CHAPTER 2

TAKING STOCK OF ECOSYSTEMS

This chapter takes on the critical question: *What condition are the world's ecosystems in?* As Chapter 1 makes clear, the capacity of ecosystems to produce goods and services ranging from food to clean water is fundamentally important for meeting human needs and, ultimately, influences the development prospects of nations. Although policy makers have ready access to information about the condition of their nation's economy, educational programs, or health care system, comparable information about the condition of ecosystems is unavailable. In fact, no nation or global institution has ever undertaken a comprehensive assessment of how well ecosystems are meeting human needs.

We know a good deal about environmental conditions in many places, and we have a fair understanding of the pressures many ecosystems face. But this information lacks the coherence and global coverage needed to provide a clear picture of the state of major ecosystems worldwide.

To help fill this information gap, this chapter presents the results of a first-of-its-kind assessment: the Pilot Analysis of Global Ecosystems (PAGE). The PAGE study assessed five of the world's major ecosystem types.

- ***Agricultural ecosystems*** or "agroecosystems" cover 28 percent of the land surface (excluding Antarctica and Greenland) and account for $1.3 trillion in output of food, feed, and fiber and for 99 percent of the calories humans consume.

- ***Coastal ecosystems*** (including marine fisheries) cover approximately 22 percent of the total land area in a 100-km band along continental and island coastlines, as well as the ocean area above the continental shelf. The coastal zone is home to roughly 2.2 billion people or 39 percent of the world's population and yields as much as 95 percent of the marine fish catch.

- ***Forest ecosystems*** cover 22 percent of the land surface (excluding Antarctica and Greenland) and contribute more than 2 percent of global GDP through the production and manufacture of industrial wood products alone.

- ***Freshwater systems*** cover less than 1 percent of Earth's surface but they are the source of water for drinking, domestic use, agriculture, and industry; freshwater fish and mollusks are also a major source of protein for humans and animals.

- ***Grassland ecosystems*** (including shrublands) cover 41 percent of the land surface (excluding Antarctica and Greenland) and are critical producers of protein and fiber from livestock, particularly in developing countries.

Together these five ecosystem types, which overlap in some places, cover the bulk of Earth's land area and a significant portion of the ocean area. They are also home to much of the world's population. Other ecosystems, such as polar zones, high mountains, ocean areas beyond the continental shelves, and even urban ecosystems account for the remainder of the area and are important in their own right (see the Appendix to this Chapter). But the condition of the goods and services produced by these five major ecosystems will largely determine how well Earth's living systems meet human needs today and in the future.

A Unique Approach

The PAGE study is unique in that it evaluated the state of five ecosystems by examining the condition of a range of goods and services these ecosystems produce:

- food and fiber production,
- provision of pure and sufficient water,
- maintenance of biodiversity,
- storage of atmospheric carbon, and
- provision of recreation and tourism opportunities.

This "goods and services approach" makes explicit the link between the biological capacity of ecosystems and human well-being.

Notably, the PAGE analysis considered not just the current level of production of goods and services, but also the *capacity* of the ecosystem to continue to produce these goods and services in the future. For example, in evaluating food production in the coastal and marine assessment, PAGE researchers looked not only at the current marine fish catch, but also at trends in the condition of the fish stocks that contribute to this catch. In this way, the PAGE study–to the extent possible–addressed the question of the sustainability of current patterns of ecosystem use (Box 2.1 The Difficulty of Assessing Ecosystems).

A Global Synthesis of Current Information

The first objective of PAGE was to review existing environmental assessments and compile available data into a globally comprehensive package. PAGE researchers synthesized information from dozens of sources:

- national, regional, and global data sets on food and fiber production;
- sectoral assessments of agriculture, forestry, biodiversity, water, and fisheries;
- national state-of-the-environment reports;
- national and global assessments of ecosystem extent and change;
- biological assessments of particular species or environments.
- scientific research articles; and
- various national and international data sets.

For each of the five ecosystem types, PAGE researchers first assembled the best information available on the extent of the

Box 2.1 The Difficulty of Assessing Ecosystems

It is enormously challenging to measure the overall condition or health of an ecosystem. The ecosystem "indicators" most readily available, and that have shaped our current understanding of ecosystems, are far from complete. Each provides only a partial description of the bigger picture, like the parable of the five blind men giving different descriptions of the same elephant because each can feel only a small part of the whole animal. These indicators include:

- *pressures* on ecosystems, including such factors as population growth, increased resource consumption, pollution, and overharvesting;

- *extent* of ecosystems—their physical size, shape, location, and distribution; and

- *production* or output of various economically important goods by the system, such as crops, timber, or fish.

Each of these indicators is important, but collectively they provide only a narrow view of ecosystem condition and how well ecosystems are being managed. Indicators of pressure, for example, reveal little about the actual health of the system. With proper management, an ecosystem can withstand significant pressures without losing productivity. Indeed, some agroecosystems have withstood the pressure of intensive cultivation for generations, but have sustained productivity with the help of organic fertilizers and crop rotation. And although growing populations may increase pressures on forests or fisheries, examples abound of community-based management systems that maintained the productivity of ecosystems even in the face of significant population growth.

Similarly, changes in ecosystem extent—such as loss of forests and expansion of agriculture—may indicate that the form of land use and the predominant vegetation have changed, but don't reveal how well the remaining forest or agroecosystem is functioning. And information about the production or output of various ecosystem goods and services doesn't provide a complete picture because production information is rarely available for nonmarketed commodities such as water filtration or storm protection; and the nonmarketed commodities are sometimes the most valuable services ecosystems provide.

Most important, none of these traditional indicators provides information about the underlying capacity of ecosystems to continue to supply their life-sustaining goods and services. The history of the world's fisheries illustrates this problem well. Routinely in fisheries around the world, overfished stocks have collapsed after several years or decades of bountiful harvests. The high production in the good years thus revealed nothing about the health of the fishery; it merely foreshadowed the exhaustion of the resource. Similarly, food production statistics don't reveal evidence of the degradation of agroecosystems that might result from excessive soil erosion or nutrient depletion, since some degradation can be offset by increased fertilization and new crop varieties. With time, though, the diminished capacity of the agricultural lands will increase production costs and may ultimately take land out of production.

Indicators of ecosystem capacity are not easy to obtain. Such indicators must probe the underlying biological state of the ecosystem, including physical factors such as soil fertility or water's dissolved oxygen content that lie at the base of the ecosystem's ability to function. For example, data about the size and structure of some marine fish stocks are available. When these basic population data are combined with knowledge of breeding cycles, the availability of basic nutrients, and large-scale ocean trends like El Niño, the result can lead to an estimate of the maximum sustainable yield for the monitored fish stocks—in other words, the maximum amount of fish that can be harvested without risking depletion of the resource. If calculated carefully, this represents a true measure of the ecosystem's capacity to sustainably produce fish.

Unfortunately, the basic biological data needed to judge ecosystem capacity are often available only for limited areas or species. Even when these data are available, the complex interactions between the elements of the ecosystem and how they affect ecosystem capacity are often unclear. Capacity indicators thus represent the frontier of ecosystem assessment and one of its most problematic aspects.

ecosystem and any modifications to the ecosystem, such as conversion to agriculture or urban areas. PAGE researchers asked:

- Where is the ecosystem located?
- What are its dominant physical characteristics?
- How has it changed through time?
- What pressures and changes is it experiencing today?

They then concentrated on assembling the best indicators of production and condition of the various goods and services produced by each ecosystem:

- What is the quantity of the service being produced (and its value, where possible)?
- Is the capacity of the ecosystem to provide that service being enhanced or diminished through time?

Essentially, for each good and service, the PAGE study asked: *Why is it important?* and *What shape is it in?* To the extent possible, researchers also included information about the plausible future condition of the ecosystem.

The results of the PAGE study were subjected to a thorough peer review by more than 70 scientific experts around the world.

An International Collaboration

Many organizations collaborated to produce the PAGE study:

- Centro Internacional de Agricultura Tropical (CIAT)
- Global Runoff Data Centre, Germany
- International Fertilizer Development Center (IFDC)
- International Food Policy Research Institute (IFPRI) (agroecosystem coordinator)
- International Institute for Applied Systems Analysis (IIASA)
- International Potato Center (CIP)
- International Soil Reference and Information Centre (ISRIC)
- Food and Agriculture Organization of the United Nations (FAO)
- MRJ Technologies, USA
- Ocean Voice International
- UN Environment Programme
- UN Development Programme
- US Geological Survey, EROS Data Center
- University of Maryland, USA
- University of New Hampshire, USA
- University of Umeå Sweden
- World Bank
- World Conservation Monitoring Centre (WCMC)
- World Resources Institute (PAGE coordinator)

The "Big Picture," but with Limitations

The goal of PAGE was not only to provide "state of the art" information about the condition of global ecosystems, but also to help identify gaps in data and information. In addition, PAGE was designed to demonstrate, on a global level, the utility of an *integrated assessment approach*–one that simultaneously assesses the full range of both goods and services an ecosystem produces rather than focusing on just one or two, such as timber production or biodiversity.

The PAGE findings provide a "big picture" view of ecosystem condition and change at a global or continental scale and indicate how these ecosystem characteristics are linked to development prospects. PAGE did not attempt to produce the more detailed site-specific data and information needed at a national scale by resource managers. Nor did it examine specific trade-offs among various goods and services (except for a few illustrative cases), since that type of analysis is most meaningful at smaller scales, such as a nation or river basin, where these choices are actually made.

Although the PAGE study strove to be as integrated as possible in its approach, it is not, strictly speaking, an "integrated assessment." A truly *integrated* ecosystem assessment would focus not on categories such as "forests" and "grasslands," as PAGE has done, but instead on spatially contiguous regions, such as an entire nation, or even a river basin. The Amazon River Basin ecosystem, for example, includes agroecosystems, coastal areas, grasslands, forests, and freshwater habitats. An integrated assessment of the Amazon would examine the array of goods and services produced from this mosaic of land uses and land cover and the trade-offs among them, rather than examine each in isolation (see Box 4.3 The Need for Integrated Ecosystem Assessments).

Nonetheless, at a global scale, the broad ecosystem categories used by PAGE provide a useful way to present information. Moreover, these categories are useful to some of the environmental institutions charged with the conservation and sustainable use of ecosystems. For example, these are the categories used by the Convention on Biological Diversity, the treaty signed by the international community in 1992.

PAGE FINDINGS: The Ecosystem Scorecard

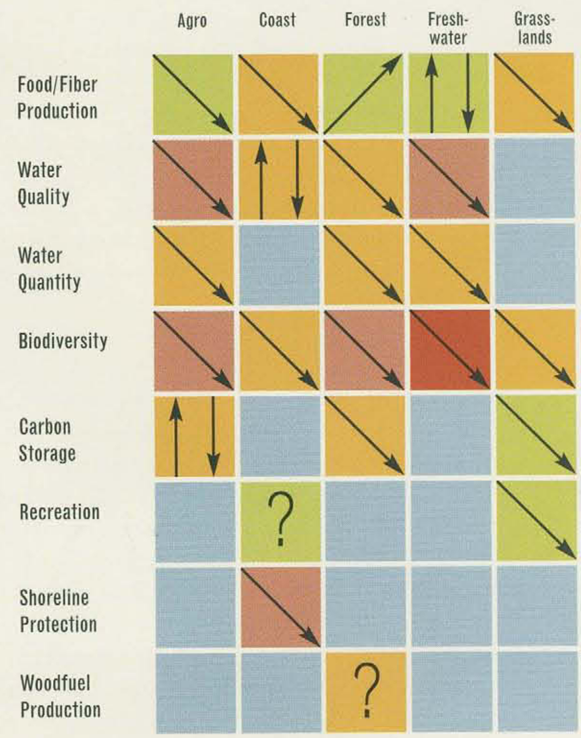
In spite of the narrowness of current ecosystem indicators, we must use them in judicious combination to assemble a picture of ecosystem status. Thus, the PAGE study has negotiated carefully through the various indicators available on ecosystem pressures, production, underlying biological condition, and physical extent to arrive at its findings.

For summary purposes, PAGE researchers chose to represent their findings as two separate "scores" for each of an ecosystem's primary goods or services (see the Ecosystem Scorecard). The *Condition* score (indicated by color) reflects how the ecosystem's ability to yield goods and services has changed over time by comparing the current output and quality of these goods and services with output and quality 20–30 years ago. It is drawn from indicators of production such as crop harvest data, wood production, water use, and tourism, as well as data on biological conditions, such as species declines, biological invasions, or the amount of carbon stored in the vegetation and soils of a given area.

The *Changing Capacity* score reflects the trend in an ecosystem's biological capacity—its ability to continue to provide a good or service in the future. It integrates information on ecosystem pressures with trends in underlying biological factors such as soil fertility, soil erosion and salinization, condition of fish stocks and breeding grounds, nutrient loading and eutrophication of water bodies, fragmentation of forests and grasslands, and disruption of local and regional water cycles.

In all cases, the ecosystem scores represent expert judgments that integrate a number of different variables, and accommodate gaps in the data sets. Although far from perfect, the Condition and Changing Capacity scores, when taken together, offer a reasonable picture of how ecosystems are serving us today, and their trend for the future, given current pressures.

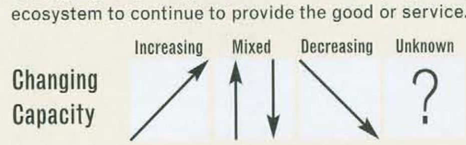
Scorecard



Key

Condition assesses the current output and quality of the ecosystem good or service compared with output and quality of 20–30 years ago.

Changing Capacity assesses the underlying biological ability of the ecosystem to continue to provide the good or service.



Scores are expert judgments about each ecosystem good or service over time, without regard to changes in other ecosystems. Scores estimate the predominant global condition or capacity by balancing the relative strength and reliability of the various indicators. When regional findings diverge, in the absence of global data, weight is given to better-quality data, larger geographic coverage, and longer time series. Pronounced differences in global trends are scored as "mixed" if a net value cannot be determined. Serious inadequacy of current data is scored as "unknown."

PAGE Findings: What Shape Are the World's Ecosystems In?

The results of the PAGE study confirm that humans have dramatically altered the capacity of ecosystems to deliver goods and services, with the most significant changes taking place over the past century. For some goods and services, such as food production, we have greatly increased the capacity of ecosystems to provide what we need, while for others, such as water purification and biodiversity conservation, we have greatly degraded their capacity. The balance sheet of the positive and negative impacts of our management of ecosystems is shown in the Ecosystem Scorecard and summarized below.

FOOD PRODUCTION

People have dramatically increased food production from the world's ecosystems, in part by converting large areas to highly managed agroecosystems–croplands, pastures, feedlots–that provide the bulk of the human food supply. The condition of agroecosystems from the standpoint of food production is mixed. Although crop yields are still rising, the underlying condition of agroecosystems is declining in much of the world. Soil degradation is a concern on as much as 65 percent of agricultural land. Historically, inputs of water, fertilizers, and technologies such as new seed varieties and pesticides have been able to more than offset declining ecosystem conditions worldwide (although with significant local and regional exceptions), and they may continue to do so for the foreseeable future. But how long can that kind of compensation continue? The diminishing capacities of agroecosystems will make that task ever more challenging.

The outlook for fish production–also a major source of food–is more problematic. The condition of coastal ecosystems from the standpoint of food production is only fair and becoming worse. Twenty-eight percent of the world's most important marine fish stocks are depleted, overharvested, or just beginning to recover from overharvesting. Another 47 percent are being fished at their biological limit and are, therefore, vulnerable to depletion. Freshwater fisheries present a mixed picture; we are currently overexploiting most native fish stocks, but introduced species have begun to enhance the harvest in some water bodies, and production from aquaculture ponds is growing steadily. Overall, the pattern of increasing dependence on aquaculture and the decline of natural fish stocks will have serious consequences for many of the world's poor who depend on subsistence fishing.

WATER QUANTITY

Dams, diversions, irrigation pumps, and other engineering works have profoundly altered the amount and location of water available for both human uses and for sustaining aquatic ecosystems. People now withdraw annually about half of the water readily available for use from rivers. Dams and engineering works have strongly or moderately fragmented 60 percent of the world's large river systems; they have so impeded flows, that the length of time it takes the average drop of river water to reach the sea has tripled. The changes we have made to forest cover and other ecosystems such as wetlands also have altered water availability and affected the timing and intensity of floods. For example, tropical montane forests, which play key roles in regulating water quantity in the tropics, are being lost more rapidly than any other tropical forest type. Freshwater wetlands, which store water and moderate flood flows, have been reduced by as much as 50 percent worldwide.

WATER QUALITY

Water quality is degraded directly through chemical and nutrient pollution and indirectly when the capacity of ecosystems to filter water is degraded and when land-use changes increase soil erosion. Nutrient pollution from fertilizer-laden runoff is a serious problem in agricultural regions around the world; it has resulted in eutrophication and human health hazards in coastal regions, particularly in the Mediterranean, Black Sea, and northwestern Gulf of Mexico. The frequency of harmful algal blooms, linked to nutrient pollution, has increased significantly in the past 2 decades. We have greatly exceeded the capacity of many freshwater and coastal ecosystems to maintain healthy water quality. And although developed countries have improved water quality to some extent in the past 20 years, water quality in developing countries–particularly near urban and industrial areas–has been degraded substantially. Decreasing water quality poses a particular threat to the poor who often lack ready access to potable water and are most subject to the diseases associated with polluted water.

CARBON STORAGE

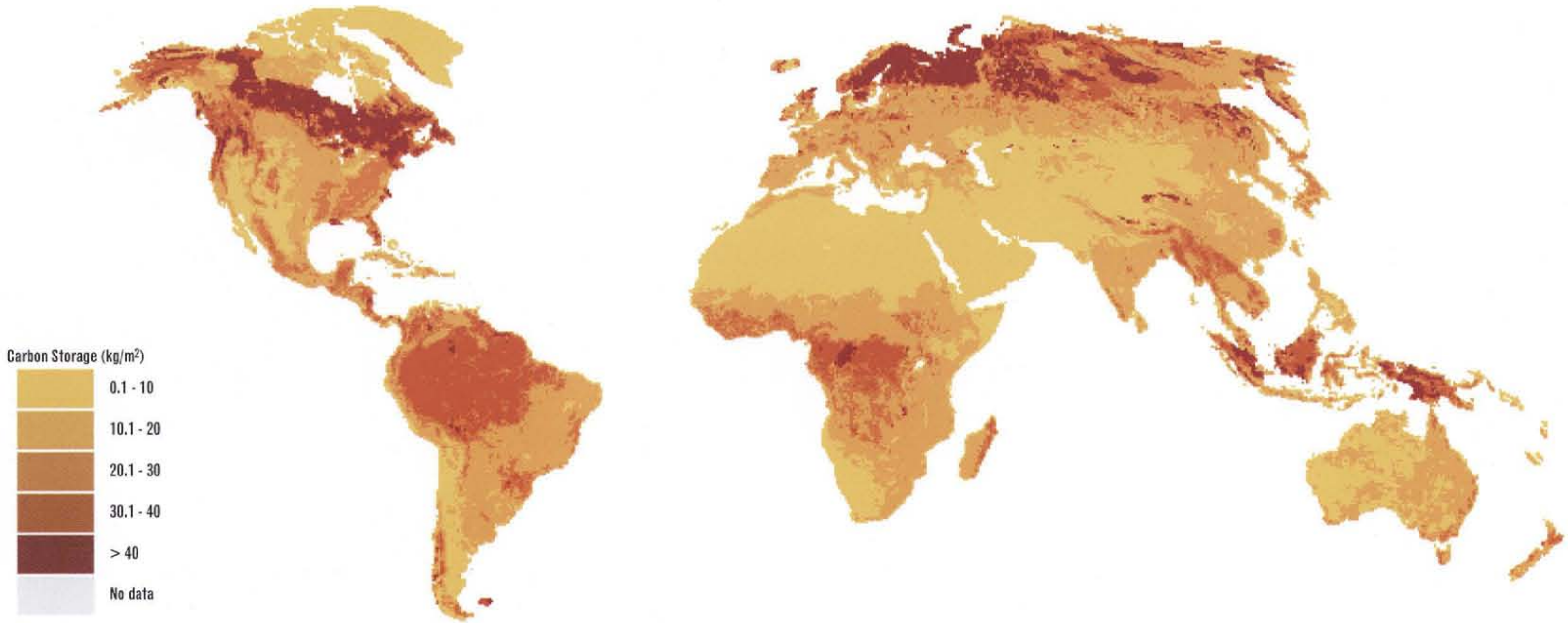
The plants and soil organisms in ecosystems remove carbon dioxide (CO_2)–the most important greenhouse gas–from the atmosphere and store it in their tissues. This carbon storage process helps to slow the buildup of CO_2 in the atmosphere. Unfortunately, the steps we have taken to increase production of food and other commodities from ecosystems have had a net negative impact on their capacity to store carbon. This is principally the result of converting forests to agroecosystems; agroecosystems support less vegetation overall and therefore store less carbon. Such land-use changes are in fact an important source of carbon emissions, contributing approximately 20 percent of global annual carbon emissions.

Ecosystems nonetheless still store significant carbon (Box 2.2 Terrestrial Storage of Carbon). Of the carbon currently stored in terrestrial systems, 38-39 percent is stored in forests and 33 percent in grasslands. Agroecosystems, which overlap grasslands and forests somewhat, store 26-28 percent. How we manage these ecosystems–whether we promote afforestation and other carbon-storing strategies or increase the forest

Box 2.2 Terrestrial Storage of Carbon

Carbon stored in terrestrial ecosystems plays a large role in the global carbon cycle. To map the distribution of terrestrial carbon storage, PAGE researchers combined recent satellite maps of Earth's vegetation with estimates of how much carbon various types of vegetation and soil store. As the map shows, the highest quantities of stored terrestrial carbon are located in the tropics and in the boreal region. In the tropics, a larger portion of the carbon is found in the vegetation, while in boreal regions, especially peatlands, most carbon is stored in the soils. Boreal peatlands are especially important carbon storage areas. Unforested lands generally store less carbon than forested ecosystems.

Global Terrestrial Storage of Carbon



Sources: Matthews et al. [PAGE] 2000. The map is a combination of two maps: a map of carbon stored in above- and below-ground live vegetation based on USGS/EDC (1999b) and a map of carbon stored in soils based on Batjes (1996) and Batjes and Bridges (1994).

Box 2.3 Are We Altering Earth's Basic Chemical Cycles?

Tracking the changes in Earth's chemical cycles—carbon, nitrogen, and water cycles—is essential to understanding the condition of ecosystems. These cycles serve as the basic metabolism of the biosphere, affecting how every ecosystem functions and linking them all on a global level. Human-induced changes in these global processes can alter climate patterns and affect the availability of basic nutrients and water that sustain plant and animal life.

The Carbon Cycle

Carbon dioxide (CO_2) concentrations in the atmosphere rose 30 percent from 1850 to 1998, from 285 parts per million to 366 parts per million (IPCC 2000:4) (see Box 1.6 Carbon Storage, p. 15). This rise in atmospheric CO_2 levels is largely the result of increased CO_2 emissions from burning fossil fuels. However, changes in use and management of ecosystems have also played a major role by releasing carbon that had been stored in vegetation and soil. About 33 percent of the carbon that has accumulated in the atmosphere over the past 150 years has come from deforestation and changes in land use (IPCC 2000:4).

Climate models tell us that rising carbon concentrations in the atmosphere will alter Earth's climate, affecting precipitation, land and sea temperatures, sea level, and storm patterns. The extent and structure of ecosystems will change as they transform in response to these basic physical parameters. Changing climate will also affect the rate of greenhouse gas emissions from some ecosystems. For example, models suggest that a warmer climate in the Arctic will elevate the rate of decomposition of the vast peat reserves in tundra and taiga ecosystems, increasing the release of CO_2 into the atmosphere.

Elevated atmospheric CO_2 can, in turn, have more direct impacts on ecosystems. Because plants depend on CO_2 for growth, elevated CO_2 concentrations will have a "fertilizer effect," increasing the growth rate of some plants and changing some of the chemical and physical characteristics of their cells. Some species will benefit more than others, and this in turn will alter the composition of biological communities.

Climate change could also have a profound impact on growing patterns and yields in agriculture. PAGE researchers estimated that a warmer climate could raise cereal production by 5 percent in mid- to high-latitude regions (mostly developed countries) but might decrease cereal yields in low-latitude regions by 10 percent (particularly in African developing countries).

The Nitrogen Cycle

Although we are more familiar with the influence humans have had on the carbon cycle, human influence on the global nitrogen cycle is more profound and already more biologically significant. In most natural systems, lack of nitrogen is an important limiting factor for plant growth, which is what accounts for significant increases in crop yields in response to nitrogen fertilizers. However, as explained in Chapter 1, the production and use of fertilizers, burning of fossil fuels, and land clearing and deforestation also increase—far beyond natural levels—the amount of nitrogen available to biological systems (Vitousek et al. 1997:5). This added nitrogen has caused serious problems, particularly in freshwater and coastal ecosystems where excess nitrogen stimulates growth of algae, sometimes depleting available oxygen to the point where other aquatic organisms suffocate, a process known as eutrophication.

The Freshwater Cycle

The scale of human impact on freshwater cycles is also massive. Humans currently appropriate more than half of accessible freshwater runoff, and by 2025, demand is projected to increase to more than 70 percent of runoff (Postel et al. 1996:7, 787). A substantial amount—70 percent—of the water currently withdrawn from all freshwater sources is used for agriculture (WMO 1997:9). By shifting water from freshwater systems to agroecosystems, crop production increases, but at significant cost to downstream ecosystems and downstream users. Some of the water diverted from rivers or directly consumed does return to rivers but, typically, carrying with it pollution in the form of agricultural nutrients or chemicals, or human or industrial waste. But as much as 60 percent of water withdrawn from rivers is lost to downstream uses (Postel 1993:56; Seckler 1998:4).

Global Cycles, Global Impacts

The importance of these global cycles to the functioning of ecosystems cannot be overstated. There is no question that sound management of Earth's ecosystems will require changes in the use of resources at a local level; but it is not enough to only examine and assess the condition of ecosystems at the local level. Some of the most important features of Earth's ecosystems—with the most profound influence on the future role of ecosystems in meeting human needs—can only be fully understood on regional and even global levels. Thus, it is vital that we examine and assess the condition of ecosystems at those levels.

conversion rate–will have a significant impact on future increases or decreases in atmospheric carbon dioxide.

BIODIVERSITY

The erosion of global biodiversity over the past century is alarming. Major losses have occurred in virtually all types of ecosystems, much of it simply by loss of habitat area. Forest cover has been reduced by at least 20 percent and perhaps by as much as 50 percent worldwide; some forest ecosystems, such as the dry tropical forests of Central America, are virtually gone. More than 50 percent of the original mangrove area in many countries is gone; wetlands area has shrunk by about half; and grasslands have been reduced by more than 90 percent in some areas. Only tundra, arctic, and deep-sea ecosystems have emerged relatively unscathed.

Even if ecosystems had retained their original spatial extent, many species would still be threatened by pollution, overexploitation, competition from invasive species, and habitat degradation. In terms of the health of species diversity, freshwater ecosystems are far and away the most degraded, with 20 percent of freshwater fish species extinct, threatened, or endangered in recent decades. Forest, grassland, and coastal ecosystems all face major problems as well. The rapid rise in the incidence of diseases affecting marine organisms, the increased prevalence of algal blooms, and the significant decreases in amphibian populations all attest to the severity of the threat to global biodiversity.

Apart from the loss of medicines, useful genetic materials, and ecotourism revenues this erosion of biodiversity represents, it also threatens the basis of ecosystem productivity. The diversity of species undergirds the ability of an ecosystem to provide most of its other goods and services. Reducing the biological diversity of an ecosystem may well diminish its resilience to disturbance, increase its susceptibility to disease outbreaks, and thus threaten its stability and integrity.

RECREATION AND TOURISM

The capacity of ecosystems to provide recreational and tourism opportunities was assessed only for coastal and grassland ecosystems. It is likely that the demand for these services will grow significantly in coming years, but the condition of the service is declining in many areas because of the overall degradation of biodiversity as well as the direct impacts of urbanization, industrialization, and tourism itself on the ecosystems being visited.

The Bottom Line

Overall, there are numerous signs that the capacity of ecosystems to continue to produce many of the goods and services we depend on is decreasing. In all five ecosystem types PAGE analyzed, ecosystem capacity is decreasing over a range of goods and services, not just one or two. PAGE results confirm that major modifications of ecosystems–through deforestation, conversion, nutrient pollution, dams, biological invasions, and regional-scale air pollution–continue to grow in scale and pervasiveness. Furthermore, human activities are significantly altering the basic chemical cycles that all ecosystems depend on (Box 2.3 Are We Altering Earth's Basic Chemical Cycles?). This strikes at the foundation of ecosystem functioning and adds to the fundamental stresses that ecosystems face at a global scale.

This downward trend in global ecosystem capacity is not impeding high production levels of some goods and services today. Food and fiber production have never been higher, and dams have allowed unprecedented control of water supplies. But this wealth of production is, in many instances, the product of intensive management that threatens to reduce the productivity of ecosystems in the longer term. Our use of technology–whether it is artificial fertilizer, more efficient fishing gear, or water-saving drip-irrigation systems–has also helped mask some of the decrease in biological capacity and has kept production levels of food and fiber high. However, services like maintaining biodiversity and high water quality and carbon storage show reductions in output that technology cannot so easily mask. In sum, the PAGE findings starkly illustrate the trade-offs we have made between high commodity production and impaired ecosystem services, and indicate the dangers these trade-offs pose to the long-term productivity of ecosystems.

The remaining sections of this chapter present an ecosystem-by-ecosystem discussion of the conclusions of the PAGE study.

The Pilot Analysis of Global Ecosystems

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Agroecosystems
Stanley Wood, Kate Sebastian, and Sara Scherr, *Pilot Analysis of Global Ecosystems: Agroecosystems, A joint study by International Food Policy Research Institute and World Resources Institute*, International Food Policy Research Institute and World Resources Institute, Washington, D.C.
December 2000 / 100 pages / paperback / ISBN 1-56973-457-7 / US$20.00

Coastal Ecosystems
Lauretta Burke, Yumiko Kura, Ken Kassem, Mark Spalding, and Carmen Revenga, *Pilot Analysis of Global Ecosystems: Coastal Ecosystems,* World Resources Institute, Washington, D.C.
December 2000 / 100 pages / paperback / ISBN 1-56973-458-5 / US$20.00

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