Philippines

Rice. The Laguna de Bay has a shoreland area of around 13,900 hectares, of which around 5,700 hectares are planted to rice. Rice production in this area can supply 14% of the total rice requirement in the Laguna de Bay region. However, this service provided by the basin is affected by a multitude of factors, such as the decrease in water level in the lake, quality of rice culture, construction of circumferential road, and land conversion. Meanwhile, due to the economic and social benefits gained from the shoreland, population growth and increasing and changing demands in resources and development activities pose a threat to the basin. Hence, institutional arrangements have been set up by LLDA on the use of shoreland and water on the lake.

Biodiversity. Six specific areas in the watershed are included as biodiversity priority areas in the Philippines due to the critical state of wildlife in these areas. The imbalance brought by the extirpation and decline of different species in the basin, as well as the introduction of alien species, has brought problems in agricultural production, particularly with some species causing damage to crops while others are considered nuisance animals in homes and public buildings. Introduction of alien species, chemical pollution, overextraction, and reduction of habitats of the wild flora and fauna pose a continuing threat to the indigenous biodiversity of the lake basin.

Climate change and the Laguna Lake Basin. Forest lands in the Laguna Lake Basin could help mitigate climate change through (1) the protection of existing forests with their carbon stocks (19,000 hectares storing about 2,850 kilotons of carbon) and (2) reforestation and rehabilitation of open and degraded lands (54,000 hectares with a potential carbon sequestration rate of 1,338 kilotons of carbon per year). Although climate change is not yet explicitly integrated in planning and implementation activities in the basin, many activities are being undertaken that indirectly contribute to the mitigation of climate change.

Funding: This work is funded by the MA and DENR.

Portugal

(See color version of locator map in Appendix A.)

Contact person:
Prof. Henrique M. Pereira
Dept. Civil e Arquitectura
Instituto Superior Técnico
Av. Rovisco Pais
1049-001 Lisboa
Portugal
E-mail: hpereira@ist.utl.pt

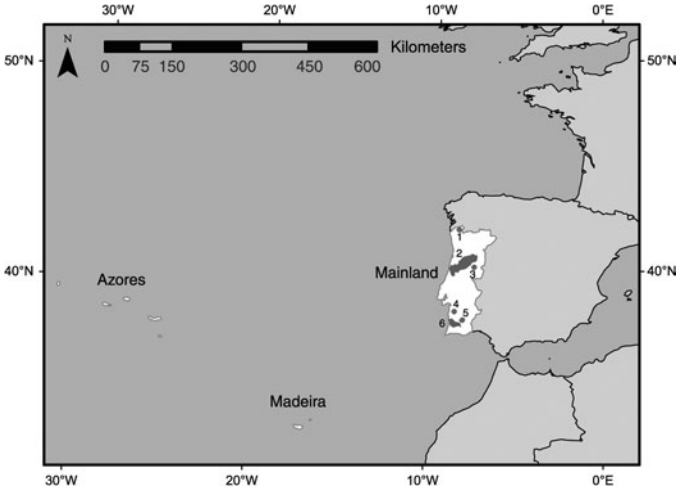
Organization: The assessment is led by Henrique M. Pereira, Tiago Domingos, and Luis Vicente. The coordinating institution is the Center for Environmental Biology of the Faculty of Sciences of the University of Lisbon. The scientific team is composed by 40 scientists from over 10 universities, research institutions and government agencies. The intended audience for the assessment is national and local decision-makers. The board of users has ten members representing government agencies, non-governmental organizations and the private sector. The advisory board is composed by seven members, including scientists and decision-makers and is chaired by Isabel Guerra (Ministry of Public Works, Transportation and Housing).

Time period: The period assessed was ecosystem service dependent, but aiming at 1964 to 2004. Scenarios are projected until 2050. The assessment started in May 2003, and the main report will be published in late 2005.

Study area: Portugal (Ocean—326,362 km^2; land—91,947 km^2), population *circa* 10 million. Analyzed MA system categories: marine, islands, coastal, inland waters, forest, mountain, cultivated, and urban. Additionally, the ''montado'' is analyzed. This is a woodland, predominantly with cork- and holm-oaks, managed for silviculture, agriculture, and animal husbandry. It occurs mostly in the south, which is a dryland area. There are two case studies at the basin scale and four at the local scale, sampling different systems.

Major findings:

Drivers. The most important drivers of ecosystem change in Portugal are: fire regime, land use changes (including abandonment of agricultural fields, afforestation, and urban sprawl), the European Union's Common Agricultural Policy, global markets, and economic growth. Other important drivers include environmental legislation, social attitudes toward the environment, tourism, demography, and exotic species. In some instances, these drivers interact synergistically. For instance, economic growth has led to increasing labor costs which, in association with reduced agricultural revenues, have led to the abandonment of agriculture, facilitating the establishment of shrubs, and hence increasing the frequency and intensity of fires.



Portugal

Overall analysis of the condition of the systems. Condition of ecosystem services is very heterogeneous across systems, with inland waters presenting more problems than any other system. Curiously, the dryland ''montado'' appears to be doing relatively well. The size of some systems is changing with forest and shrub land expansion and the partial abandonment of cultivated fields. The estimated economic value of ecosystem services from the forest is at least 900 million Euros per year, with at least 20% of this value coming from nonmarketed services such as soil and flood protection. Furthermore, 5% of the total employment is associated with the forest sector.

Food production. During the second half of the twentieth century, food production in the cultivated systems grew much slower than national food demand. Use of fertilizers and pesticides is generally low, when compared with other EU countries. Nevertheless, there is excessive fertilizer use in some places, causing contamination of underground water. Other localized problems include soil erosion due to poor agricultural practices and loss of fertile soil to urban sprawl and other land uses. Fish landings from the ocean and the coast have decreased over the last decade, but at the same time, oceanic fish stocks have improved and the majority of oceanic species are above the precautionary biomass threshold. Nevertheless, some oceanic species are overexploited and, in a few cases, even with strong regulation, recovery will be very difficult. Coastal fisheries are doing worse than oceanic fisheries, partially because of pollution and eutrophication. In inland waters, there has been an increase in food production due to aquaculture but the sustainability of that production has been decreasing due to its impacts on water quality.

Freshwater provisioning. About 75% of water consumption is associated with agricultural activity and about half of the water comes from underground sources. Despite some localized problems (including highly variable intra- and inter-annual runoff in the south), there are no critical problems of supply and demand of water in Portugal. However, there are serious problems with water quality. Several aquifers in the cultivated systems (particularly those in the central coastal region) have problems with nitrate pollution and saline intrusion. Moreover, several rivers are heavily polluted from industrial, farming, and domestic activities, with eutrophication occurring in some basins. Finally, despite the increase in total forest area over the last decades, the capacity of forests to provision freshwater has not improved significantly due to the increase in fire frequency and because the majority of the forest area increase is with eucalyptus plantations, which are worse than oak or pine forest for water provisioning.

Timber and cork. Annual fellings for wood supply are about the same amount as the net annual increment in forests with the same main function. However, better management could both improve annual increments by more than 20% and the sustainability of the production in terms of fertilizer use, soil erosion, and nutrient depletion. The dryland ''montado'' produces more than 50% of world cork, a process that has high ecological sustainability.

Biodiversity. Broadly speaking there is a spatial overlap between terrestrial biodiversity and human populations in Portugal: areas with more species are also under the highest pressure for development. However, most sites with high irreplaceability of biodiversity are protected under the Natura 2000 network. Still, biodiversity is declining in most sys-

tems, both in populations of indicator species such as top predators and in area of rare or vulnerable habitats. The worst situations are found in forest, inland water systems, coastal areas and urban areas: in northern and central Portugal only a tiny proportion of forest is native oak forest, instead monocultures of eucalyptus and pine dominate; inland water systems have suffered from dam construction, pollution and eutrophication; in coastal areas the pressure from urban development and tourism has led to the loss of wetlands and other habitats; in urban areas lack of green parks and poor urban planning is the main problem. Some marine species such as seabirds and mammals have decreased their range or population size, but surveys of ocean fish species do not show negative trends. Some cultivated systems such as cereal pseudo-steppes and slough fields are particularly important for biodiversity but their maintenance is threatened due to agricultural abandonment. On the other hand, agricultural intensification in some other areas has led to landscape homogenization and loss of biological diversity including loss of domestic races.

Soil protection and water cycle regulation. Critical ecological problems with soil protection and water cycle regulation services occur in the urban system (poor urban planning) and in the coastal areas (loss of wetlands and infrastructure development near cliffs). In some cultivated areas in the south of Portugal, cultivation of cereals with excessive tillage in inadequate soils and the decreasing use of crop rotation has led to soil degradation, recovery being particularly difficult in that dryland area. The forest system is affected by fire frequency, which causes soil loss during rainfall, deterioration of water quality downstream and increased run-off.

Climate regulation. Current knowledge of the role of Portuguese forests in carbon sequestration is limited. An (under)estimate of Net Biome Productivity is about 1.52 million tons of carbon per year, which accounts for 7% of carbon emissions in 2000. While carbon sequestration capacity has been improving due to the increase in total forest area, this improvement is hampered by increases in fire frequency and intensity.

Recreation. In 2000, total income from tourism represented about 8% of GDP. The vast majority is associated with mass tourism in coastal areas, where signs of saturation and even deterioration of recreation quality are appearing. Hunting is one the most important recreational services in forest, cultivated and mountain systems, with an estimated annual economic value of 60 million Euros. The recent creation of associative hunting zones and tourism hunting zones implementing a user-pays philosophy and the assurance of no-hunting rights to land owners may improve the condition of this service. But concerns have been raised about predator control in these zones. There are about 2 million non-hunting visit-days per year to forest and mountain areas. Furthermore, there is now an increase in demand for rural tourism in areas with traditional agricultural practices. Finally, dam construction in inland waters has provided new opportunities for recreation, including sailing and bathing areas.

Scenarios: The assessment team started by trying to develop its own scenarios, but it turned out that these overlapped partially with the global MA scenarios. So a decision was made to build on the work already done for the MA global scenarios, and adapt those scenarios to the Portugal scale. This process is ongoing but it is already clear that different scenarios have very different outcomes in terms of the evolution of ecosystem services and that the most important drivers at the Portugal scale may differ from the drivers at the global scale. Also, scenarios bring out trade-offs between different ecosystem services.

Responses: One of the major responses analyzed was the acquisition of farms by a national scale environmental NGO in a specific "hot spot" area for hosting biodiversity, the cereal pseudo-steppe, responding to land use changes driven by the European Union's Common Agricultural Policy and the pressure to create eucalyptus plantations. This multi-scale intervention of an environmental NGO has been very useful. The technical capacity and intervention influence of the NGO, owing to its national scale, has been applied at the local level. At the same time, this experience has had feedback on its intervention at the national scale. However, the strong focus of the NGO on biodiversity conservation has led to a low performance with respect to soil conservation. Managing this trade-off is still an open problem.

Ecosystem services and human well-being in the mountain community of Sistelo: From the perspective of the Sistelo community, some of the local criteria for well-being are closely related to local ecosystem services but the majority are not. People recognize many services provided by ecosystems, particularly provisioning services, but also cultural and regulating services. Some components of well-being such as material well-being have been improving over the last decades, while some ecosystem services such as food production have been declining. This disconnect between well-being and ecosystem services at the local scale is a consequence of the increased buying power that individuals now have, which allows individuals to substitute local ecosystem services for goods from the outside.

For further information:

Web site: www.ecossistemas.org

Pereira, H.M., T. Domingos, and L. Vicente (eds.), 2003: *User Needs and Response Options Report. Portugal Millennium Ecosystem Assessment.* Available online at ecossistemas.org.

Pereira, H.M., T. Domingos, and L. Vicente, 2004: *State of the Assessment Report. Portugal Millennium Ecosystem Assessment.* Available online at ecossistemas.org.

Funding: The Portugal assessment received a $32,500 grant from the MA. Other grants and support totaling about $6,000 came from: Caixa Geral de Depósitos, Universidade de Coimbra, Universidade Católica Portuguesa, and Caminhos de Ferro Portugueses. In-kind contributions from the researchers' institutions and from Fundação da Ciência e Tecnologia totaled about $100,000.

SAfMA Regional Scale Assessment (SAfMA Regional)

A component of the Southern African Millennium Ecosystem Assessment

(See color version of locator map in Appendix A.)

Contact person:
Dr. R.J. Scholes
CSIR Environmentek
PO Box 395
Pretoria 0001
South Africa
E-mail: bscholes@csir.co.za

Project team: The assessment was conducted by Bob Scholes, Oonsie Biggs, Jenny Cooper, Gavin Fleming and Tinyiko Malungani of the Council for Scientific and Industrial Research in Pretoria, and Alison Misselhorn of the University of the Witwatersrand in Johannesburg.

Time period: The period assessed was 1960–2000. Scenarios were projected to 2030. The assessment was completed in June 2004.

Intended audience: National and regional decision-makers.

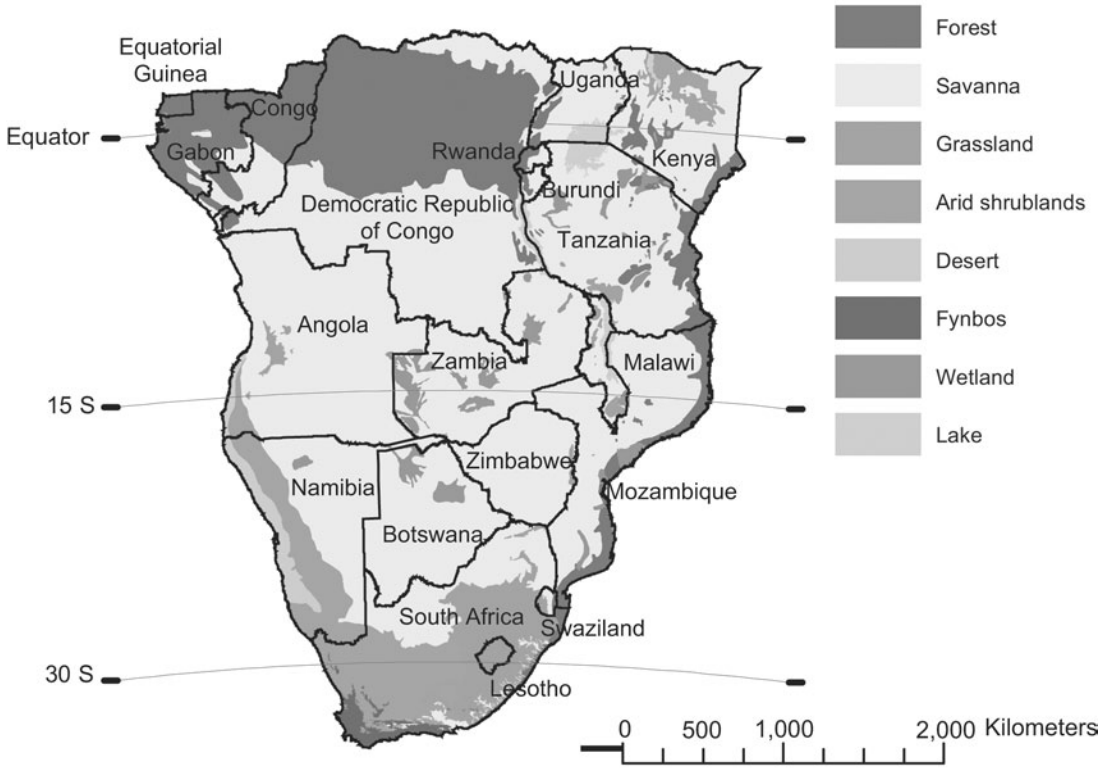
Major findings:
By standard measures of well-being, the countries of the southern African region are on average in the bottom quarter of the world ranking, and even the best-off countries are in the bottom half. The total population of the study region in 2001 was 275 million, increasing at 2.2% per annum. One third of the population is urban, and this fraction is rising rapidly.

Fresh water. Southern Africa, broadly speaking, has a water-scarce south and a water-rich north. There is high potential for conflict over the many shared water basins, both between countries and between sectors. A key policy response in the critically dry countries has been to make water allocation more market-related, after first protecting the minimum needs of people and riparian ecosystems.

Food. The region as a whole produces nearly enough carbohydrate crops to meet the minimum needs of its population, but due to distribution inequities, up to 25% of the population is undernourished. The situation regarding protein nutrition is serious. The protein supply for people living north of the Zambezi river is below the minimum daily requirement, and declining. There is little scope for increased off-take from natural fisheries, half of which are already overfished. There is technical opportunity for greater protein off-take from livestock. Currently, a significant part of the unsatisfied nutritional needs of the region are probably derived from natural ecosystems.

Biomass fuel. Three quarters of energy for household cooking and heating in the region is supplied by wood and charcoal. There are wood fuel supply shortages in a number of clearly delineated areas, but overall wood growth is adequate for a sustainable harvest. Use of biomass fuels has climate change mitigation advantages but, if burned under poorly ventilated conditions, is the major cause of poor indoor air quality and leads to severe health problems.

Air quality. Domestic wood burning, wild fires, and industry currently contribute almost equal amounts to regional air pollution, which due to the unique circulation pattern over southern Africa, often reaches alarming levels during the winter months. Emission increases in the future will necessitate a collective, multinational approach to managing air quality.



Southern African Regional Assessment. This covered 19 countries in mainland Africa south of the equator, and eight major biome types. (Scholes and Biggs 2004)

Biodiversity. Southern Africa has a disproportionately high fraction of global biodiversity. In most instances it is nearly intact, both inside and outside protected areas, but certain groups of species, and certain unique locations, are endangered. The most highly transformed ecosystem type is grassland. The current forested area (including woodlands) is estimated to be 4 to 5 million square kilometers, depending on the forest definition adopted. Using a new index developed for the study, it is calculated that 85% of the pre-colonial biodiversity is intact in the region. The natural features of the region form the basis of a major nature-based tourism sector, already contributing significantly to the regional economy, and growing three times faster than agriculture or forestry.

Scenarios. The study explored the consequences to ecosystem services of two political and economic scenarios. One projects forward the current trend of slow economic growth, marginalization from the global economy, and weak governance. The other assumes that efforts to put the region onto a different development pathway through stronger governance are successful, leading to higher economic growth rates and greater industrialization and infrastructural development. In the first scenario, direct dependence on ecosystem services, especially in rural areas, overwhelms local supply in many places, leading to accelerated degradation and transformation. In the second, limited water supply and deteriorating air and water quality constrain the improvements in quality of life.

Synthesis. Overall, there is a remarkable spatial congruence between areas where ecosystem services are under pressure, and locations of recent conflict. This interaction probably works both ways: in some cases, the conflict may be a result of the shortage of resources; in others, the resultant breakdown of authority may be the cause of the resource exploitation. At least four of the eight Millennium Development Goals will not be met in the region unless attention is given to stabilizing ecosystem services.

For further information: See Scholes, R.J., and R. Biggs (eds.), 2004: *Ecosystem Services in Southern Africa: A Regional Assessment*. CSIR, Pretoria, South Africa. 75 pp. Available online at www.maweb.org.

Funding: This work was funded by the MA, including a grant from Norway, administered by UNEP.

SAfMA Gariep Basin Assessment (SAfMA Gariep)
A component of the Southern African Millennium Ecosystem Assessment

(See color version of locator map in Appendix A.)

Contact person:
Albert van Jaarsveld
Faculty of Science, University of Stellenbosch
Private Bag X1, Stellenbosch 7602 South Africa
E-mail: asvanj@sun.ac.za

Project team and institutions: The assessment was conducted by Erin Bohensky, University of Pretoria; Belinda Reyers, University of Stellenbosch; Albert van Jaarsveld, University of Stellenbosch; Christo Fabricius, Rhodes University; Louise Erasmus, University of Pretoria; Aimee Ginsburg, University of Stellenbosch; Claudia Holgate, Monash University; Tony Knowles, University of Stellenbosch; Lefulesele Nteletsana Lebesa, Lesotho Agricultural Research Division; Michele Pfab, Gauteng Department of Agriculture, Conservation, Environment, and Land Affairs; Marna van der Merwe, CSIR; Charlie Shackleton, Rhodes University; and Lethiwe Zondo, University of Natal.

Time period: The period assessed was 1993–2003. Scenarios were projected to 2030. The assessment was completed May 2004.

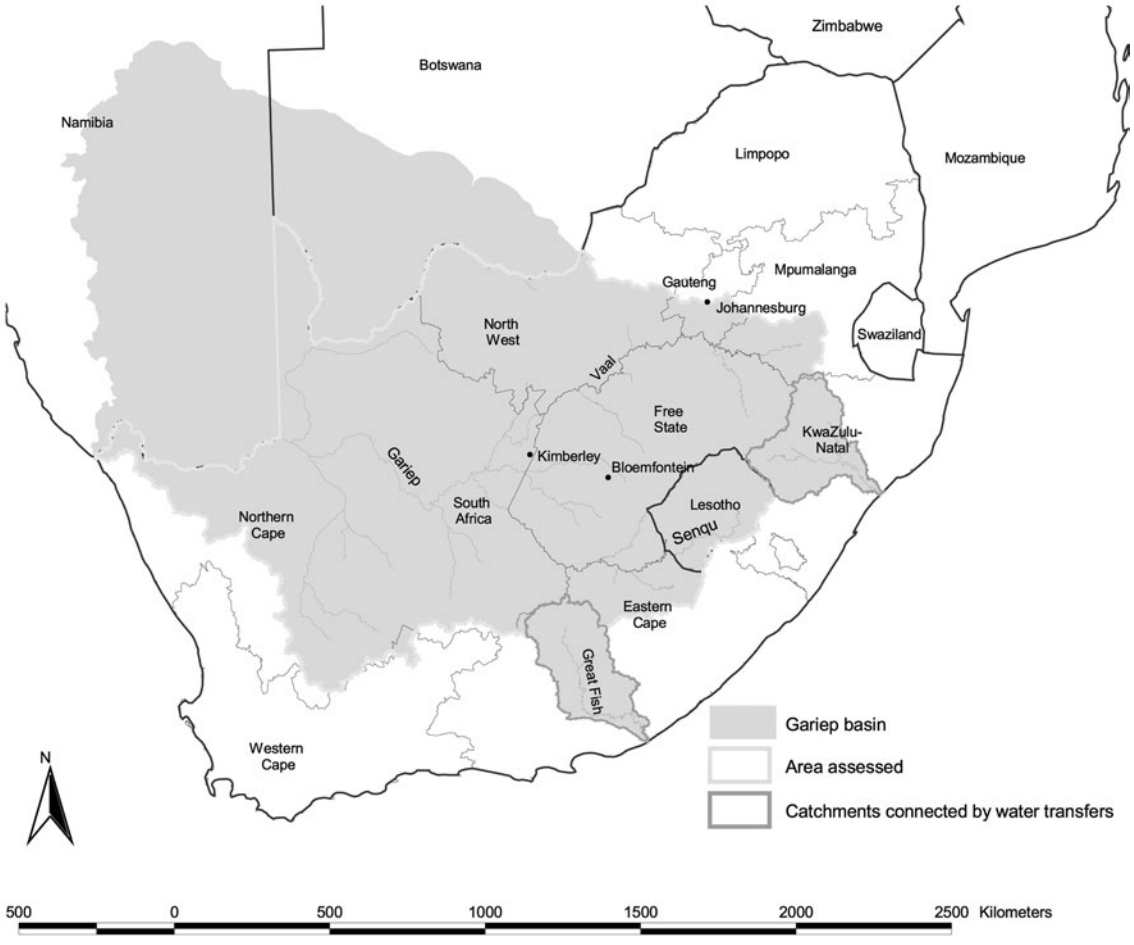
Intended audience: national and provincial level decision-makers, research institutions.

Issues addressed:

Fresh water. The Gariep is a water-scarce basin, with runoff distributed disproportionately across the landscape. It is the region's most regulated basin, with large dams and extensive transfer schemes, most notably from the Lesotho highlands to the growing urban area of Gauteng. Transformation has altered biodiversity, and water quality problems threaten domestic and irrigation supplies. The water sector is currently being decentralized and is initiating pricing policies to recover the full costs of using water. The National Water Act of 1998 prioritizes allocation of water to ecosystems and basic human needs, but ecological requirements have yet to be defined, while infrastructure to deliver water is lacking in some rural areas, and some households cannot afford to pay for water services.

Food. Food production in the Gariep contributes to livelihoods, markets, raw materials foreign exchange, and surplus or ''savings.'' Agriculture is a source of water and air pollution and mismanagement has resulted in significant land degradation. Fertilizers and pesticides may have negative effects on health, while genetically modified organisms are controversial but offer promise for boosting agricultural productivity. Food security is being compromised by declining household incomes, changes in land tenure and market access, and HIV/AIDS. Subsistence farming, food gardens, wild foods, game farming, and bushmeat are important food sources not usually reflected on national balance sheets.

Energy services. In the rural areas and the informal economic sector, biofuels remain an important energy source, while electricity or fossil



Location of the Gariep Basin, International Boundaries, South African Provincial Boundaries, Major Rivers, and Major Cities. Note that the actual Gariep basin extends beyond the area assessed. (Bohensky et al. 2004)

alternatives supply urban households. About 70% of South Africa is electrified, dropping to 50% in rural areas and 3% in Lesotho. Local fuelwood depletion occurs in some rural areas, while burning of coal, though abundant, produces high carbon dioxide and sulfur dioxide emissions, affecting air quality and contributing to greenhouse gas emissions. Potential for solar power is very high in the Gariep, but investment in alternative energy technologies remains limited.

Mineral services. Minerals are of special interest in the Gariep basin because of their contribution to the economy and employment. Mineral extraction creates excessive ecological disturbance which interferes with ecosystem function and biodiversity, and by-products of mining affect air and especially groundwater quality. Mining legislation passed in recent years has required the sector to implement more sustainable and equitable practices, though in general, the largest benefits of mineral services rarely accrue to those who bear the cost of mining's externalities.

Cultural services. Cultural services exist across the landscape but may be highly localized, such as sacred pools and forests, taboos, rituals, religion, language, and ecological knowledge systems. Cultural services in some areas are threatened by land use pressures, increasing urban contact, modernization, and influences of other cultures. Some cultural services in the Gariep basin are recognized formally by South Africa's Natural Heritage Act and the World Heritage Convention.

Biodiversity. The Gariep basin is less well protected than South Africa on average, despite the occurrence of two important biodiversity areas—the Succulent Karoo and Drakensberg highlands—within its boundaries. About 84% of the Gariep basin remains in its natural state, while the rest is transformed mostly by cultivation (93%), followed by urbanization (4%) and overgrazing and fuel wood removal (4%). The Grasslands, being nearly 30% transformed, are the most threatened biome and most poorly protected. While overall protected areas are increasing and several large transboundary parks have been or will soon be established, conservation in South Africa is moving away from a sole focus on protected areas and is embracing other techniques, such as economic incentives for promoting conservation on private or communal land.

For further information: The full study is published as Bohensky, E., B. Reyers, A.S. van Jaarsveld, and C. Fabricius (eds.), 2004: *Ecosystem Services in the Gariep Basin: A Basin-Scale Component of the Southern African Millennium Ecosystem Assessment (SAfMA),* SUN Press, Stellenbosch, South Africa, 152 pp. Available at www.maweb.org

Funding: This work was funded by the MA, including a grant from Norway, administered by UNEP.

Kristianstad Wetlands, Sweden (Sweden KW)

Contact person:
Thomas Hahn
Centre for Transdisciplinary Environmental Research
Stockholm University, 106 91 Stockholm, Sweden
E-mail: hahn@ctm.su.se

Project team and institutions:
Carl Folke*, Thomas Hahn*, Åse Johannessen**, Jon Norberg**, Per Olsson* and Lisen Schultz*
*Centre for Transdisciplinary Environmental Research (CTM), Stockholm University
**Department of Systems Ecology, Stockholm University

Advisory committee:
Sven-Erik Magnusson*, Karin Magntorn* and Hans Cronert**

*Ecomuseum Kristianstads Vattenrike (EKW), Kristianstads kommun, 291 32 Kristianstad
**Scania County Board Administration, Länsstyrelsen i Skåne län, 291 86 Kristianstad

Time period: Condition and trend assessment applies to the years 1989–2003. Scenarios are under development. The project timeframe is 2001–2005.

Area description: Kristianstad Wetlands is a semi-urban area of high biological and cultural-historical values in southeastern Sweden. It was designated to have international importance by the Ramsar Convention on Wetlands in 1974, and is currently being evaluated to become a UNESCO Man and the Biosphere Reserve. KW covers 1,100 square kilometers of the Helgeå River catchment area and the coastal regions of Hanö Bay within the municipality of Kristianstad. The whole catchment of the river is 4,749 square kilometers. KW includes Sweden's largest areas of flooded meadows used for grazing and hay-making. Many of the unique values of the area are associated with these social-ecological systems, which depend on both the proliferation of grazing and hay-making, and the annual flooding of Helgeå River. The wetland areas are directly connected to Kristianstad, a city of 28,600 inhabitants. The whole municipality has 75,000 inhabitants.

Methods and approaches:
This assessment was carried out in an area where the ecosystems have been managed in an adaptive collaborative process since 1989, by the Ecomuseum Kristanstad Vattenrike (EKW) and local steward associations. The assessment area was chosen because Kristianstad Wetlands appears to be an example of a successful response to a perceived decline in ecosystem services. The response consists of formulation and implementation of the ecosystem management approach, including involvement of many different stakeholder groups (local steward associations), linking scales, combining knowledge systems, and using ecosystem services while maintaining them. The assessment identified three types of knowledge relevant to ecosystem services: (1) ecological knowledge, (2) technology and knowledge of management practices, and (3) knowledge of social processes behind management practices. Ecological knowledge involves knowledge of flora and fauna and their diversity as well as ecological processes and functions at various temporal and spatial scales and how these processes are linked across scales. Our aim was to draw lessons from KW that could be applied in other areas. In addition, the assessment process would strengthen the on-going management by providing useful frameworks such as resilience theory and the MA conceptual framework. Understanding social factors such as learning, trust building, sense making, conflict resolution, as well as navigating rules, incentives, and funding are crucial for increasing the capacity of managing ecosystem services in a sustainable fashion.

Information was collected through literature review, including scientific reports and other reports such as vegetation surveys, species inventories, land use maps, historical records, protocols, and annual reports. We also conducted social-ecological inventories and semi-structured interviews with key informants.

Key findings:
Social mechanisms behind transformation toward ecosystem management. In KW, the self-organizing process was triggered by the perceived threats to the area's cultural and ecological values among people of various local steward associations and local government. The threats challenged the generation of ecosystem services in the area. We show how one individual, a key leader, played an instrumental role in directing change and transforming governance. The transformation involved three phases: (1) preparing the system for change, (2) using a window of opportunity, and (3) building social-ecological resilience of the new desired state. The local policy entrepreneur initiated and created trust-building dialogue and mobilized social networks with actors across scales, and started processes for coordinating people, information flows and on-going activities, and for compiling and generating knowledge, understanding, and management practices of ecosystem dynamics. Sense-making, collaborative learning, and creating public awareness were part of the process. A comprehensive framework with a shared vision and goals that presented conservation as development and turned problems into possibilities was developed and contributed to a perception shift of the values of the wetland landscape among key actors. A window of opportunity at the political level opened in 1989, which made it possible to transform the governance system into a trajectory of ecosystem management. The transformation involved the establishment of a new municipality organization, EKW. This flexible organization serves as a bridge between local actors and governmental bodies and NGOs at different organizational levels. Such a bridging organization is critical in the adaptive governance of the wetland landscape. It is also critical in initiating and maintaining social-ecological processes and strategies that contribute to resilience such as developing motivation and values for ecosystem management, directing the local context through adaptive co-management, and navigating the larger sociopolitical and economic environment.

Major vulnerabilities. KW's vulnerabilities include dependence on a few key individuals and on the European Union's system of agricultural subsidies, the Common Agricultural Policy. Although EKW is a flexible organization with no legal authority, it has taken initiatives for land use plans that have been sanctioned by the municipality or national agencies. The present application to become part of the Man and the Biosphere Program is another means to decrease vulnerabilities.

Role of local stewards. Social-ecological inventories are useful for providing the baseline information on ecosystem condition and existing management, and for strengthening capacity to manage ecosystems. Local stewards can provide local ecological knowledge derived from detailed, long-term monitoring and active management of ecosystem services. In addition, they often collaborate within horizontal and vertical networks with shared management responsibilities (adaptive co-management). Thus local steward associations can play an important role in ecosystem management, and should be included in efforts to strengthen capacity to manage ecosystems for human well-being.

Added value of community-level assessments. Community-based assessments include fine-scale processes that are hidden at larger scales. They also involve local users and managers, who directly influence the ecosystem. In doing this, they can reveal local ecological knowledge which

is site-specific, detailed and long-term, and complements scientific knowledge. Communities can also give lessons for sustainability, in the sense that they have managed their ecosystems for a long time. In addition, strengthening capacity to manage ecosystems sustainably requires involvement of all people who shape the ecosystem.

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Schultz L., P. Olsson, C. Folke, and Å. Johannesen. In manuscript. Ecosystem management by local steward associations: A case study from Kristianstads Vattenrike, Southern Sweden. Presented at the conference ''Bridging Scales and Epistemologies,'' Egypt, March 2004.

Budget, funding: Total budget is around $200,000 annually. Project donors are the Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning and the Swedish Research Council. In-kind contributions were provided by the Centre for Transdisciplinary Environmental Research and the Department of Systems Ecology, Stockholm University.

Acknowledgments: We would like to thank all the local stewards in Kristianstad who have contributed to the assessment, especially the Ecomuseum Kristianstads Vattenrike. Thanks also to the Resilience Alliance for important contributions during the meeting held in Kristianstad in September 2003. Finally, we thank our donors and the staff at the MA secretariat for enabling this assessment.

Stockholm Urban Assessment (Sweden SU)

(See color version of locator map in Appendix A.)

Contact person:
Johan Colding
The International Beijer Institute of Ecological Economics
The Royal Swedish Academy of Sciences
Box 50005 SE-104 05 Stockholm, Sweden.
E-mail: johancspammersbegone@beijer.kva.se

Project team and institutions:
Johan Colding,[1] Thomas Elmqvist,[2] Carl Folke, [1,2] Jakob Lundberg,[2] Karin Ahrné, [3] Erik Andersson, [2] Stephan Barthel,[2] Sara Borgström, [2] Andreas Duit,[4] Henrik Ernstsson[2]

[1] The International Beijer Institute of Ecological Economics, The Royal Swedish Academy of Sciences
[2] Department of Systems Ecology, Stockholm University
[3] Centre for Transdisciplinary Environmental Research (CTM) Stockholm University
[4] Department of Ecology and Crop Production Science, Uppsala

Advisory committee: Peter Schantz, Stockholm University College of Physical Education and Sports, and Stefan Lundberg, Swedish Museum of Natural History.

Time period: 2001–2005.

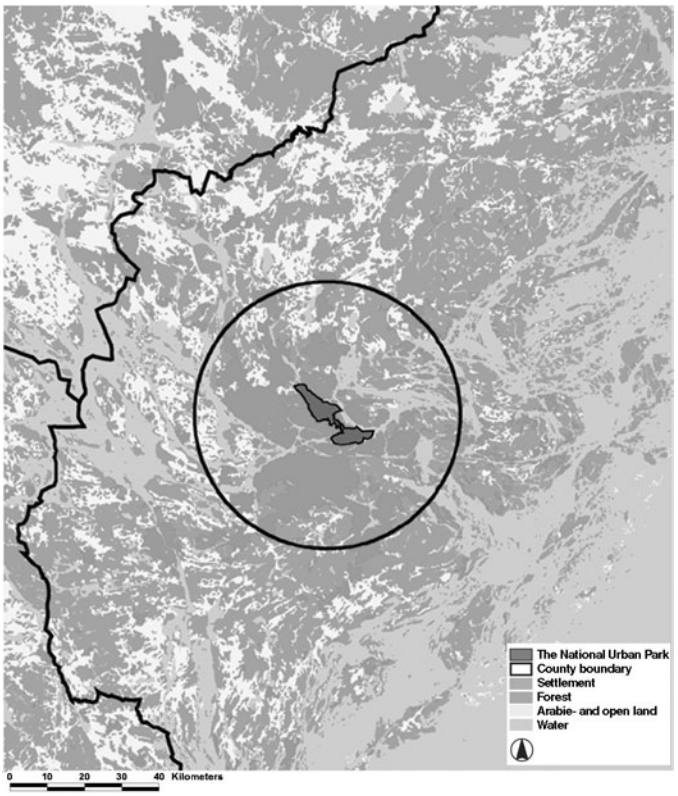
Area description:
Stockholm County consists of a total land and water area of 678,500 hectares, representing about 2% of the total land area of Sweden, and extending about 180 kilometers from north to south; 46% of the land area constitutes forest, 18% agricultural lands, 14% settled areas, and 22% represents other land uses (Statistical Yearbook of Sweden 1998).

Stockholm County has the largest population concentration in Sweden, with more than 1.8 million people, and is projected to grow to 2.4 million people within 30 years. Due to population increase and urban development, the region displays degradation of ecosystems, with a loss of both common and red listed species. The overall objectives of the Stockholm Urban assessment are to investigate how adaptive capacity can be built to better adapt to change and, more specifically, to find effective ways to manage urban ecosystem services. Stockholm Urban covers the greater metropolitan area of Stockholm and has at its center the Stockholm National Urban Park (NUP), a 2,700 hectare woodland area located adjacent to the inner city of Stockholm.

Methods and approaches:
The urban assessment focuses on the provision of ecosystem services and functions and the support provided by green areas. The role of local users, their management practices, institutional arrangements, and local ecological knowledge in the use and management of unprotected green areas is investigated. Recreation represents an important ecosystem service generated by urban green areas, and it is estimated that NUP has 15 million visitors per year and that 97% of the urban population in Stockholm will visit one of the urban green areas once a year; 47% will make visits every week.

The main direct drivers analyzed are green area loss, which leads to loss of aesthetic, recreational, and cultural values that in turn may lead to reduced human health and well-being. The *main indirect driver* leading to green area loss is population growth, with the associated urban sprawl, drivers that are reinforced by economic growth, coupled with institutional mismatches for ecosystem management and a lack of understanding of ecological support functions.

The common response to mitigate the effects of green area and biodiversity loss has been ratification of conventions and development



The Stockholm Urban Assessment. This assessment is located within a circle with a radius of 20 km surrounding the most central parts of the city. The National Urban Park is located in the center of this circle.

of new governmental policies, including establishment of nature reserves and national parks. Local public response also exists through interest groups that put pressure on authorities. Local stakeholders may also influence biodiversity management through their own land use and management practices. Linked to NUP alone, there are some 45 nongovernmental organizations representing 175,000 members that are loosely involved in green area management.

The methods and tools used include GIS assessments, gap analysis, and modeling; statistical trends; and inventories of key stakeholder groups with accompanying interviews. Key supplemental sources include a physical regional development plan by the County Council (RUFS 2001), and a new government program of reserves coordinated by the County Administrative Board.

Key findings:

Main conclusions from the analyses so far are that, in order to sustain ecosystem services, spatial and temporal interactions of ecosystem processes have to be recognized, and that these interactions have to be mimicked in appropriate spatial and temporal scales for management and communication. Our analyses also illustrate the great potential of management models of complex social-ecological systems, where scientific knowledge is combined with practices and knowledge that are generated among resource users locally in adaptive co-management processes. Co-management already exists in some parts of Stockholm County. For example, a wetland project known as ''Tyreså-projektet'' within a major system of lakes south of Stockholm aims to coordinate the lake management among six municipalities, and to handle upstream/downstream problems related to eutrophication. A major future aim will be to evaluate the prospects of introducing arenas of adaptive co-management to supplement the current management paradigm. Such arenas may be especially useful to establish around unprotected green areas managed by local stakeholders that promote ecological support functions. Co-management may also be useful in areas where protected areas exist and where locally managed green space may function as buffer zones and for management of weak links that connect larger green areas. A challenge in this context is to analyze management practices and local ecological knowledge among the locally evolved interest groups in order to strengthen their role in adaptive co-management processes and to engage them in monitoring and evaluation of outcomes from management projects.

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Funding: Donors for the project were the Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning and the Swedish Research Council. In-kind contributions were provided by the Centre for Transdisciplinary Environmental Research and the Department of Systems Ecology, Stockholm University.

Acknowledgments: We would like to thank all the local stewards in Stockholm who contributed to the assessment. We would also thank our donors and the staff at the MA secretariat for enabling this assessment.

Northern Range, Trinidad

(See color version of locator map in Appendix A.)

Contact person:
Angela Cropper
The Cropper Foundation,
Building 7, Fernandes Industrial Centre, Eastern Main Road
Laventille, Trinidad and Tobago.
E-mail:acropper@thecropperfoundation.org

Project co-sponsors: the Cropper Foundation, the University of the West Indies, the Tropical Re-Leaf Foundation, the Trust for Sustainable Livelihoods, the Environmental Management Authority.

Project team: The technical work of the assessment is being undertaken by individuals representing a fairly wide range of expertise and disciplines drawn from a consortium of local organizations. Leadership and oversight for the technical work is being provided by a Steering Committee of 13 members, who represent the project's organizing partners (nongovernmental organizations, public authority, university) plus others.

Advisory group: The Advisory Group comprises 13 members, representing the main user groups, and includes individuals from key public and corporate entities, as well as civil society and community organizations, all serving in their personal capacities.

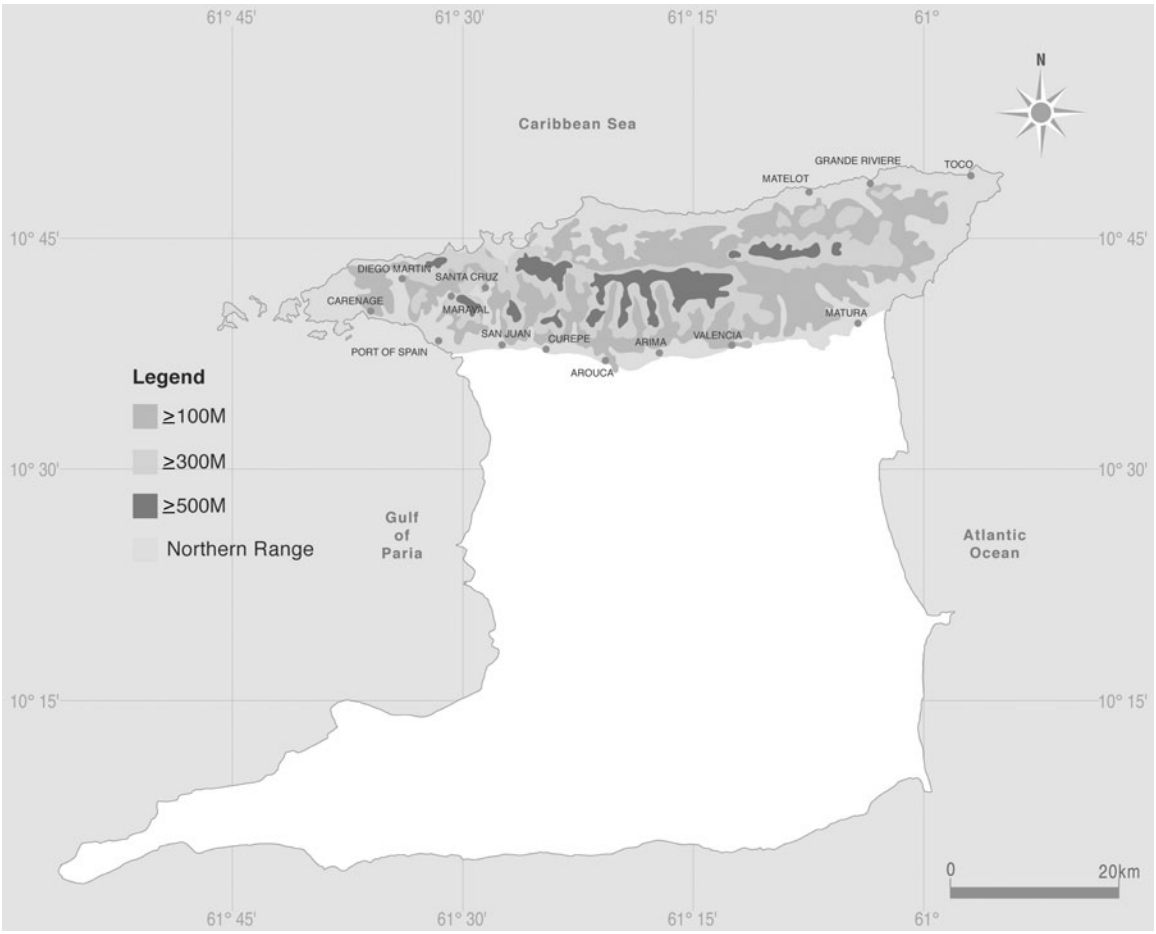
Time period: Planning for the Northern Range Assessment began in October 2002; the project was formally launched in March 2003, and is scheduled to be completed in mid-2005.

Year range for condition and trends analysis: Overall, the period for which the assessment of condition of, and trends in, Northern Range (NR) ecosystem services is undertaken varies among the services because of unevenness in the data. Much of the analysis therefore relies on expert opinions and qualitative information rather than on quantitative data.

Year range for scenarios projections: 2000–2025, extending beyond the national vision exercise for 2020.

Summary of important findings:
The Northern Range contributes to human well-being through the provision of fresh water, land space for housing and agriculture, and food; and through its considerable amenity value. There is evidence of extensive land conversion and forest degradation especially within the more accessible valleys of the southern slopes and especially in the western reaches of the range, close to the urban center. These, together with housing and agricultural settlements, authorized and unauthorized, on the slopes of many of the valleys, and unregulated quarrying sites have impacted negatively on freshwater resources. The northern slopes are steeper, less easily accessible, and less densely populated, and are consequently less disturbed than the southern slopes. There are many policy instruments and regulations relating specifically to the NR, but these are generally poorly implemented and enforced. Several public, community, and civic initiatives are being undertaken to contribute to restoration and improved management of Northern Range assets.

Forest resources. Approximately 75% of NR land is owned by the state. It is estimated that 67.5% of the range is currently forested, of which



Map of Trinidad, Highlighting Topography and Major Towns of the Northern Range (Kenny 2000)

85% to 95% is primary forest. Extensive conversion and a high incidence of human-caused forest fires are the main threats to forest resources, with the resulting effects being increased surface runoff and soil erosion, leading to a greater frequency of flood events and an overall decrease in surface water quality. About 14.8 % of the NR is designated as forest reserves to which restrictions apply. In addition, approximately 22% of NR land is under consideration as Environmentally Sensitive Areas that will contribute to forest conservation while providing for continued enjoyment of the amenity value. Several public, community, and civic initiatives to reforest and protect watersheds are in train.

Freshwater resources. The surface and groundwater resources of the NR are the primary source of fresh water for Trinidad, providing approximately 50% of Trinidad's potable water. The rivers are also important for recreational activities and for the harvesting of edible freshwater species. While the present overall quality is judged as good, and current supply exceeds demand, there is a trend of decreasing quality and quantity due to watershed degradation. It is projected that water availability per capita will decrease, and that by 2025 supply will barely meet demand, especially in the driest months. The cost of substituting the water provided by the NR with desalinated water is estimated at TTD804 million ($128 million) per year, based on performance of an existing desalinization plant in Trinidad. The government is attempting an integrated watershed management approach with its Draft National Water Resources Policy 2002 which establishes a framework for addressing issues such as land use planning, public water quality and supply, and flooding.

Coastal resources. The coasts of the NR contribute to human well-being through coastal fisheries, shoreline stabilization, and coastal water quality regulation, and are also the most popular beaches for recreational activities in the island. Sheltered harbors offer ideal conditions for marinas, which support a thriving and expanding boating industry. However, coastal development, land-based sources of pollution, inadequate services at recreational sites, and overexploitation of some popular species threaten these resources. There is competition for limited coastal land space, and this is exacerbated by the location of developments that are not shoreline dependent. The Draft National Water Resources Policy 2002 attempts to provide a framework for integrated coastal zone management.

Biodiversity. The biodiversity of the NR, considered at the species level, is important for its economic value in terms of timber and wild meat harvesting, and for its amenity value, especially as it relates to recreation and ecotourism development. However, species diversity, abundance, and distribution are all declining, especially in the western region of the range, due to land conversion and degradation, and overhunting of species. The ratification in 1996 of the Convention on Biological Diversity led to the development of the National Biodiversity Strategy and Action Plan in Trinidad and Tobago in 2001, with its main objectives being the improvement of the treatment of biodiversity issues in sectoral policies and plans and improved policy commitment and enforcement, as well as community involvement in helping to preserve the biodiversity resources of the Northern Range. Several community initiatives are currently in process to help protect vulnerable species while making small contributions to household income.

References: This assessment draws on a wide range of published and unpublished information, interviews with experts, consultations with three Northern Range communities, and on the MA conceptual framework.

Funding: The majority of the professional effort required for conducting the assessment is being provided on a voluntary basis by collaborators on the project (Steering Committee, including the project cosponsors, Working Group members, community members, Advisory Group). Financial support is being provided by the MA, the British High Commission in Trinidad and Tobago, the Cropper Foundation, and the local UNDP/GEF Small Grants Programme.

Vilcanota, Peru

(See color version of locator map in Appendix A.)

Contact person:
Alejandro Argumedo
Director
Asociacion ANDES
Ruinas 451
Cusco, Peru
E-mail: andes@andes.org.pe

Location: The Vilcanota sub-region is located in the Peruvian Andes, near Cuzco.

Lead institution: The assessment will be undertaken by the International Center of Traditional Knowledge, Ecology, and Policies (CICTEP), which is a project of the Asociación ANDES, a community-based Quechua-Aymara organization working on conservation and livelihoods promotion in the Andes region. To undertake the assessment, CICTEP will work closely with the Ausangate Community Association (a community organization of Ausangate sub-region associated to ANDES) made up of the indigenous communities of Tinqui, Tayancany, Cotaña, Mahuayani, Pausipanpa, and Anjasi.

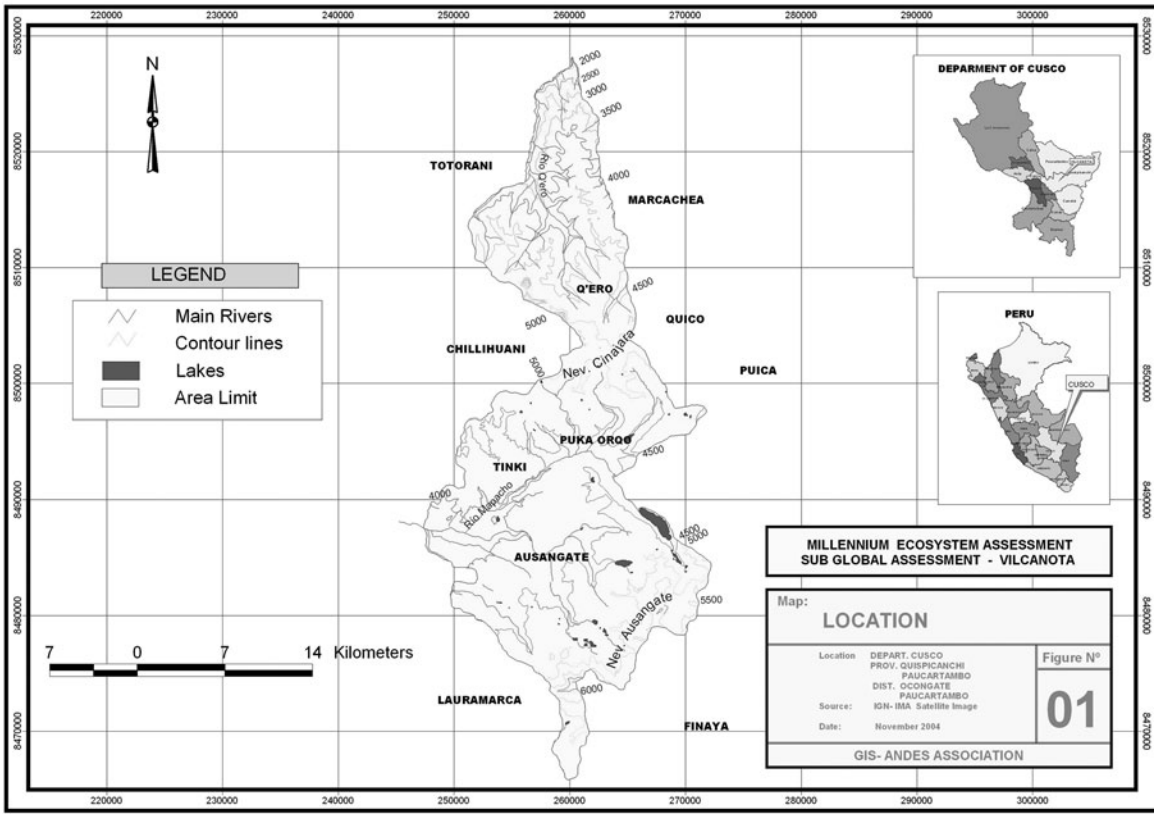
Focal issues: The main objective of this assessment is to assess the state of the ecosystem in the Vilcanota sub-region of the Peruvian Andes. It is imperative to do so as soon as possible due to the increasing intensity of global dynamics and drivers such as mass tourism and mining. These impacts are significant at the sub-regional and local level, particularly in terms of the ecological and socio-cultural dimensions. This may cause short and long term loss of capacity for self-reliance, and the erosion of biological and cultural diversity.

Ecosystem services being assessed: Spirituality, water, soil, agrobiodiversity.

Key features of the assessment:
The Vilcanota sub-region is the second most important ice-capped mountain range of the Peruvian Andes. It comprises 469 glaciers in an area of 539 square kilometers. The mountain range gives origin to an extended watershed system. The Ayacachi and Central Vilcanota systems are located in the northeast. In the north, the main systems are Qosnipata and Pilcopata, which border the Manu National Park. To the east the Marcapata and San Gaban are the main watersheds, and in the south is located the Vilcanota system which constitutes the Sacred Valley of the Incas. These systems border two main differentiated ecosystems at the regional level: the Amazon rainforest to the east and the Andean valleys to the west.

This ecosystem differentiation, as well as historical factors, have produced a very rich biological and cultural diversity in the region characterized by the existence of a large number of endemic species. Rich local knowledge and practices have made possible the adaptive management of natural resources for sustaining local livelihoods. Locals believe that systems and values, including the treatment of mountains as divinities, have allowed for the maintenance of a strong local cultural identity that approaches nature on the basis of concepts of relatedness to the natural world.

The area is also a known hot spot of biodiversity in the region, characterized by the existence of a large number of endemic species. It also an area of concentrated native agrobiodiversity and livestock populations. Natural resources are now under pressure and local land users have little means to improve their livelihoods. Present day changes and the influence of a liberalized world economy, particularly mining and tourism, have created social and cultural tensions and ecological degradation, making it particularly crucial to carry out an ecosystem assessment in this important ecoregion.



Vilcanota, Peru

The primary users of the assessment will be the communities of Tinqui, Tayancany, Cotaña, Mahuayani, Pausipanpa, Anjasi which form the Ausangate assessment area. Surrounding communities and the municipality of Ocangate will also use the assessment. The assessment will be completely user-driven.

Time frame, budget: The total cost is $127,000. The assessment will take place during the period 2003–2005. Partial funding was given by the MA.

Downstream Mekong River Wetlands, Viet Nam (Downstream Mekong)

Contact person:
Dr. Mai Trong Thong.
Institute of Geography
Vietnamese Academy of Science and Technology
18 Hoang Quoc Viet, Cay Giay, Hanoi, Viet Nam
E-mail: thongvdl@hn.vnn.vn

The project has been conducted by an assessment team that is headed by Dr. Mai Trong Thong (Institute of Geography) and includes approximately 30 scientists and experts employed at Institute of Geography, Institute of Ecology and Biological Resources, and Institute of Physics, Vietnamese Academy of Science and Technology (Hanoi), and University of Can Tho (Can Tho city).

The assessment team has been supported by an Advisory Committee encompassing experienced scientists from the Institute of Geography, experts from Institute of Development Strategy (Ministry of Planning and Investment) and local decision-makers.

Time period: The time range for the conditions and trends assessment is 1980–2002.

Summary of key findings:
The downstream Mekong wetlands (also known as the Cuu Long River Delta or Mekong Delta) covers an area of 39,000 square kilometers and is home to 16.1 million people (2001), with favorable conditions for agriculture and aquaculture. Since the 1980s, the intensified development of regional agricultural and aquaculture production has brought about a breakthrough in poverty alleviation. Local income of the poorest had increased by 50% by 2001, compared to 1995. The miracle in regional economic growth, unfortunately, parallels the sharp degradation of ecosystems and ecosystem services, which in turn challenges local human well-being. In looking at the conditions and trends of regional ecosystem services using the MA integrated assessment methodology, the assessment in its first phase identified drivers of the degradation in the condition of ecosystems, and identified out-of-control exploitation practices and policies, which resulted from economic pressure and overpopulation and are linked to rapid change in land use associated with market regulations. Up to 1999, the condition of ecosystem services was declining. Thanks to agricultural restructuring, amended planning options, and more serious management, the condition of regional ecosystems has tended to improve since 2000. Such findings concerning regional ecosystem services, some of which are stated below, captures not the entire, but the core, picture of the regional ecosystems.

Rice, fish, and shrimp as provisioning services. Provisioning of rice, fish, and shrimp are the most significant services of ecosystems in the Downstream Mekong wetlands. The extensive conversion of wetlands into paddy fields started in late 1980s and made the region the biggest rice producer nationwide. After this came the development of fish and shrimp production, which was a new milestone in the regional and national export-led economies. The economic blossoming in the areas led to a jump in regional poverty reduction on the one hand and, unfortunately, a degraded state of ecosystems on the other hand, including decreasing biodiversity and a polluted environment.

Timber and non-wood forest products. Known as a region having a large area of melaleuca and mangrove forests, timber and non-wood forest products remain basic benefits to some local communities. These products include timber, fuelwood, construction materials, food (mammals, amphibians, reptiles and birds, and vegetables), medicines, etc. As a result of large-scale destruction of forests, many of these products are becoming rare or extinct. Forest inhabitants are struggling to escape deep poverty through the direct exploitation of forests and are subject to increasing scarcity of forest goods and services.

Regulating services: alum soil and fresh water. The available literature shows very little analysis or assessment on regulating services of the downstream Mekong wetlands and what studies have been undertaken are almost all qualitative and not thorough, which caused considerable difficulty for the assessment team in approaching this analysis. In the region, there are two areas of regulating services of most interest. One is alum soil regulation and the other is freshwater regulation. Wetland ecosystems along with flooding systems are helpful factors preventing pyrite from being oxidized to form sulphate as well as dissolving and washing away generated acid. At the same time, the wetlands, in particular the melaleuca forests, are recognized as playing a vital role in regional water regulation. Recently, human activities including irrigation and drainage construction have weakened the natural alum-washing process and water storage and purification, which in turn has affected the sustainability of agricultural production.

Cultural services. This region with poetic landscapes is inspirational and, at the same time, is the birthplace of many performance arts such as Ca nhac tai tu, Ca vong co, etc. Riverine scenes, orchards, trade villages, bird sanctuaries, special use forests, which are typically available in the region, are potential sites for ecotourism. At the same time, folk tourism that focuses on tourist activities associated with historical vestiges, religious works (Khmer pagodas, Ba Chua Nui Sam temple, etc.), and traditional festivals (Ngo junk competition, etc.) has been the focus of local communities.

For further information: The full study of the conditions and trends will be published as Downstream Mekong River Wetland Ecosystems: Conditions and Trends Assessment. Key findings will be summarized in a summary for decision-makers.

Funding: The planning phase ($5,000) and the conditions and trends assessment phase ($55,000) were funded by the MA, with significant in-kind contributions from the Institute of Geography and local authorities. Fundraising for the scenarios and responses phase of the assessment is in process.

Western China

(See color version of locator map in Appendix A.)

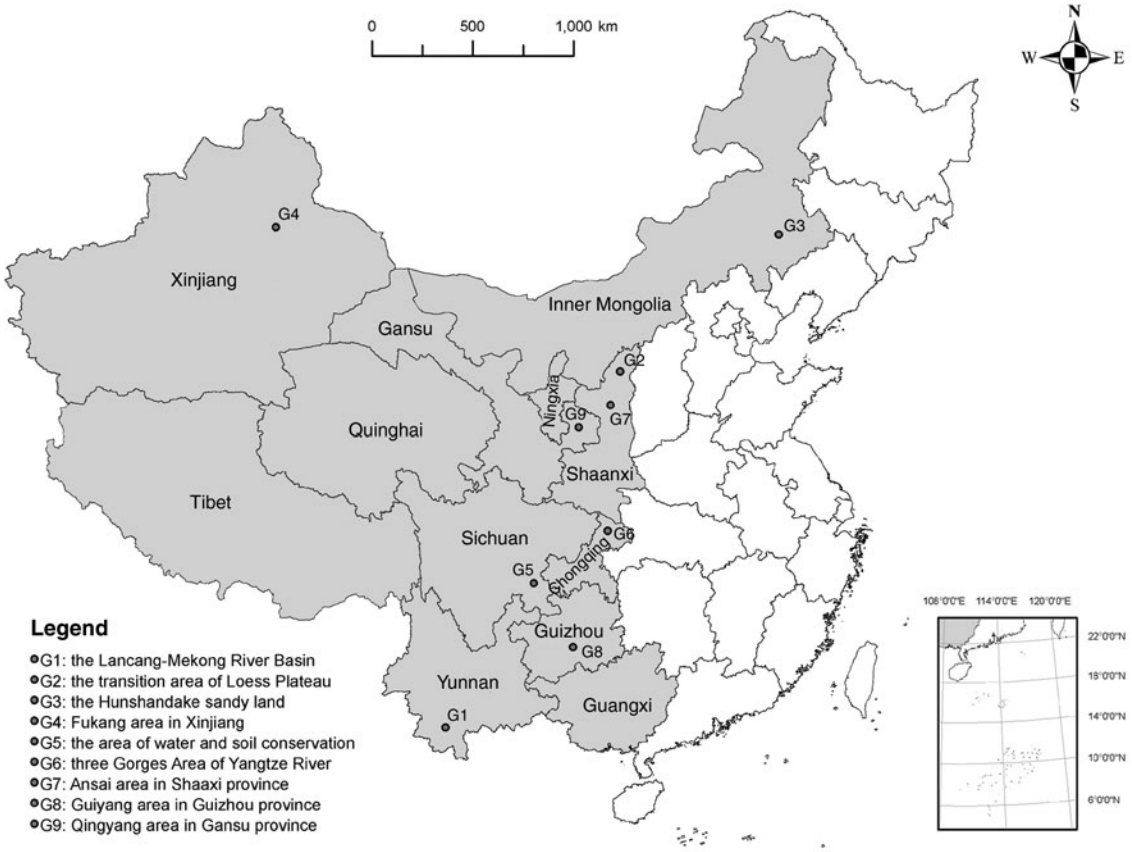
Principal investigator:
Prof. Jiyuan LIU
Director-General, Institute of Geographical Sciences and Natural Resources Research
Chinese Academy of Sciences
A11 Datun Road, Anwai, 100101 Beijing, China
E-mail: Liujy@igsnrr.ac.cn

Contact person:
Dr. Tian Xiang YUE
Leading Professor of Ecological Modelling and GIS
State Key Laboratory of Resources and Environment Information System
Institute of Geographical Sciences and Natural Resources Research
Chinese Academy of Sciences
A11 Datun Road, Anwai, 100101 Beijing, China
E-mail: yue@www.lreis.ac.cn.

Assessment area: The decision to prioritize the development of the western region of China is a significant step taken by the government of China. The Western China ecosystem assessment aims to help protect and improve the ecosystem services of the western region of China and to enhance their contributions to the successful implementation of the western development strategy by considering a menu of possible policy and management options for sustaining ecosystem services. The western region of China, which has been economically backward and ecologically fragile, administratively consists of 12 provinces, including 5 provinces in southwest China, 5 provinces in northwest China, the Inner Mongolia Autonomous region, and the Guangxi Zhuang Autonomous region. The five provinces in southwest China are Sichuan province, Chongqing city, Yunnan province, Guizhou province, and Tibet Autonomous region. The five provinces in northwest China are Shaanxi province, Gansu province, Ningxia Hui Autonomous region, Xinjiang Uygur Autonomous region, and Qinghai province. The land area of the western region of China is about 6.8 million square kilometers, accounting for 70% of the land area of China.

Assessment process: The work of the Western China assessment was funded by the Chinese government, and organized into 22 research teams and sub-teams. An International Advisory Committee was formed, which first met in November 2002 in Beijing, where the the primary outline of the assessment report was reviewed. Integration meetings were held, including leaders from the 22 research teams and sub-research teams of the Western China assessment, academic authorities in China, policy-makers from relevant departments of the central government, and officials from local governments. Team members also attended MA working group meetings. The final report was completed in early 2005.

Methods:
Ecological zoning of China was a necessary component of the integrated ecosystem assessment approach taken. Combining the water-thermal features and the topographical ones, China was divided into 10 first-level ecological zones. The first-level ecological zones were further classified into 54 second-level ecological divisions. On the basis of the ecological zoning and established information systems, models for analyzing ecosystem services were developed. Trends and scenarios for water and food supply services of various ecosystems, carbon storage,



The Western Region of China. The red points represent typical areas at local scale.

and biodiversity were analyzed by combining the developed models with geographical information systems (GIS).

To analyze the relationship between ecosystem services and human well-being as well as effects of human activities on ecosystems, the Western China assessment developed a method of surface modeling of population spatial distribution (SMPD), by which trends and scenarios of spatial population distribution were analyzed. A model of critical thresholds was developed, based on human carrying capacity of ecosystems and population density.

To deal with the issues of multiscale information integration and error problems of GIS, a method of high precision surface modeling (HPSM) was constructed in terms of the fundamental theorem of surfaces. Results of numerical tests show that different spatial scales have little impact on HPSM precision, which means that HPSM can solve multiscale problems. However, HPSM needs to employ a grid generation method so that standardized grid generation regulation of surface modeling may be established. Grid computing is a useful technique for solving the problems of computing capacity overload, which are caused by complex numerical simulations.

The responses chapter discusses protection and conservation activities, ecological countermeasures in different regions, and the grain-for-green policy. Scenarios of converting land use versus planned policy targets were developed in terms of the grain-for-green policy.

Findings: Driving forces

Population. Since the 1930s, China's population has increased about three times. Although the birth control policy has restrained rapid population growth, annual births still number more than 9.5 million China because of the huge population base. The results from SMPD show that human population distribution in China has ranged from high in the east to low in the western and middle regions of China during the period from 1930 to 2000.

Climate change. Since 1950, China has experienced a trend of climate warming and general increases in precipitation. Since the 1980s, the mean annual temperature has increased by 0.25 degrees Celsius. The warming climate trend was found in most parts of China, but with significant regional differences. The mean annual temperature is increased by 0.5 degrees Celsius north of latitude of 35 degrees north. However, temperature has been on a decreasing trend in some parts of Guanzhong Plain, in the higher reach of the Yangtze River, and in the south of the Yangtze River basin. Precipitation has increased in northwest China since 1980. There is a decreasing trend of precipitation in most parts of southwest China and in the southern part of Tibet Plateau. In northwest China, precipitation has increased to different degrees in spring, summer, and autumn.

Land-use and land-cover change. The significant trend in land-use and land-cover change in the western region of China during the period from 1990 to 2000 was that the area of cropland increased through the conversion of grassland or woodland. Almost 1.8 million hectares of new cropland were cultivated, and most of which was dry farming land. At the same time, grassland and woodland decreased by 2.1 million hectares and 0.3 million hectares respectively. Urbanization was also significant in the western region of China. The built-up area increased by almost 10% in the last decade.

The grain-for-green policy. In recent years, China's grain output has grown steadily. Several consecutive bumper harvests have left the country with huge stockpiles of grain. This has created good conditions for implementing a massive farmland-to-forests campaign. To compensate for losses, farmers will receive subsidies, in the form of grain and money, for turning cultivated land back into forest and pasture. To minimize income losses that farmers might suffer from forest and pasture restoration, it is suggested that where natural conditions allow, fruit and other commercially valuable trees be planted. While the government will provide seedlings, farmers will be responsible for taking care of the restored forests and pastures and will retain all the profits from planting trees and grass on cultivated land.

Findings: Ecosystem services

Potential farmland productivity. The analysis of change of photosynthetic-thermal farmland productivity in each province of the western region of China during the 1990s shows that the potential farmland productivity has increased in the northern region of Inner Mongolia Autonomous Region, Xinjiang Uygur Autonomous Region, and Ningxia Autonomous Region. This increase was mainly from the increase of photosynthetic-thermal productivity in drylands and paddy fields. The gross increase of photosynthetic-thermal farmland productivity in the western region of China overall was mainly from drylands. Combined with the land use change in the western region of China in 1990s, it can be concluded that the change of photosynthetic-thermal farmland productivity was closely related to the change in area under cultivation.

Water. The land area of northwest China constitutes 44.5% of the total land area of China, while annual water resources of 234.4 billion cubic meters on average are only 8% of the total annual water resources for the whole of China; further more, available water in the northwest is less than 120 billion cubic meters. In general, the inland basin in the northwest has great capacity for regulation of supply through ice and snow in the mountain glaciers, and the quantity of water resources is thus relatively stable.. Rainfall in southwest China is abundant. The annual water resources amount to 1,275.2 billion cubic meters, while the available water resources amount to less than 347 billion cubic meters. The total amount of water resources and the water resources per capita in southwest China are richer than the northwest China.

Biodiversity. Ecosystems in the western region of China include 171 types of forests, 85 types of wetlands, 94 types of bushes, 47 types of grasslands, 72 types of meadows, and 49 types of deserts as well as 21 different types of tundra, alpine cushion vegetation, and talus vegetation. Although there exist rich ecosystem types in the western region of China, biodiversity faces many threats. Field studies in the 1980s showed that deforestaton has not only reduced panda habitat from 25 million hectares in the 1970s to 13.9 million hectares in the 1980s, but has also fragmented panda habitat into dozens of small, isolated patches. Some 1,000 pandas were divided into more than 20 small groups by highways, rivers, clear-cutting sites, farmlands, and villages. The smallest existing giant panda population consists of only 3 to 5 individuals. Overgrazing and agricultural conversion have reduced both the extent and quality of grassland ecosystems. Long-term overgrazing has degraded more than half of these grasslands; some 25% has been severely degraded. Over the past 20 years, grass yields have been reduced by one-third.

São Paulo Greenbelt, Brazil

Contact person:
Rodrigo A. B. M. Victor
Instituto Forestal
Reserva da Biosfera do Cinturao Verde da Cidade de São Paulo
Rua do Horto, 931, São Paulo, 02377-000 SP
Brazil
E-mail: rabmvictor@yahoo.com.br

Project institutions: The assessment is coordinated by the São Paulo State Forest Institute, and the preliminary assessment phase team was drawn from the following institutions: University of São Paulo (Education College, Architecture and Urbanism College, Agriculture College, São Carlos Engineering College), São Paulo State University, University of Campinas, Geological Institute, Botanical Institute, Institute of Agriculture Economics, International Ecology Institute, Fishing Institute.

Assessment focus: The São Paulo Green Belt Sub-global Assessment aims to provide the region's decision-makers with information on the importance of ecosystem services provided by the Green Belt to São Paulo and Santos metropolises, how the drivers generated by urbanization threaten the continuity of these vital processes, the consequences of these phenomena for human well-being, and the response options for dealing these issues.

Time period: The preliminary assessment phase was July–December 2003. The full assessment period is 2005–2007.

The following services were preliminarily assessed: supporting services (ecosystem condition and trends and major ecological processes), freshwater, food security, forest resources, climate regulation, run-off regulation, carbon sequestration, sustainable tourism, social benefits. The full assessment shall include more services as more researchers are being incorporated into the process. The list below summarizes the main services and their relevance to human well-being and biodiversity:

	Ecosystem Service	Description/Importance of Ecosystem Service
Supporting Services	ecological processes and biodiversity	The Atlantic Forest is one of Earth's richest biomes in biodiversity; maintaining its biological abundance is an ethical duty of the population and also important for protection of the biological safety of human beings. Locally, the Green Belt (GB) woods are important ecological corridors, true links connecting different forestland regions of Brazil.
Provisioning Services	underground and surface water supply and conservation	Water resources within the GB supply water to over 20 million people. Their endangerment can lead to a collapse in public supply, whose shortage is already felt today during the dry season. There is also a strong correlation between forests and water quality, with serious economic implications.
	food security	Today, 15% of the world's food is produced in backyards and small land tracts (Ian Douglas, Univ. of Manchester, 2002, personal communication). The GB has this tradition and today is one of Brazil's top organic produce regions . Besides, the choice for agriculture in areas surrounding cities is regarded as an alternative to the expansion of big cities.
	forest resources	The forest-originated raw material produced in the Green Belt is representative for São Paulo State's forest-based economy, mainly as a function of reforestation.
Regulating Services	climatic regulation	The SPGB relates directly to climate regulation in the region, in counterpoint to the urban area that causes temperature to rise (heat islands). It has been suggested that this phenomenon has some linkages to the issue of thermal balance that influences rainfall patterns, leading to heavy floods in urban areas.
	soil protection and run-off regulation	The GB controls soil erosion, regulates runoff, and minimizes floods and public calamities.
	carbon sequestration and pollutant reduction	The GB has 311,407 hectares of undergrowth and 84,620 hectares of reforestation, all growing vegetation playing an important part in sequestering the carbon dioxide generated by metropolises.
Cultural Services	social use	Metropolises like São Paulo and Santos lack green areas. The GB is often the only alternative for the population to be in contact with the natural environment. This is crucial for the physical and psychological health of the population.

References: R. Victor et al., ''Application of the Biosphere Reserve Concept to Urban Areas: The Case of the São Paulo City Green Belt Biosphere Reserve,'' available at http://www.unesco.org/mab/urban/urbandocs.htm.

Funding: The preliminary assessment was funded by UNESCO, São Paulo Forest Institute, and the Environment Ministry ($7,000), with substantial in-kind contributions from the mentioned institutions. For 2005, there will be financial contribution from the Forest Institute and the Environment Ministry (around $30,000). Other funding sources are being sought.

Trade, Poverty, and the Environment

Contact person:
Owen Cylke
Senior Program Officer
Macroeconomics for Sustainable Development
World Wildlife Fund
1250 24th ST, NW
Washington, DC 20037
E-mail: Owen.Cylke@wwfus.org

Lead institution: WWF's Macroeconomics Programme Office (MPO)

Project description:
Launched in 2002, the trade assessment project will be working through 2005 with partners in Chile, China, India, Madagascar, Mexico, South Africa, and Viet Nam, to identify impacts of trade liberalization on rural poverty and the environment (particularly land and water) but also to work with business, civil society, governments, and international bodies to minimize the adverse impacts and to assure the maximum contribution of global trade to rural livelihood and sustainability goals.

The project is divided in two stages of eighteen months each. The principal focus of the first stage is on analysis, undertaken by research teams in each of the participant countries, complemented by research and policy activities at the WWF-World Bank coordination unit in Washington, D.C. The principal focus of the second stage is on communication and outreach to be carried out by the WWF Network and WWF-MPO.

The goals of the project are to develop knowledge, mechanisms, and platforms for business, civil society, governments, and international organizations to: (1) identify trade polices, rules, and related institutional and management interventions that can better achieve human development and sustainability goals; (2) better understand the trade-offs involved—for the environment and the rural poor—in decisions concerning trade policy and rules; and (3) align institutional, management, and policy options with the level of governance where they can be most effective. These goals are drawn directly from the MA framework for assessment.

Our intent is to: (1) establish an open dialog with business, civil society, government, and international agencies; (2) develop an analytic understanding of impacts, opportunities, and options from a combination of country-based case studies and the international literature and debate; and (3) promote institutional, management, and policy options emerging from the work—through advocacy, capacity-building, and partnerships—at all scales, from the local to the international, and within the organizations engaged and supporting the project itself

The focus on case studies is based on the hypothesis that to identify the impacts and opportunities associated with trade liberalization we need to go beyond national averages and look at real people in real places. The case study countries are **Chile:** conversion of the Valdivian Forest to plantation and industrial production; **China:** intensification of agricultural production in the Central Yangtze; **India:** conversion of forest land and mangroves for aquaculture in West Bengal; **Madagascar:** conversion of forest areas to sisal and maize production in the Spiny Forest; **Mexico:** expansion of cattle ranching and related agricultural products in the Chihuahuan desert areas; **South Africa:** conversion of commercial agriculture to export; **Viet Nam:** expansion of coffee, rice and shrimp production in Truong Son Mountains.

The first project component to become associated with the MA is in India. It will be undertaken by the Institute of Economic Growth at Delhi University. The related outreach program will be the responsibility of WWF India. The Principal Investigator and Project Leader is Dr. Kanchan Chopra (kc@ieg.ernet.in); the Co-Project Investigator is Dr. Pushpam Kumar (pl@ieg.ernet.id); and Ms. Veera Kaul Singh is responsible for outreach (vsingh@wwfindia.net).

The case study will address the Sunderbans region of West Bengal, India. It is located at the apex of the Bay of Bengal, and is characterized by sandy beaches, mud flats, coastal dunes estuaries, creeks, inlets, and mangrove swamps. It is also home to national parks, tiger reserves, and other wildlife sanctuaries. The region is under ecological threat from a growing aquaculture industry.

The case study will address the following principle issues: the conditions in the coastal and marine ecosystem prior to acceleration of aquaculture for export; the associated level of well-being of different groups as a consequence of ecosystem services provided by the system; the plausible future changes in health, livelihood, and security made available to different groups in the region; the implication of these changes for disruption in the capability of the ecosystem to provide the level of services provided in the base-year; and recommendations to enhance the well-being and conserve the ecosystem (examining the trade-offs and synergies set in motion by different responses, strategies, and policy interventions).

The Northern Highlands Lake District, Wisconsin

(See color version of locator map in Appendix A.)

Contact person:
Dr. Steve Carpenter, Professor
Center for Limnology
University of Wisconsin
Madison, WI 53706
USA
E-mail: srcarpen@wisc.edu

Location: The Northern Highlands Lake District (NHLD) covers 5,300 square kilometers of the extreme northern part of Wisconsin, USA. It is to the south and east of Lake Superior at a latitude of 46°N.

Lead institution: University of Wisconsin, Madison. The assessment also involves people from the local business community, the Lac du Flambeau Band of Lake Superior Chippewa Indians, other residents of the region, recreational users, local government, NGOs, media representatives, and the State management agency (the Wisconsin Department of Natural Resources, or WDNR).

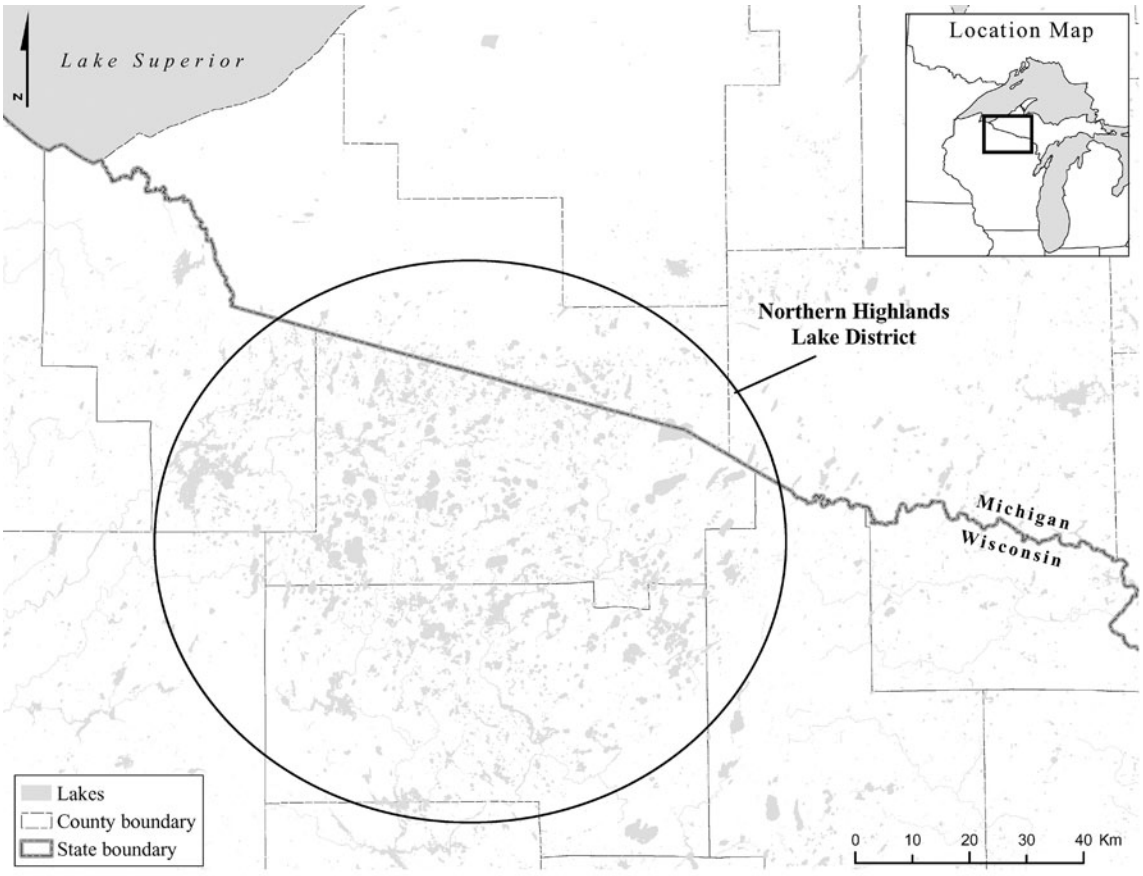
Focal issues:
The Northern Highlands Lake District of Wisconsin is in transition from a sparsely settled region to a more densely populated one. Expected changes offer benefits to northern Wisconsin residents, but also threaten to degrade the ecosystem services that residents ultimately rely on. Because the future of this region is uncertain, it is difficult to make decisions that will avoid potential risks and take advantage of potential opportunities.

Key issues derive from the rapid transition of the region driven by development. Conflict centers on multiple demands for limited land and water, especially limited lakeshore land. Social-ecological challenges include:

- growth and diversification of the economy,
- maintenance of traditional values (amid multiple definitions of "traditional"),
- competing use of resources (such as land for timber harvest versus recreational use),
- incompatible recreational uses (such as motorized versus silent outdoor recreation),
- population growth,
- impacts of forest management,
- overpopulation of deer,
- negative impacts of lakeshore development on water quality and fisheries,
- exotic species, and
- impacts of fish harvesting and stocking.

Many of these issues are addressed through workshops, scenarios, and scientific research.

Ecosystem services: We are addressing the ecosystem services provided by lakes in the NHLD. To assess the sustainability of these ecosystem services, we need to understand how different people use and transform ecosystems, the dynamics of ecosystems, and the external forces that are shaping the region. We therefore examine interactions among population and economic growth, lakeshore development, social conflict, regional-local institutions, forestry, hunting, fishing, biodiversity, ecotourism, ethnotourism, and other forms of recreation in the region.



Project outputs: In addition to producing assessment reports and scientific articles, we intend to become a ''virtual center'' for integrated, science-based understanding of the NHLD. We will maintain an ongoing discussion with local people and develop tools, such as scenarios, in collaboration with them. We aim to express our findings in plain language, simple computer games, art, and other formats that are widely understandable. We will establish a network of citizens in the region who are knowledgeable about navigating long-term change.

Key features of assessment region:
Lakes are a key characteristic of the NHLD, with thousands of natural lakes that together cover about 11% of the surface area in the region. An additional 25% of the area is wetland. Most lakes in this area are clear, with low amounts of nutrients. Most of the lakes receive their water from precipitation, although many are seepage lakes that are connected only by groundwater. Determinants of water quality include water color, nutrient input, presence of toxins (such as mercury), and presence of disease-causing organisms (such as *Giardia*). At the present time, water quality is good in most of the lakes. Many of the lakes support high-quality game fisheries. Walleye (*Stizostedion vitreum*) is the most popular sport and table fish. Important sport fisheries exist for muskellunge (*Esox masquinongy*), northern pike (*Esox lucius*), black basses (*Micropterus* spp.), and diverse panfish. Quality of sport fishing is sensitive to harvest, as is evident from the high catch rates and abundant trophy-size fishes in lakes that are managed with regulations that restrict harvest. In addition to fish harvest, other important effects of people on the lakes include removal of woody habitat from nearshore areas, introduction of destructive exotic species (especially rusty crayfish, *Orconectes rusticus,* rainbow smelt (*Osmerus mordax*), and Eurasian milfoil *Myriophyllum spicatum*), nutrient enrichment, deposition of mercury (from coal-fired industries far to the west of the NHLD), and hydrological modifications.

Ecosystem services derived from the NHLD are dominated by tourism and forest products. Tourism is based on the natural beauty of the area, the abundant wildlife (including diverse non-game species plus popular game species such as ducks, grouse and deer), and the legendary fishing opportunities. Ethnotourism, centered on the Lac du Flambeau reservation, is a small but growing sector of the economy. Important outdoor activities include boating (from paddlecraft to large motorized boats), all-terrain vehicle use, and snowmobiling. Forestry centers on pulpwood for Wisconsin's thriving paper industry.

In addition to these readily quantified ecosystem services, the NHLD contributes a number of ecosystem services that are not often quantified. Two important tributaries of the Mississippi River, the Wisconsin and St. Croix rivers, arise in the NHLD. Waters from the NHLD also flow to Lake Superior. Thus the NHLD is an important source of clean water for two of the major river systems of North America, the Mississippi and the St. Lawrence. The aggrading forests of the NHLD may be significant carbon sinks (although the carbon budget of the landscape has not yet been quantified). The thousands of individual lakes harbor remarkable genetic diversity of aquatic organisms. This diversity has been quantified only partially. Unfortunately, fish stocking practices and invasions of exotic species are eroding this diversity of aquatic resources.

For further information:
http://limnology.wisc.edu/NHLD/index.htm. A Web page with basic information about the project and additional links.
http://www.ecologyandsociety.org/vol7/iss3/art1. A peer-reviewed published paper about the NHLD and the scenarios developed on the possible futures of the region.
http://www.lakefutures.wisc.edu. A description of the scenarios.

Timeframe, budget: Open-ended timeframe. Funding is mainly from University of Wisconsin.

Appendix C

Authors

Australia
Colin Filer, Australian National University
Simon Foale, Australian National University
Habiba Gitay, Australian National University
Anthony McMichael, Australian National University

Cameroon
William Mala, Centre for International Forestry Research

Canada
Chuck Rumsey, Round River Canada
Ellen Woodley, Terralingua

Chile
Hernán Blanco, Recursos e Investigación para el Desarrollo Sustentable (RIDES)
Andrés Marín, Recursos e Investigación para el Desarrollo Sustentable (RIDES)

China
Dong Suocheng, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences
Yue Tianxiang, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences

Colombia
Dolors Armenteras, Humboldt Institute
Andrés Guhl, Universidad Nacional de Colombia
Alexander Rincón, Humboldt Institute

Costa Rica
Esther Camac-Ramirez, Asociacion IXACAVAA
Fabricio Carbonell Torres, Asociacion IXACAVAA

Egypt
Mohamed Tawfic Ahmed, Suez Canal University
Manal Hefny, Suez Canal University

Germany
Gerhard Petschel-Held, Potsdam Institute for Climate Impact Research

India
Shivani Chandola, Wildlife Institute of India
Yogesh Gokhale, Indian Institute of Science
Pushpam Kumar, Institute of Economic Growth
Ankur Patwardhan, Research and Action in Natural Wealth Administration (RANWA)
Bibhab Talukdar, Ashoka Trust for Research in Ecology and the Environment (ATREE)

Indonesia
Doris Capistrano, Center for International Forestry Research

Italy
Monika Zurek, Food and Agriculture Organization

Japan
Masataka Watanabe, National Institute for Environmental Studies

Kenya
Thomas Tomich, World Agroforestry Centre
Sandra J. Velarde, World Agroforestry Centre

Malaysia
Marcus J. Lee, The WorldFish Center
Ciara Raudsepp-Hearne, Millennium Ecosystem Assessment

The Netherlands
Kasper Kok, Wageningen University

Papua New Guinea
Jane Mogina, University of Papua New Guinea

Peru
Alejandro Argumedo, Asociacion ANDES

Philippines
Maria Victoria Espaldon, University of the Philippines Los Baños
Rodel Lasco, University of the Philippines Los Baños
Ben S. Malayang III, Philippine Sustainable Development Network
Maricel Tapia, University of the Philippines Los Baños

Portugal
Tiago Domingos, Universidade Técnica de Lisboa
Inês Gomes, Universidade de Lisboa
Margarida Ferreira, Universidade de Lisboa
Elvira Pereira, ISCSP, Universidade Técnica de Lisboa
Henrique M. Pereira, Universidade de Lisboa
Cibele Queiroz, Universidade de Lisboa
Luís Vicente, Universidade de Lisboa

South Africa
Reinette (Oonsie) Biggs, Council for Scientific and Industrial Research
Erin Bohensky, University of Pretoria
Georgina Cundill, Rhodes University
Christo Fabricius, Rhodes University
Belinda Reyers, Council for Scientific and Industrial Research
Robert Scholes, Council for Scientific and Industrial Research
Albert van Jaarsveld, Stellenbosch University

Sweden
Carl Folke, Stockholm University
Thomas Hahn, Stockholm University
Jakob Lundberg, Stockholm University
Per Olsson, Stockholm University,
Lisen Schultz, Stockholm University

Thailand
Louis Lebel, Chiang Mai University
Pongmanee Thongbai, Thailand Institute of Scientific and Technological Research

Trinidad and Tobago
John B. R. Agard, University of the West Indies
Keisha Garcia, The Cropper Foundation
Sarika Maharaj, The Cropper Foundation

United States of America
Elena Bennett, University of Wisconsin at Madison
Polly Ericksen, Earth Institute, Columbia University
Cheryl Palm, Earth Institute, Columbia University
Walter V. Reid, Millennium Ecosystem Assessment
Jeffrey Romm, University of California at Berkeley
Cristián Samper, National Museum of Natural History, Smithsonian Institution
Robert T. Watson, The World Bank
Maria Fernanda Zermoglio, University of California at Davis

Zimbabwe
Tim Lynam, University of Zimbabwe
Constancia Musvoto, University of Zimbabwe

Appendix D

Abbreviations and Acronyms

AI	aridity index
AKRSP	Aga Khan Rural Support Programme
AMF	arbuscular mycorrhizal fungi
ASB	alternatives to slash-and-burn
ASOMPH	Asian Symposium on Medicinal Plants, Spices and Other Natural Products
AVHRR	advanced very high resolution radiometer
BCA	benefit-cost analysis
BGP	Biogeochemical Province
BII	Biodiversity Intactness Index
BMI	body mass index
BNF	biological nitrogen fixation
BOOT	build-own-operate-transfer
BRT	Bus Rapid Transit (Brazil)
BSE	bovine spongiform encephalopathy
Bt	*Bacillus thuringiensis*
C&I	criteria and indicators
CAFO	concentrated animal feeding operations
CAP	Common Agricultural Policy (of the European Union)
CAREC	Central Asia Regional Environment Centre
CBA	cost-benefit analysis
CBD	Convention on Biological Diversity
CBO	community-based organization
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCN	cloud condensation nuclei
CCS	CO_2 capture and storage
CDM	Clean Development Mechanism
CEA	cost-effectiveness analysis
CENICAFE	Centro Nacional de Investigaciones de Café (Colombia)
CFCs	chlorofluorocarbons
CGIAR	Consultative Group on International Agricultural Research
CIFOR	Center for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
CONICET	Consejo de Investigaciones Científicas y Técnicas (Argentina)
COP	Conference of the Parties (of treaties)
CPF	Collaborative Partnership on Forests
CSIR	Council for Scientific and Industrial Research (South Africa)
CV	contingent valuation
CVM	contingent valuation method
DAF	decision analytical framework
DALY	disability-adjusted life year
DDT	dichloro diphenyl trichloroethane
DES	dietary energy supply
DHF	dengue hemorrhagic fever
DHS	demographic and health surveys
DMS	dimethyl sulfide
DPSEEA	driving forces-pressure-state-exposure-effect-action
DPSIR	driver-pressure-state-impact-response
DSF	dust storm frequency
DU	Dobson Units
EEA	European Environment Agency
EEZ	exclusive economic zone
EGS	ecosystem global scenario
EHI	environmental health indicator
EIA	environmental impact assessment
EID	emerging infectious disease
EKC	Environmental Kuznets Curve
EMF	ectomycorrhizal fungi

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

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

RRA rapid rural appraisal

RUE rain use efficiency

SADC Southern African Development Community

SADCC Southern African Development Coordination Conference

SAfMA Southern African Millennium Ecosystem Assessment

SAP structural adjustment program

SAR species-area relationship

SARS severe acute respiratory syndrome

SBSTTA Subsidiary Body on Scientific, Technical and Technological Advice (of CBD)

SEA strategic environmental assessment

SEME simple empirical models for eutrophication

SES social-ecological system

SFM sustainable forest management

SIDS small island developing states

SMS safe minimum standard

SOM soil organic matter

SRES Special Report on Emissions Scenarios (of the IPCC)

SSC Species Survival Commission (of IUCN)

SWAP sector-wide approach

TAC total allowable catch

TBT tributyltin

TC travel cost

TCM travel cost method

TDR tradable development rights

TDS total dissolved solids

TEIA transboundary environmental impact assessment

TEK traditional ecological knowledge

TEM terrestrial ecosystem model

TESEO Treaty Enforcement Services Using Earth Observation

TEV total economic value

TFAP Tropical Forests Action Plan

TFP total factor productivity

TFR total fertility rate

Tg teragram (10^{12} grams)

TK traditional knowledge

TMDL total maximum daily load

TOF trees outside of forests

TRIPS Trade-Related Aspects of Intellectual Property Rights

TSU Technical Support Unit

TW terawatt

UMD University of Maryland

UNCCD United Nations Convention to Combat Desertification

UNCED United Nations Conference on Environment and Development

UNCLOS United Nations Convention on the Law of the Sea

UNDP United Nations Development Programme

UNECE United Nations Economic Commission for Europe

UNEP United Nations Environment Programme

UNESCO United Nations Educational, Scientific and Cultural Organization

UNFCCC United Nations Framework Convention on Climate Change

UNIDO United Nations Industrial Development Organization

UNRO United Nations Regional Organization (hypothetical body, in *Scenarios*)

UNSO UNDP's Office to Combat Desertification and Drought

USAID U.S. Agency for International Development

USDA U.S. Department of Agriculture

VOC volatile organic compound

VW virtual water

WBCSD World Business Council for Sustainable Development

WCD World Commission on Dams

WCED World Commission on Environment and Development

WCMC World Conservation Monitoring Centre (of UNEP)

WFP World Food Programme

WHO World Health Organization

WIPO World Intellectual Property Organization

WISP weighted index of social progress

WMO World Meteorological Organization

WPI Water Poverty Index

WRF white rot fungi

WSSD World Summit on Sustainable Development

wta withdrawals-to-availability ratio (of water)

WTA willingness to accept compensation

WTO World Trade Organization

WTP willingness to pay

WWAP World Water Assessment Programme

WWF World Wide Fund for Nature

WWV World Water Vision

Appendix E

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 policymakers 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 mater.

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 tropic 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 tropic 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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