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VALUATION AND MANAGEMENT OF TROPICAL FORESTS: A THEORETICAL AND EMPIRICAL ANALYSIS

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1. Introduction

Tropical forests provide a wide variety of services to humankind (Repetto, 1988; Peters, Gentry, and Mendelsohn, 1989; and Reid and Miller, 1989). Yet, as documented in these and other sources, the forests are under threat. Repetto observes that, since World War II, deforestation has shifted from temperate to tropical forests and that, in most developing countries today, deforestation is accelerating (pp. 2-15). Table 1 shows that, at 1981-1985 annual rates of deforestation, there are a number of countries where forests will disappear within 30 years. Others, having larger reserves, are losing vast areas every year. A question that naturally arises is, given the value of the tropical forest resource, why is it being destroyed? The answer, it seems to us, is that a very substantial part of the value simply does not get counted, either because it is hard to measure or because it is not captured by those who make the decisions on deforestation. The latter reason has been discussed at length elsewhere (see, for example, Binswanger 1991). Here, we focus on the issue of measurement, by providing a framework for a more complete valuation of tropical forests.

We begin in the next section with a discussion of the major uses of tropical forests, paying particular attention to the relationships among uses. For example, are they compatible with forest preservation? Are they sustainable? Section 3 provides the elements of a framework for valuation and management, taking account of the varied uses. The time dimension will be important here. One issue is, of course, sustainability. Another is feasibility of a sequential pattern of use; livestock ranching may follow the clearing of land for a timber harvest but not vice versa. Finally, as we shall show, the present value of a tract of land will depend on how uncertainty about

future values is treated. In fact, it is the interaction between the feasibility of alternative patterns of forest use and uncertainty about their benefits that generates the main theoretical results, given in Propositions 1 and 2 in section 3. Section 4 contains an empirical application to the valuation and management of a forested area in Thailand.

2. The Uses of Tropical Forests

Uses and Utilitarianism: A Caveat

When we talk about uses of the forest, we have in mind human uses. This is an important distinction, since some would argue that human uses and the values to which they give rise are not deserving of any special consideration when it comes to a decision on whether to preserve a tropical forest. According to one interpretation of this view, nature has rights; to exploit nature is just as wrong as to exploit people (Nash, 1989). Another interpretation is that nonhuman species are intrinsically valuable, independent of any use they may be to humans (Callicott, 1986). We would prefer not to take issue directly with this view. Rather, we would observe that economics is about the human use and valuation of resources. As such, it is embedded in utilitarianism. In the larger philosophical universe, utilitarianism is, of course, only one of many possible approaches to questions of ethics and choice. Advocates of preservation for its own sake are presumably appealing to an alternative to philosophical utilitarianism. In this paper, we confine our focus to what we understand to be the subject matter of economics—the uses and values of resources to humans. At the same time, we recognize that decisions, especially public decisions, affecting tropical forests may be made on the basis of a variety of other considerations as well—including, perhaps, inherent rights or intrinsic values.

There is an important point to note in this connection. Often in environmental economics, we speak of intrinsic or 'nonuse values,' referring to the benefits some

people derive from the mere existence of a natural environment (such as, for example, the Amazon rain forest) even though they make no use of it. In our judgment these benefits are likely to be quite significant for many environmental resources and are legitimately included in our notion of economic value. However, as Batie (1989) points out, this is still a utilitarian view in that the resources, although not used, have value in relation to human welfare. Taking into account this extension of the notion of economic value, a better title for this section of the paper might be: 'The Goods and Services Provided by Tropical Forests,' with the understanding that among these services is the existence of the forests, apart from any use to which they may be put by humans.

There is a further, and equally important, point to be made here. We shall very shortly be talking about local and global environmental services provided by standing tropical forests. These environmental services are, as we shall see, quite tangible and, indeed, impinge quite directly on human activities. Existence value, as just defined, does not. It is derived from the knowledge that the forests or other environmental resources are alive and well, again, apart from any human activity affected by them.

Uses Compatible With Preservation

Several kinds of human activities in and around the forests appear to be reasonably compatible with preservation: hunting and fishing; gathering of food such as nuts and fruits; gathering of forest products such as rubber, oils and medicines; and trekking/camping or ecotourism. By definition, the creation of preserves also falls within this category. We observe in passing that all of these uses are sustainable; they create low intensity, short duration ecosystem disruption and permit recovery of ecosystem functions (Uhl *et al.*, 1990).

Standing tropical forests are also associated with the provision of environmental services, as distinguished from the uses just noted. There are, no doubt, a number of ways in which these services can be classified, but one that in our judgment will be helpful in discussing valuation issues is as local and global. What we are calling local environmental services are, perhaps, best understood by considering some of the consequences of deforestation. For example, the loss of forest cover leads to soil erosion which, in turn, aggravates flooding and contributes to premature silting of reservoirs for irrigation and electric power production. Though local, these impacts are not trivial. It is estimated that revenue losses from sedimentation behind just one dam in Costa Rica have reached a level of $133-$274 million (Postel and Heise, 1988, p. 92).

At a global level, tropical deforestation appears to be related to what may well be the gravest environmental issues of our time: the 'greenhouse effect' and the wholesale extinction of species. As is well known, the buildup of several trace gases in the atmosphere (most importantly, carbon dioxide) is expected to lead to a substantial warming over the next several decades with an attendant rise in sea level and change in patterns of precipitation. Potential consequences, to coastal settlements, to agriculture, and to other activities, have been discussed at length in many places (see Nordhaus, 1991, and Cline, 1991). What is important to note here is that deforestation, almost entirely tropical deforestation, is estimated to account currently for a very substantial fraction of global carbon emissions—between one-fifth and one-half as much as the burning of fossil fuels (Postel and Heise, p. 94).

The second global environmental issue we noted is the threatened loss of species. Although this is the popular perception of the issue, it would be more accurate to speak of the threatened loss of biodiversity. The point of the distinction is that biodiversity, as well as being the source of potentially valuable individual species, is an input to such ecological processes as nutrient and water cycling, soil generation,

erosion control, pest control, and climate regulation—all essential to human survival (Reid and Miller, 1989, p. 88). With respect to individual species, wild relatives of economically important crops, trees, and livestock often carry unique genes that can be used to improve the characteristics of the domesticated stocks or just help them survive changes in the environment. Plants, animals, and micro-organisms found in the wild are also major sources of medicines and industrial substances. Reid and Miller note that tropical species have been particularly important sources of medicines because many active medical compounds are derived from the toxins that they have evolved to combat predation. More generally, tropical forests are important to the conservation of biodiversity because it is believed that they contain more than half of the world's species, though only 7 percent of the land surface. About half of all vertebrates and vascular plant species occur in tropical forests, and recent discoveries of great insect species richness there suggest tropical forests may account for as much as 90 percent of all of the world's species (Erwin, 1982). Although one cannot predict with a high degree of confidence that a particular tract of tropical forestland will be the source of a cure for cancer, or a liquid hydrocarbon, or a desirable crop characteristic, the chances of finding any or all of these are surely greater, the greater is the preservation of tropical forests generally.

Traditional Agriculture and Land Recuperation

Swidden agriculture, or shifting cultivation is sometimes considered a major cause of deforestation. A study by the National Academy of Sciences (1982, p. 13), for example, concludes that at least half of current deforestation results from shifting cultivation. But by traditional shifting agriculture, we have in mind the kind of activity that involves little disturbance to the forest cover and root systems outside the small plot under cultivation, and that allows the plot to regenerate for 20-30 years before a new round of cutting and burning. The small area, short duration and moderate

intensity of the farming allow the land to recuperate in the long run. Swidden agriculture cannot be considered compatible with short run preservation goals but the forest recovery makes this use compatible with long run preservation goals.[1] As noted by Gradwohl and Greenberg (1988, p. 102), many forested areas once considered 'virgin' are now believed to have been occupied for centuries by people practicing shifting agriculture. The difficulty arises when population pressures—and perverse incentives as, for example, the linking of ownership rights to the clearing of land—result in the cutting of what had been protective buffer zones and a shortening or even elimination of the fallow period. It is this 'nontraditional' agriculture that is implicated in deforestation.

Commercial Forestry

Particularly in Africa and Southeast Asia, the first step in the conversion of tropical forests is typically opening an area to logging. Commercial forestry covers a variety of activities—including selective culling of highly valued woods; clear-cutting for timber or pulp production; and plantation harvesting of an introduced, nonnative species. Of course, there is also cutting for fuel, but this is more prevalent in relatively arid areas as opposed to tropical moist forests (Gradwohl and Greenberg, p. 37).

Plantation forestry faces sustainability and irreversibility constraints. The chief problem is the loss of nutrients once the trees are cut since, in tropical forests, the soil is relatively poor, with most of the nutrients stored in the vegetation (Gradwohl and Greenberg, p. 31). This poor soil prohibits long term timber rotations and discourages the natural reforestation of these large areas. The relative irreversibility of the conversion away from natural forest is underscored by the

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[1]Tropical forest recovery on these small plots occurs only where regeneration mechanisms exist and where the soil satisfies growth requirements (Uhl, *et al.*, p. 33). These conditions appear to be met in many tropical settings because the fire-enriched soils are not completely degraded during the farming period and the small plot size permits seed dispersal across the plots.

invasion of hardy grasses that out-compete many early successional tree species. Furthermore, some tree crops, such as eucalyptus, leave remnants that further discourage natural regeneration or crop production. In addition, during the period when the soils and management support timber crop rotations the monocultures provide little of the original forest's ecosystem functions (Tongpan *et al.*, 1990).

Commercial Agriculture

Commercial agriculture includes both plantation farming (of such crops as bananas, sugarcane, rubber, and pineapple) and livestock production, especially (in the Amazon and other tropical American forests) beef cattle ranching. To these activities, one might add intensive subsistence agriculture, involving both shifting and continuous cultivation (the latter, primarily irrigated paddy rice).

Like commercial forestry, large-scale or intensive agriculture may not be sustainable. Long-term, continuous cultivation or grazing leads to soil erosion and loss of nutrients and, at least in the case of cultivation, tends also to involve heavy application of fertilizers and pesticides. The buildup and dispersal of these substances, in turn, interferes with the provision of local environmental services. As with forestry, (costly) management inputs can make an agricultural operation relatively sustainable. Mulching, the use of careful cultivating techniques, long fallow periods, and avoidance of poorer soils can all contribute to this objective (Gradwohl and Greenberg, p. 32). The intensity and duration of the land use, however, may prohibit tropical forest regeneration after farm abandonment.

Other Extractive Activities: Mining, Water Resource Development, and Transportation

To some extent, extractive activities are just an extension of the hunting and gathering that is consistent with forest preservation. For example, medicinal substances, meat, skins, plumage, and even live animals may be taken for export

rather than subsistence. Additionally, however, fairly large areas may be affected by mining, water resource, and transportation projects. Of all of the uses discussed thus far, these are probably the most disruptive of the forest ecosystem and their consequences almost certainly the most difficult to reverse. By definition, a mining project cannot be sustainable, though it can, of course, produce great wealth over the life of the mine. Water impoundments (the construction of large dams for irrigation or hydroelectric power) will also have finite lives as reservoirs silt up over several decades. Moreover, as we have seen, the silting process is accelerated by deforestation and resulting soil erosion.

3. A Framework for Valuation

We start by making a distinction between valuing the specific services provided by a forest and valuing the forest itself, viewed as an asset generating a stream of services over time. Mapping from the valuation of service flows to the valuation of the asset raises the issue of allocation of forestland among alternative uses. As indicated in the preceding discussion, a great many different kinds of goods and services are provided by the forest, not all of them compatible with each other. In the circumstances, a choice among them is required, and this choice will dictate the value of the forest. In effect, the forest can be regarded not as a single asset but rather as a portfolio of assets, whose composition can be varied over time (subject to some constraints). Thus, the forest cannot be valued without regard to future choices about how it will be managed: Valuation cannot be divorced from decision making. The issue of choice is particularly relevant in the tropical forest setting, given the wide range of uses and activities relative to those supported by temperate forests in developed countries.

In this section we lay out a framework for valuing a tract of tropical forestland, allowing for different choices about the uses of the forest and taking into account constraints on the sequencing of uses. We are deliberately vague about the size of