POLICY FORUM: ECOLOGY

International Ecosystem Assessment

Edward Ayensu, Daniel van R. Claasen, Mark Collins, Andrew Dearing, Louise Fresco, Madhav Gadgil, Habiba Gitay, Gisbert Glaser, Calestous Juma, John Krebs, Roberto Lenton, Jane Lubchenco, Jeffrey A. McNeely, Harold A. Mooney, Per Pinstrup-Andersen, Mario Ramos, Peter Raven, Walter V. Reid,* Cristian Samper, José Sarukhán, Peter Schei, José Galízia Tundisi, Robert T. Watson, Xu Guanhua, A. H. Zakri

Despite technological developments, we are still intimately connected to our environment. Our lives depend on ecosystem goods such as food, timber, genetic resources, and medicines. Ecosystems also provide services including water purification, flood control, coastline stabilization, carbon sequestration, waste treatment, biodiversity conservation, soil generation, disease regulation, maintenance of air quality, and aesthetic and cultural benefits (*1, 2*). We know too little of the current state and future prospects of these goods and services: a system of international assessment is urgently needed. Without such a system, development will not be sustainable.

Making Ends Meet

Historically, changes in technology and land use helped to reduce harmful social and economic consequences of imbalances between the supply and demand for ecosystem goods and services. For example, between 1967 and 1982, 0.24% per year growth in the extent of agricultural lands combined with a 2.2% per year increase in cereal yields led to net increases in per capita food availability, despite a 32% increase in world population (*3*). Similarly, declining production of fish and timber in natural ecosystems has been partially offset by increased production through aquaculture and plantations (although often with significant ill effects such as increased water pollution and loss of biological diversity) (*4*).

These changes in land use and technology have had profound impacts on natural ecosystems. About 40 to 50% of land on the Earth has been irreversibly transformed (through change in land cover) or degraded by human actions (*5*). For example, more than 60% of the world's major fisheries will not be able to recover from overfishing without restorative actions (*6*). Natural forests continue to disappear at a rate of some 14 million hectares each year (*7*).

The magnitude of human impacts on ecosystems, combined with growing human population and consumption, means that the challenge of meeting human demands will grow. Models based on the United Nations' intermediate population projection suggest that an additional one-third of global land cover will be transformed over the next 100 years (*8*). By 2020, world demand for rice, wheat, and maize is projected to increase by ~40% and livestock production by more than 60% (*3*). Humans currently appropriate 54% of accessible freshwater runoff, and by 2025, demand is projected to increase to more than 70% of runoff (*9*). Demand for wood is projected to double over the next 50 years (*1*).

These growing demands can no longer be met by tapping unexploited resources, and trade-offs among goods and services have become the rule. A nation can increase food supply by converting a forest to agriculture but, in so doing, decreases the supply of goods that may be of equal or greater importance such as clean water, timber, biodiversity, or flood control. Finally, projected climate change may well exacerbate the problem of balancing supply and demand, particularly in developing countries where adaptation will be constrained by financial and other resources. Although no one questions that these are significant changes, we need to develop ways to quantify their impacts.

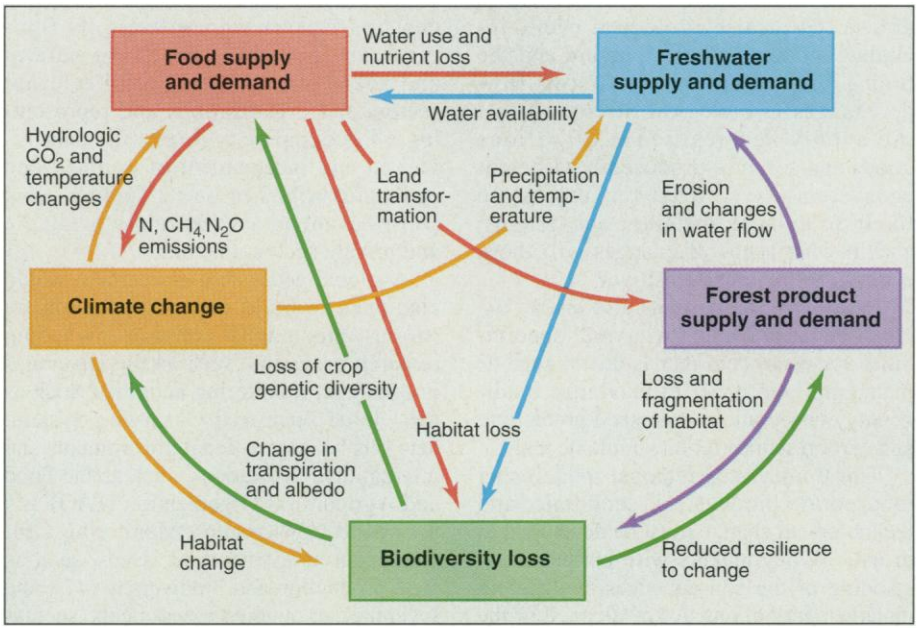
The Integrated Approach

Sectoral approaches to management—focused on agriculture, forestry, or water supply—made sense when trade-offs among goods and services were modest or unimportant. They are insufficient today, when ecosystem management must meet conflicting goals and take into account the interlinkages among environmental problems (see diagram). For this reason an integrated, or "multiple functions," approach to analysis of ecosystems must be adopted.

Reactive management was inevitable when ecological knowledge was insufficient to allow more reliable predictions. Today, given the pace of global change, human welfare is utterly dependent on forward-looking, adaptive, and informed management decisions.

An integrated, predictive, and adaptive approach to ecosystem management requires three basic types of information.

First, reliable site-specific baseline information on ecosystems (including



Linkages among various ecosystem goods and services (food, water, biodiversity, forest products) and other driving forces (climate change) [modified from (*1*)].

The authors are members of a Steering Committee exploring the merits of launching a Millennium Assessment of the World's Ecosystems.

*To whom correspondence should be addressed. E-mail: waltreid@attglobal.net

the amount, economic value, and condition of the goods and services produced) must be more widely available. In particular, information on the output and value of nonmarketed ecosystem goods and services has rarely been available historically, despite evidence that these economic values may be significant to management decisions (*10*), nor is information available on the capacity of the ecosystem to maintain production of particular goods and services.

Second, knowledge of how the production of goods and services in specific ecosystems will respond to biophysical changes must be made available to public and private sectors. Ecosystem management will ultimately require quantitative answers to such questions as (i) How do ecosystems differ in their response to elevated nitrogen, carbon dioxide, and sulfur concentrations, and how will this affect the goods and services they produce? (ii) How do ecosystems differ in the manner in which land cover change affects the local hydrological cycle, including amounts of precipitation and the timing and amount of runoff? (iii) How do changes in biological diversity affect the supply and resilience of various goods and services produced by different ecosystems? (iv) What thresholds are likely to exist in different ecosystems, and to what types of changes will those ecosystems be most sensitive?

Better forecasting tools also enable exploration of potential "win-win" opportunities for ecosystem management, such as managing land cover to maximize biodiversity conservation, watershed protection, and carbon sequestration simultaneously.

Third, integrated regional models that incorporate biophysical, economic, and technological change must be developed to provide policy-makers with better understanding of the consequences of different management options. A key element of the development of these models will be the need to ensure coherence between data collected at various scales, so that global models can be informed by regional and local data and can be downscaled for regional analyses.

Assessment Design

Other major international science assessments, such as the Global Biodiversity Assessment and the assessments of the Intergovernmental Panel on Climate Change, have been conducted over 3- to 4-year periods, with budgets of $5 million to $20 million, and with important contributions of time and expertise from the research community. A worldwide ecosystem assessment conducted with a similar scale of effort could significantly aid national and international decision-making. Ideally, such an assessment would be repeated at 5- or 10-year intervals to facilitate monitoring of ecosystem changes, progress in response to those changes, and to incorporate new research findings. Such a process would galvanize international attention around the importance of ecosystems for human development and the consequences of actions that we might take, or fail to take, to ensure effective management of these systems.

An international assessment could be either fully independent of governments or established through an arrangement among governments with a formal link to one or more international bodies, such as U.N. conventions. A system of strict peer review could maintain the scientific independence of its findings. Experience with past assessments suggests that, in order to succeed, assessors must ensure that their product is (i) demand driven—with the choice of issues guided by the decision-makers who will use its findings; (ii) inclusive—involving natural and social scientists from all relevant sectors and organizations and representing all geographic regions; (iii) peer reviewed and independent of political and economic influence on its findings; and (iv) relevant to a wide range of public and private sector stakeholders.

A global ecosystem assessment would also need to build on and not duplicate various international activities, including research programs, such as the Diversitas Programme; monitoring activities, such as the Global Terrestrial Observing System; data sets held by national governments and international institutions, such as the Food and Agricultural Organization (FAO) and the World Conservation Monitoring Centre; recent assessments of issues, such as food production and biodiversity (*11*); and several other ongoing assessments, such as the FAO Global Forest Resources Assessment 2000 and the Global International Waters Assessment. Without the information from these related activities, an integrated assessment of world ecosystems would be impossible, but these activities alone are insufficient to meet the needs we have identified.

Because ecosystems are differentiated in space and time, sound management requires careful local planning and action. An international ecosystem assessment must ultimately be complemented by, and informed by, detailed local monitoring and assessment. Local and regional assessments alone are insufficient, however, because some processes are global and because local goods, services, matter, and energy are often transferred across regions. The worldwide assessment should thus help to catalyze the establishment of appropriate monitoring and assessment institutions from highly centralized processes at a global level to highly decentralized processes at a local level.

Both the challenge of effectively managing earth's ecosystems and the consequences of failure will increase during the 21st century (*12*). Decisions taken by local communities, national governments, and the private sector over coming decades will determine how much biodiversity will survive for future generations and whether the supply of food, clean water, timber, and aesthetic and cultural benefits provided by ecosystems will enhance or diminish human prospects. The scientific community must mobilize its knowledge of these biological systems in a manner that can heighten awareness, provide information, build local and national capacity, and inform policy changes that will help communities, businesses, nations, and international institutions better manage Earth's living systems. We believe that the time is right—at the turn of the millennium—to undertake the first global assessment of the condition and future prospects of global ecosystems.

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