Conserving Biodiversity: Reconciling Local and Global Public Benefits

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Poverty and biodiversity are interlinked in many ways. A number of studies (Dasgupta 1993, 1995; Pearce and Warford 1993) have identified correlations between rural poverty, population growth, landlessness, and pressures on natural resources—including biodiversity. Moreover, the links between poverty and biodiversity run in both directions. Poverty can undermine biodiversity, and biodiversity loss and the resulting degradation of ecosystems can exacerbate poverty. Biodiversity sustains the productivity of ecosystems, enabling them to provide economically important local services such as the hydrological cycle—including flood control, water supply, waste assimilation, nutrient recycling, soil conservation and regeneration, and crop pollination (Daily 1997). Loss of biodiversity causes long-term damage to people's health and food security.

Yet poor people often ignore the long-term effects of biodiversity loss. A number of studies have found that income levels influence the rate at which people discount the future. Although poor people may be risk averse, they tend to heavily discount the future environmental impacts of their actions (see Holden, Shiferaw, and Wik 1998; Pender 1996; and Perrings and Stern 2000). That is, they place more weight on the short-term cash benefits of intensive agriculture and forestry than on the long-term benefits (economic and otherwise) of conservation.

This chapter argues that the apparent tradeoff between poverty reduction and biodiversity conservation is largely false. Moreover, it could be avoided—or at least significantly reduced—by introducing some rather basic policy reforms. These reforms could improve the well-being of all interested parties—rich and poor, public and private. Biodiversity conservation is a public good that offers benefits across a wide range of temporal and spatial scales. Current strategies for conserving it often focus on its global benefits, ignoring its local benefits. Yet by doing so, these strategies not only fail to deliver important local benefits, they also place at risk a global public good: maintenance of the global gene pool. An optimal pattern of protection should reflect both the global and local public benefits of biodiversity conservation. The policy reforms offered in this chapter are designed to achieve that goal.

Special attention is paid to the different public and private benefits from biodiversity as a public good and to their implications for its conservation. In particular, the chapter considers the different interests of national, regional, and global stakeholders in biodiversity conservation and draws conclusions for strategies to protect certain areas, for the financing of conservation efforts, and for institutional reforms at the national and international levels.

Biodiversity as a public good

To understand the problem of biodiversity loss and to identify efficient and effective conservation strategies, it is useful to disentangle the various dimensions of the complex good *biodiversity conservation.* According to the Convention on Biological Diversity, biodiversity means "the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN 1992, art. 2, para. 1). Understanding biodiversity's various dimensions as a public and private good makes it easier to understand incentives to conserve it. This section considers two properties of biodiversity: its local and global public benefits and its private and public benefits (see also Sandler 1993).

Local and global public benefits

Biodiversity loss typically imposes two rather different costs. The first results from the loss of genetic information. The most obvious such loss is caused by the global extinction of species. But such losses also result from the fragmentation or demise of individual (local) populations. The genetic information contained in any species is spatially structured, and the extirpation of any genetic population involves a largely irreversible loss of information. Accordingly, biodiversity loss at any level diminishes the world's gene pool—an intergenerational global public good (Sandler 1999). This gene pool comprises the genetic information contained in the set of species on Earth as well as the information that may be provided in the future through the evolution of those species.

The second cost of biodiversity loss results from the reduction, fragmentation, exclusion, or deletion of a species from managed ecosystems. Such processes may or may not mean that the species is at risk of extinction. But again, a public good is at stake. The conservation of species in managed ecosystems protects the functioning of those systems and the ecological services they provide (table 1). Changes in the abundance of species in local systems may undermine those services—that is, biodiversity loss may generate multiple bads.

TABLE 1

Ecosystem functions and services

Regulation functions	Production functions	Carrier functions	Information functions
Ecosystems support economic activity and human welfare by: • Protecting against harmful cosmic influences • Regulating climate • Protecting watersheds and catchments • Preventing erosion and protecting soil • Storing and recycling industrial and human waste • Storing and recycling organic matter and mineral nutrients • Maintaining biological and genetic diversity • Exerting biological control • Providing migratory, nursery, and feeding habitats	Ecosystems provide basic resources such as: • Oxygen • Food and drinking water • Water for industry, households, and other users • Clothing and fabrics • Building, construction, and manufacturing materials • Energy and fuel • Minerals • Medicinal resources • Biochemical resources • Genetic resources • Ornamental resources	Ecosystems provide space and a suitable substrate for: • Habitation • Agriculture, forestry, fishery, and aquaculture • Industry • Engineering projects such as dams and roads • Recreation • Nature conservation	Ecosystems provide aesthetic, cultural, and scientific benefits through: • Aesthetic properties • Spiritual and religious significance • Cultural and artistic inspiration • Educational and scientific information • Potential information of value to future scientists

Source: Heywood 1995, p. 879.

Not all of nature's services are beneficial. They also include risks and threats such as malaria infection in tropical areas. Thus the benefits of biodiversity conservation need to be balanced against its costs. Moreover, not all community members may agree on the value of the benefits of conservation. Conflicts of interest need to be resolved through the political process.

The local and global benefits of biodiversity conservation involve public goods in the sense that the benefits are largely nonexclusive and nonrival. The global public good—the information contained in the gene pool—is a pure public good. But the local benefits of biodiversity conservation have a quasi-private character. They include benefits that can be privately captured, such as harvests from wild stocks. The quasi-private nature of such benefits explains why international conservation strategies tend to focus more on global than on local benefits—more on ex situ conservation and protection of biodiversity "hot spots" than on conservation of local ecosystems.

Private and public benefits

The local services provided by well-functioning ecosystems are often pure public goods: nonrival in consumption and nonexcludable, available for all people to enjoy. But the individual components of an ecosystem are often private goods. Biological resources such as animals and plants are rival in consumption and, if harvested in sufficient quantities, scarce. Worldwide, biological resources such as timber, fish, ivory, and medicinal plants are privately owned and routinely traded in international markets. Property rights matter because in the absence of coordinated conservation efforts, the level of conservation effort is determined by the value of conservation that can be captured privately. That is, biodiversity conservation is an impure public good. Some of its benefits may be captured privately, and some accrue to everyone.

As with other public goods, biodiversity conservation suffers from free riding. Without coordination, individuals and countries will not volunteer conservation efforts beyond the level in their own interest, and that level is determined by the value of conservation that can be captured privately. Every community member has an incentive to free ride on the conservation efforts of other community members and to neglect the benefits that his or her conservation efforts confer on other members (see appendix).

The same problem occurs at the global level. Every member of the global community has an incentive to free ride on the conservation efforts of others and to neglect the benefits that his or her conservation efforts confer on other members of the global community. The extent of the free-rider problem depends on the production technology used to supply public goods (Sandler 1997).[1]

Biodiversity conservation is a complex good that supports multiple, often contradictory services. Conservation may involve tradeoffs between private and public benefits and between local and global public goods. Effective conservation requires cooperation within and between local and global communities. Where compliance is difficult to monitor and enforce, concerned stakeholders must provide their full participation and support. But optimal participation and cooperation require well-informed decisionmaking. The value of biodiversity provides an important guide for decisionmaking.

The value of biodiversity

The values of most environmental public goods are unknown. Few reliable estimates are available for the costs of underproviding such goods and the benefits of corrective action. Biodiversity is no exception, because valuing it poses many conceptual and methodological challenges. Although such efforts have generated a large literature, the results remain rudimentary. Existing estimates of the benefits of global conservation are hardly adequate for decisionmaking (see Costanza and others 1997 for an implicit valuation). And while the value of the private benefits of biological resources is a useful proxy for the value of local biodiversity conservation, it is no more than a lower bound.

Valuing local benefits

Markets for foods and fibers are the main drivers of resource allocations in agriculture, forestry, and fisheries. But the market prices of products from these sectors typically do not reflect the costs to society of private agricultural specialization, land conversion, or marine exploitation. Market prices do not capture the value of global public benefits such as carbon sequestration or of local public benefits such as watershed protection, habitat provision, and nutrient recycling. Thus estimates of biodiversity values based on the market prices of outputs are poor reflections of social opportunity costs.

For example, the value of tropical forestland harvested for timber and nontimber products is the privately capturable value of land that is common property or subject to open access use. This value is typically lower than the value of the same land were it converted to other uses such as tourism. For example, a World Bank study of Mantadia National Park in Madagascar found that opening the park to tourism would generate more than three times the benefits of its use by local populations (Munasinghe 1993; Kramer and others 1994).

A similar problem exists in production systems. Market forces encourage farmers to choose crops with narrow genetic bases but high mean yields. As a result farmers often ignore the benefits to the farming community of greater genetic diversity in terms of averting the risk of crop failure. In ecological terms, biodiversity ensures that ecosystems are resilient, with resilience defined as a system's capacity to retain productivity following disturbance (Holling 1973; Common and Perrings 1992; Levin and others 1998). Lower diversity increases mean yields (at least in the short run) but also increases risk. Conversely, greater diversity reduces risk, but at the potential cost of lower mean yields. The farming community's attitude toward risk will determine its concern about the effect of diversity on the variance of yields.

Estimates of the value of biodiversity that can be captured privately, such as the value of harvested products, are poor proxies for the value of biodiversity conservation as a local public good. Most ecological services requiring a mix of species are not valued in the market. Prices do not reflect the implications of changes in land use for the provision of ecological services. In principle, valuing conservation efforts in terms of local public benefits requires specifying a production function that describes the relationship between the conserved species and the relevant ecological services (Mäler 1974; Smith 1991).[2] In practice, few studies specify this functional relationship.[3]

Valuing global benefits

Few studies have assessed the value of maintaining the global gene pool, the global public good secured by biodiversity conservation. (The exception are studies on carbon sequestration, which is largely independent of the diversity of species; see Pearce and Moran 1994; Brown and Pearce 1994; Fankhauser 1995; and Pearce 1998.) There are no credible estimates of the impact that local or global species extinctions have on the value of this global public good.

One very crude indicator is provided by the grants given by the Global Environment Facility (GEF) for global biodiversity conservation. The GEF finances conservation in developing countries if the efforts meet two criteria: they are additional to (that is, over and above) what the countries would do if they had only local or national benefits in mind, and they contribute to agreed global environmental goals. In principle, grants are based on the net incremental costs of biodiversity conservation (see also the financing chapter by Kaul and Le Goulven in this volume). The funds disbursed during the first eight years of GEF operations (1990–98) indicate ecosystem and conservation priorities (table 2).

The largest portion of GEF funding for biodiversity went to forest systems (40 percent), followed by coastal, marine, and freshwater systems (17 percent) and mountain systems (6 percent). Thus the bulk of GEF funds were targeted at conserving biodiversity in "natural" rather than "managed" ecosystems—particularly in ecosystems with high levels of endemism. Less attention was paid to biodiversity in agroecosystems. This pattern reflected the fact that the global public benefits of biodiversity conservation lie in the emergency prevention of species extinctions in so-called hot spots.

But in recent years GEF's approach has changed, and it now has a program that promotes the conservation and sustainable use of genetic resources of actual or potential importance to agriculture and food production. Specifically, the program supports projects that protect or enhance the ecological goods and services provided by biodiversity in agroecosystems.

TABLE 2

Global Environment Facility allocations for biodiversity conservation, 1990–98

(millions of U.S. dollars)

Type of disbursement	Pilot phase, 1990–93	GEF 1, 1994–98	Total (percent)
Ecosystem specific	**212.3**	**356.4**	**74.1**
Arid and semiarid systems	29.6	51.8	10.6
Coastal, marine, and freshwater systems	57.1	72.1	16.8
Forest systems	107.3	202.6	40.4
Mountain systems	18.3	29.9	6.3
General and institutional	**121.9**	**76.5**	**25.9**
Enabling grants	14.0	25.2	5.1
Short-term responses	107.9	51.3	20.8
Total	**334.2**	**432.9**	**100.0**

Source: Pearce, Moran, and Krug 1999.

Current trends in biodiversity loss—and conservation responses

Ecosystems face many pressures. The ways that local communities, countries, and the international community respond to those pressures reflect the various dimensions of the publicness of biodiversity conservation—of linked collective action problems as well as the costs of biodiversity loss and benefits of conservation. Current trends in biodiversity loss indicate that conservation is underprovided. This section reviews these trends and the conservation strategies adopted to counter them.

Estimates and costs of biodiversity loss

Underinvestment in biodiversity conservation has led to what scientists agree is a global mass extinction event (Wilson 1992; Leakey and Lewin 1997). The World Wildlife Fund estimates that in the past 30 years the world has lost a third of its natural wealth (WWF 2000). But scientists disagree on the number of species going extinct and on the economic and biological consequences of these extinctions (Ehrlich 1998). Because habitat destruction is often cited as the main cause of species extinctions, natural forest loss is the measure most often used to estimate species extinctions. Extinction rates are highest in low-income countries, although biodiversity loss was also significant during earlier stages of development in today's industrial countries (WWF 2000). Still, current global extinctions largely reflect local land use decisions in developing countries.

Changes in land use affect biodiversity in both managed systems and their ecological hinterlands. Consider agroecosystems. Market-induced specialization, animal and plant selection, and modern plant and animal breeding have narrowed the genetic base of agriculture to the point where most of the global food supply derives from a handful of species: wheat, rice, corn, oats, sorghum, plantains, tomatoes, potatoes, cattle, sheep, pigs, chickens, and ducks. Moreover, within each of these species there has been a substantial loss of genetic diversity. For example, the adoption in recent decades of high-yielding rice varieties has led to the abandonment of traditional varieties bred over thousands of years. In India 10 rice varieties account for about three-quarters of production. Before the green revolution about 30,000 varieties were cultivated, with no dominant varieties. Bangladesh, Indonesia, and Sri Lanka exhibit similar concentrations of production in a small number of varieties (Cervigni 2001).

The global cost of the local loss of land races and wild relatives is the forgone opportunity to use their genetic material to breed or engineer desirable traits in crops that could be cultivated worldwide. All cultivated crop varieties and livestock strains contain genetic material from land races, wild relatives, and traditional livestock strains. At least half of the increase in agricultural productivity during the 20th century was due to artificial selection, recombination, and intraspecific gene transfers. For example, Mexican beans have been used to improve resistance to the Mexican bean weevil, which destroys or damages up to 25 percent of stored beans in Africa and 15 percent in South America. Thus the loss of land races and traditional varieties has potentially high global costs.

A further consequence at the local level is that agroecosystems have become more susceptible to shocks and changes in environmental conditions. Adopting crops with a narrow genetic base increases average yields, but it also increases the variance of yields (Conway 1993). The public good at stake in the simplification of agroecosystems is their capacity to maintain productivity over a range of conditions. Preliminary estimates confirm that the loss of crop genetic diversity increases the variance of farm incomes in both industrial countries (Gatto 2001) and developing countries (Prakash and Pearce 2001).

Conservation strategies

Historically, the scale of biodiversity conservation efforts has been related to the resource catchment of the society involved (Gadgil 1996). For example, conservation in hunter-gatherer, shifting cultivator, and horticultural societies was location-specific and often embedded in nature worship. Conservation efforts included protection of sacred groves, ponds, and river stretches. These protected areas provided a range of benefits. For example, the sacred groves (called *orans*) in the Indian state of Rajasthan supported the fuel and fodder needs of local communities while safeguarding tree growth (box 1; see also Gokhale and others 1998; Gadgil, Berkes, and Folke 1993; and, for examples from a range of indigenous societies, Posey 1999).

In addition to their amenity, cultural, and spiritual significance, protected areas have been important sources of foods, fuels, fibers, seeds and other plant regeneration material, and habitat for important species such as pollinators. Many such areas offered reserve supplies of foods, fuels, and fibers that were exploited only in extreme conditions. That is, they represented community savings, though in the form of real rather than financial assets. Such protected areas were typically small, often between 1 and 10 hectares and seldom more than 100 hectares.

As societies' resource catchments have grown, so have protected areas. Agrarian societies protected aristocratic hunting preserves that sometimes extended over thousands of hectares. These areas also provided fodder, fuelwood, and small game for the common people. In addition, industrial (and some developing) countries have created national parks that cover hundreds and sometimes thousands of square kilometers—initially to provide recreation and more recently to conserve biodiversity.

The international community has developed two ways to conserve biodiversity. In situ conservation involves protecting ecosystems and natural habitats and maintaining viable populations of species in their natural surroundings (UN 1992, art. 8). Ex situ conservation refers to conservation in zoos, botanical gardens, breeding programs, germplasm laboratories, and gene and seed banks (UN

BOX 1

TRADITIONAL PROTECTED AREAS—THE *ORAN* OF DOLI KALAN

Orans are a traditional, extensive system of sacred forests and pasture lands in the semiarid and arid tracts of the Indian state of Rajasthan. Until 1954 orans were under the control of local landlords, and all villagers observed a taboo on the felling of green trees and used deadwood and fodder in a regulated fashion. These lands were brought under government control in 1954, but in the absence of an alternative system of regulation, orans have been overused and encroached on for agriculture and habitation.

The 34-hectare oran of Doli Kalan (Barmer district) is an exception due to the Bishnoi farmers in the village. Bishnois are a religious sect committed to protecting *Prosopis cinerarea* trees, peafowl, and antelope. They are the dominant community in Doli Kalan and, despite no legal backing, they keep all outsiders away from their oran. They also enforce a strict taboo on lopping any green parts from the oran, including leaves of *Prosopis cinerarea* trees. As a result this oran has well-maintained tree cover and a good population of peafowl and antelope.

Source: Gadgil 1998.

1992, art. 9). Ex situ conservation is aimed at protecting the gene pool. In situ conservation protects both genetic information and the ecological services supported by the conserved species.

As noted, in many countries in situ conservation involves large parks or protected areas in biodiversity hot spots and other high-endemism areas. Large protected areas offer important scale economies. By reducing the ratio of boundary length to protected area, for example, they lower the cost of protection per hectare. And by concentrating on species-rich areas, they lower the cost per species saved. Still, the creation of large conservation areas ignores the fact that biodiversity conservation offers two quite different sets of benefits—that is, it is a joint public good. In addition to preserving genetic information, biodiversity conservation supports the kind of ecological services that motivated historical conservation efforts. These services tend to increase with the ratio of boundary length to protected area. They also depend on the proximity of the protected area to the activities that benefit from the services.

The local public goods offered by biodiversity conservation imply a different scale and pattern of protected areas. They are less sensitive to species richness or endemism. They are also more closely connected to the productivity and resilience of managed, productive agriculture, forestry, and fisheries. The provision of distinct public goods generally requires conservation of distinct sets of species. The set of pollinators is not the same as the set of nutrient recyclers, the set of soil stabilizers, and so on.

From the perspective of these ecological services, one society has a limited interest in the conservation efforts of other societies, because the benefits of conservation in other societies do not accrue to it. Indeed, different societies may have conflicting interests in the diversity of species. Eco-tourists, recreational hunters, and wildlife ecologists in industrial countries are typically interested in different species and different protection regimes than are crop and livestock farmers in developing countries. The first group generally prefers larger protected areas. The second group prefers smaller areas, with overlapping zones for conservation and productive use. If conservation efforts are intended only to maintain the global gene pool, focusing on hot spots is probably the most efficient and effective strategy. But if poverty reduction is also a goal, current conservation strategies need to be rethought to capture the value of biodiversity for local communities.

Moving toward more sustainable and equitable use of biodiversity

At current deforestation rates, tropical forest habitats will nearly disappear within 50 years. The main reason, as noted, is that the private benefits of conservation are less than the private opportunity costs of conversion (Panayotou 1995). So, in the absence of coordination, what is the best way to enhance the private benefits of conservation? And what is the best way to coordinate national and international conservation efforts?

As a first step, more detailed studies are needed on the costs of a business as usual approach and the benefits of alternative conservation options—including the likely distribution of those benefits. In addition, given the plethora of international, regional, and bilateral agreements on biotic and abiotic resources (Brown Weiss 1993), the interactive effects of such agreements need to be better understood. Many multilateral negotiations aim to induce countries to adopt national conservation policies that provide global benefits. The Convention on Biological Diversity and its financial instrument, the Global Environment Facility, and the International Treaty on Plant Genetic Resources for Food and Agriculture (developed by the UN Food and Agriculture Organization) both emphasize the benefits to nation-states of acting in the global interest.[4] But neither of these international agreements nor the principles guiding Global Environment Facility operations address local interests in protecting important ecosystem services.[5]

Because most local conservation efforts are limited by the private returns to conservation, countries must reassess their national incentive structures. Biodiversity loss is the result of two sets of failures: market failures and public policy failures. Adjusting national incentives has, in turn, two elements. One is generating incentives for biodiversity conservation. The other is discouraging perverse incentives against conservation.

But incentives are also needed to protect public goods at the local level, where millions of foresters, farmers, hunters, harvesters, herders, and fishers use environmental resources every day. Local incentives imply a mix of direct incentives (taxes, subsidies, grants, compensation payments, user fees and charges), indirect incentives (through fiscal, social, and environmental policies), and disincentives (prosecution leading to fines and other penalties).

Thus a dual-track approach is needed. International agreements are important for the international coordination of conservation efforts and for the provision of national incentives to protect the global gene pool. National policies are essential to link countries to international frameworks and to foster national cooperation and fairness. But international and national frameworks will achieve little unless biodiversity conservation makes sense locally—in the context of local ecosystems and local people's lives. Local communities must be fairly rewarded for conservation efforts they make in the national, regional, and global interest, and those conservation efforts must be consistent with the protection of local public goods. A locally rooted conservation strategy calls for some or all of the following policy measures.

Co-locating production and conservation areas

Creating and maintaining large protected reserves in areas with high biodiversity will undoubtedly remain part of the international strategy for biodiversity conservation. But large protected areas alone will not solve biodiversity loss at the local or the global level. A strong case can be made for a complementary system of many small protected areas.

For many environmental gradients, smaller protected areas can capture variation more effectively than can larger areas. In addition, smaller areas can better meet local conservation needs in agriculture, forestry, and fisheries. This decentralized approach matches the conservation practices of traditional societies. Reports from the northeastern hill states of India, for example, suggest that at least 10 percent of the land area is conserved as sacred groves or ponds—meeting the goal proposed at the Fourth World Congress on National Parks and Protected Areas. But the protected area is extremely dispersed (Gadgil, Hemam, and Reddy 1997).

Protecting a few large islands of globally significant diversity surrounded by oceans of low-diversity landscapes does not ensure sustainable, equitable use of biodiversity. What is needed is a two-pronged approach. The global public good, the world's gene pool, can be partly protected by creating special refuges. But protecting the local public good requires achieving an optimal—not necessarily maximal—level of biodiversity in production forests, aquatic bodies, and pastoral and arable ecosystems. This goal is best achieved by co-locating production and conservation areas.

A practical guide to the appropriate scale of governance for local environmental public goods may be provided by the spatial spread of traditional access rights. The formal recognition of those rights would be a good starting point for the (re)institution of local authorities empowered to manage access to those goods and to have a say in determining the local-private balance in the use of local ecosystems. India's joint forest management committees offer an example of this approach (box 2). Similar indigenous management systems have emerged in other parts of the world (Ostrom 1990; World Resources Institute and others 1993).

The global public benefits of biodiversity conservation would also gain from a greater emphasis on complementary local efforts because such a dual-track approach would facilitate species innovation. This approach would add dynamic efficiency to the static efficiency provided by maintenance of the gene pool, with significant potential benefits for humankind's future well-being.

Although the most important goal of this strategy is to develop conservation efforts that increase direct local benefits, there are potential global benefits from local conservation efforts. For example, and as noted, the global cost of the local loss of land races and wild relatives is the forgone opportunity to use their genetic material to breed desirable traits in crops cultivated worldwide. According to the incremental cost argument, those responsible for local conservation efforts should be compensated for such global benefits. A decentralized approach to local conservation is indispensable. But its success will critically depend on whether it "pays"—and hence, whether it offers a fair deal and becomes self-sustaining.

BOX 2

Indigenous management systems—the Dhani Village Forest Committee

All community-based forest resource management institutions that existed in India prior to British rule were dismantled when the state took over forestlands. More productive lands were converted into "reserve" forests, dedicated to production of commercial timber. Less productive lands were assigned as "revenue" forests for meeting local biomass needs. But because communities had no control over revenue forests, they were treated as open access resources. Reserve forests were depleted of valuable timber but retained better vegetative cover during British rule. Revenue forests, devoid of all regulation, were far more degraded. At independence in 1947 the demand for commercial timber rose rapidly as a result of promotion of forest-based industries, and reserve forests too were soon depleted.

More recently, the system of joint forest management was introduced. Local communities were given some authority to protect patches of forests and assigned a share of the timber as a reward (Gadgil and Guha 1995). This approach has been successful despite the reluctance of forest managers to share authority with villagers, their refusal to assign good forestland for this purpose, and the lack of cohesion in many village communities. Although there is a limited number of formal village forest committees, the legal recognition accorded to them has triggered the establishment of thousands of informal such committees entirely managing their own affairs without any involvement by the forest authorities in tribal villages in the state of Orissa.

The Dhani forest committee is one such committee. It brings together five villages and has promoted the regeneration of 840 hectares of forest tract since 1987. Among the committee's notable features are its flexible regulations, implemented in an adaptive fashion. The general body of the committee oversees the management of the forest as well as issues such as framing rules, resolving conflicts, taking action against offenders, and distributing benefits. The general body has a regular meeting once a year. But in an emergency-such as a forest offense or amendment of existing rules, a meeting of the general body can be called at any time.

Over the years the committee has changed its rules in response to changing conditions. In the first year of operations, for instance, no people or cattle were permitted to enter the forest. After that the area was opened for grazing outside the rainy season from October to June. At the same time, people were permitted to enter the forest to collect dry and fallen wood and leaf litter between July and February. Subsequently, poor members of the community were permitted to extract a limited quantity of fuelwood.

continued overleaf

BOX 2 CONTINUED

Restoration of the vegetation has led to the return of wildlife to the area. The Dhani Village Forest Committee considered a proposal to declare the forest a wildlife sanctuary. But the proposal was rejected on the grounds that it would lead to a takeover by the government and denial of villager access to forest resources that had been replenished by their voluntary efforts (Gadgil 1998).

Through the Convention on Biological Diversity, some of these issues are being addressed in international negotiations. For example, the International Treaty on Plant Genetic Resources for Food and Agriculture recognizes the roles and rights of local farmers. In fact, Africa has developed a model law for protecting the rights of local communities, farmers, and breeders and for regulating access to biological resources (Egziabher 2001, p. 11). But the success of such decentralized management systems depends on the willingness of the international community to support a bottom-up perspective—one in which local ecosystem conservation is the foundation of the global institutional architecture for biodiversity conservation.

Adjusting incentives

As noted, better ways are needed to compensate individuals and communities for local conservation efforts. This implies establishing property rights and incentives that confront people with the full costs of their actions and providing compensation for those who confer local or global public benefits on others.

Take watershed protection. Although communities derive considerable benefits from local watershed protection, the main beneficiaries are often downstream users who are protected from floods and who receive larger flows of higher-quality water than would be the case without protection. The watershed value of forests should be reflected in water and irrigation prices, perhaps through a fee for watershed protection. These fees should then accrue to the community authorities responsible for forest protection.[6] In countries that rely on hydropower, such as Costa Rica, El Salvador, Lao People's Democratic Republic, Sri Lanka, and Vietnam, watershed protection costs could be recouped through electricity tariffs.

Conservation could also generate income through levies on activities such as eco-tourism and the recreational and commercial harvest of wild-living resources. The co-location of many wildlife reserves, wildlife management areas, and hunting concessions in terrestrial systems, and of marine protected areas and fisheries in aquatic systems, reflects the dual role of protected areas. The areas are both conservation mechanisms and reservoirs for the harvested species. Co-location strategies are attractive because the complementarity of conservation and exploitation increases revenue—for example, wildlife reserves support eco-tourism while adjacent hunting concessions support recreational hunting. Indeed, the potential benefits from the commercial harvest of protected species are the expressed motivation for creating marine protected areas (Roberts 2000).

Such co-location strategies are typically far more profitable than better-known arrangements for bio-prospecting. Bio-prospecting contracts between pharmaceutical companies and developing countries, such as between Merck and Costa Rica's Institute Nacional de Biodiversidad, have received a lot of publicity. The contracts seek to mobilize investment in biodiversity conservation by offering the companies access to genetic resources, protected by the assignment of intellectual property rights to genetic "discoveries" (Schulz and Barbier 1997). In addition, bio-prospecting offers local people a fair share of the deal to make conservation worthwhile for them. But such contracts are not widespread, and they generally have not yielded competitive returns (Barbier and Aylward 1996; Simpson, Sedjo, and Reid 1996; Pearce, Moran, and Krug 1999).

Similarly, there is potential for local conservation benefits through emissions trading, especially when it involves forest conservation for carbon sequestration (see Castro and Cordero in this volume). But emissions trading involving reforestation for carbon sequestration is less obviously linked to biodiversity conservation and should probably be discounted (Barbier and Perrings 2001).

The financing of local conservation efforts is complex. Communities seeking to relate their conservation efforts to the global public good may need considerable support. They will find themselves linked to international markets and actors with far more power, information, and skills in determining costs and benefits. Certainly, international agreements and national policies can do more to ensure that emerging markets and trade in environmental goods and services work as well as possible. But markets are primarily intended to achieve allocative efficiency. Additional instruments may be needed to ensure that the benefits of conservation are fairly distributed. That said, the local benefits of local conservation efforts, if properly recognized and compensated, are often sufficient to warrant action regardless of any global benefits. Indeed, this should be the primary focus of reform.

Extending the Global Environment Facility

The equitable sharing of international benefits faces powerful obstacles. The Global Environment Facility's incremental cost principle implies that countries should be compensated for contributing to global public goods. But the structure of international markets and the rules governing international trade and investment mean that transactions falling outside the facility's projects carry no guarantee of equitably shared benefits.

The solution is not to restrict those markets. Indeed, there is considerable scope for markets to be further developed to deliver external benefits to local biodiversity conservation. But if local communities are to be compensated for agroecosystem conservation efforts that yield global benefits, the Global Environment Facility's focus and resources need to be extended. Developing countries have a strong interest in and an even stronger argument for such an extension.

The Global Environment Facility's long-standing emphasis on creating protected areas has started to be relaxed in recognition of the fact that many off-reserve conservation and development projects increase biodiversity protection in reserves as a side benefit. A financially strengthened Global Environment Facility might serve both the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture by addressing the incremental costs of biodiversity conservation in agroecosystems. The main beneficiaries would be small farmers, as custodians of agricultural biodiversity—consistent with the reference to equitable benefit sharing in the convention and the recognition of farmers' rights in the treaty. More important, the new approach would reflect the concerns of developing countries, which argue that the loss of species in local production systems—and especially the loss of intraspecific crop genetic diversity—has been undervalued in global conservation strategies.

International institutional reforms

At the international level, legislative and operational responsibility for the conservation of genetic diversity rests with a range of UN and other agencies: the Food and Agriculture Organization, United Nations Environment Programme, United Nations Educational, Scientific, and Cultural Organization, World Intellectual Property Organization, World Trade Organization, and through the Global Environment Facility, the World Bank and United Nations Development Programme. Given this fractured architecture, some analysts have called for the creation of a World Environment Organization (Whalley and Zissimos 2000) or Global Environment Organization (Runge 2001). These suggestions have also been prompted by the view that the World Trade Organization is not the place to discuss the environmental effects of trade (Bhagwati 2000; Barrett 2000). In addition, as this chapter has shown, no institution systematically addresses trade in global environment services, such as the global public benefits of biodiversity conservation.[7]

As a first interim step pending the formation of a World Environment Organization or Global Environment Organization, it is worth considering the World Heritage Action Trust (2000) recommendation to establish a UN consultative council on biodiversity and food security. This council could promote initiatives by UN agencies and other organizations and reconcile conflicting approaches to the issues. More important, it could explore the institutional requirements of a strategy for protecting the global public interest in off-reserve biodiversity conservation, particularly in sustainably managed agroecosystems.

A second proposal could be to support the extension of the Consultative Group on International Agricultural Research (CGIAR). The CGIAR was established in 1971 to help developing countries meet their food security needs. During its first 20 years the CGIAR, through its 16 international centers, conducted research for developing countries and established the world's largest collection of germplasms. Thus the CGIAR has contributed significantly to the provision of such global public goods as the global gene pool and knowledge for all (Dalrymple 2001). But the subglobal public benefits of conservation have traditionally not been considered in conservation strategies. In the mid-1990s the CGIAR underwent a reorientation (Waters-Bayer 2001). It seems that it is now well positioned to pursue the dual-track approach to conservation suggested here, complementing its tradition of providing global benefits with a decentralized conservation strategy such as its proposed participatory plant breeding program.

Conclusion

Biodiversity conservation offers both local and global public benefits. But these benefits tend to be undervalued, and conservation efforts tend to be motivated more by their private benefits than by any public benefits. The little coordinated international conservation that does occur is focused on the global public benefit of biodiversity—maintenance of the gene pool. Conservation policy should consider four reforms:

- Complementing current large-scale conservation efforts with a decentralized strategy that co-locates production and conservation areas, and puts area management rights and responsibilities in the hands of local authorities.
- Adjusting incentives to reward local communities for their conservation efforts—and to hold accountable actors who produce negative externalities.
- Extending the Global Environment Facility's portfolio and resources to support local conservation efforts that yield global public benefits.
- Consolidating the international institutional architecture to allow more systematic trade in global environmental services.

If these reforms were implemented, the tradeoffs between poverty reduction and biodiversity conservation would be less sharp. Biodiversity conservation and poverty reduction could not only go hand in hand, but would be mutually reinforcing.

Appendix

Formally, suppose that V^i denotes the welfare of the ith of n communities. This welfare is assumed to depend on consumption of a bundle of market goods, x^i, and a global public good, biodiversity conservation, $Y = y^1, y^2, \ldots, y^n$. If there are m members of the ith community, this implies that $V^i = V^i(U_1^i,\ldots,U_m^i)$ and $U_j^i = U_j^i(x, y_j^j, y_1^i, \ldots, y_m^i)$ for all $j = 1,\ldots,m$. The problem faced by the ith community is of the general form:

$$\mathrm{Max}_{xi,\,yi}\ V^i = V^i(x^i, y^i, Y).$$

That is, the ith community obtains benefits directly from its conservation efforts, y^i, and from the global benefits generated by its contribution to global conservation efforts, Y. Barbier and Perrings (2001) pose the problem for the ith community in the following way:

$$\mathrm{Max}_{xi,\,ui}\ V^i(.) = V^i(x^i, y^i, C(Y, Z) \mid x^i + py^i = I^i)$$

where $C(Y, Z)$ is a conservation function that increases with the size of the global public good (the level of biodiversity), Y, $C_Y > 0$, and the resources committed to conservation, Z, $C_Z > 0$. If all communities do not cooperate, the welfare of the ith community is maximized where:

$$\frac{V^i_{Y^i}}{V^i_{x^i}} = p - \frac{V^i_c}{V^i_{x^i}} C_{y^i}$$

whereas the welfare of the global community requires that:

$$\frac{V^i_{Y^i}}{V^i_{x^i}} = p - \Sigma \frac{V^i_c}{V^i_{x^i}} C$$

The extra terms reflect the conservation benefits that the ith community confers on others. If the "cost" of conservation is denoted as w, the globally optimal level of conservation will satisfy:

$$\frac{V^i_{Y^i}}{V^i_{x^i}} = p - w \frac{C_Y}{Y_Z}$$

NOTES

1. The supply technology, in turn, depends on the nature of the public good. Consider the control of biological invasions, a "weakest link" public good. A national quarantine policy to protect against invasive pathogens reduces the risk to all people in the country concerned. The benefits of quarantine are neither rival nor exclusive: if one person benefits from the protection offered by a quarantine policy, it does not affect the cost of quarantine or reduce the benefits of quarantine to others. But the level of protection offered to the entire community depends on the level of protection supplied by the least effective quarantine facility. If one quarantine facility fails to

identify and exclude an invasive pathogen, all are at risk. That all other quarantine facilities may do so is irrelevant. Ex situ genetic conservation measures, by contrast, are "best shot" public goods. In this case free riding imposes no costs on society.

2. Specifically, if Q is the marketed output of an economic activity and it depends on both a range of marketed inputs, $\mathbf{x} = x_1,\ldots,x_n$ (capital, labor, materials, and so on) and on a natural resource, R, that depends on the set of species, $s = s_1,\ldots,s_m$, then the production function can be written as:

$$Q = Q[x_1,\ldots,x_n, R(s_1,\ldots,s_m)].$$

If P denotes the value of Q, then the value of the ith species, s_i, is the value of the marginal impact of that species: $(PdQ/dR)(dR/ds_i)$. If a change in the abundance of the ith species also affects the abundance of other species in the community, then the value of the ith species, s_i, is $PdQ/dR[dR/ds_i + (dR/ds)(ds/ds_i)]$. That is, it includes both the direct and indirect impacts of a change in the abundance of s_i.

3. An early exception is the valuation by Hodgson and Dixon (1988) of watershed functions in Bacuit Bay, Palawan, the Philippines. This study considered the off-site effects of forest depletion—specifically, the impact of logging activities on sedimentation that in turn affected coral cover, coral diversity, marine tourism, and fish production in Bacuit Bay. The study found that annual sediment deposits of 100 million metric tons per square kilometer led to the extinction of one coral species a year. This extinction was correlated with a 0.8 percent decrease in fish biomass. The negative impact on coral cover of annual sediment deposits of 400 million metric tons per square kilometer was calculated to cause a 2.4 percent decrease in fish biomass.

4. The International Undertaking on Plant Genetic Resources for Food and Agriculture, adopted by the Food and Agriculture Organization (FAO) in 1983, was the first international agreement on the management of food and agricultural plant genetic resources. After the Convention on Biological Diversity was adopted in 1992, the specificity of agricultural biodiversity was acknowledged by the parties to the convention, and the FAO's undertaking was revised to harmonize with the convention. In November 2001 the FAO adopted the undertaking as the International Treaty on Plant Genetic Resources for Food and Agriculture. The treaty will go into effect once 40 countries have ratified it.

5. Barrett (1994) concludes that, at best, an agreement like the Convention on Biological Diversity could achieve an outcome only slightly better than the noncooperative Nash equilibrium. For biodiversity conservation to increase, locally capturable returns to investment in it will have to improve.

6. The Dunoga Bone Combined Irrigation and National Park System in Sulawaesi, Indonesia, shows how water fees can be used to finance biodiversity conservation.

7. The Convention on International Trade in Endangered Species deals with international markets for individual species or products of species. This is different from the trade in global environmental services, such as carbon sequestration or biodiversity conservation, discussed in this chapter.

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