Chapter 16

Ecosystem Services in Subsistence Economies and Conservation of Biodiversity

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Natural and human-impacted ecosystems provide a range of goods and services to human societies and play a vital role in sustaining many, if not ultimately all, human endeavors and enterprises. The goods, in the form of drinking water, fish and shellfish, wood and nonwood products, constitute significant components of local and national economies and sustain livelihoods of millions of people living in and around ecosystems. Dasmann (1988) has appropriately termed such inhabitants as the ecosystem people, to distinguish them from the biosphere people. Ecosystem people include forest dwellers, herders, fishers, and peasants, who rely on biological resources of local ecosystems to fulfill most of their needs. Biosphere people include urban dwellers of the industrialized societies and people engaged in high-input agriculture and animal husbandry. They do not depend on local ecosystems for their basic needs; the catchment area for their resource needs is the whole biosphere. For the ecosystem people, natural communities have been an integral part of their lives for millennia. In many ways, the ecosystem people behave as integral components of the ecosystems they inhabit (Gadgil 1995).

Environmental economists often make the distinction between goods and services provided by ecosystems. Ecosystem goods harvested by people are, however, often products of ecosystem processes such as biotic interactions, energy flow, and nutrient cycling. In the case of ecosystem people there is an additional justification in considering all goods as ecosystem services. Although the ecosystem people harvest many products from ecosystems, these

products are used primarily to sustain their own livelihoods, which are embedded in the ecosystem in which they live. In contrast, the biosphere people extract ecosystem products for commercial purposes. Of course, with monetization of subsistence economies, and with increased commercial exploitation of ecosystem products, the ecosystem people also become engaged in extraction of resources far beyond the levels necessary to meet their own needs, for use by the biosphere people. Nevertheless, even when products are harvested commercially, the ecosystem people often derive only subsistence-level wages for the time spent in harvesting products. These wages, together with products gathered for their own use, may fall more appropriately under ecosystem services than under ecosystem goods.

Resource managers and conservation biologists have until recently ignored the importance of ecosystem services in supporting the livelihoods of ecosystem people and the potential contributions that such people can make to conservation of biodiversity. Livelihoods based on ecosystem services provide a direct link between people and biodiversity in much of the developing world. The reliance of local communities on ecosystem services to sustain their livelihoods can form the basis of grassroots support for conservation efforts. Yet attempts to involve ecosystem people in conservation activities have been sporadic and limited (Western and Henry 1994).

Here we assess the importance of ecosystems in sustaining the livelihoods of millions of ecosystem people. We first define ecosystem services of interest and identify problems in valuation of these services in the context of sustaining livelihoods of ecosystem people. Despite difficulties in valuation, we provide some estimates of the amounts and importance of services. We show that technological changes are leading to the disruption of these services and the unsustainable use of the resources. We conclude with a discussion of policy changes that should enhance the probability of sustainable use of services and goods, and incorporate ecosystem people in efforts to conserve biodiversity. Specifically, this chapter has two goals: the first is to demonstrate the importance of ecosystem services in the livelihoods of ecosystem people and rural poor, and the second is to show how the ecosystem people can be and should be involved in conservation efforts.

Problems in Valuation of Services

Environmental goods and services are often valued by making an initial distinction between use and non-use values (Pearce and Moran 1994). The use value may be subdivided into direct use value and indirect use value. The former refers to the value of goods and the latter to services. Goulder and Kennedy (chapter 3, this volume) distinguish a third type of service, the provision of production inputs, that includes many types of services associ-

ated with ecosystem processes and generally included under indirect use value. The non-use value may be distinguished into bequest and existence values. The bequest value simply refers to the value an individual ascribes to the knowledge that others may benefit from a resource or service in the future. The existence value is derived from the knowledge that an environmental resource or service exists. Option value or the price an individual is willing to pay to retain the options of using services at a future date is generally included under the non-use value but can also be applied to goods.

Traditional valuation techniques pose at least five major problems in quantifying ecosystem services with respect to subsistence economies. First, valuation techniques, particularly with respect to indirect use value and non-use values, involve subjective value judgments of people living in modern urbanized societies. Application of such value judgments to societies with radically different social and economic structures not only poses methodological difficulties but also raises moral and ethical issues. If indeed many of the societies that rely on ecosystems for subsistence livelihoods are an integral part of the ecosystem they live in, then valuation exercises tend to place monetary value on a particular lifestyle and culture by those who do not share these lifestyles and cultural values.

Second, the valuation techniques are relatively easy to apply in fully monetized economies that are homogeneous and involve individuals who are well informed about choices and in a position to exercise various options. In contrast, subsistence economies in various parts of the world are very heterogeneous, with different value systems. Moreover, economies often are not fully monetized and individuals are not well informed about choices and are economically and socially constrained to exercise various options.

Third, despite the availability of sophisticated techniques, certain benefits remain difficult to quantify in monetary forms. For example, as is well known, ecosystem people use a wide variety of medicinal plants for their health care. However, contributions of medicinal plants to the local economy are hard to quantify. The efforts to value plant medicines emphasize the option value for pharmaceutical companies but ignore the uses of herbal medicines by local people (Brown 1994). For local communities, surrogate values derived from health care costs of comparable income groups in rural or urban areas may not be used because people in such areas spend less than they would like to because of the high costs in relation to their ability to pay. In contrast, the ecosystem people are free of such constraints because herbal medicines collected from the forest do not impose heavy costs.

The productivity of ecosystem goods, which form the basis of subsistence economies, depends on the functioning of the ecosystems. For example, a multitude of processes are involved in the production of ecosystem goods; the formation of such products as fruits and seeds alone requires a wide array of biotic interactions. Processes such as pollination, seed dispersal, and

even nutrient uptake require interaction among plants, animals, and microorganisms. In theory, the functional processes can be valued, but current valuation methods for products do not assign value to functional processes (Vatn and Bromley 1995), implying that such processes are free.

Valuation of cultural, religious, and spiritual services is even more difficult than that of goods and ecological services from natural ecosystems. Interestingly, such services, at least in partly monetized economies and in areas experiencing rapid depletion of natural habitats and ecosystems, may be more vital to the well-being than the goods from the ecosystem. In many countries, sacred groves or ponds persist even in areas where landscape has been modified for centuries to eliminate natural forest, as for example in the Western Ghats and the Meghalaya state of India. These sacred sites in many cases may fulfill only religious, spiritual, and cultural needs. Existence value can perhaps cover cultural, religious, and spiritual services, but apart from the appropriateness of assigning monetary value to such services, there is little experience in applying valuation techniques to such services.

Another problematic area in valuation is the contribution of ecosystems to human knowledge. As is well known, ecosystem people have accumulated a large body of practical knowledge about the uses of organisms and their interactions with the environment for medicinal and other purposes. This practical knowledge provides biosphere people with a springboard for new developments and innovations in medicine, agriculture, forestry, horticulture, animal husbandry, toxicology, and other endeavors. This practical knowledge is lost with the destruction of ecosystems and extinction of species. The value of such knowledge has been increasing steadily with the growing number of environmental challenges and with increasing potential of technology to transform practical knowledge to new goods and services.

The fourth hurdle in valuation is that costs and benefits, actual and perceived, of conserving a given area are different for different sectors of the society (Wells 1992). However, valuation methodologies do not take into account variation among different sectors of society in assigning value to ecosystem services. For example, ecosystem services such as pure air and water and biodiversity may be perceived to be more valuable by a person living in an urban environment, devoid of biodiversity, and full of polluted air and water, than by a person living in or around pristine ecosystems. Thus, for many ecosystem services, actual as well as potential benefits may be less valued by the ecosystem people than by the biosphere people.

Finally, subsistence-level benefits from ecosystems are also undervalued when the human costs associated with the destruction of the ecosystem are not taken into account, as is often the case. The livelihood strategies of ecosystem people tend to be tightly linked to extraction and utilization of goods and services of local ecosystems, for their own use as well as for exchange on the market in an essentially unprocessed form. Such human

groups have few skills that can be exchanged for a livelihood when deprived of access to the ecosystem goods and services on which they have long depended. Displacement of ecosystem people is therefore always accompanied by great human suffering, as when tribals are forced to migrate to urban shantytowns when their forest habitat is taken over by mining or river valley projects. The costs of creating impoverished ecological refugees are manifested as expenditures in poverty alleviation programs.

Quantification of Services

Despite the problems in valuing ecosystem services as they relate to subsistence economies, the importance of such services can be assessed in a wide variety of ways. We may estimate the number of people who derive their livelihoods from harvesting ecosystem productivity, the value of particular crops, the contribution to cash income of households, the proportion of households that rely on ecosystem products, the total GDP derived from ecosystem goods, and the value of services on a per hectare basis. The various attributes of these parameters in terms of advantages and disadvantages are listed in table 16.1. It is important to note that none of these parameters incorporates marginal costs of extraction or marginal benefits of biodiversity (see chapter 3, this volume).

Number of persons. In India alone, approximately fifty million people (5 percent of the total population) are assumed to live in and around forests and presumably derive a subsistence level of their livelihood from forest products (NCHSE 1987). In Brazil, 1.5 million people, or 20 percent of the economically active persons in the Amazon region, derive a significant portion of their livelihood from extraction of natural products (Browder 1992). These numbers do not include the people involved in the preserving and marketing of forest-based products, nor the people employed in forest-based industries. For both India and Brazil, the number of people who rely on harvesting of ecosystem products for their livelihoods could easily double when freshwater and marine ecosystems are taken into account, as both countries have huge coastlines and many large rivers. However, the exact number of people dependent on freshwater and marine ecosystems is not known.

Value of specific products. The value of particular products in unprocessed form or the revenue to the state generated by the harvest of the products may provide another mechanism to assess the contribution of natural ecosystems to subsistence economies. Rattan is perhaps one of the most celebrated examples of a precious nontimber forest product. The international

Table 16.1. Attributes of various parameters to assess the contribution of ecosystem services to subsistence economies

	Attributes				
Parameter	Direct Measure of Importance to Ecosystem People	Easy to Estimate	Estimates Non-Use Value	Incorporates Marginal Costs of Extraction and Benefits of Biodiversity	Importance to Policy Makers
Number of persons dependent on ecosystem services for livelihood	X	X			
Value of specific products	X	X			X
Contribution to cash income	X	X			
Proportion of households dependent on ecosystem services for livelihood		X			
Contribution to GDP			X		X
Value per hectare			X		X

and domestic trade in rattan was valued at US$4.0 billion and US$2.5 billion, respectively, in the 1980s (Manokaran 1990). The number of people employed in the rattan furniture industry in Indonesia alone is estimated to be 150,000 (Manokaran 1990). Another example is the tendu leaves from the Indian subcontinent. Tendu leaves from trees of *Diospyros melanoxylon* are used to wrap tobacco to produce bidis, a form of inexpensive cigarettes. The tendu leaves generate an annual revenue of US$160 million for the state of Madhya Pradesh in India. The leaves are just one among the hundreds of various types of nontimber forest products harvested from forests of India.

Contribution to cash income of households. The contribution of ecosystem products to cash income is difficult to ascertain because of limited information about the quantities of goods extracted and their disposal at the household level. The harvested products are used by the household members themselves, made available to others in the community, and sold or bartered for cash or other commodities and services. Cash income is generally reported from the last component pertaining to sale and exchange. However, even for this fractional component, cash income derived from the products can be substantial. For example, indigenous communities in and around the Biligiri Rangan Hills, a protected area in southeast India, derive 48–60 percent of their cash income from ecosystem products (Hegde et al. 1996). In West Bengal, India, nontimber forest products, including fuelwood and fodder from young regenerating forests, contribute 22 percent of the cash income of village households in and around forests (Malhotra et al. 1991). These figures are average figures from all the households surveyed in areas that are heavily forested.

Proportion of households dependent on ecosystem products. The proportion of households that rely on ecosystem products depends largely on the proximity to the ecosystem, size of the catchment area, and economic status of the people. Quantitative data are not available, but we would expect all households of settlements in and around large natural ecosystems in the developing world to derive a substantial portion of their income or livelihoods from ecosystem products. As mentioned earlier, a substantial proportion of the population in countries like India and Brazil is dependent on ecosystem products. With economic growth, the economy should diversify and the proportion of households that derive income from ecosystem services, as well as the extent of reliance on products, might be expected to decline (Godoy and Bawa 1993).

Contribution to GDP. The relative contribution to the gross domestic product could be another indication of the importance of ecosystem goods, even though goods and services from subsistence economies generally are discounted in the calculation of GDP, and GDP does not take into account ecosystem services. Unfortunately, GDP figures do not include all ecosystem products: for terrestrial ecosystems only forest products are included, and timber is often the main entry. However, for India, Lal (1992) has conducted a preliminary analysis of the annual rent from forests for both goods and services and found the rent to be more than 25 percent of the GDP; officially the contribution of forestry to GDP is listed as 1.2 percent. More important, Lal's analysis indicates that ecosystem products, including fuelwood and fodder, which are the basis of subsistence economies, constitute

approximately 13 percent of the total value of forest goods and services. We should keep in mind that Lal's preliminary valuation does not include freshwater or coastal ecosystems.

Services per hectare. A number of attempts have been made to quantify the value of ecosystem services on a per hectare basis. Godoy et al. (1993) reviewed a number of studies and estimated the net value of nontimber forest products at approximately US$50 per hectare per year. These estimates include only ecosystem goods. For dry deciduous forests in India, Chopra (1993) estimates the value of nontimber forest products and services such as soil conservation, nutrient cycling, and tourism and recreation to be in the range of US$220–$335 per hectare per year. The use value for nontimber products in certain regions of Mexico has been estimated to be US $330 per hectare per year (Alcorn 1989). Interestingly, the 1991 gross domestic product (GDP) estimates for Mexico and India, respectively, are US$1,501 and US$836 per hectare, and almost certainly do not capture the values for ecosystem services cited above. The various estimates for ecosystem services in the above examples differ with respect to various goods and services included and are based on several untested assumptions. Nevertheless, the estimates are useful in drawing the attention of policy makers to undervaluation of ecosystem goods and services. The refinement of these estimates by incorporation of additional data can provide an assessment of the true importance of ecosystems in sustaining livelihoods of the ecosystem people.

Subsistence Economies, Sustainability, and Conservation of Biodiversity

It is apparent that a very large number of ecosystem people in biodiversity-rich regions of the world are dependent on the harvest of biological resources with their own labor from a limited-resource catchment area. In economic terms, the value of the products extracted by the ecosystem may not be very large because subsistence economies, by definition, involve the most impoverished sectors of society. Inclusion of non-use values into contributions of the ecosystems can provide better estimates of the economic value of the ecosystem, but, although the non-use values are substantial, we lack adequate mechanisms to quantify these values.

However, the real issue is not how valuable these ecosystem services are in relation to subsistence economies, but whether we can build on the ultimate dependence of ecosystem people on ecosystem goods and services of their immediate environments and turn them into stewards of the local living resources and biodiversity, and, in the process, enhance the quality of their lives. We believe the answer to be in the affirmative. There is abundant

evidence that ecosystem people, settled for long in a locality and in full control of their own resource base, exhibit a number of cultural practices that promote sustainable use of biological resources and conservation of biodiversity (Gadgil and Berkes 1991; Gadgil et al. 1993). Such practices include limitations on harvest levels, e.g., number of sheep grazed on community pasture or wood harvested from community woodlots; lowering of harvesting pressures when there is evidence of overharvesting, e.g., temporary ban on fishing from coral reef lagoons; total protection in vulnerable life stages, e.g., birds breeding at a heronary; total protection of certain keystone resources, e.g., trees of genus *Ficus* in many parts of India; and the total protection of certain biological communities, e.g., sacred ponds and forests. Such practices, dependent either on a notion of the sacred or taboo or on social conventions, seem to have evolved and persist because they serve long-term interests of a small, well-knit human group in ensuring sustained availability of a diversity of resources.

In recent times, however, the dependence of human societies on diversity of resources from their immediate environments has been greatly reduced by technological progress. People are now capable of moving resources over large distances and transforming them extensively. With access to greatly expanded resource catchments, people may no longer suffer from depletion of resources in their immediate environments. For this category (the biosphere people with access to resources of all the biosphere) there is little motivation to sustainably use and promote persistence of a wide diversity of resources in any particular locality. Often, they do protect environments in their immediate vicinity to ensure healthier, aesthetically more pleasing ambiences for themselves, but this transfers the pressures of resource extraction to localities farther away. These localities tend to be inhabited by people with little economic or political clout, such as the ecosystem people, and results in the loss of control over their own environments to devote these locales to supply resources to biosphere people. At the same time, the ecosystem people have started to receive a trickle of supplies of a diversity of resources through the developing markets. The ecosystem people are thus no longer as completely dependent on a diversity of local resources as before, nor can they regulate unsustainable usage of these local resources. Under the circumstances, they tend to lose their motivation to sustainably use local living resources and conserve local biodiversity, and become suppliers of whatever little they can gather for the larger markets. These resources they tend to gather in an unsustainable fashion, contributing to the degradation of ecosystem goods and services (Gadgil and Guha 1995).

There are several examples of commercialization having deleterious effects on biodiversity. Rattan, mentioned earlier in the chapter, is becoming scarce in many countries (Manokaran 1990). There are numerous other examples of unsustainable extractions of nonwood forest products (Nepstad

and Schwartzman 1992, Murali et al. 1996). In general, an increase in trade of exportable ecosystem products by indigenous communities is expected to result in depletion or extinction of populations yielding such products, while species that are nontradeable are likely to increase in abundance (Wilkie et al. 1995).

Many interacting factors are responsible for unsustainable extraction of resources. Commercialization and trade introduce boom and bust cycles and reliance on export markets over which producers have little control. Intrusion of external market forces leads to the loss of control over resources by indigenous groups and to the breakdown of traditional institutions promoting sustainable extraction. Moreover, paucity of resources in degraded environments increases poverty in already impoverished sectors of the society, and poverty, in turn, leads to further deterioration of the environment.

Policy Options

The degradation of ecosystem goods and services affects the local ecosystem people far more directly and adversely than it does any other human group. So, of all people, these local ecosystem people retain the highest levels of motivation for maintaining healthy levels of ecosystem goods and services in their own localities. This motivation cannot, however, be molded into effective action so long as they do not have: (1) control over their resource base; (2) adequate management; (3) incentives to conserve biodiversity; and (4) equity in bearing the cost of conservation. Several policy reforms would therefore be required to integrate the use of ecosystem resources by rural poor and conservation of biodiversity.

Tenurial control. The first and most important prerequisite for turning ecosystem people into stewards for good management of their environments is to restore to them control over the resource base. In the absence of tenurial control over resources or the land or water supporting the resources, the ecosystem people have little incentive to sustainably extract resources to which there is open access.

In India, joint forest management that seeks to partially restore the control of forest resources to local communities has had some success in regeneration of degraded forests. The state forests in India, until the last century, were largely under community control (Gadgil and Guha 1992). Appropriation of the forests by the state during the last one hundred years without addressing the forest-based subsistence requirements of the ecosystem people has created an acute conflict between the people and the government agencies over use and conservation of biodiversity. The joint forest

management plan is supposed to resolve some elements of this conflict. The basic concept of the plan is simple: Forest protection committees at the village level safeguard regenerating forests under the control of the state in exchange for access to nontimber forest products as well as a share in timber production. The joint forest management plan apparently has succeeded in regenerating degraded forests, but its contribution to resurrecting original levels of biodiversity and ecosystem functions is not clear. Simple access to state-owned forest resources without an active monitoring program does not eliminate the possibility of resource depletion, nor does it prevent loss of some ecosystem functions. More important, the joint forest management plan circumvents the tenurial issue. In order to be more effective, the joint management plans must address, in addition to property rights, issues related to inventory, productivity, and extraction of ecosystem products (see below).

Management. Tenurial control by itself would not be sufficient to conserve as well as sustainably utilize biodiversity. Without an adequate management plan, modern market forces have the capability to deplete resources even when extraction levels are low. Thus, conservation of biodiversity in many ecosystems is likely to remain an elusive goal without the involvement of the ecosystem people in management plans, regardless of the extent of trade in ecosystem products.

The management plans must be adaptive plans, based on continual monitoring of the abundance and extraction levels of resources being harvested. Extraction should be in proportion to production, which is likely to vary over space and time. Sustainable levels of harvests, particularly for a diverse array of products from terrestrial ecosystems, are difficult to determine because of problems in defining sustainability, and because any large-scale export of materials from the ecosystem is likely to have deleterious consequences on the structure and function of the ecosystem. Given these difficulties, only flexible adaptive management plans could prevent depletion of resources and must be put in place.

Depletion could also be prevented by value addition. Many ecosystem products that form the basis of subsistence economies often leave the point of origin in an unprocessed state. As a result, harvesters realize very low value from extracted products. For example, the Soligas, the indigenous people of the Biligiri Rangan Hills in southwest India, harvest, among other things, amla (*Phyllanthus emblica*) fruits from tropical forests. The fruits, used for pickles, jams, and medicinal products, are exported from the forests in a raw state, and the Soligas secure minimal income based simply on the amount of labor invested in the harvest of fruits. However, the income derived from amla, which averages US$6.60 per capita, could be increased to

US$87.75 per capita if the Soligas were to directly process and market these fruits (Uma Shankar et al. 1996). Amla is only one of the many products harvested by the Soligas. If the economic returns for even five products were to be enhanced by a factor of five for each product, the total income, or value, to the Soligas could be increased by a factor of twenty-five. Another example is rattan. In 1971, the value of rattan exported by Indonesia was US$0.8 million, but in 1988 the value had increased to US$194.6 million, primarily due to value addition (Manokaran 1990). Value addition can enhance the income and reduce the amount extracted in cases where extraction is not sustainable.

There are often several impediments to value addition. Extractors lack the capital or infrastructure for processing the product locally, and the scale of operation is often too small to justify processing at the site of extraction. Moreover, the ecosystem products are not directly marketed by the harvesters. The extractors have little information about the demand, the market channels, and, in many cases, even the eventual fate of the products.

However, value addition by itself cannot promote sustainable harvests or ensure economic benefits to the ecosystem people. Processing and marketing of products will have to be community based and under the full control of local populations. Moreover, the community-based enterprises must have a biological monitoring system that tracks levels of extraction and production and monitors the impact of harvests on ecosystem structure and function. Such community-based enterprises are now beginning to take shape in many ecosystems (Biodiversity Conservation Network 1995). A recent report of FAO further discusses the management, infrastructure, and policy requirements for extractive economics that seek to enhance rural incomes and promote sustainable use of forest products (FAO 1995; see also Murrieta and Rueda 1995).

Incentives. Restoring to ecosystem people full control and management of their own localities may help maintain these ecosystems in better health and provide higher levels of the ecosystem's goods and services, but this alone would not be sufficient to motivate them to maintain high levels of biological diversity. That would require further incentives, and in the modern context these would have to be economic incentives. Thus, if the localities inhabited by the large numbers of ecosystem people in the tropical countries are to maintain or be restored to high levels of biological diversity, we must devise a system of rewards to local communities linked to levels of local biodiversity (Panayotou 1994; Gadgil and Rao 1994, 1995). These rewards should be viewed as service charges to the ecosystem people for helping provide global ecosystem services for the conservation of biological diversity. The ecosystem people ought to provide these services in a highly cost-

effective fashion. This is because they automatically acquire the detailed l
cality and time-specific knowledge of the behavior of local ecosystems, s
necessary for effective, adaptive management, in the course of their dai
pursuit of obtaining a livelihood. The local ecosystem people are also bes
situated to monitor all human impacts on the ecosystems, and therefore
control them, provided they have the requisite authority. They also have so
cial structures to minimize exploitation of resources. Finally, being relative
poor, these people would be willing to take on the task of maintaining an
restoring local biodiversity for low levels of compensation. There is ever
reason to believe, therefore, that vesting local ecosystem people with contro
over their own environments, and paying them service charges to maintai
and restore biodiversity would be a very effective way of taking good care
the ecosystems of these parts of the earth. Involving ecosystem people
such a system would enhance their quality of life, as well as confer a mea
sure of dignity on them. That too would be a socially just course of actio
(Gadgil and Rao 1995).

Equity. A fundamental cause of environmental degradation is the inequi
in distribution of benefits and costs of conserving natural resources and b
ological diversity. As emphasized by Wells (1992), benefits of biodiversi
are widely dispersed, whereas costs of conservation are highly localized.
a sense, restoration of tenurial control and provision of economic incentive
are designed to relieve inequities in the benefit-cost ratio of conservation. In
equities, however, stem from several socioeconomic factors, and equity ca
only result from a series of reforms at the local, national, and global levels.

Conclusions

Millions of people depend on natural ecosystems for their livelihoods. It
difficult, however, to quantify the contribution of natural ecosystems to su
tain livelihoods because of problems in assigning monetary values
lifestyles, culture, religious beliefs, and many other aspects of people's live
that are intimately associated with their natural surroundings. Subjecti
and value-laden criteria used in valuation techniques also do not genera
much confidence in the figures one may be able to obtain from such met
ods. Nevertheless, on the basis of the number of people involved in harves
ing ecosystem products, the value of particular products, the contribution
cash income to households, the proportion of households that rely
ecosystem products for a substantial portion of the cash income, the GD
derived from ecosystem goods, and the value of products on a per hectar
basis, it is obvious that the maintenance of ecosystem services is critical

the well-being of millions, if not billions, of people on earth. The functioning of natural ecosystems is also important for the future increases in incomes of people relying heavily on ecosystem products for their survival.

Currently, commercialization and trade of ecosystem products that primarily benefit people living far away from natural ecosystems, as well as the loss of local control over natural resources, breakdown of traditional regulations and institutions governing the extraction of resources, and inadequate management, are leading to the degradation of many natural ecosystems. The total dependence of ecosystem people on natural ecosystems makes them extremely vulnerable to the disruption of ecosystems. Thus, significant alteration of the structure and function of ecosystems due to land-use changes or uncontrolled commercialization of ecosystem products is often accompanied by great suffering of ecosystem people as well as loss of biodiversity.

The continuous flow of services from ecosystems and conservation of biodiversity require that the ecosystem people be more actively involved in conservation than they have been in the past. For ecosystem people to resume the stewardship of natural resources, tenurial control of resources to local communities must be restored, adaptive management plans fine-tuned to changing resource levels on the basis of continual monitoring resources must be developed, economic incentives to conserve biodiversity must be provided, and inequity in the benefit-cost ratio of conservation at the local level must be reduced. The intimate dependence of a large segment of humanity on ecosystems offers a great opportunity for people-based conservation activities in ecosystems facing degradation.

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References

Alcorn, J. B. 1989. "An economic analysis of Huastec Mayan forest management." In *Fragile Lands of Latin America*, J. O. Browder, ed., pp. 182–206. Westview Press, Boulder, Co.

Biodiversity Conservation Network. 1995. *Biodiversity Support Programs, Biodiversity Conservation Network: 1995 Annual Report.* World Wildlife Fund, Washington, D.C.

Browder, J. O. 1992. "Social and economic constraints on the development of market-oriented extractive reserves in Amazon rain forests." *Advances in Economic Botany* 9: 33–42.

Brown, K. 1994. "Approaches to valuing plant medicines: The economics of culture or the culture of economics?" *Biodiversity and Conservation* 3: 734–750.

Chopra, K. 1993. "The value of non-timber forest products: An estimation for tropical deciduous forests in India." *Economic Botany* 47: 251–257.

Dasmann, R. F. 1988. "Toward a biosphere consciousness." In *The Ends of the Earth*, D. Worster, ed., pp. 277–288. Cambridge University Press, New York.

FAO (Food and Agriculture Organization) 1995. *Non-Wood Forest Products for Rural Income and Sustainable Forestry.* Food and Agriculture Organization of the United Nations, Rome.

Gadgil, M. 1995. "Prudence and profligacy: A human ecological perspective." In *The Economics and Ecology of Biodiversity Decline*, T. M. Swanson, ed., pp. 99–110. Cambridge University Press, New York.

Gadgil, M. 1996. "Managing biodiversity." In *Biodiversity: A Biology of Numbers and Difference*, K. J. Gaston, ed., pp. 339–360. Blackwell Scientific Publications, Oxford.

Gadgil, M., and Berkes, F. 1991. "Traditional Resource Management Systems." *Resource Management and Optimization* 18:127–141.

Gadgil, M., F. Berkes, and C. Folke. 1993. "Indigenous knowledge for biodiversity conservation." *Ambio* 22:151–156.

Gadgil, M., and Guha, R. 1992. *This Fissured Land: An Ecological History of India.* University of California Press, Berkeley.

Gadgil, M., and Guha, R. 1995. *Ecology and Equity: The Use and Abuse of Nature in Contemporary India.* Routledge, London.

Gadgil, M., and Rao, P. R. S. 1994. "A system of positive incentives to conserve biodiversity." *Economic and Political Weekly* (Aug. 6):2103–2107.

Gadgil, M., and Rao, P. R. S. 1995. "Designing incentives to conserve India's biodiversity." In *Property Rights in a Social and Ecological Context*, S. Hanna and M. Munasinghe, eds., pp. 53–62. The Beijer International Institute of Ecological Economics and The World Bank, Washington, D.C.

Godoy, R., and Bawa, K. S. 1993. "The economic value and sustainable harvest of plants and animals from the tropical rain forest: Assumptions, hypotheses, and methods." *Economic Botany* 47: 215–219.

Godoy, R., Lubowski, R. and Markandaya, A. 1993. "A method for the economic valuation of non-timber forest products." *Economic Botany* 47: 220–233.

Hall, P., and Bawa, K. S. 1993. "Methods to assess the impact of extraction of non-timber tropical forest products on plant populations." *Economic Botany* 47:234–247.

Hegde, R., Suryaprakash, S., Achot, L., and Bawa, K. S. 1996. "Extraction of non-timber forest product in the forest of Biligiri Rangan Hills, India. 1. Contribution to rural income." *Economic Botany*, in press.

Lal, J. B. 1992. "Economic value of India's forest stock." In *The Price of Forests: Proceedings of a Seminar on the Economics of the Sustainable Use of Forest Resources*. A. Argawal, ed., pp. 43–48. Centre for Science and Environment, New Delhi.

Malhotra, K. C., Deb, D., Dutta, M., Vasulu, T. S., Yadav, G., and Adhikari, M. 1991. "Role of non-timber forest produce in village economy: A household survey in Jamboni Range, Midnapore District, West Bengal." Unpublished paper, Indian Institute of Biosocial Research and Development, 3A Hindustan Road, Calcutta.

Manokaran, N. 1990. *The State of the Rattan and Bamboo Trade*. The Rattan Information Centre, Institute Penylidikan Perhutanan Malaysian (FRIM), Kepong, 52109, Kuala Lumpur.

Murali, K. S., Shankar, U., Shaanker, R. U., Ganeshaiah, K. N. and Bawa, K. S. 1996. "Extraction of non-timber forest product in the forest of Biligiri Rangan Hills, India. 2. Impact of NTFP extraction on regeneration, population structure, and species composition." *Economic Botany*, in press.

Murrieta, J. R., and Rueda, R. P., eds. 1995. *Extractive Reserves*. International Union of Conservation of Nature. Gland, Switzerland.

NCHSE (National Centre for Human Settlements and Environment). 1987. *Documentation on Forest and Rights*, vol. 1. National Centre for Human Settlements and Environment, New Delhi.

Nepstad, D. C., and Schwartzman, S., eds. 1992. *Non-Timber Products from Tropical Forests: Evaluation of a Conservation and Development Strategy*. Special issue of *Advances in Economic Botany* 9:1–164.

Panayotou, T. 1994. *Economic Instruments for Environmental Management and Sustainable Development*. International Environment Program, Harvard Institute for International Development, Harvard University. Manuscript.

Pearce, D., and Moran D. 1994. *The Economic Value of Biodiversity*. Earthscan Publications Limited, London.

Shankar, U., Murali, K. S., Shaanker, R. U., Ganeshaiah, K. N., and Bawa, K. S. 1996. "Extraction of non-timber forest product in the forest of Biligiri Rangan Hills, India. 3. Productivity, extraction and prospects of sustainable harvest of Nelli (*Emblica officinalis*)." *Economic Botany*, in press.

Vatn, A., and Bromley, D. W. (1995). "Choices without prices without apologies." In *The Handbook of Environmental Economics*, D. W. Bromley, ed., pp. 56–81. Basil Blackwell, Oxford, England.

Wells, M. 1992. "Biodiversity conservation, affluence and poverty: Mismatched costs and benefits and efforts to remedy them." *Ambio* 21:237–243.

Western, D., and Henry, H., eds. 1994. *Natural Connections: Perspectives in Community Based Conservation*. Oxford University Press, New York.

Wilkie, D. S., Godoy, R., and Brokaw, N. 1995. "The impacts of trade on indigenous economies and biological diversity: A microeconomic approach." Manuscript.