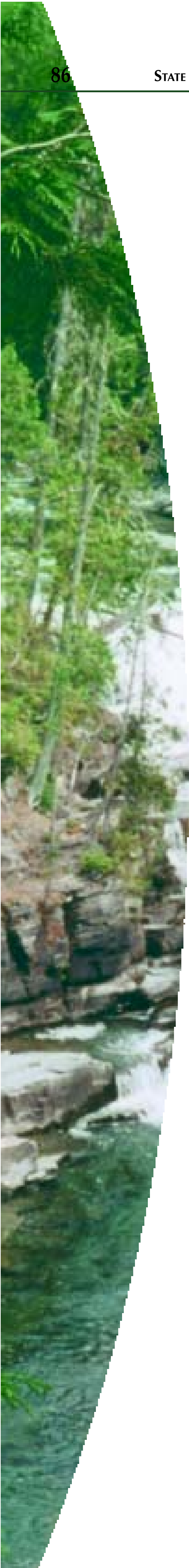


How sustainable use of forests can contribute to conserving biological diversity

The term "biological diversity" entered the public vocabulary only about 15 years ago, but its arrival signalled a new and more comprehensive approach to conservation, bringing together information, knowledge, awareness, ethics, forestry, protected areas, agricultural practices, economics, intellectual property rights (IPRs), land tenure, trade and other elements for the holistic management of ecosystems. The concept has encouraged land-use planners to revise outdated approaches, such as excluding people from their traditional lands in the name of conservation or focusing on one forest benefit to the exclusion of others. It also led to the adoption of the Convention on Biological Diversity (CBD), which has now been ratified by more than 180 countries.

CBD captures the essence of the modern approach to the management of living resources. Its three objectives, all contained within the same sentence (thereby showing their fundamental unity) are "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (Article 1). The convention thus recognizes that sustainable use is an essential part of conservation, and vice versa, and that an equitable distribution of benefits is essential to achieving both. It follows that the conservation of biological diversity is an integral component of sustainable forest management.

The present chapter explores some of the issues involved in conservation of biological diversity and sustainable forest management, showing how they are related and suggesting how criteria and indicators for conservation can be developed as part of the broader set of criteria and indicators for sustainable forest management.

Conserving biological diversity is an ethical imperative because all life has a right to exist, and humans should not knowingly cause any loss of this diversity. From a more practical angle, biological diversity provides many benefits to humans, supporting the systems that store and cycle nutrients essential for life, absorbing and breaking down pollutants, recharging groundwater, producing soil and protecting it from excessive erosion, providing the basis for all improvements to domesticated plants and animals, and providing numerous raw materials for industry and medicine. In more general terms, the variation in life provides the basis for adapting to changing conditions.

SOME KEY CONCEPTS IN BIOLOGICAL DIVERSITY CONSERVATION IN RELATION TO FORESTS

CBD defines biological diversity as the variability among living organisms, including diversity within species, between species and of ecosystems. It is thus an attribute of life and a property of assemblages of organisms. Strictly speaking, what is used, misused, conserved or destroyed is not biological diversity itself but biological resources, which CBD defines as "genetic resources, organisms or parts thereof, populations or any other biotic component of ecosystems with actual or potential use or value for humanity".

For the first time in a binding international instrument, the intrinsic value of biological diversity has been recognized, along with its ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic value. However, the main focus is on benefits to people from the sustainable use of biological resources.

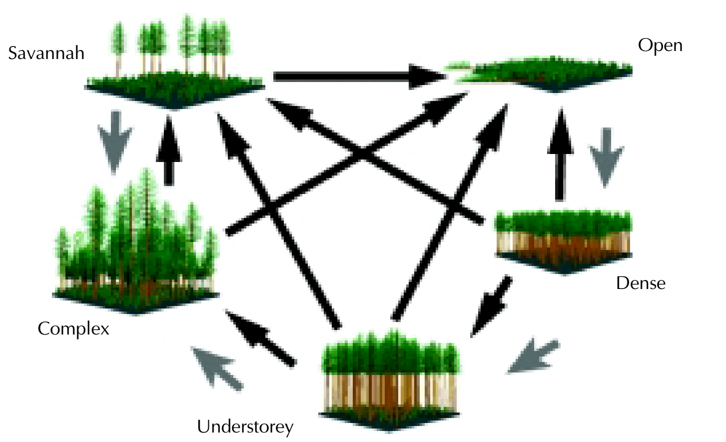
The people who use these biological resources have many different needs, interests, cultures and goals. The global industrial society that characterizes the modern world consumes vast amounts of such forest resources as timber, fibre, food and fodder. Thus, macroeconomic decisions taken far away from forests often determine the fate of forest biological diversity and the way land is used. The forested areas where species diversity is richest are often remote from the centres of power, but the people who live in these areas are strongly affected by economic decisions taken in distant capitals. Although forest residents also make decisions about resources that may result in the conversion of a forest into another form of land use or the local extinction of a species, evidence indicates that people who have lived for a long time on the land seldom cause such extinctions.

New research on forest ecosystems is being applied to the conservation of biological diversity. Findings indicate that forests are loose, temporary assemblages of species, each of which behaves according to its own needs, depending on specific physiology, morphology, demography, behaviour and dispersal capacity. "Because of a continual turnover of ecological conditions, local communities show a continual turnover of species, at one time gaining species because the scale of processes allows a certain type of trait, and at others losing them again because the same trait happens to have resulted in too great a risk of extinction. Biological diversity is both the result and expression of all sorts of adaptations of life to the environmental turmoil; it can only be maintained as long as this turmoil exists" (Hengeveld, 1994). These new insights are the basis of managing dynamic ecosystems as a whole, recognizing the many different forest structures found in nature (Oliver and Larson, 1996) (Figure 6).

Conserving this natural dynamism in the face of unnatural pressures, such as fragmentation, invasive alien species and climate change, is a major challenge for forest managers, requiring judgements about the scale on which benefits are to be delivered to people. As Daily *et al*. (1997) point out: "The continued existence of coniferous tree species somewhere in the world would not help the inhabitants of a town inundated by flooding because of the clearing of a pine forest upstream. Generally, the flow of ecosystem goods and services in a region is determined by the type, spatial layout, extent, and proximity of the ecosystems supplying them." Because forests are dynamic, highly complex and unique to the site in which they are located, it is not sufficient to conserve one minimum viable population of a species or one example of an ecosystem. Instead, conservation approaches must recognize the dynamism of systems, the dependence of local people on forest resources and the need to build redundancy into systems of protecting biological diversity.

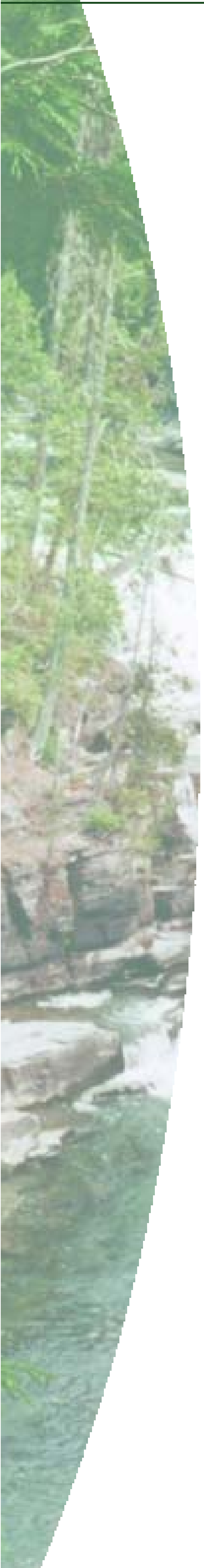
Approaches being developed under many forest-related international agreements and programmes call for forests to be managed to meet multiple national objectives, including: supplying timber, fibre and energy; keeping options open for

FIGURE 6
Complexity and dynamism of forests: a diversity of structures is needed to protect all species



Constant changes in forest structure and species composition result from plant growth, disturbances, species migration, climate changes and other processes.

Source: Oliver and Larson, 1996.



future economic use; fulfilling an aesthetic function; and providing the nation's share of global benefits. If these sometimes conflicting objectives are to be achieved at a time of rising expectations and shrinking government budgets, new approaches are required. The development of appropriate policies for managing forests in the twenty-first century warrants consideration of some of the critical issues facing the conservation of forest biological diversity.

CRITICAL ISSUES IN CONSERVING FOREST BIOLOGICAL DIVERSITY

Fragmentation

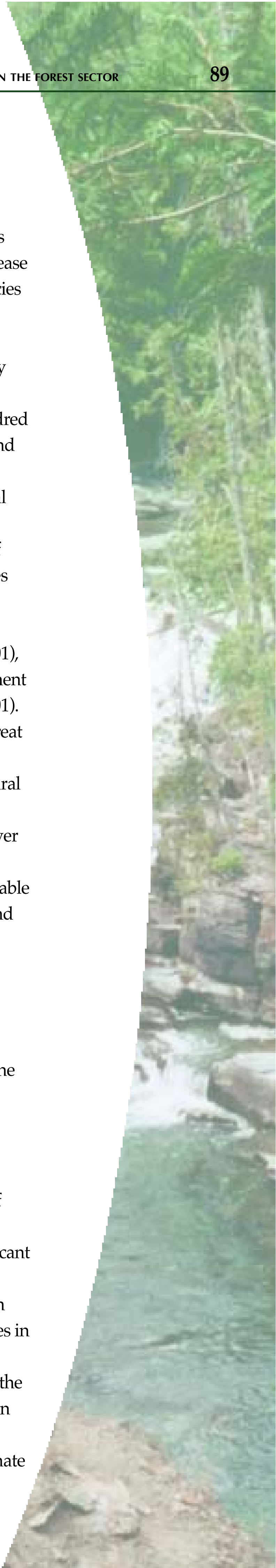
Although deforestation is widely recognized as a major conservation issue, the related issue of habitat fragmentation receives insufficient attention. As human pressure increases in both temperate and tropical forests, areas that were once continuously forested have become more fragmented. In the Brazilian Amazon alone, the area of forest that is now fragmented (with forests less than 10 000 ha in area) or prone to edge effects (less than 1 km from clearings) is more than 150 percent greater than the area that has actually been deforested. Recent research indicates that small fragments have very different ecosystem characteristics from larger areas of forest, containing more light-loving species, more trees with wind- or water-dispersed seeds or fruits, and relatively few understorey species. The smaller fragments also have a greater density of tree falls, a more irregular canopy, more weedy species and unusually abundant vines, lianas and bamboos. Thus, they preserve only a highly biased subset of the original flora and fauna, which is adapted to these conditions (Laurance, 1999; Laurance *et al*., 2000).

A study comparing the density of lowland birds in unlogged and recently logged forests in Seram, Indonesia found that few bird species were excluded from logged forest and several were common in both habitats. Species that were rare in unlogged forests were no more likely to decline after logging than were the common ones. However, while birds with restricted global ranges fared no worse than widespread species, several endemic forms were seriously affected. Because so many of the birds of Indonesia are restricted to single islands, logging concessions need to be examined at an individual island level to ensure that endemic forms are not threatened (Marsden, 1998).

For some species of forest bird, fragmentation reduces nesting success, and hence the number of offspring that they can produce. In some temperate forests, fragmentation exposes some species to greater rates of nest predation by mammals and nest parasitism (in which birds lay eggs in the nests of other species, which then raise these offspring at the expense of their own). Reproduction rates are sometimes so low for some species in the most fragmented landscapes that their populations depend on immigration of other populations from areas with more extensive forest cover (Robinson *et al*., 1995; Askins, 1995). Conservation strategies therefore need to ensure the preservation and restoration of large, continuous forest habitats in each region.

Research on the impact of natural forest fragmentation on the distribution of mammals in Lope Reserve in central Gabon found that total mammal biomass was highest in the forest fragments, at 6 010 kg per square kilometre. Of eight species of primate, four were more common, two occurred with similar densities, and two were much less common in the fragmented habitat. Most mammal species moved between continuous forest and forest fragments, but a few resided permanently in some fragments. The diversity and high biomass of large mammals found within the forest fragments suggests that fragmentation *per se* will not be catastrophic for most of these species. However, since logging typically results in greatly increased hunting – sometimes only to feed the logging crews, but more often to sell meat and other animal products on lucrative international markets – the remaining structurally intact forest may be emptied of primates and other large mammals and birds (Tutin, White and MacKanga-Missandzou, 1997).

Surveys conducted over 28 years in Kibale National Park, Uganda quantified the long-term effects of both low- and high-intensity selective logging on the density of five common primates. The results suggest that, in this region at least,



low-intensity selective logging could be one component of plans to conserve primates. On the other hand, high-intensity logging, typical of most logging operations in the tropics, is incompatible with primate conservation (Chapman *et al*., 2000).

Invasive alien species

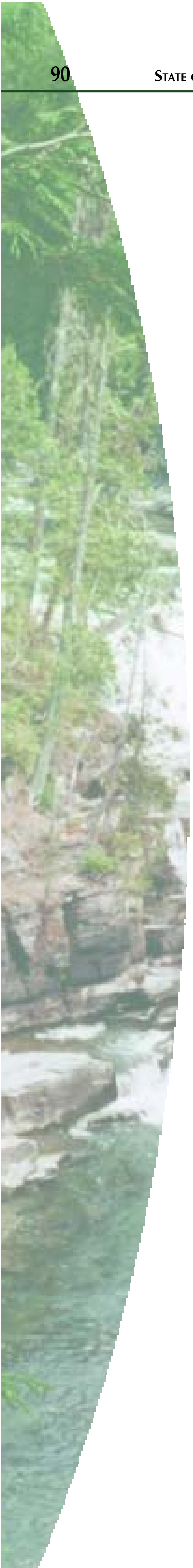
As the global movement of people and products expands, so does the movement of plant and animal species from one part of the world to another. When a species is introduced into a new habitat – for example, oil palm from Africa into Indonesia, *Eucalyptus* species from Australia into California, and rubber from Brazil into Malaysia – the alien species typically requires human intervention to survive and reproduce. Indeed, many of the most popular species of tree used for agroforestry are alien or non-native and prosper in their new environments partly because they no longer face the same competitors, predators and pests as in their native environment. Such alien species are economically very important and enhance the production of various forest commodities in many parts of the world.

In some cases, however, species introduced intentionally become established in the wild and spread at the expense of native species, affecting entire ecosystems. Notorious examples of such invasion by alien woody species include the introduction of kudzu (*Pueraria lobata*) from Japan and China into the United States, where it now infests over 2 million hectares; the ecological takeover of the Polynesian island of Tahiti by *Miconia calvescens*; the spread of various species of Northern Hemisphere pine and Australian acacia in southern Africa; and the invasion of Florida's Everglades National Park by *Melaleuca* species from South America. Of the 2 000 or so species that are used in agroforestry, perhaps as many as 10 percent are invasive. Although only about 1 percent are highly invasive, they include popular species such as *Casuarina glauca*, *Leucaena leucocephala* and *Pinus radiata* (Richardson, 1999). Great care is required to ensure that such species serve the economic purposes for which they were introduced and do not escape to cause unanticipated negative effects on native ecosystems.

Perhaps even worse are invasive alien species that are introduced unintentionally, such as disease organisms that can devastate an entire tree species (e.g. Dutch elm disease and chestnut blight in North America) or pests that can have a major effect on native forests or plantations (e.g. gypsy moths and long-horned beetles). The economic impact of such species amounts to several hundred billion dollars per year (Perrings, Williamson and Dalmazzone, 2000), much of it in forested ecosystems, even within well-protected national parks. The 1951 International Plant Protection Convention was established to address some of these issues, and new international programmes are now addressing the most serious problems. The World Conservation Union (IUCN) has developed a global strategy (McNeely *et al.*, 2001), and best practices for prevention and management have been identified (Wittenberg and Cock, 2001). However, as global trade grows, so does the threat from devastating invasive species of insect and pathogen. They could fundamentally alter natural forests and wipe out tree plantations, the latter being especially vulnerable because of their lower species diversity. Efforts related to both conservation of biological diversity and sustainable forest management need to recognize clearly and address the issue of invasive alien species.

Climate change

Forests are often highly sensitive to climate, judging by the past distribution of forest types during periods with different climates and by the vegetation bands on mountains. While the Intergovernmental Panel on Climate Change (IPCC) and associated national research programmes are generating valuable new information, forecasts of the potential impact of climate change on forests remain somewhat speculative. Some contend that the most significant threats are drying trends, changes in rainfall patterns, changes in fire regimes and changes in seasonality, which would in turn lead to changes in species distribution and composition. Others suggest that forests may be equally affected by the indirect effects of climate on soil properties or on reproduction. In the final analysis, the most important factor may well be the impact of climate



change on human populations, affecting settlement and consumption patterns, which will then influence how forests are used. Nonetheless, the capacity of tree species to shift their ranges in response to climate change also depends on ecological factors, such as dispersal mechanisms. Trees propagated by seeds that are scattered by the wind or carried by animals may disperse more easily than others (Peters and Lovejoy, 1992). In addition, the changing ranges of animal species may affect those tree species that depend on them for propagation.

A growing body of research has examined the possible effects of climate change on individual species and biotic communities. Findings suggest that biological communities will shift in intricate and unexpected ways as the geographical distribution of species is altered individually rather than in community units (FAUNMAP, 1996). Furthermore, because species are interrelated, any advantage falling to a given species in an ecosystem will affect other species in ways that are not always predictable. As climates change, the rates of species invasion and extinction are likely to accelerate, bringing about complex changes in species composition and interaction (Mooney and Hobbs, 2000). Thus, rather than causing a simple northward or uphill shifting of ecosystems with all inhabitants intact, climate changes will reorganize forest biological communities and force evolutionary changes. Populations located near the edge of a species' range, narrowly endemic species and endangered species that exist only in protected areas or other limited habitats are especially vulnerable to regional vegetation shifts. Species already threatened by direct exploitation, habitat loss and habitat degradation are likely to be particularly susceptible to new threats (Peters and Lovejoy, 1992; Schneider and Root, 2002).

INTERFACE BETWEEN BIOLOGICAL DIVERSITY AND SUSTAINABLE FOREST MANAGEMENT

While timber production often dominated the way in which forests were managed in the twentieth century, new pressures in the twenty-first century demand a more nuanced approach, calling for the delivery of multiple goods and services. The public expects forestry plans to provide adequately for the protection of watersheds, indigenous people to be able to occupy their traditional homelands (even if they are in economically valuable forests), a system of protected areas to cover all major ecosystem types in the country, and any exploitation of timber and other forest products to be sustainable. Sustainable forest management based on ecosystem principles – such as maintaining healthy breeding populations, conserving soils, avoiding erosion, allowing natural fire regimes and carefully planning roads to minimize impact – is therefore entirely consistent with what is required to conserve biological diversity.

Managing natural forests for sustainability requires moving beyond the outdated concept of maximum sustainable yield. In many parts of the world, the focus on this aspect has simplified the forest structure, replacing natural mixed forest with single-species and even-aged monocultures. While the area of planted forests is still very small (less than 5 percent of total forest area), the selection and breeding of planting stock – and in some cases intensive management – tend to narrow genetic diversity and reduce the number of associated species. Intensifying the management of natural and planted forests has often involved eliminating competing species, draining wetlands, suppressing natural fires and accelerating rotation cycles. At least in the short term, these activities have led to an increase in productivity, often at the expense of forest quality because of threats to forest-dwelling fauna and increased vulnerability to various pests. Sustained-yield forestry, designed to provide a steady stream of timber, is therefore not synonymous with sustainable forest management, which gives greater attention to various ecological processes and the range of related goods and services.

Sustainably produced timber

Since timber is the most valuable forest product in many forest ecosystems, a critical question is how it can be produced sustainably without depleting biological diversity. Natural forest management is widely advocated as the best hope of making forest land more profitable while maintaining biological diversity. Post-harvest surveys of a spectrum of tropical forests indicate a range of logging effects, from local extirpation to substantial increases in the local density of some species (Bawa and Seidler, 1998). This suggests that there are no easy answers.

A review of research on the impact of logging practices on tropical forest ecosystems and biological diversity concluded that the logging of mature forests commonly leads to a local increase in species diversity as structural and associated microclimatic changes create patches of habitat and food resources that are attractive to species typically residing in secondary forest and forest edges (Johns, 1997). However, populations of many taxa typically resident in forest understoreys markedly decline and remain locally scarce or absent for many years. Thus the most appropriate compromise between logging and the conservation of biological diversity in tropical forests is to have small undisturbed forest areas preserved within a larger matrix of production forest, a prescription that is being attempted in peninsular Malaysia and elsewhere (Poore *et al.*, 1989).

Several studies indicate that sustained timber-yield management of tropical moist forest can be technically and economically feasible (Rietbergen, 1993; Dykstra and Heinrich, 1992; Poore *et al.*, 1989), although little such technology is as yet being applied. However, it is possible, especially with low-intensity selective felling, to design harvesting operations that satisfy requirements for environmental, social and economic sustainability while reducing costs by a substantial margin. Recent developments in certifying environment-friendly timber indicate that progress is being made on the timber production side of sustainable forest management (Donovan, 2001), especially in temperate forests.

Non-wood forest products

While timber is economically the most important forest product, many other products are valued both on world markets and by local people. One study found that nearly 6 000 species of rain forest plants in Southeast Asia have economic uses (Jansen *et al.*, 1991; see Table 8). Moreover, many of these non-wood forest products (NWFPs) are of particular value to the local people, providing a ready store of products to meet their everyday needs for health, food and aesthetic pleasure. Animal species are also highly valued at the local and global levels, with the trade in skins, meat and live animals accounting for hundreds of millions of dollars per year (Reynolds *et al.*, 2001).

Although people in rural areas depend on hunting as a source of food or income and have been sustainably harvesting wild products for thousands of years, today's increasing population, more sophisticated technology and changing social, economic and political structures have removed most traditional controls over how such resources are harvested. Serious problems concerning hunting seem particularly difficult to address where governance is weak. Moreover, with greater access to remote forest areas and high prices on the international market, wildlife management agencies are too stretched to deal with increased incidences of overharvesting.

If benefits are to be provided on a sustainable basis to local communities and to countries at large, more effective controls may be required to

TABLE 8
Selected economic uses of Southeast Asian tropical rain forest plants

Product/commodity group	**Species** *(number)*
Timber trees	1 462
Medicinal plants	1 135
Ornamental plants	520
Edible fruits and nuts	389
Fibres	227
Rattans	170
Poisonous and insecticidal plants	147
Spices and condiments	110
Others	1 790
Total	**5 950**

Source: Jansen *et al.*, 1991.

maintain populations of harvested plants and animals at productive levels. The means to accomplish this will vary, but they must be built on sound economic and ecological principles, and often on traditional institutions. Establishing additional well-managed protected areas may at least partly restore the balance between hunter and prey that has enabled populations to survive and thrive in rural areas.

Benefits for people and society: a systems approach

An essential component of any effort for sustainable forest management is the economic viability of the various enterprises involved. While timber extraction is the most obvious money-earner, many other economic activities are possible. Furthermore, if local people can benefit financially from enterprises that depend on the biological diversity of the forest, they might reasonably be expected to support the conservation and sustainable use of forest ecosystems. Salafsky *et al*. (2001) tested this idea extensively across 39 sites in Asia and the Pacific through such activities as ecotourism, distilling essential oils from wild plant roots, producing jams and jellies from forest fruits, collecting other forest products and sustainably harvesting timber. The study concluded that a community-based enterprise strategy can indeed lead to conservation, but only under conditions that depend on external factors, such as market access. Moreover, any such enterprise can be sustainable only if it can adapt to changing circumstances. Because many forested areas are subject to political or economic turmoil, fire, drought and other external factors, this adaptability is essential to long-term sustainability. The complexity of factors affecting forests also calls for multiple levels (local, national and international) of biological diversity protection, providing the redundancy that ensures that all genes, species and ecosystems are conserved.

If the potential benefits of conserving forest biological diversity are to be converted into real and perceived goods and services for society at large, and especially for local people, a systems approach is needed. Its elements would include:

- at the national level, an integrated set of protected areas encompassing various levels of management and administration, including national, provincial and local governments, non-governmental organizations (NGOs), local communities, indigenous people, the private sector and other stakeholders (McNeely, 1999);
- within the framework of market-based economic systems, greater participation by civil society in economic development, extending to the management of both production forests and protected areas, especially for tourism and the sustainable use of certain natural resources (Szaro and Johnston, 1996);
- a large geographical scale (sometimes called a bioregion) for resource management programmes, within which protected areas are considered components in a varied landscape, including farms, production forests, fishing grounds, human settlements and infrastructures (Miller, 1996);
- cooperation among private landowners, indigenous people, other local communities, industry and resource users;

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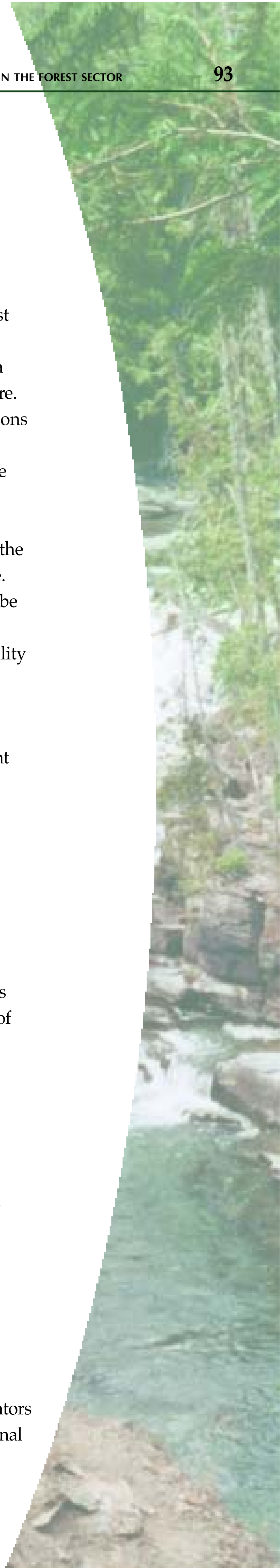
If local people benefit financially from enterprises that depend on the biological diversity of the forest – as does this seller of oils, creams, ointments and traditional medicines derived from forest plants in Brazil – they might reasonably be expected to support the conservation and sustainable use of forest ecosystems



- the use of economic incentives, tax arrangements, land exchange and other mechanisms to promote conservation of biological diversity;
- the development of administrative and technical capacities which will encourage local stakeholders, universities, research institutions and public agencies to harmonize efforts.

A programme for sustainable forest management that encompasses conservation of biological diversity needs to include both firm government action and alliances with stakeholders. Inasmuch as national governments cannot delegate their role as guarantors of the conservation of their countries' natural heritage, authorities need to build the capacity to fulfil their regulatory and management duties and responsibilities. However, civil society can share certain rights and responsibilities regarding the management of living natural resources, as long as the ground is carefully prepared and the rights and responsibilities are adequately defined. Given the interests of NGOs, industry, indigenous people and local communities who live within or close to protected areas and other forested regions, alliances should be created that enable each stakeholder to have a role according to clear government policies and laws.

CRITERIA AND INDICATORS FOR CONSERVATION OF BIOLOGICAL DIVERSITY

In view of the great variability of natural systems and the lack of any single measure of biological diversity, developing appropriate criteria and indicators to guide management interventions is a challenging task. This variability also makes it hard to determine the specific impact of any management measure on biological diversity. Any forest management action is likely to have a range of effects on the various components of biological diversity, benefiting some while damaging others. In addition, it is often difficult to show a correlation between changes in different components, even in those rare cases in which changes can be detected within relatively short time frames. Even where it is possible to demonstrate specific changes in biological diversity within a reasonable length of time, obtaining the necessary data may require substantial investment in monitoring programmes. In addition, many of the greatest threats to biological diversity are caused by policy measures that may be instituted from a distance, so that the effects are hard to measure.

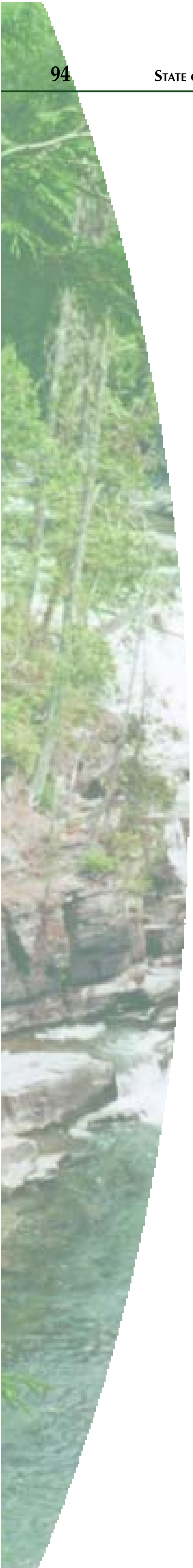
Despite such challenges, several organizations have developed criteria and indicators that generally fit within a pressure–state–response framework, where pressure is the cause of biological diversity loss, state is the current status of biological diversity and response is the set of measures taken to address the pressure. These criteria and indicators are designed to be applied by resource managers at the forest management unit level, where the responsibility lies for their implementation. Each indicator needs to be:

- relevant, relating to an explicit objective;
- representative, covering the most important aspects of sustainability;
- accurate, correctly reflecting the extent to which the objective is met;
- feasible in terms of data availability and collection costs;
- credible, analytically sound and replicable using standardized measurements;
- sensitive, showing trends over time;
- responsive, reflecting changes in conditions and differences among places and groups of people (Prescott-Allen, 1998).

Indicators appropriate for assessing conservation of biological diversity as part of sustainable forest management might include:

- the area of forest under sustainable management regimes;
- the percentage of the human population in and around the forest that is involved in sustainable production activities;
- population trends for certain designated species of plant or animal;
- the extent to which fragmentation remains within the limits of natural variation;
- the influence of invasive alien species.

One comprehensive set of criteria and indicators has been prepared by the Center for International Forestry Research (CIFOR, 1999).



CONCLUSIONS

The values that different sectors of society attach to various forest goods and services have changed more rapidly and deeply in the past few decades than ever before, and will continue to do so. The impact of climate change, forest fragmentation and invasive alien species on forest biological diversity has also increased considerably. These changes cannot reasonably be expected to slow down – and, indeed, many experts expect them to accelerate. The challenges facing forest communities, scientists, conservationists and foresters in the future are therefore likely to be very different from those facing them today. Society needs a range of approaches to forest management in order to provide multiple benefits to a wide variety of stakeholders with a legitimate interest in conserving forest biological diversity and using forests sustainably.

Within the context of sustainable forest management and in the face of global change, the following measures can help to conserve forest biological diversity:

- protection of large areas of forest, where this is still possible;
- rebuilding of connectivity between small adjacent protected areas by promoting reforestation of the landscape and restoring habitats;
- protection of forest edges against structural damage, damage by fire and colonization by invasive alien species, by leaving a natural buffer zone of forest that could be managed to resemble a natural ecotone (a transitional zone between vegetation types);
- softening the edges between matrices by diversifying and promoting less intensive types of land use, managing the use of fire, minimizing the application of toxic chemicals and controlling the introduction of plant species from outside the region (Gascon, Williamson and da Fonseca, 2000);
- allocation of the whole forest landscape to specified land uses, including:
  - protected areas for conservation, tourism and non-consumptive uses;
  - protection forests, for example to control erosion or protect watersheds;
  - production forests managed under sustained-yield principles for timber and other forest products;
  - planted forests for intensive production of specific commodities;
- inclusion of ecological reserves within commercial forests to protect seed sources, watercourses and critical habitats;
- forest management decisions based on the legitimate needs of local people for access to the range of forest resources upon which their livelihoods depend.

Sustainable forest management requires the development and implementation of sustainable production systems that are adapted to the different forest ecosystems. These should include scientific, technological, economic, social, financial and educational components to ensure sustainability. The exact combination of goods and services to be provided from any particular forested region should be based on dialogue among industry, government, academics, local communities and NGOs, thereby bringing democracy to forests and enhancing the likelihood of sustainability. ◆

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