chapter 7

Technologies for **Undisturbed Forests**

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Chapter 7

Technologies for Undisturbed Forests

HIGHLIGHTS

Maintaining Sample Ecosystems

- Preserving samples of undisturbed tropical forests can help protect representative flora, fauna, and habitats and thus maintain biological diversity and goods and services provided by forests. But there is a disparity in the distribution of protected areas.
- It is essential to improve the management of existing protected areas, since many are protected only on paper. The United States can contribute by providing increased opportunities to educate and train resource managers and technicians.
- There is growing recognition that protected area management should include more socioeconomic and institutional considerations. The UNESCO Man and the Biosphere Program system of biosphere reserves is one approach that emphasizes these components. It, however, suffers from the lack of strong, consistent U.S. commitment and support.

Making Undisturbed Forests More Valuable

- The value of tropical forests could be increased by developing new products or by encouraging the collection and processing of existing products. This could be done with investment to analyze traditional uses of forest products, develop markets, and promote sustainable management systems.
- Improved assessment of the value of nonwood tropical forest products, especially in subsistence economies, could provide incentive to include development of these resources in economic development planning.

INTRODUCTION

Proven methods and techniques to sustain undisturbed tropical forests* are few. Of these, establishing parks and protected areas probably is the most common method. A few other examples exist where selected renewable resources are extracted from a tropical forest to generate income while the forest and its resources remain essentially intact.

Political expediency often determines when and where a park or protected area is established. The rapid loss of forests in most tropical countries forces people to try to establish protected areas whenever and wherever the opportunity arises regardless of whether adequate, continuing protection will be available to care for the land and its resources. Many protected areas exist only on paper and in fact continue to undergo destruction.

Resource conserving technologies that tap the potential of undisturbed forests, such as butterfly and crocodile farming (see p. 172), are rare. while these two examples affect few people, they are important illustrations of how human well-being can be linked directly to maintaining the productivity of tropical forest resources. Such systems can work, but a great need exists to develop other integrating approaches if such methods are to provide significant benefits while sustaining undisturbed tropical forests,

*"Undisturbed tropical forests are defined as areas where trees are the dominant woody vegetation covering more than 10 percent of the ground and where trees have not been cut during the past 60 years. This definition includes both primary and old secondary forest, both closed and open forest (22).

MAINTAINING SAMPLE ECOSYSTEMS

Why Projecct Tropical Forest?

Parks and protected areas can fulfill a variety of objectives. These vary according to the character of the area, but can include:

1. protecting and maintaining representative samples of major biogeographical provinces to support evolutionary continuity and the health of the Earth's life support system;
2. protecting representative, as well as unique, samples of natural systems, landscapes, and life forms;
3. protecting natural areas needed to support development activities (e.g., watersheds and ground water recharge areas);
4. providing in situ* protection of plants and animals that may make substantial, though perhaps currently unforeseen, contributions to human development (e.g., supply new food or drug sources);
5. providing sites for research and education to increase scientific knowledge that can be used to develop new technologies to manage such systems;
6. protecting cultural, archeological, or natural monuments; landscapes of historical or cultural interest; or unusual geological formations; and
7. providing esthetic pleasure, opportunities for healthy and constructive recreation, and revenues from tourism (11).

Status of Protected Areas

Establishment of parks and protected areas in the world has burgeoned in the last two decades. The greatest increase in the number of protected areas has occurred in developing countries. Nearly one-half (160 million hectares (ha)) of the worldwide total of protected natural areas are found in the Tropics (3,21). Protected areas in Central America, for example, grew rapidly from 24 units (1.7 million ha] in 1969 to 124 units (4.8 million ha) in 1981 (2). Unfortunately, some of the designated areas are protected only on paper. No data are available on what portion of the parks and protected areas worldwide suffer illegal hunting, logging, farming, and livestock grazing, but anecdotal evidence suggests that such illegal use is a common problem in the tropical nations.

Substantial increases in the area given protected status over the past two decades indicate that the values of undisturbed forest resources are being more widely recognized. This progress is due at least in part to a growing awareness among nations of the social, economic, and ecological benefits accruing from appropriately managed protected areas (7,8).

An FAO/UNEP study indicates about 3 percent of the closed tropical forest has been given park or other legal protected status (see app. table A-2). Such protected lands are unequally distributed; at least half are located in just four countries–India, Zaire, Indonesia, and Brazil. In addition, the International Union for the Conservation of Nature and Natural Resources (IUCN), which monitors the worldwide distribution of protected areas, reported in 1981 that some ecological types are either not represented or are underrepresented by existing protected areas.

Techniques to Design, Establish, and Maintain Protectedd Areas

Siting Protected Tropical Forests

Many of the first tropical parks and reserves were established for esthetic and recreational purposes (14). Lands were set aside because of spectacular scenery or unique land forms, following the precedent set by the United States. Although such lands can provide income from tourism and recreation, they may not be designed or located to sustain other important values associated with undisturbed forests. Park borders in the past usually ignored animal migration routes and important adjacent ecosystems. Some areas in Africa, for example, protect important watering areas for wildlife

*Protecting stock in the original habitat rather than in places such as gene banks or botanical or zoological gardens.

Photo credit" H Bollinger

Forest clearing for agricultural settlement often proceeds in spite of the site's legal status as a protected area. This settlement is in a Kenyan forest listed officially as a preserve by the Forest Department

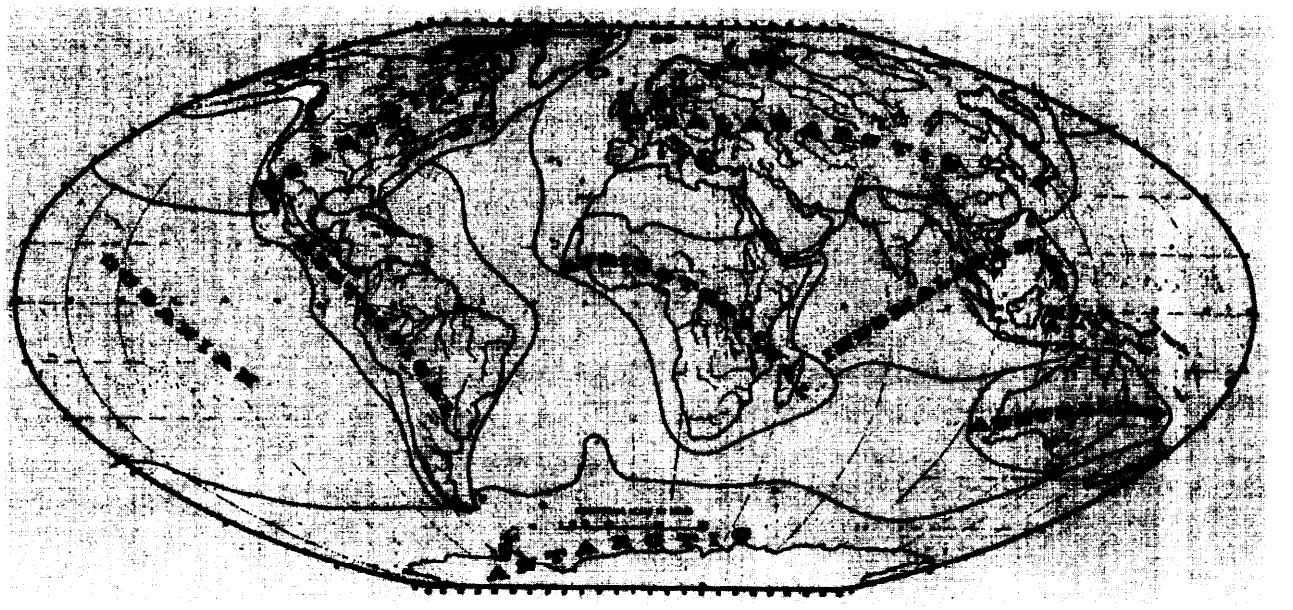
but do not protect the upland watersheds that are necessary to maintain water supplies. Furthermore, rural people living in or near parks have often been disregarded or displaced.

More recently, planners have begun to look beyond simple scenic values to emphasize a broad range of biological resources and environmental services in protected area designation. Techniques for siting areas to be protected are becoming more scientific and integrative.

A classification system used to identify appropriate locations for protected area establishment worldwide is based on ecological categories. This system divides the Earth into eight large "realms" (fig. 24), which in turn are subdivided into 193 biogeographical "provinces" (21). Realms are continent or subcontinent-sized areas with unifying features of geography, fauna, and vegetation. Provinces are more detailed subdivisions, each characterized by a major biome type such as "tropical humid forest,"" tropical grasslands, " or "tundra communities." Ideally, selection of protected sites should include representative samples from each realm and province.

Within a province, the location—as well as the number, size, and shape of protected areas—is important to biological conservation. The scientific basis for determining these characteristics is theoretical. Few *studies* have tested the theories with species other than birds (18). Two criteria have emerged for selecting sites to safeguard biological diversity. One is

Figure 24.-Terrestrial Biogeographic Realms of the World



SOURCE: M. Udvardy, *World Biogeographical Provinces,* IUCN Occasional Paper No. 18, 1975.

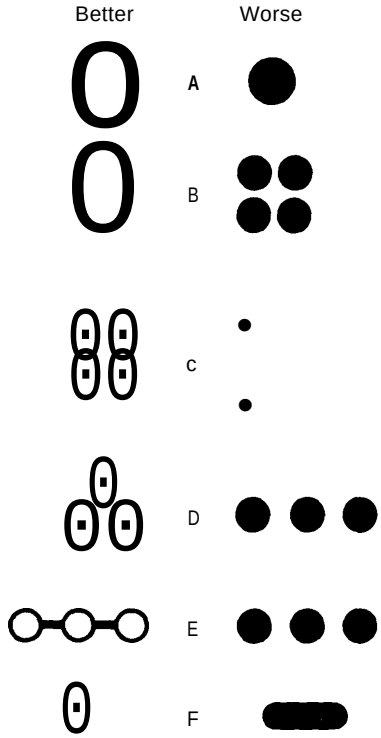
the relative degree of species endemism of a particular site. Areas of high species endemism are those containing many highly localized species. A related criterion is the number of species, or species diversity, at the site. All else being equal, the more biologically diverse a site, the greater its potential value.

A number of inferences about how park size and shape affect maintenance of biological diversity have been drawn from studies of tropical island biogeography (fig. 25). These studies have found that the risk of species extinctions within a protected area—in essence a biological island—can be minimized through careful design of the site. An appropriate size can be determined by including all the natural features that constitute a self-sustaining ecological system. However, to maintain their full complement of plant and animal species, most sites need to be large. This is because many tropical species occur naturally at low densities. Below a certain minimum population, these species are more vulnerable to problems of population instability and the risk of extinction.

For example, the minimum viable population size for long-lived organisms with low natural mortality rates is believed to be about 50 individuals in the short term (50 to 100 years) and 500 in the long term (6). Ideally, sites should contain at least this number of their rarest species. The size required to do this varies with type of species and ecosystem, but determining actual size is an area of great scientific uncertainty. Recently, scientists in Brazil have begun a series of experiments to measure rates of loss of biological diversity that occur with variations in protected area size and shape under various tropical forest conditions (12). Such research produces results slowly. In the meantime, some scientists have suggested 2,500 square kilometers as the minimum area of tropical rainforest needed to safeguard most species (20). This suggested rule-of-thumb often is impractical, given the socioeconomic and political situations of many tropical countries.

Biogeographical considerations are only some of the factors needed to determine the appropriate shape of protected areas. where

Figure 25.—Design of Protected Areas



Suggested geometric principles, derived from island biogeographic studies, for the design of protected areas. In each of the six cases labeled A to F, species extinction rates WIl be lower for the reserve design on the left than for the reserve design on the right.

SOURCE International Union for the Conservation of Nature, The *World (Conser.* vation *Strategy* (Gland, Switzerland: IUCNWNEPNVVVF, 1980).

maintenance of specific environmental services is a high priority, it should be reflected in the area's shape. For example, watershed catchments have specific shapes. In addition, the needs and interests of local people also should help determine the shape, size, and location of protected areas.

Establishment and Management Techniques

Different categories of protected areas such as national parks, biological reserves, and cultural monuments serve different objectives and purposes. The management strategy chosen depends on the particular combination of benefits that are desired (table 27). Protected areas should include two types of reserves: 1) lands where ecosystems are protected with a minimum of human manipulation (sometimes called strict nature reserves or national parks); and 2] lands where particular resources or parts of the ecosystem are protected, but where collection of some products and some manipulative research is allowed and managed, particularly for education and training (11).

Simply designating protected areas on a map does not assure that the land will be managed to provide the greatest possible benefits. A management plan is needed. A planning procedure that has proven effective for a variety

Table 27.-Wildland Management Categories

Management category/Characteristics
1. **National *Park:*** Wild or primary ecosystems with little evidence of human intervention; contains unique features of national or international significance.
2. ***Natural monument:*** An area generally encompassing only one natural feature that is of national or international significance.
3. ***Scientific or biological reserve:*** Lands that are generally not altered by man-and contain floral and)or faunal species of national or international importance. Size depends on habitat needs of target species.
4. ***Wildlife sanctuary or refuge:*** Land encompassing the vital habitat resources of animal species or communities of national or international significance.
5. ***Resource reserves:*** A transitory state where a primary ecosystem will be maintained in a natural state until more definite management goals are determined.
6. ***National forest:*** Extensive forested lands important for wood production and watershed protection.
7. ***Game reserves:*** Lands containing populations of native wild species of fauna and/or habitat suitable for the pro duction of wild fauna protein, animal products, or for viewing or sport hunting.
8. ***Protection zones:*** Generally small areas that do not meet the objectives of other wildland categories but that require the kinds of strict land-use control provided by wildland management techniques.
9. ***Recreation areas, scenic rivers,*** **and highways:** Relatively large areas with outstanding natural or seminatural scenery and the physical potential to be developed for a variety of outdoor recreational uses.
10. ***Seen/c easements and*** **rights-of-way:** Regions outside of park or reserve boundaries that merit protection, usually for esthetic reasons—i.e., access roads, shorelines, mountains, scenic overviews, etc.
11. ***Cultural monuments:*** Sites or **areas containing historical, archeological, or other cultural features of national or international significance.**
12. ***Integrated river basin regional development programs:*** Integrated regional land-use planning that includes wildlands conservation as an integral component of development.

SOURCE: K. Miller and D. Glick, "Methods for the Establishment and Management of Protected Areas for Tropical Primary Foreat and Woodland Resources," OTA commissioned paper, 1982.

of tropical wildland conditions is shown in table 28. This process is continuous and interactive with built-in monitoring and evaluation components. Thus, the procedure helps ensure that data on how management affects the resources within the designated site, how it affects the surrounding area, and how the surrounding area affects the site will be collected and continually used to improve management.

The traditional approach to park establishment and management has often failed to take into account local cultures and has excluded local people. Consequently, protection of designated areas has often not been effective. Local people, with no incentive to protect the park, ignore the area's legal status. Given increasing needs to develop rural lands in recent years, protected area planning has begun to incorporate more economic and social consideration (14). Although some socioeconomic and other social science analyses are being incorporated into the planning process, methods to use these data as yet are not fully used.

Appropriate management of tropical forest protected areas necessitates active participation by many individuals and groups. The principal participants include:

1. ***Planning Team.***—Establishment and management planning is best conducted by a team of specialists representing both environmental and sociological fields (e.g., park planners, ecologists, foresters, wildlife biologists, rural developers, anthropologists, sociologists, economists, environmental educators, and community developers).
2. ***Rural People.—***The people living in or adjacent to proposed or established protected areas must play an active role in park planning, establishment, and management. Meeting their resource needs is an important factor in the success of a protected area.
3. ***National Decisionmakers.—Government*** and nongovernment leaders must support conservation activities if adequate financial and legislative support for forest protection is to be procured.
4. The ***General Public.—If*** widespread public support exists for the creation of parks and reserves, government leaders are more likely to support such efforts,
5. ***The Global*** Community,—International political and development agencies can-be instrumental in promoting wildland protection. Development of tropical forests in many cases is directly affected by multinational businesses and global political bodies (14).

This broad approach, although it can be unwieldy, facilitates involvement by both those people who directly or indirectly will affect or be affected by the forest resource (generally rural people) and the people and agencies that must support or implement the management programs.

Support from local citizens can be increased if protected areas are designed so benefits accrue to local inhabitants (25). An example is Nepal's Royal Chitwan National Park. Chitwan was declared a park in 1973 to demonstrate that the conservation of nature was an integral part of Nepal's plans for economic develop-

Table 28.—Steps in Planning a Park or Protected Area

1. **Gather background Information, Including analysis of administrative, organizational, legal, and political context for the park.**
2. **Conduct a field inventory of natural and cultural resources and land-use and development aspects of the area.**
3. **Analyze constraints on planning the park.**
4. **State specific objectives on planning the park.**
5. **Divide the area into management zones, identifying sites where specific activities and developments are to take place.**
6. **Draft preliminary, practical park boundaries.**
7. **Design management programs for protecting, using, and administering the park.**
8. **Prepare an integrated development program for the plan: what is to be built; what supplies, equipment, and materials are needed; what infrastructure and utilities are required; and what staff and institutions will be involved.**
9. **Analyze and evaluate the proposal.**
10. **Design the development schedule.**
11. **Publish and distribute the management plan.**
12. **Implement the plan.**
13. **Analyze and evaluate the plan.**
14. **Solicit feedback and** revise the plan as needed.

SOURCE: K. Miller and D. Glick, "Methods for the Establishment and Manage. rnent of Protected Areas for Tropical Primary Forest and Woodland Resources, " OTA commissioned paper, 1982.

ment. The park's conservation record is impressive: its population of rhinoceroses rose from about 100 in 1968 to at least 300 in 1978, and its tiger population increased from 25 in 1974 to as many as 60 in 1980 (15). But that success created conflicts with local residents. They suffered loss of crops, livestock, and occasional loss of life caused by park animals and they encountered other conflicts with park regulations. But as part of a broad program of resettlement, public participation in the park's management, and compensation for losses, the government decided to allow villagers to use the park to collect tall grasses for building materials. Since most of the needed thatch grasses outside Chitwan had disappeared, the people realized that the park protected their interests, too, and relations have improved considerably (15).

It is also important to ensure that once areas have been designated, their status should not be changed except for some compelling higher public interest. Because of the need for coordination and top-level decisionmaking, the power to establish any protected area should be by law. Approval should be required of the highest body responsible for legislative matters in the country or region—e.g., parliament or legislative assembly. Similarly, amendment or abolishment of any protected area should be through superseding legislation and determination of this highest authority. This may not be politically or administratively possible in some countries. In cases where the highest legislative level of approval is not possible, review and approval should be required at least from a competent authority at a level higher than the agency which is responsible for managing the protected area (11).

Finally, even if all elements of appropriate tropical forest management are met, the destruction of adjacent ecosystems can seriously affect resources within the reserve boundaries. Therefore, protected areas management must broaden its scope of concern from protecting "patches" of natural areas to implementation of environmentally appropriate land-use practices in nonpark areas (18). The complementarily of conservation and development increasingly is appreciated as protected areas are incorporated into broader regional and local development plans and into development projects to enhance their economic performance.

The UNESCO-MAB Concept. Few innovative conservation actions have been developed to integrate protected areas directly with the surrounding biophysical and socioeconomic setting. One program with this objective is the United Nation's Man and the Biosphere (MAB) Program initiated by UNESCO in the early 1970's. The goals of MAB are to encourage the study of human impact on natural renewable resources and promote the application of appropriate knowledge and experience to maintain these resources for long-term development. The MAB program also provides a network for information exchange among developed and developing countries.

The MAB biosphere reserves program attempts to integrate conservation of protected areas with surrounding socioeconomic needs. The biosphere reserves use management and zoning to facilitate human activity within certain sections of the reserve (5). This concept emphasizes the needs of local populations and seeks to define ways where specific economic benefit in the form of revenues and products from the reserve can be returned to the local people.

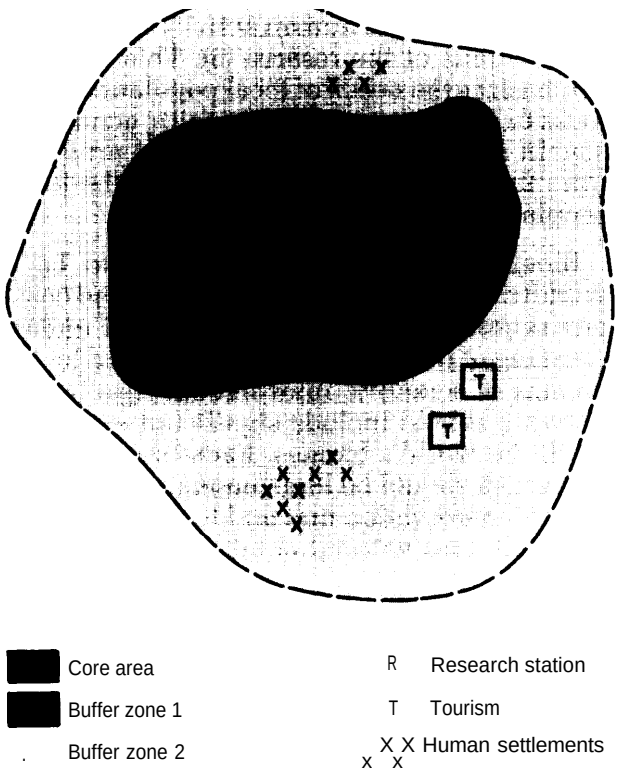
Biosphere reserves are intended to be a worldwide network of protected land and coast environments linked by international understanding of purposes and standards and by exchange of scientific information. Ideally, the network should include significant examples of all the world's biomes. Each biosphere reserve also should be large enough to be an effective conservation unit and to accommodate different uses without conflict.

The zoning concept applied to a biosphere reserve normally includes a well-protected "core area" surrounded by one or several "buffer areas" where manipulative research or ecologically sound land uses are allowed. This buffer acts as a transition zone integrating the reserve into the surrounding region. The de-

sign of a reserve (fig. 26) can be adapted to different geographical, ecological, or cultural situations, including, for instance, cases where animals migrate from one part of the reserve to another or where a cluster of core areas need protection. This concept differs from traditional designs because it is an open, rather than closed, system. It considers the management problems of the surrounding areas and provides for needs of local populations (l).

Each participating country designs its own program under the minimum requirements of MAB. Thus, practices vary from country to country depending on available manpower, resources, and political commitment. Representation to MAB, however, may provide a tool for developing-country experts to improve the national and international visibility of their conservation work. To a limited extent, the UNESCO-MAB program can sponsor outside experts to provide technical assistance in countries where they are needed.

Figure 26.—A Typical Biosphere Reserve



In the comparatively short life of the MAB biosphere reserve effort, the concept behind biosphere reserves—the improved integration of long-term conservation and socioeconomic needs—has become increasingly recognized as an important and, in some areas, a critical tool for effective conservation of natural systems. However, additional field experience and monitoring are needed to evaluate the successes of existing biosphere reserves. Current indications seem to be that biosphere reserves suffer from some of the same problems as other protected areas—lack of adequate institutional support, lack of adequate staff and funds, and poor coordination with other activities and with government concerns.

Conclusion

Actions to establish and manage protected areas could help protect undisturbed forest resources and prevent some resource degradation in the Tropics. Protecting sample ecosystems in some system of protected areas can be an important technique to preserve representative flora, fauna, and habitat and, thus, maintain ecological diversity and a range of goods and environmental services in tropical areas.

An unknown number of the Tropics' protected areas are inadequately managed and suffer deforestation and other resource degradation. Factors that contribute to these problems are a lack of commitment at the government level, insufficient funds, and scarcity of trained personnel in tropical countries to carry out the many tasks involved in planning, designing, and managing protected undisturbed tropical forests. If the first two factors persist, it may be preferable to improve the management of existing protected areas through appropriate institution-building activities rather than create new areas on paper which would further overextend the limited funds and human resources. Since lack of appropriately trained personnel is an important constraint, the United States can make a significant contribution by making U.S. expertise more readily

available—through universities, nongovernmental organizations, and government agencies such as the National Park Service.

The objectives of protected areas have evolved from strict protection to a broader approach that considers socioeconomic and institutional factors. Thus, the need to develop and test methods based on the latter approach grows. Few such conservation techniques have been developed. The MAB biosphere reserves are one attempt to integrate conservation with development. However, development of the biosphere reserve concept is still at the experimental stage in both tropical and temperate zone countries. The U.S.-MAB effort, while effective considering the minimal funding it has received, is constrained by a reduction of support and a lack of a strong, consistent U.S. Government commitment. Stabilizing the U.S. commitment to MAB would enable U.S. scientists to contribute their skills and expertise to develop further this innovative conservation option. This might encourage additional international support for various MAB programs as well.

MAKING UNDISTURBED FORESTS MORE VALUABLE

The environmental services provided by undisturbed forests frequently are not enough incentive for individuals to maintain uncut forests. One way to clarify the importance of uncut tropical forests is to document the value of their environmental services and use this information to convince government decisionmakers to invest in protecting the forests. However, while this is important for parks, it has not proven a practical method to protect large forest areas in less developed countries. Another approach is to enhance the value of forests by managing them for wood production, However, cutting trees is disruptive of the forests' ecology and, for many types of tropical forests, wood harvesting technologies that are profitable and yet do not degrade the resource base have not been demonstrated. Thus, both for legally protected areas and for certain other undisturbed areas, sustaining the forest depends on making it more valuable without cutting the trees.

Many useful and valuable forest products are produced with little or no associated wood harvest. More organized harvesting, processing, and marketing of these products, coupled with development of new products, markets, and management infrastructures (including organization of local institutions to regulate harvesting) could greatly enhance the value of undisturbed forest [17,23).

Nonwood Products

Nonwood products include those obtained from the wood, bark, leaves, or roots of trees as well as products obtained from other vegetation and from animal and insect life in the forest. These products obtained near and in forests are directly or indirectly dependent on forest ecosystems. Examples include gums, resins, drugs, dyes, essential oils, spices, naval stores (turpentine, rosin, and derived products), and livestock forage as well as a wide variety of fibers used to make baskets, mats, ropes, and buildings. The value of some of these products is not well quantified. Some, such as certain specialty oils, may be relatively unimportant economically. Others, such as natural-base pharmaceuticals and certain fibers used in household goods, serve currently irreplaceable functions, either locally or internationally.

One example illustrating the potential of nonwood tropical forest products is silk, a product gathered for thousands of years in some areas, yet having considerable potential for development. Most silk is produced by domestically reared caterpillar larvae on a strict mulberry leaf diet. In India, however, an extensive cottage industry produces silk from wild tasar silkworms that feed on a variety of wild trees. For centuries, forest-dwelling people have produced this coarse, strong, tan silk. Tasar silk

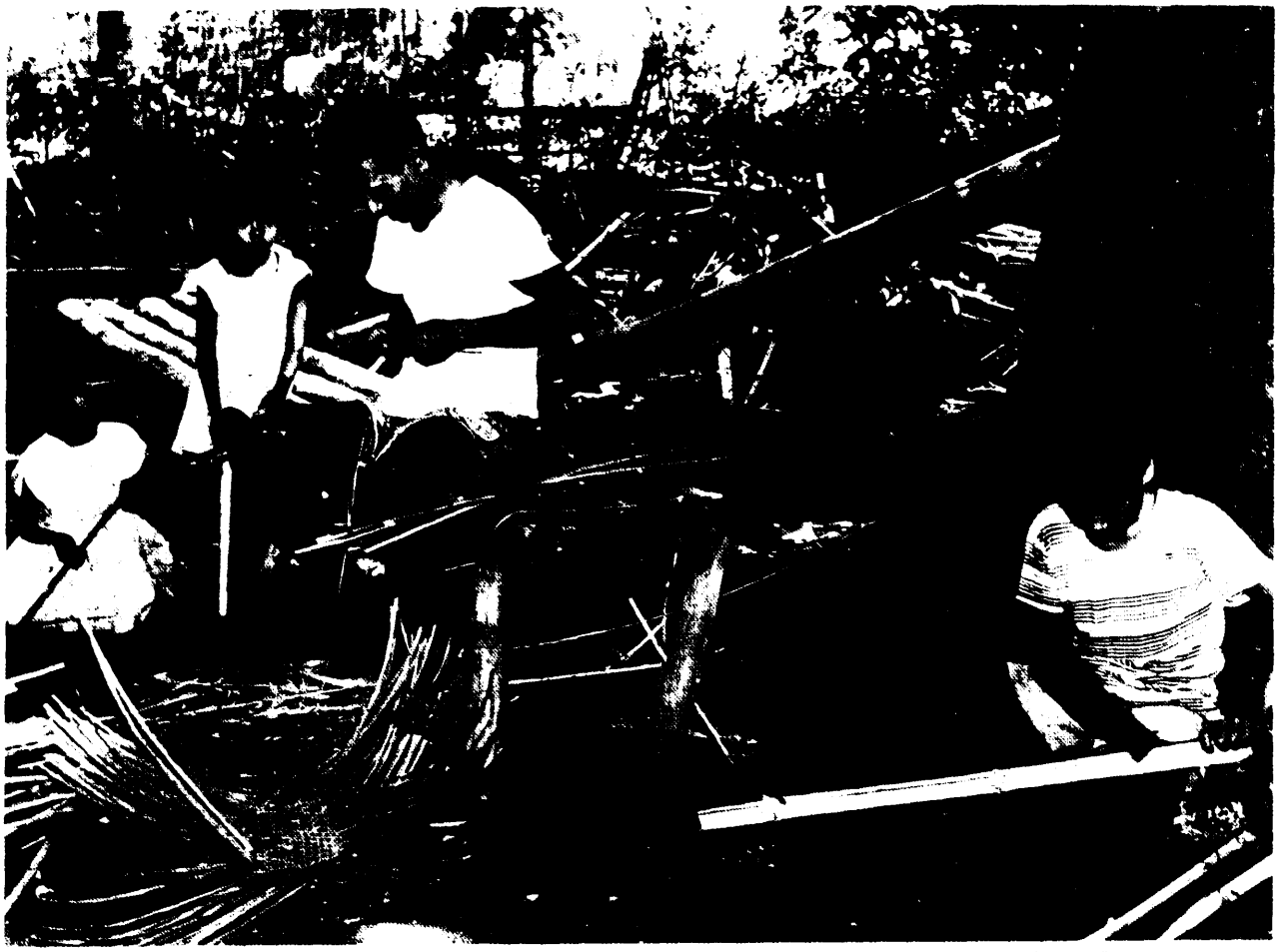


Photo cradit: S. Bunnag for FAO

Bamboo has many subsistence and commercial uses, including village handicrafts. Here Philippine villagers make "birdcage" lampshades for the tourist market

export earnings in India totaled US $4.4 million in 1976 and the industry employed at least 100,000 families (9).

Tasar silk is secreted by several species of the genus ***Antheraea.*** India alone has at least eight species, but only one, ***A. mylitta,*** has been exploited commercially. The little research that has been done to improve production shows great promise: breeding experiments have produced a 169-percent increase in silk weight. Similarly, tests of rearing techniques have shown potential to increase the average income per family from $30 per year to $250 in 45 days (10).

The main tasar silk-producing countries today are China and India. However, the food plants that can support tasar silkworms cover 7.7 million ha in the Tropics. This seems to offer significant opportunity for other developing countries to develop industry, employment, income, and a raised standard of living for forest-dwelling people while encouraging maintenance of forest ecosystems that are habitat for the silk-producing species (9).

Forest Food Sources

Meat from wild animals and fish, fruits, nuts, honey, insects, fungi, and vegetables are all im-

portant forest food sources. Despite the impact of modern agricultural techniques and crops, in many parts of the world these wild food sources continue to contribute significantly to local diets. In regions that are unsuitable for conventional animal husbandry, "bush meat" is often a main source of animal protein. For example, in Ghana nearly three-quarters of the meat consumed is from wild animals (4), Even where cultivated crops such as cassava or corn are staples, the great variety of food types available from the forest is important for adequate nutrition.

Small Animals

Giant rats, turtles, capybara, grasscutters, and other small animals are sought-after foods in some developing countries, with scientific husbandry, these animals could become important sources of much-needed protein. Further, the development of some of these food sources could provide incentives to sustain tropical forests,

Capybara, for instance, are the world's 1argest rodents—they weigh up to 100 lbs. Capybara live in family groups on the edges of ponds, lakes, rivers, and swamps in Central and South America. They eat only plants—preferring coarse swamp grasses, aquatic plants, and weeds such as water hyacinth. Wild and semidomesticated capybara has been a meat source for centuries, but only recently have Venezuelans begun farming them. Researchers there report that capybara digest food 3% times more efficiently than cattle. They are fecund, producing six young in a year. Further, their leather commands a high price and is sought by glovemakers because it stretches in one direction only (4,24).

Examples of Nonwood Products

Various essential oils are obtained from natural sources. For instance, sandalwood oil is one of the best known of all perfume oils. It is produced mainly in India from both wild and cultivated trees. Attempts to synthesize the oil have been unsuccessful.

Chemicals, including drugs, are important forest products for both local and world populations. Various modern pharmaceuticals—e.g., quinine from cinchona bark—are of tropical origin. Another useful forest chemical is lac used in shellac, waxes, and binding and stiffening agents. Lac is secreted by a tropical insect that feeds on tree sap.

Gums such as chicle are obtained from wild trees in forests of Central America. Natural gums are primary ingredients of chewing gum and are used in many processed foods. They contribute both to export revenue and to local employment.

Naval stores—turpentine, rosin, and derived products—can be produced from tropical pines by a technically simple process without damaging the trees.

Forage is another traditional benefit provided by forest resources. Ground and tree vegetation are both used-though tree fodder is particularly important in areas with a prolonged dry season. In the past, there has been little active management of forest fodder resources.

Fibers obtained from forest vegetation are especially important in subsistence cultures, where they are used for making baskets, mats, rope, furniture, and in construction. Some fibers are marketed (e.g., for wicker-work).

Spices are found in and around most forests, though commercial production is usually in plantations. Pepper, clove, nutmeg, cinnamon, and vanilla typically are plantation crops but do exist in the wild. Cardamom is harvested both in the wild and from plantations. The plant thrives in the shade and might increase the per-hectare return from tropical forests.

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Examples of Forest Food Sources

One of many forest fruits is the multipurpose ***Borassus*** palm. The milk of the unripe fruit is marketed as a nourishing and popular drink. The ripe, yellow fruit is eaten. Finally, some fruits are left to sprout cotyledons that are eaten fried (16). More well-known tropical fruits include mango, papaya, guava, banana, pineapple, coconut, avocado, and breadfruit.

Amidst all the greenery of the forest exists a great variety of edible vegetables and foliage. An estimated 500 species are used in Africa alone **(13).**

Forest rivers, coastal areas, and mangrove forests harbor an abundance of fish, **crustaceans,** and **molluscs** that make significant contributions to local diets.

Wild animal protein-from mammals, birds, reptiles, amphibians, and invertebrates-contributes to diets in many cultures. Rodents and ungulates are particularly common meat sources.

Palm oil is produced from the fruit of wild palms. The trees also supply palm wine and fibers. A forest species with great potential for oil production is Raphia palm, which thrives in swampy, high rainfall areas. Other species, including the tallow and neem trees also are, or could be, sources of oil products **(16).**

Honey and wax production is another function of the forests that provides essential products for local populations. The introduction of modern beekeeping methods could expand this use with only moderate inputs.

Nuts are a common and protein-rich food source in forests important both locally and for trade. Betel nut, cashew nuts, and Brazil nuts are examples.

Gamo Ranching[1]

About three-fourths of the citizens of Zaire and Ghana rely on wildlife as their main meat source (4)—a situation common in some other tropical nations. As pressures on wildlife populations and habitats increase, more attention is being given to the idea of game ranching. Problems could arise, however, because creating commercial markets for these new food sources could induce subsistence gatherers to exploit wild game for income. Unless these activities are carefully regulated, this could result in overexploitation of wild game.

Husbandry of indigenous wildlife offers some potential to provide incentives to sustain the quality of dry open forest and shrubland habitats where most ungulates are found. Native wild species generally are adapted to their natural environment and, thus, tend to require less water and be more resistant to disease than exotic livestock. Native species thrive on local vegetation and typically may be better suited to arid and semiarid ranges than conventional livestock. Further, native species' efficiency of food use usually compares favorably with livestock (19). In national parks of Zaire and Uganda, for instance, each square kilometer of land can support 24 to 37 tons of wildlife (10 species) compared with only 3 to 5 tons of cattle (23).

Much remains to be learned about the husbandry of wild species. Further, there are drawbacks to this technology. Wild meat can contain parasites, making inspection, for commercial markets a problem. Initial costs to acquire, stock, fence, and manage a range of adequate size can be high, and questions remain about whether such operations can be profitable and sustainable. However, in time game ranching might be developed to act as an incentive to preserving wild species and their habitat.

[1]See *Water-Related Technologies for Sustainable Agriculture in Arid/Semiarid Lands: Selected Foreign Experience—Background Paper* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, OTA-BP-F-20, May 1983), for more information on game ranching in Africa.

Innovative Forest Products

A wide variety of forest products that are not now harvested or are only gathered on a small or subsistence scale might have commercial potential. Development of markets for such products can provide income for rural people, thus reducing their need to overexploit forest resources, and can provide incentives to protect wild populations and their habitat. To develop these alternative forest products, wild breeding populations must be retained, habitat managed, and gathering activities regulated.

Papua New Guinea is a forerunner in efforts to take advantage of tropical forest biological resources. Much of Papua New Guinea remains covered by undisturbed tropical moist forest, and exploiting the economic value of its organisms is helping to safeguard this habitat. Papua New Guinea has developed management systems to domesticate, propagate, and harvest cassowaries (for feathers), megapodes (for eggs), wallabies and deer (for meat and hides), and a number of other species. Because insect collection is profitable, the government has declared insects a national resource and is the only country in the world to specify insect conservation a national objective in its constitution (23). These projects demonstrate a strategy that could be applied in other areas or to other organisms.

Production strategies dependent on wild breeding populations of threatened species face a serious constraint. unless expansion of the

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Examples of Innovative Approaches to Tropical Forest Resources Managment

Butterfly farming is an example of development of a commercial product from an unusual tropical forest resource. Once thought of as pests if common, or collector's items if rare, butteerflies have become a profitable forest resource for villages in Papua New Guinea. Butterflies provide a high value, low capital outlay investment: no tree clearing, fences, or veterinary services are required. Each year, millions are sold to museums, entomologists, craftspeople, and collectors. Collectors have paid as much as $1,00 for a specimen of the brilliantly coloreed birdwing butterfly. &

A system of management has been developed to control the production and exploitation of this resource. Villagers attract butterflies by planting preferred flowering shrubs around the edge of fields. Nearby, they plant the leafy plants that the caterpillars eat. The combination provides a complete habitat for the butterflies' lifecycle. The farmer simply harvests specimens as time and demand allow. Because the butterflies are collected under relatively controlled conditions, they typically are of higher quality than wild-caught specimens. Consequently, the demand for poached specimens is reduced.

Some 500 villagers are rearing or collecting butterflies, beetles, and other insects for export. The government has established an insect farming and trading agency to help market insects to overseas buyers. Profits return to the villagers. Because the program relies on healthy wild populations to keep the farms stocked, it provides an economic incentive to preserve forest habitat.

Crocodiles also are raised for profit by villagers in Papua New Guinea. Loss of forest habitat often exerts great pressure on forest wildlife, particularly the large predator species. In an innovative experiment in Papau New Guinea, a management scheme has been developed to counteract this trend--and produce benefits for local villagers, crocodiles, and, indirectly, forests.

Crocodiles in the wild lay between 30 and 70 eggs each year, but few of those actually survive to reach breeding size. Commercial hunting garners some income from the species, but threatens breeding populations because hunters seek the biggest specimens. Recognizing that a ban on hunting would be unenforceable and unpopular, the government restructured trade to discourage the shooting of breeders and encourage exploitation of the hordes of tiny hatchlings. They banned the sale of large skins, while assistance agencies helped to develop a management system to collect hatchlings in the wild and raise them to marketable size in captivity.

The scheme, though not without problems, shows some success. Crocodiles are raised for a year or two and sold by villagers for up to $100 each. (Young crocodiles have a better feeding efficiency than livestock: 1¼ lbs of food gives 1 lb of weight gain, while conventional livestock requires 5 to 8 lbs of food for 1 lb of weight gain.) Crocodile production brings Papua New Guinea $4 million in foreign exchange each year. Because the program is based on harvesting young hatchlings from the wild, the economic value of the wild populations and their habitats becomes apparent. It gives a tangible, economic value to wildlife protection.

SOURCE: N. Vietmeyer, "Underexploited Plant and Animal Resources for Developing Country Agriculture," *Background Papers for Innovative Technologies for Lesser Developed Countries*, Office of Technology Assessment workshop prepared for the U.S. House of Representatives, Committee on Foreign Affairs, September 1981.

markets for nonwood forest products is accompanied by strict regulation of gathering activities and preservation of habitat, the opportunity for profit will induce people to gather without regard for maintaining the breeding populations. Animal populations may decline precipitously. This occurred, for example, in fruitbat populations on the U.S. Pacific island of Guam.

Fruitbats area much sought after food source on Guam. But habitat destruction and overhunting have exhausted their populations to a point where one species is probably extinct and the other endangered. The demand for this delicacy, however, remains high and fruitbats are now being imported from islands in the U.S. Trust Territory, further increasing hunting pressure in these areas. On the island of Yap,

fruitbats have cultural significance which in the past had limited their harvest. But the attraction of Guam's markets has increased illegal hunting and export. Hunters will shoot into nesting colonies, disregarding the wounded or lost bats. Thus, the indigenous Yapese fruitbat is being harvested unsustainable and may become extinct if management and enforceable regulation are not instituted.

Conclusion

Forest ecosystems house complex associations of vegetation, wildlife, and other potential resources. If methods were developed to use these nonwood forest resources more fully—either by discovering new, valuable products or by facilitating collection and processing of established products—some of the incentives for deforestation would be reduced and more forests might escape conversion to unsustainable uses.

To do this, some marketable advantage must be identified in the local environment, then developed to provide sustained economic returns. This process calls for improved management of the resource system, which best comes from using modern science to build on a foundation of traditional knowledge. But governments often have too little information on the long-term value of their forests and invest very little in development of forest products other than timber. U.S. expertise could be applied to this problem, especially from the fields of ecology, botany, business administration, and forest management.

The lack of development of nonwood forest products may result partly from the fact that nonwood and subsistence food products gathered from tropical forests have rarely been accounted for in economic analyses. Such products generally are used in subsistence economies and have no easily defined "market value." Where they are commercially exploited, it is in a marketing system so diffuse that the product flows are seldom measured. Improved assessment of the role of forest products in subsistence economies and improved development of markets for nontimber forest products could cause decisionmakers to associate greater value with undisturbed forests.

Creation of new markets for previously unused tropical forest plants and animals or expansion of local markets for previously underused products could present new opportunities to overexploit forest resources. Unless management and regulatory systems are instituted along with market development, wild breeding stock may be depleted to fill market demand.

The various opportunities that exist to increase the value of the standing forests offer significant benefits to people as well as to forests. The management systems under development in Papua New Guinea are examples of how such systems can provide employment opportunities, income for local residents, new sources of food or other human needs, and opportunities for exports and increased foreign exchange. Increasing commitments from U.S. and other assistance agencies to develop sustainable management systems and markets for nonwood products could act to alleviate a variety of social problems.

CHAPTER 7 REFERENCES

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