Forestry For Sustainable Development

WORKING PAPER 10

The Nontimber Values of Tropical Forests

by

Norman Myers

November 1990

Forestry For Sustainable Development Program
Department of Forest Resources
College of Natural Resources
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PREFACE

The author of this paper, Dr. Norman Myers, is an associate in the Forestry For Sustainable Development (FFSD) Program at the University of Minnesota. Preparation of this paper was supported in part by the United Nations Environment Program. It is the tenth in a series of working papers produced for the FFSD Program at the University of Minnesota that represent work in progress. The purpose of these working papers is to stimulate discussion among individuals working in the field of interest.

The major objectives of the FFSD Program are to:

1. Improve the availability and usefulness of existing technical knowledge related to forestry for sustainable development - translate state-of-the-art scientific and technical information into practical and easily usable management guides and training materials that can be used effectively in planning and implementing development projects that will contribute to sustainable development; and

2. Improve the policy and organizational environment to encourage application of sustainability strategies - identify and develop effective institutional mechanisms, both at the policy and project levels, for introducing sustainability strategies into the development planning process at an early enough stage to influence project or program design.

The focus of the Program is on social forestry and related strategies within a watershed management framework as an integrating mechanism for moving toward sustainability in land use and in natural resource-based development projects. It involves an interdisciplinary group of faculty from the University of Minnesota, and associates at the University of Arizona, Yale University, Oxford University, the InterAmerican Development Bank, and other development groups. The FFSD Program is part of the University of Minnesota's Center for Natural Resource Policy and Management in the College of Natural Resources.

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THE NONTIMBER VALUES OF TROPICAL FORESTS

by
Norman Myers[1]

BACKGROUND

Tropical forests are being misused and overused through forms of exploitation that focus on just a single output, e.g., hardwood timber or cattleland beef or agricultural opportunity--and these forms of exploitation entail gross disruption, if not destruction, of forest ecosystems with disregard for other outputs available such as nontimber products and environmental services. So a key question arises: is it possible to exploit the forests for products and services in ways that do not entrain depletion of forest resources, i.e., that can be harvested in sustainable (because self-renewing) fashion?

This paper focuses on this key question, and seeks to answer it by looking at several categories of nontimber products and exploitation models, e.g., extractive reserves, traditional forest land agroecosystems and biodiversity. It also looks at a related management strategy to safeguard forests, vis the buffer zone: how far does this serve to supply a cordon sanitarie, especially if human use of the buffer zone features a mixture of forestry and nonforestry activities?

The rationale behind the paper is that we need to move beyond the unduly depletive modes of exploitation that now characterize almost all our use of tropical forests (Fearnside 1989a, Kohlhepp and Schrader 1987, Myers 1983, 1984, 1990, Robinson 1988). But this, in turn, raises a further key question: how far, both in principle and practice, can alternative exploitation modes, such as those addressed here, prove competitive with established modes (logging and the like)? Or, to be more concise, can they demonstrate that they supply a viable alternative in commercial and economic, also social and political, senses--and, if so, how far can we formulate broadscope models for widespread application? Or will they turn out to be so site-specific that it will be difficult to draw out any commonalities of approach for a development paradigm?

EXTRACTIVE RESERVES

One of the most promising options for sustainable forest land exploitation lies with the concept of extractive reserves, pioneered by the late Chico Mendes, among others, in the Brazilian state of Acre (Anderson 1990, Fearnside 1989b, Hecht and Cockburn 1989, Instituto Brasileriro de Geografia e Estatistica 1984, Schwartzman and Allegretti 1987, 1989). Broadly speaking, more than 13,000 people have been harvesting wild rubber and other products in some 27,500 sq km of Acre, supplying an annual income far above what could be derived through cattle ranching and small-scale agriculture. The reserves offer more than 30 products with commercial value, plus noncommercial items such as food and medicines (Fearnside 1989b) consumed by the extractivists themselves. In the main, the extractivists comprise 68,000 rubber-tapper families (minimum figure) (Instituto Brasileriro de Geografia e Estatistica 1984), and these families are estimated to occupy between 4 and

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7 percent of Amazonia altogether, at a typical density of one family per 300-500 ha (Fearnside 1989b).

As a measure of some economic values at issue, note that nonwood products extracted in Acre, Rondonia and Amazonas were worth an annual value of US$48 million as far back as 1980. Yet of Acre's 148,000 sq km of forests, well over 5,000 sq km have been destroyed and another 28,750 have been grossly degraded in the past few years. The "opportunity costs," i.e., the potential extractive-reserve revenues foregone, are already estimated to amount to hundreds of millions of dollars in this one state alone (Hecht and Cockburn 1989).

Notwithstanding the publicity that has been accorded to the extractive reserves of Acre, the same basic strategy is exemplified by experience in the northern Peten in Guatemala (Heinzman and Reining 1990). Comprising 35 percent of the country, the 36,000 sq km area is still almost 60 percent forested, even though tree cover is being rapidly depleted through incursions of settlers and squatters at a rate that surpasses 250 people per day on average, or almost 100,000 people per year. The most valuable of the extractive-reserve products is foliage collected from two species of palms, *Chamaedorea elegans* and *C. oblonghea*, both known locally as "xate." The foliage is sold on the international market where it is used as greenery in floral arrangements for weddings and funerals. Extending across a forest tract of some 14,000 sq km and with densities as high as 8,500 plants per ha, these understory palms grow to no more than 3 m in height, thus they are restricted to mature forests with their high shade and humidity. This means that extensive forest disturbance, let alone deforestation, serves to eliminate the resource (Heinzman and Reining 1990).

Up to 7,000 forest-dwelling people are currently involved in extraction processes in the Peten, from harvesting and treatment to transportation and marketing of the plant materials. In 1987 some 140 million leaves were produced for export (primarily to the United States, but almost 60 million to Europe), with a foreign-exchange value to Guatemala of almost $2 million, or 0.4 percent of all such exchange earnings (Heinzman and Reining 1990).

In addition, there are two other major extractive products known locally as chicle (*Manilkara zapota*) and allspice (*Pimienta officinalis*). Several other nontimber products with significant value are available, e.g., ornamental and medicinal plants, latexes, fruits, nuts, and construction materials, all of which can be extracted sustainably (Heinzman and Reining 1990).

Note, moreover, that these extractive economies overlap in terms of people involved, transportation networks and forest camps. When demand for one product ebbs seasonally, other products can be harvested. Taken all together, they provide a broad resource base which actively exploits the inherent diversity of the forest tracts. They give the forest high economic value, while offering rural individuals a mode of deriving diverse incomes.

The predominant current use of the Peten forests is milpa, small-scale subsistence farming based on forest clearing, cropping for two years, followed by six years of fallow. A preliminary analysis of the milpa system (Heinzman and Reining 1990), employing a 9 percent discount rate for calculating present values, generates a net present value of $182 per ha, assuming constant yields over each succeeding cycle. If soil fertility diminishes from cycle to cycle as is usually the case, milpa generates a net present value of only $138 per ha. By contrast, xate extraction offers a net present value of $380 per ha, assuming constant yields over time, and about $170 per ha if a mortality loss of 5 percent per year is assumed. In short, the strategy of a xate-based extractive reserve, as revealed by the net present value of cash income, appears to offer an unusually beneficial economic use of forest lands, with income well above that to be derived from traditional slash-and-burn agriculture--which is not only economically inefficient but ecologically unsustainable.

Given the demonstrated potential of extractive reserves, one might well ask, why is the strategy not more widely applied elsewhere? One answer to this perplexing question lies with the perception of the forestry "expert" as regards nontimber products. They do not rank as "real" products like timber or beef that proclaim their (limited) value through a multitude of signals of the marketplace. Timber and beef are readily recognized and understood by government planners--unlike the bewildering multitude of nontimber products that present a "messy" challenge of tabulation, evaluation and marketing. To this extent, the problem lies not with the forests and their outputs, but with lack of understanding on the part of forestry planners. As an American news reporter (Carterton 1988) has put it, "Until the shades fall from the eyes of forestry experts, the forests themselves will continue to fall. Commercial timber, unfortunately, supplies a pretty solid beam to block the vision."

All in all, and in the experience of this writer, extractive reserves present a viable alternative for tropical forest exploitation on a sustained-yield basis. The strategy is highly adaptable to a variety of local circumstances, depending not only on the forest products available but on the level of rural infrastructure (commercial outlets, marketing networks, credit facilities and the like), and on the degree of cash-economy involvement desired by communities in question.

Equally significant, the extractive reserve concept lends itself to much elaboration and diversification in accord with the spectrum of products that could be further developed for self-renewing harvests. For illustration, consider the research model recently developed in western Amazonia (Peters et al. 1989). A single hectare of forest has been found to yield a sustainable annual harvest of wild fruits and latex with a net present value of around $6,330, using a discount rate of 5 percent. In contrast, a sustainable harvest of 30 m^3 per ha of tree volume every 20 years, yields a net present value of $490 per ha (Peters et al. 1989). But note that the two sets of outputs as documented are not strictly comparable: the first appears to refer to finished products ready for a consumer market, while the second refers to the value of logs standing in the forest; and the analysis reveals various other economic shortcomings (Mendelsohn and Uhl 1990).

Also in western Amazonia there is scope to exploit just a single resource, the oil-bearing vine (*Fevillea* spp.), on a sustainable basis, with revenues far exceeding what could be earned from logging (Gentry and Wettach 1986). The vines' seeds contain a higher content of oil than any other dicotyledonous plant known. If other vines and lianas in the forest were to be cut in order to increase the numbers and growth of the *Fevillea* vines, the per ha output of oil would compare to the most productive plantations of e.g., the African oil palm--but do it without cutting a single natural-forest tree, albeit with more than zero impact (not much of which needs to be significantly disruptive). Of course, this does not mean there must be similar economically valuable plants in Caribbean forests. But given our extreme ignorance of the economic properties of the region's forest plants, it would be surprising if a number did not offer significant economic and export potential--all unknown as that potential still remains.

For a more broad-ranging extractive-reserve prospect, consider a preliminary investigation of potential within a forest tract of Amazonia in Ecuador. According to a preliminary and exploratory appraisal (Paucar and Gardner 1981), and drawing on the experience of local people who have long taken a self-sustaining harvest of wildlife products (partly in the form of meat for consumption, and partly in the form of skins and hides for export), wildlife proves to be a strongly renewable resource provided the level of exploitation is not excessive. As much as 85 percent of animal protein consumed by local people comes from wild animals, notably pacas, pecaries, deer, tapirs and agoutis, among more than 40 mammal species in all. A sustainable harvest of wild meat can amount to 240 kg per sq km, with a market value (late 1970s value) of about $1.8 per kg, or a total of almost $440 overall (Paucar and Gardner 1981). (Were the harvest to be systematized, and expanded to include birds, turtles and fish, the minimum potential value could be increased as much as ten times).

Furthermore, since almost one-third of Ecuadorian Amazonia consists of swamps and rivers, there is plenty of scope for the harvest of caimans, at least two per ha per year. Thus, a square kilometer could yield an estimated 200 caimans per year. Since a caiman measuring 1.5 m in length is worth roughly $145 for its hide at farm gate prices, a single square kilometer of such habitats could produce on a sustainable basis as much as $29,000 per year for the hides alone, not counting the value of the meat.

In addition, each square kilometer of forest can renewably produce 20 primates each year for biomedical research. With an individual being worth between $200 and $300 at farm gate prices, a self-renewing harvest of wild primates could generate a minimum of $4,000 per year. (For sure, many people object to the prospect of using wild primates to foster human health; and in the past, wild primate stocks have almost invariably been overexploited, sometimes critically so. But if this essential factor can be taken care of, there appears to be no additional objection to a sustainable harvest of wild primates, particularly insofar as the harvest should help to promote the survival of the primates' forest habitats.)

This all means, using the values given above, that a forest tract of one square kilometer could, under scientific management, produce a sustainable crop of caiman and primates alone with a potential market value of perhaps $33,000 per year. This amounts to a market value of about $330 per ha per year, with a present gross value before costs of $6,000 per ha (using a 5% discount rate). In contrast, Peters et al. (1989) report an estimated present value of gross returns (discounted at 5%) from a typical Amazonian cattle pasture in Venezuela of $2,960 per ha, without allowing for costs of weeding, fencing, or animal care.

TRADITIONAL FOREST LAND AGROECOSYSTEMS

Certain forest-dwelling communities, often made up of tribal peoples, offer myriad insights into ways to make sustainable use of forest plants and animals for food and other purposes. To illustrate, let's consider one of the most species-rich zones on earth, western Amazonia, in order to examine the subsistence strategies developed by its forest inhabitants in order to make sustainable farming use of forest ecosystems. The case study serves as an illustrative example of agroecosystems elsewhere in tropical forests, where ethnobotanical knowledge promotes self-renewing exploitation of wild species. The more we can draw on the accumulated folkloric experiences of tribal peoples, the more we shall be able to formulate agrodevelopment models for replication in other parts of the tropical forest zone. In essence, the western Amazonia strategy depends on the exploitation of all forest resources that can be harvested in sustainable fashion (for some background documentation, see Posey et al. 1984). As such, the strategy incorporates three principal elements: 1) agriculture and aquaculture; 2) cropping of wild and semidomesticated species for food, notably plants but also mammals, fish, reptiles and the like; and 3) harvesting of a range of other forest products for additional purposes, such as building materials and medicine. These three activities are not practiced in isolation from each other. Rather they are pursued in concert, with mutually supportive benefit.

Nor is the lifestyle confined to patches of cleared homesteads in forest environments. Rather it combines an intensive use of croplands with an extensive use of surrounding forest ecosystems. In other words, the strategy seeks to make self-sustaining use of such sectors of the forest as are cleared, while drawing widely on renewable resources of the forest environs.

The strategy thus contrasts markedly with conventional agriculture in Amazonia, which leads to erosion and compaction of soils, to leaching of nutrients, to outbreaks of episodic pests and diseases, to rapidly declining crop yields and degradation of soils, and to clearing of ever-greater tracts of forest. Hence, it also contrasts with those variations of semimodernized agriculture that depend upon substantial inputs of synthetic fertilizers among other artificial additives. In short, it is a "native" agroecosystem, practiced with virtually no external inputs.

The basis of the system is the growing of crops for food, in conjunction with trees for fruits, fertilizer and fuel. To these ends, the system mobilizes a wide variety of multitiered and multiuse crops. In a fully developed system, it can feature as many as 100 species in a single hectare. This all adds up to a polycultural system of agriculture that, by virtue of its diversity, goes some way to mimicking the ecological complexity and biotic stability of the natural forest.

A host of crops is available, even though few feature in established cropping systems. In the topmost layer are palms, which provide food and a variety of other products, together with leguminous trees used for fertilizer as well as fuel and building materials. At middle level are cacao and coffee bushes, together with leguminous vines and beans for food and nitrogen; also at this level are cash crops such as lemongrass, cassia, ipecac and zingiberaceous (e.g., ginger, cardamom, turmeric, etc.) species. At the lower levels are short-stemmed cereals such as rice, plus root and tuber crops such as taro, yams and sweet potato, also vegetables and weed-type crops for green manure. Interspersed among these diverse crops are insect-repellant plants among other biocontrols, and cucurbits with built-in resistance to weeds.

Certain tribes utilize a remarkable array of forest plants. The Siona and Secoya Indians of eastern Ecuador utilize no fewer than 224 species, most of them for foods, with others for materials for tools, construction purposes and crafts (Vickers and Plowman 1984). The Chacobo Indians of northern Bolivia grow 40 species of food crops in their garden farms, ranging from rice and maize to papayas, water melons and cashews (Boom 1985); and they utilize a remarkable 80 percent of the surrounding forest's trees, shrubs, vines and herbs for foods, clothing, housing and medicines. Some of these tribes are adept at cash-cropping of forest products. For instance, the Gavioes Indians of western Brazil are so capable of production, transporting and marketing of forest goods, that in some areas with dense stands of Brazil nut trees the produce generates more revenue than an equivalent area of pasture devoted to cattle ranching (Ramos 1980).

In addition to plants, these tribal peoples make widespread use of forest animals. In some floodplain areas, for instance, smallholders raise the capybara, the world's largest living rodent which often attains the size of a pig. In its natural habitat, it puts on weight at a rate of more than 50 g a day, which under captivity and with better feeding proves to be 3.5 times more efficient in meat production than cattle, generating an average of 63 kg of meat per ha--while the net cash return is almost three times higher. The capybara produces between 1.2 and 1.8 litters per year, with four to six, and occasionally eight, progeny per litter. The animal can be harvested at a rate of about 40 percent of stocks per year, by contrast with only 10 percent or so for cattle.

Other animals used in semidomesticated state include the paca, agoutis, manatees, several species of river turtle and the green iguana lizard, among other wild herbivores. Whatever the species, all can be raised on sectors of homesteads interspersed among crop patches, through integrative management systems.

So much for terrestrial components of the agroecosystems. In addition, there is the aquaculture dimension. Basin-wide Amazonia contains the most diverse freshwater fish fauna in the world. Were the fish resource to be even superficially exploited in systematic fashion, it could generate far more animal protein for the region than the 60,000 sq km of cattle ranches already established (Goulding 1980, Smith 1981).

Moreover, these established forms of meat production are often supplemented by harvesting of wild creatures from the surrounding forest--not only pacas and turtles, but also tapirs, peccaries, deer, primates, birds, armadillos and snakes. The Yekuana Indians of southern Venezuela harvest 9 species of terrestrial mammals, 9 species of monkeys and 18 species of birds on a self-renewing basis through time (Frechione 1981). A number of other human communities consume an average of 25 g of wild meat per day, occasionally 10 times as much. In the Peruvian sector of Amazonia, rural people obtain well over four-fifths of their animal protein from hunting and fishing. In one extensive area, they consume an average of over 50 g a day of wild animal meat, plus 135 g of fish, by contrast with 22 g of domestic fowl and 12 g of pig meat (Frechione 1981).

This short review provides a preliminary appraisal of smallholder agroecosystems in Amazonia forest lands. What is further needed is urgent development through trial schemes and demonstration projects. This presents a fine opportunity for innovative and action-oriented research on the part of governments and aid agencies. Ultimately we can visualize a potential agroeconomy emerging, based on sustainable use of forest resources, plants and animals alike, that are naturally adapted to nutrient-poor soils of forest land zones of the humid tropics. Such an economy would offer through its cash crops a lead-in to the market economy and economic advancement of a scale and type that accords with local proclivities.

VALUE OF BIODIVERSITY

There has been much written in recent years about the value of tropical forests' biodiversity in commercial and economic senses (Myers 1982, Oldfield 1989, Wilson 1988). As the most species-rich biome on earth, with perhaps 30 million out of a postulated 35 million species planetwide, the forests offer a vast reservoir of genetic resources that can make many contributions to modern agriculture, medicine and industry. Among established products are damar, sandalwood, resins, kopal, several essential oils and edible oils, fruits, nuts, fibers, canes, natural silk and exudates. All these nonwood products can be harvested with virtually no disturbance of forest ecosystems.

Conventionally known as "minor" forest products, these turn out to be not so minor when we consider their variety and value (Lasschuit and van Eerd 1983). Peninsular Malaysia's forests contain at least 1,250 nontimber plant species of use to humans, or roughly one in six of all species (Jacobs 1982). This total, moreover, does not include many additional food plants that are gathered from the forest in small quantities; nor does it include all medicines; and it includes only a few items from several other major categories. So the true proportion could be as high as one plant species in three. Making an approximate extrapolation based on the one-in-six estimate above (albeit derived from a very meager data base), one finds that some 15,000 plant species in tropical forest could well offer potential for material goods (Jacobs 1982).

What are some of the economic values involved? Rattan exports from Indonesia are now worth some $90 million per year (Cornelius 1984). Rattans, being tough, climbing palms, are in a sense woody materials, but they are included here since they are not generally classified by foresters as timber products. In 1981 Indonesia's exports of patchouli oil were earning around $12 million a pear, and of related oils more than $25 million (Tcheknavorian-Asenbauer and Wijesekera 1982). Together with exudates and sundry other products, totalling 80,000 tons in all, Indonesia's nonwood products brought in foreign exchange totalling around $200 million in 1982, up from $28 million in 1973 (Gillis 1986). True, Indonesia's nonwood products are better developed than those of most tropical forest countries, and to this extent the data may not be characteristic of other countries. But they reveal the potential that awaits methodical development. Moreover these figures reflect only a crude minimum calculation of total revenues. They compare with export earnings from wood products of $583 million in 1973 and $899 million in 1982 (Gillis 1986).

For a more extensive and systematized assessment, consider the case of India. In 1977 total net revenues accruing to the government from the forestry sector, including many sources apart from commercial timber, amounted to $336 million (Gupta and Guleria 1982). Of this total, nonwood forest products accounted for $134 million, or 40 percent (and their share of forestry exports 63 percent). Since an estimated three-fifths of all nonwood forest products are consumed on the spot by local people, they do not enter the cash economy, and hence are not incorporated into national accounting figures. So a realistic figure for the value of these products probably exceeds $200 million. Among leading categories in 1977 were medicinals, drugs, and pharmaceuticals, worth $38.4 million; lac and lac products, $19.8 million; gums, resins and balsams, $14.6 million; bamboos, $6.8 million; and essential oils, $5.9 million (Gupta and Guleria 1982).

Equally important, the rate of growth in revenues from India's nonwood products during the period 1970-77 amounted to 15.6 percent per year, way ahead of that for commercial timber. In addition, nonwood products were generating much employment, more than 70 percent of the 2.3 million man-years in the forestry sector overall. The true figure for employment, including those man-years not counted by official surveys, can be roughly estimated at as many as 4 million (Gupta and Guleria 1982).

Note, moreover, that scientists have conducted intensive screening of only one plant species in 100 and a mere one animal species in 10,000 or less, in order to assess their utilitarian values. Thus, we can expect that whole cornucopias of new foods and pharmacopoeias of new medicinals, plus abundant new materials for industry, could become available if we were to undertake a comprehensive and systematized assessment of what awaits.

For instance, cancer specialists estimate there are at least 20 plant species with potential to generate superstar drugs along with lines of the rosy periwinkle's two potent therapies used against blood cancers (Duke 1990). The commercial sales of these two drugs now amount to some $280 million per year worldwide (with economic benefits to American society of some $340 million per year) (Douros and Suffness 1981). If we conservatively reckon that average annual sales since their release onto the market in 1961 have been in the order of $100 million per year, and if we suppose the genetic-material contribution to the drugs has been roughly one percent of their commercial value, the rosy periwinkle can be said to have been worth $30 million over a period of 30 years. Regrettably not a cent of these revenues have reverted to the source country, Madagascar, so the country's government has no commercial or economic incentive to safeguard the 4,000 plant species that are at risk in Madagascar's fast-declining forests.

In addition, the forests offer myriad sources of new foods, for example fruits. Temperate-zone plants have given us only about 10 fruit species altogether, whereas the tropics have supplied us with almost 200 species, and over 3,000 species are available in all (Smith et al. 1990). The main tropical source of fruits is the forest biome, particularly the Southeast Asian sector. Around 125 species of fruit plants are cultivated in Southeast Asia (Smith et al. 1990), many of them having originated in the forests; and more than 100 other fruit trees grow wild in the forests, several of them producing edible fruits, and others offering potential for crossbreeding with established crop species. In New Guinea alone there are more than 200 wild fruits that delight the palates of local forest dwellers, yet they have still to be allowed their chance to make their point in the marketplace, and thus to supply a rationale for conservation of their forest habitats.

A well-known instance of Southeast Asian fruits is the durian (*Durio zibethinus*), with delectable taste and execrable smell (the experience of consuming a durian can be described as eating an almond-flavored custard in a public toilet). Also from Southeast Asia comes the rambutan (*Nephelium lappaceum*), a table fruit that is bright red and covered with whiskers. Perhaps tastiest of all fruits from Southeast Asia is the mangosteen (*Garcinia* *mangostana*), though regrettably the plant appears to offer little genetic variability. For those people who favor citrus fruits such as oranges and tangerines, the pummelo (*Citrus grandis*) offers a suitably stimulating taste: it yields a larger harvest than most citrus crops, and it can grow in saline conditions.

Equally abundant and diverse could be the fruits of South America, when we get around to cataloguing them all (Balick 1985). The tree tomato (*Cyphomandra betacea*) resembles an elongated tomato, though with much sweeter taste. The feijoa (*Feijoa* spp.) is a relative to the guava with a pineapple-like flavor. Perhaps best tasting of all South American fruits is the naranjilla (*Solanum quitoense*), a relative of the tomato, with a taste somewhere between a pineapple and a strawberry, and well deserving of its local name, "the golden fruit of the Andes." As a curiosity from South America, we can note the jabaticaba, a grape-like fruit that grows straight from the bark of its vine, with a flavor similar to that of the finest Concord grapes.

These are but a few examples of new foods awaiting us in the wild. Indeed a number of them have already made their way into our supermarkets. North American stores are starting to feature all manner of new vegetables and fruits: since 1970 the average number of items available has doubled from about 65 to more than 130 items, and in a number of instances as many as 250. This specialty produce, mostly from Asia and Latin America, has become a $100-million-a-year business (Vietmeyer 1986).

Among some leading entrants into the worldwide market are exotic items such as caladaza (pumpkin-like in appearance), tindora (a cucumber-like vegetable), jicama (a sweet-tasting root), calamondin (a sour lime-like citrus used as seasoning for fish and meats), jak fruit (the world's largest tree fruit, weighing 27 kilograms or more, featuring a yellow filling with a musky flavor), longan (a small-sized relative of the lychee), carambola (a sweet fruit that resembles a bright yellow star when cut), manzano (a banana with a pink skin), and cherimoya (described by Mark Twain as "deliciousness itself"). In addition there are lemongrass, Barbados cherries, and bitter melons, among more than 200 other little-known products.

Those persons who may suppose these out-of-the-way items will never become accepted on large-scale in supermarkets may reflect that we are today familiar with many crops our parents scarcely heard of: avocado, bean sprouts, chili peppers, adzuki beans and garbanzos--all of which are now as "everyday American" as apple pie. Recall too our experience with the kiwi fruit (*Actinidia deliciosa*), introduced into American supermarkets as recently as 1961, and within 20 years enjoying a market of more than 10,000 tonnes worth $22 million a year (Vietmeyer 1986).

As for the industrial-materials field there are thousands of tropical forest plants that await investigation and development. According to Brazilian scientists (Mors and Rizzini 1966), fewer than 200 of Amazonia's 30,000 plant species (twice as many as in the United States) have been assessed for their potential contributions to modern industry. Yet as far back as 1979 Brazil's exports of essential oils and other perfumery compounds and associated resinoids amounted to $21.5 million.

Thus, the value of biodiversity in tropical forests, while potentially a resource of immense worth, remains undetermined in methodical fashion (though see Norton (1987) for a preliminary and exploratory appraisal). We should note, moreover, that the citation of a good number of specific cases of plants with economic value (as presented in this paper) tells us something about individual species, nothing about biodiversity per se. Were the biodiversity of tropical forests to comprise only 1,000 species (instead of perhaps 30 million), and we could invoke evidence of the economic value of 500 of them, this would still say all too little about the intrinsic biodiversity value of the 1,000 species. Equally to the point, we should remember that new fruits or medicinals (or, for that matter, environmental services such as clean water and clean air) from wild species are no more than *products* of species and their diversity; by contrast, the diversity of species itself raises different questions, whether in terms of economic quantification or not.

Regrettably there are hardly any substantive efforts underway to tackle the research and analytic challenge of biodiversity and its "worth." The case continues to go largely by default--as is the situation with the great bulk of nonwood products from tropical forests. The instances of extractive reserves, traditional agroecosystems and the like remain isolated initiatives. Clearly there is urgent need for a full-scope, interdisciplinary and integrative effort to appraise the situation overall.

BUFFER ZONES AS A FOREST-SAFEGUARD MEASURE

As is well known and widely documented, many sectors of the tropical-forest biome are increasingly subject to encroachment by small-scale settlers (or "shifted cultivators" (Myers 1989)). Within extensive tracts of forests there are few forest guards, hence protection systems tend to be deficient at best. An obvious response is to establish sizeable parks and reserves in order to safeguard exceptional-value forest ecosystems with their species complements. But in turn, this strategy usually has to depend on strong support from local communities.

In recognition of this situation, an increasingly popular response is to establish buffer zones around protected areas. These buffer zones serve to compensate local people for the loss of access to the resources of preserved areas. At the same time, they are characterized by land-use restrictions that offer additional safeguards to protected areas as "core zones" (Dosso et al. 1981, International Union for Conservation of Nature and Natural Resources 1987, Kavanagh 1985, Mitchell 1987, Oldfield 1988, Wright et al. 1985).

Buffer zones can be defined as "areas peripheral to national parks or reserves which have restrictions placed on their use to give an added layer of protection to the nature reserve itself and to compensate villagers for the loss of access to strict reserve areas" (MacKinnon 1981). To cite a specific instance, buffer-zone legislation in Cameroon defines the legal limits of a buffer zone as "a protection zone situated at the periphery of a national park, nature reserve or wildlife reserve, intended to mark a transition between these areas and the areas where hunting and agriculture can be freely practiced" (Dasmann 1984).

Worse, local people are inclined to perceive protected areas as government-imposed restrictions on their traditional rights--while outright preservation has little or no basis in their social systems. As a result, there tends to be much agricultural settlement, poaching of wildlife and gathering of forest products in disregard of protected-area laws. In essence, laws that do not enjoy local support cannot be enforced over the long haul.

In this unstable situation, there is a role for the further forest-safeguard measure supplied by buffer zones. Generally speaking, buffer zones supply two sets of benefits, biological and social. In terms of biological benefits, buffer zones are intended to provide a physical barrier to human encroachment onto core territories. They thus enlarge the effective area of protection against human activities that would be antithetical to the purposes of the core zone. In addition, they enhance the environmental services provided by the reserve, for instance by protecting watersheds and contributing to climate stability. As for social benefits, buffer zones promote self-renewing use of certain categories of forest products within the territories surrounding a protected area, these products being such (small in volume while high in value) that they can be harvested with only minimal disturbance of forest ecosystems.

To achieve these two sets of benefits, a number of basic criteria are generally required. First, the buffer zone's vegetation should be maintained in form as close as possible to that of the protected area. Second, the buffer zone should permit only those forms of agricultural activity that are compatible with the conservation needs of the overall unit, i.e., the protected area and buffer zone considered together. Third, human exploitation of buffer-zone resources should be based upon traditional, locally adapted lifestyles and resource management practices.

Already a broad array of buffer zones exists, often in the form of Biosphere Reserves. They range from a 50 sq km zone around the 150 sq km Nature Reserve of Ipassa-Makokou in Gabon, to a 561 sq km zone around the 1,162 sq km Ziama Massis Nature Reserve in Guinea, and to a 1,800 sq km zone around the 5,970 sq km Fronterizo Darien National Park in Panama.

How well do buffer zones work? The record is decidedly mixed. Around the Jengka Triangle area in Peninsular Malaysia and the Kakamega Forest Reserve in Kenya, the approach seems to afford such fine protection to core territories that even dense human settlements in the environs are persuaded to refrain from encroaching on forest preserves (J. Spears, pers. comm.). The same seems to apply around the Korup Park in Cameroon (C. Wicks, pers. comm.), and around the Mt. Cyclops Reserve in Irian Jaya (Poffenberger 1988). But in many other instances the tendency is for the buffer zone to be managed with only meager measures of enforcement, and illegal encroachment onto core areas persists. This appears to be primarily due to sheer pressure of human numbers and general land hunger, rather than to lack of local communities' understanding of the theoretical value of the buffer zone concept. With stricter management and better relations between protected area managers and local leaders, there could be more productive outcomes. But in the main, the strategy fails to live up to its promise--and in the future there will likely be still greater pressures for local communities with their growing numbers to disregard the legal provisions of the buffer zones, and to encroach onto core areas. Fine as is the strategy in principle, it does not generally work out in practice.

REFERENCES

Anderson, A. B. (ed.). 1990. *Alternatives to deforestation: Steps toward sustainable use of the Amazon rain forest*. New York: Columbia University Press. 281 pp.

Balick, M. J. 1985. Useful plants of Amazonia: A resource of global importance. In *Key environments: Amazonia*, eds. G. T. Prance and T. E. Lovejoy, 339-68. New York: Pergamon Press. 442 pp.

Boom, B. M. 1985. Amazonian Indians and the forest environment. *Nature*, 314(6009):324.

Carterton, J. R. 1988. Tropical forests: What we also need to do. *Christian Science Monitor*, July 18.

Cornelius, L. 1984. *Bamboo and rattan: Restoring the "most neglected" resources of Southeast Asia*. Ottawa, Canada: International Development Research Center.

Dasmann, R. F. 1984. The relationship between protected areas and indigenous peoples. In *National parks, conservation and development*, eds. J. A. McNeeley and K. R. Miller, 667-71. Washington, D.C.: Smithsonian Institution Press. 825 pp.

Dosso, H., J. L. Guillaumer, and M. Hadley. 1981. The Tai project: Land-use problems in a tropical rain forest. *Ambio*, 10:120-25.

Douros, J. D., and M. Suffness. 1981. New antitumor substances of natural origin. *Cancer Treatment Reviews*, 8:63-87.

Duke, J. A. 1990. *News on phytomedicinals*. Beltsville, MD: USDA, Agricultural Research Laboratory.

Fearnside, P. M. 1989a. Forest management in Amazonia: The need for new criteria in evaluating economic development options. *Forest Ecology and Management*.

Fearnside, P. M. 1989b. Extractive reserves in Brazilian Amazonia. *BioScience*, 39(6):387-93.

Frechione, V. 1981. Economic self-development by Yekuana Amerinds in south Venezuela. Doctoral dissertation. Pittsburgh, PA: University of Pittsburgh.

Gentry, A. H., and R. W. Wettach. 1986. *Fevillea*--a new oil seed from Amazonia Peru. *Economic Botany*, 40:(2)177-85.

Gillis, M. 1986. *Non-wood forest products in Indonesia*. Chapel Hill, NC: Department of Forestry, University of North Carolina.

Goulding, M. 1980. *The fishes and the forest: Explorations in Amazonian natural history*. Los Angeles, CA: University of California Press.

Gupta, T., and A. Guleria. 1982. *Non-wood forest products in India*. New Delhi: I. B. H. Publishing Co.

Hecht, S., and A. Cockburn. 1989. *The fate of the forest: Developers, destroyers and defenders of the Amazon*. London: Verso Press. 266 pp.

Heinzman, R., and C. Reining. 1990. *Sustained rural development: Extractive forest reserves in the northern Peten of Guatemala*. TRI Working paper #37. New Haven, CT: School of Forestry and Environmental Studies, Yale University. 104 pp.

Instituto Brasileiro de Geografia e Estatistica (IBGE). 1984. *Producao extractiva vegetal*. 1981, vol. 9. Rio de Janeiro, Brazil: IBGE.

International Union for Conservation of Nature and Natural Resources. 1987. *Buffer zones for tropical rain forests: Management guidelines*. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources.

Jacobs, M. 1982. The study of minor forest products. *Flora Malesiana Bulletin*, 35:3768-82.

Kavanagh, M. 1985. Planning considerations for a system of national parks and wildlife sanctuaries in Sarawak. *Sarawak Gazette*, 111:15-29.

Kohlhepp, G., and A. Schrader (eds.). 1987. *Homem e natureza na Amazonia*. West Germany: Im Selbstverlag Geographisches Institut der Universitat Tubingen.

Lasschuit, J. A., and F. A. C. van Eerd. 1983. *Minor forest products and non-timber products of the forest*. Wageningen, Netherlands: University of Wageningen.

MacKinnon, J. 1981. *Guidelines for the development of conservation buffer zones and enclaves*. Bogor, Indonesia: World Wildlife Fund.

Mendelsohn, R., and C. Uhl. 1990. Critique of the Peters et al. 1989 paper. *Bioscience* (in press).

Mitchell, A. H. 1987. *Community managed buffer zone development in Irian Jaya: Social forestry pilot projects at Cyclops Mountains and Bik*. Bogor, Indonesia: World Wildlife Fund.

Mors, W. B., and C. T. Rizzini. 1966. *Useful plants of Brazil*. San Francisco, CA: Holden-Day. 166 pp.

Myers, N. 1982. *A wealth of wild species: Storehouse for human welfare*. Boulder, CO: Westview Press. 274 pp.

Myers, N. 1983. Tropical moist forests: Over-exploited and under-utilized? *Forest Ecology and Management*, 6(1):59-79.

Myers, N. 1984. *The primary source: Tropical forests and our future*. New York/London: W. W. Norton. 399 pp.

Myers, N. 1989. *Deforestation rates in tropical forests and their climatic implications*. London: Friends of the Earth.

Myers, N. 1990. *Natural resource-based export initiatives in Central America and the Caribbean*. Washington, D.C.: Commission for the Study of International Migration and Cooperative Economic Development.

Norton, B. G. 1987. *Why preserve natural variety*. Princeton, NJ: Princeton University Press. 281 pp.

Oldfield, M. L. 1989. *The value of conserving genetic resources*. Sunderland, MA: Sinauer Associates.

Oldfield, S. 1988. *Buffer zone management in tropical moist forests: Case studies and guidelines*. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources. 49 pp.

Paucar, A, and A. Gardner. 1981. *Establishment of a scientific research station in the Yasuni National Park of the Republic of Ecuador*. Washington, D.C.: The National Zoo.

Peters, C. M., A. H. Gentry, and R. O. Mendelsohn. 1989. Valuation of an Amazonian rainforest. *Nature*, 339(6227):655-56.

Poffenberger, M. 1988. A community-managed buffer zone for a nature reserve, Indonesia. In *Saving the tropical forests*, eds. J. Gradwohl and R. Greenberg, 97-98. London: Earthscan Publications.

Posey, D. A., J. Frechione, J. Eddins, and L. F. da Sylva. 1984. Ethnoecology as applied anthropology in Amazonian development. *Human Organization*, 43:95-107.

Ramos, A. 1980. Development, integration and ethnic integrity of Brazilian Indians. In *Land, people and planning in contemporary Amazonia*, ed. F. Barbira-Scazzocchio, 222-29. London: University of Cambridge Press.

Robinson, M. H. 1988. Are there alternatives to destruction? In *Biodiversity*, ed. E. O. Wilson, 355-60. Washington, D.C.: National Academy Press. 521 pp.

Schwartzman, S., and M. H. Allegretti. 1987. *Extractive production in the Amazon and the rubber tappers' movement*. Report to the Environmental Defense Fund. Washington, D.C.

Schwartzman, S., and M. H. Allegretti. 1989. *Extractive reserves: Scope and potential*. Report to the World Wildlife Fund-U.S. Environmental Defense Fund, Washington, D.C., and Instituto de Studos Amazonicas, Curitiba, Brazil.

Smith, N. J. H. 1981. *Man, fishes and the Amazon*. New York: Columbia University Press. 180 pp.

Smith, N. J. H., D. L. Plucknett, J. T. Williams, and P. Green. 1990. *Tropical forests and crop genetic resources*. Washington, D.C.: International Fund for Agricultural Research. (In press).

Tcheknavorian-Asenbauer, A., and R. O. B. Wijesekera. 1982. *Medicinal and aromatic plants for industrial development*. Vienna, Austria: United Nations Industrial Development Organization.

Vickers, W. T., and T. Plowman. 1984. Useful plants of the Siona and Secoya Indians of eastern Ecuador. *Fieldiana Botany*, New Series 15. Chicago, IL: Field Museum of Natural History.

Vietmeyer, N. D. 1986. Lesser-known plants of potential use in agriculture and forestry. *Science*, 232:1379-84.

Wilson, E. O. (ed.). 1988. *Biodiversity*. Washington, D.C.: National Academy Press. 521 pp.

Wright, R. M., B. Houseal, and C. DeLeon. 1985. Kuna Yala: Indigenous biosphere reserve in the making. *Parks*, 10(3):25-27.