

# Confronting the human dilemma

How can ecosystems provide sustainable services to benefit society?

**Harold Mooney, Angela Cropper and Walter Reid**

Four years in the making, the Millennium Ecosystem Assessment (see *Nature* 417, 112–113; 2002) is released this week (starting 30 March). This gigantic endeavour explores the link between human well-being, the status of ecosystems and their sustainable use.

What has this assessment taught us about developing our planet, and will it, or should it, be continued? To answer the first part of this question, the assessment is an invaluable record of where we stand now, and why. But for it to be useful, the answer to the second part of the question must be 'yes'. We need to take a consistent approach to measuring the status and trends of the world's ecosystems. To take one example, the Convention on Biological Diversity has set the target of reducing the rate of global loss of biodiversity by 2010. But the data to evaluate whether this goal is being met are not readily available, as biological diversity is more than just an enumeration of species present or absent — it includes parameters such as the populations of species and the ecosystems in which they reside. In addition, biodiversity is just one of the many aspects of change in ecosystems and their related functions assessed in the Millennium Ecosystem Assessment. Only from a periodic audit of the state of our natural resource base can we determine if we are indeed approaching sustainability.

At present, there are no formal plans to repeat the Millennium Assessment. There should be, and we hope that the informal discussions among the current sponsors will bear fruit from the seeds sown by the many smaller, ongoing sub-global assessments that were stimulated by the assessment.

## Achievements and goals

Although there has been a steady increase in many indicators of human well-being in many parts of the world — such as an increase in personal wealth, a longer life-span and access to plentiful and inexpensive food — these benefits have not been universally distributed. There are still more than one billion people surviving on less than one dollar a day and nearly that many are undernourished. About 1.1 billion people lack access to a basic water supply and more than 2.6 billion lack access to basic sanitation. It is this disparity that has driven the United Nations to set the goals of halving the proportion of people living on less than one dollar a day, reducing the proportion of



**Sustaining ecosystems does more than just aid conservation, it saves resources for human use.**

people suffering from hunger and halving the proportion of people with no sustainable access to safe drinking water and basic sanitation. To achieve these goals by 2015, it is accepted that nations have to achieve sustainable development and reverse the losses of environmental resources.

The Millennium Ecosystem Assessment took a new pathway of evaluating the status of the Earth's human support systems. Rather than the standard environmental audit, the new assessment places audits of numbers of organisms and so on into the context of how ecosystem changes have affected human well-being, and how they may do so in the foreseeable future. It had to find a link between the status of biotic systems and the status of individuals in various societies in the world to estimate the capacity of ecosystems to provide services that benefit society. Many of these links are obvious, but others have not been appreciated, nor have all these linkages been quantified. In essence, we had to make a large leap from the current styles of evaluations of status and trends in ecosystems to an entirely different approach — an ecosystems services database related to how ecosystems and societies operate, and how they interrelate.

## Current status of ecosystems

Human societies have made marked progress in increasing provisioning services, such as crops and livestock, to meet the demand of a growing population (see overleaf). Food is

more abundant and cheaper than in the past. Despite these dramatic accomplishments, there are still more than 850 million undernourished people, and some advances in production are at the cost of other services essential for human well-being, such as ocean fisheries, wood for fuel, genetic resources and — perhaps the most important — fresh water. It is the poor in many nations that are most directly dependent on services from ecosystems, and the degradation of these systems can exacerbate their poverty. Millions of people face the reality of the declining availability of cheap protein from local fisheries, inadequate water for sanitation or live on degraded landscapes.

There are a number of issues that cloud the goal of sustaining a high level of provisioning services. The use of fertilizer in agriculture has greatly increased to meet food demand, but at the cost of polluting off-site unmanaged ecosystems, such as groundwater, rivers and coastal fisheries. In many regions, water for irrigation is being pumped from groundwater and in some cases from fossil sources. Rivers are dammed and diverted for irrigation, altering ecosystems that depend on this water — causing the loss of many of the services they provided.

Further, we are diminishing crucial 'regulating' services responsible for climate, erosion, air- and water-quality control, as well as for the regulation of pests and natural hazards. We are losing these services due to massive land-surface conversion, atmosphere alteration, eutrophication, overharvesting and the impact of invasive species. The Millennium Assessment concluded that 60% of the ecosystem services evaluated were either being degraded or being used unsustainably.

As an example, cultivated systems (areas where at least 30% of the landscape is in croplands, confined livestock production or freshwater aquaculture) now cover a quarter of the Earth's surface, partly by conversion of temperate grasslands, Mediterranean-climate forests and many tropical ecosystem types. Forests have essentially disappeared from 25 countries, with 9.4 million hectares being lost annually from the Earth's surface. Historically important fisheries have collapsed or are overfished, one third of the mangrove forests for which there are historical data have been lost, as have 20% of the coral reefs, with a further 20% degraded. Nearly 40% of the rivers of the world have been fragmented. Species and populations of species are being lost at unprecedented rates, while at the same time the global biota is becoming homogenized owing to the introductions of alien

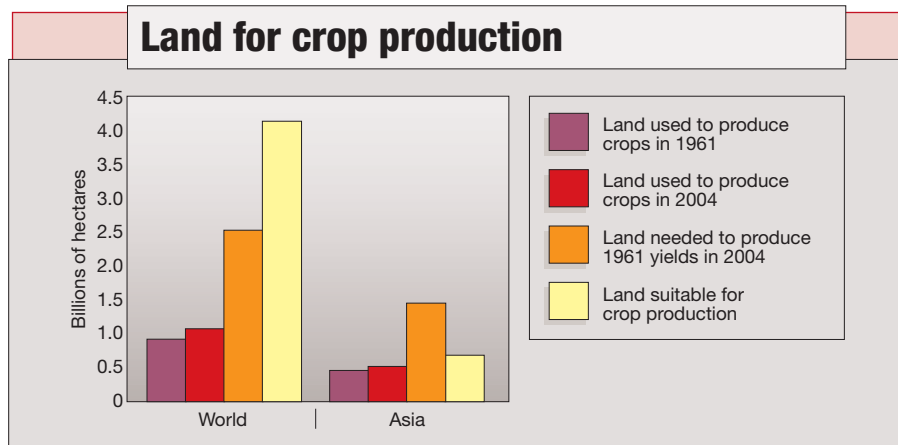
species to new regions. These examples represent major losses of pieces of the biosphere machinery, which have a serious impact on the delivery of ecosystem-regulating services — impacts such as greater prevalence of infectious diseases in disrupted ecosystems, adverse effects on local climates by ecosystem modification, and the loss of flood protection (as in the recent tsunami in Indonesia).

## What we can do

The drivers of change in ecosystems and their services will continue in direction and intensity. So how can these trends be reversed to achieve sustainability and to relieve the negative impacts of the loss of services to society, particularly to the disadvantaged? New pathways and approaches can and must be taken. But these are major initiatives, which will mean profound changes in the way global society operates. As learned in the Millennium Assessment, favourable responses need to take place at all levels, from the local to the global. Global mechanisms do not necessarily solve local problems, yet are an important part of the overall solution. At the same time, local players and solutions can feed into regional and global approaches. The players at these different levels address different decision-makers, who can collectively put in place the major changes that are needed for ecosystem sustainability.

The Millennium Assessment examines the merits of options for mechanisms and policies, to accomplish the goal of maintaining and enhancing the delivery of ecosystem services to society. Some of these require major reorganization in the way we do business. At present, our organizational structures address separately the issues of a single resource, such as agriculture, fisheries or the environment. There is little interaction within and between each issue, and much less again with trade and the treasury bodies. The lesson of the Millennium Assessment is that all these resource issues are interrelated: action on one issue has consequences for another. It is crucial to address how to minimize the trade-offs (biodiversity or clean water for agricultural yield), either on-site or by managing landscapes. One important example of how this process can work is the EU system of directives for nitrate accounting on landscapes.

Some institutional innovations are moving towards more integrated views of issues and responses to them. For example, Britain has a government department for Environment, Food and Rural Affairs. These are all closely interrelated domains, but in other countries are often handled by competing agencies. Elsewhere, interagency groups are evolving to address central issues such as climate change, but their effectiveness is hampered by competitiveness and politics. We need new kinds of institutions in better



## Cropland expansion versus intensification

A key trade-off in cultivated systems is between increasing the amount of cropland needed to meet growing food needs versus increasing the productivity of each hectare of cropland. The 'land-sparing' impact of modern farming practices has mainly been achieved by yield increases from use of crop monocultures with improved crop varieties, fertilizer inputs and irrigation. For example, if yields of the six major crop groups that are cultivated on 80% of the total cultivated land area had remained at 1961 yield levels, it would require an additional 1.4 billion hectares of land in 2004 — more than double the amount currently used (see graph). This represents 34% of total land area suitable for crop cultivation, and would have required conversion of large areas of uncultivated land that support rain forests, grassland savannahs and wetlands. In Asia alone, it would require an additional 600 million

hectares, which represents 25% more land area than is suitable for cultivation on this continent. Asia would now be heavily dependent on food imports if crop yields had remained at 1961 yield levels. Although this increase in productivity has saved some land from conversion, it has resulted in greater impact on other services through water withdrawals, excessive nutrient loads and pesticide use.

The key ecological question is therefore whether environmental services — other than food production at regional and global scales — would be enhanced by focusing food production on less land under intensive management with high yields, versus expanding cultivated area in lower-yielding systems using farming practices that preserve environmental services at the field and local levels. Few studies have addressed this issue using sound, ecological analytical methods.

positions to achieve sustainability of ecosystems that provide for human well-being.

We must also try to improve the economics. Although provisioning services are enmeshed in the local (and increasingly global) marketplace, regulating services are not. We must accelerate our ability to value ecosystem-regulating services at the national level, as well as the ecosystem services that provide crucial cultural amenities, and ensure that these values are considered in decision-making.

Some progress is being made. Costa Rica has established a system of conservation payments, under which contracts are brokered between international and domestic 'buyers' and local 'sellers' of sequestered carbon, biodiversity, watershed services and scenic beauty. On a global scale, the Ecosystem Marketplace consortium is beginning to track transactions, pricing trends and buyers' requests on the carbon, water and biodiversity markets. It is predicted that the global carbon market will reach US\$44 billion by 2010.

We need to eliminate the subsidies that promote the excessive use of ecosystem services and evaluate more carefully the

trade incentives that damage ecosystem services. We must work harder to educate the public on the strong links between sustainable ecosystems and the lives of humans. The role of new technologies in more efficient use of natural resources is crucial and needs more incentives.

There is plenty that can and needs to be done to deal with the crisis that has already enveloped us. The path is open for scientists to quantify, to a much greater extent, the way in which the operation of ecosystems is directly linked to human well-being, and hence model the course of human activities on future outcomes of the delivery of these services. The Millennium Assessment is certainly providing a strong stimulus for such studies. ■

*Harold Mooney is in the Department of Biological Sciences, Stanford University, California 94305, USA. Angela Cropper is at the Cropper Foundation, Port of Spain, Trinidad and Tobago. Walter Reid is the Director of the Millennium Ecosystem Assessment, 4225 Glen Ave., California 94611, USA.*

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