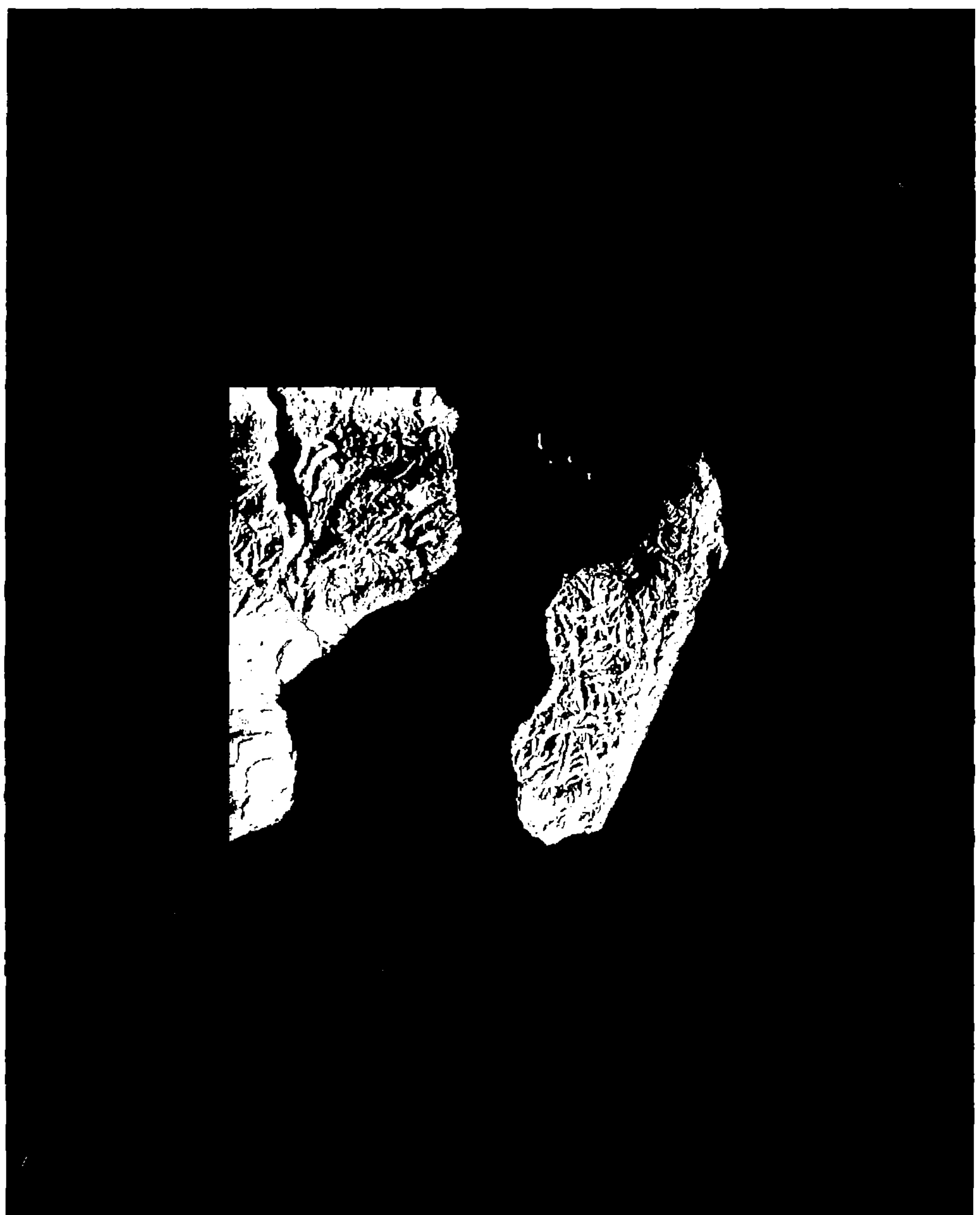
WORLD BANK ENVIRONMENT PAPER NUMBER 13

# Valuing Tropical Forests

## Methodology and Case Study of Madagascar

Randall A. Kramer, Narendra Sharma,
and Mohan Munasinghe



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# *Foreword*

This research emerged out of the World Bank's parallel concerns with environment and forest resources. In 1989, the Bank issued the environmental assessment operational directive (EAOD), which set down mandatory requirements for the environmental assessment of all its projects. Subsequently, in 1992 the Bank issued its seminal work on the stewardship of world forest resources (including tropical rainforests) entitled "A World Bank Policy Paper: The Forest Sector." This publication examined causes of forest degradation and deforestation and explored alternatives for improving the management of forest resources for development and conservation of biodiversity. The lack of knowledge of economic benefits provided by forests, or costs associated with depletion of forest resources and degradation of forest lands, was acknowledged to be handicapping management decision making, project analysis, investment decisions, and environmental assessment.

Thus, based on concerns arising from both environment and forestry, it was recognized that there was a need to increase research on the economic value of tropical forests to help policy makers form wise decisions on the utilization and conservation of tropical forest resources. The study reported in this document represents the first such work supported by the World Bank to explore the frontiers of economic analysis by applying nonmarket valuation methods to the environmental services provided by protected forests.

The study provides encouraging results from which further work can be done to develop techniques and methodologies to more fully understand the economic consequences of policy, investment, and management choices. By improving economic information on the benefits and costs arising from forest use and misuse, forest valuation can lead to improved decision making and help policy makers strike a balance among economic development, biodiversity, recreation, watershed protection, commodity production, and other objectives.

Edward V.K. Jaycox
Vice President
Africa Region

# *Editors' introduction*

The loss of large areas of tropical forests has become a major concern of the world community. Although there are many causes of tropical deforestation and forest degradation, an important cause appears to be an undervaluation of forests by markets and governments. One reason for this undervaluation is that many forest products, such as food and medicinal products, are traded in informal markets for which there are little data. Another reason is that many services provided by forests, such as carbon storage, biodiversity protection, recreation, and watershed protection, are not traded in markets; hence, their economic values are often ignored. Even where environmental values are recognized, they may not be measured or used to promote efficient resource management.

This volume examines some causes of tropical deforestation and explores forest valuation issues in the context of a protected area project. Part A (Chapters 1 and 2) sets out the context of tropical deforestation and loss of biodiversity and provides a framework for examining the economic value of forests. Chapter 1 describes the main functions of forests and the salient facts concerning deforestation. Chapter 2 outlines the three key dimensions of sustainable development: economic, social and environmental; and then defines the vital contribution that forests make to sustainable development. An analytical framework is described. Part B (Chapters 3 to 8) is devoted to a detailed case study of Madagascar that illustrates the practical application of the techniques of analysis to the valuation of forests described earlier. Chapter 3 describes the case study area (Mantadia Park) and general analytical approach. Chapters 4 and 5 describe how impacts on the park are valued by two user groups: local villagers and international tourists. The spatial dimensions of linkages between human activity and area ecosystems are explored in Chapter 6. In Chapter 7, existence values of rain forests to North Americans are estimated. Finally, the main findings and conclusions of this volume are summarized in Part C.

The editors appreciate the assistance of a large number of individuals in Durham, Washington, and Madagascar who have made contributions to this volume. Special thanks are due to Sanath Ranawana for assistance in preparing the manuscript, Mary Matthews for copyediting and Nancy Minnich for word-processing. The editors and authors especially thank the many villagers, tourists, scientists, and government officials who graciously provided the data used in this report.

# *PART A: CONCEPTUAL FRAMEWORK*

# 1. Deforestation Issues

*Mohan Munasinghe and Narendra Sharma*

Between 1850 and 1980 about 60 percent of forests and woodlands in North Africa and the Middle East were destroyed due to the pressure of human activity. During the same period, tropical Africa lost 20 percent, southern Asia lost 43 percent, and Latin America lost 19 percent of existing forest cover (Rowe, Sharma and Browder 1992). In spite of efforts to rectify the problem, deforestation in the tropics has continued unabated and by some estimates may even be increasing. According to the FAO-sponsored *Forest Resources Assessment 1990 Project*, which covered 97 percent of all tropical forests, the estimated annual loss of tropical forests during the late 1980s was 16.9 million hectares, compared to 11.3 million hectares during the early 1980s (United Nations - FAO 1992). While open access forests have suffered most, even parks and protected areas are threatened (for a comprehensive review, see Munasinghe and McNeely 1994).

**Forest Types and Functions**

Tropical forests consist of dry and moist forests, each accounting for roughly one half of the total worldwide. Tropical moist forests are further divided into rain forests and deciduous forests. Rain forests make up about two-thirds of all tropical moist forests and are the richest in terms of biomass and biological diversity. Deciduous forests generally lie on the edge of rain forests, and are characterized by more defined dry and wet periods (Sharma et al. 1992). Although tropical dry forests are also subject to large-scale destruction, the major emphasis of the global community has been on addressing the loss of tropical moist forests.

The increasing scale of human activity worldwide has prompted the search for approaches to development that are more "sustainable." As economies grow, so does the strain on the finite natural environmental systems that support life on the planet. The natural environment provides three main types of services necessary to sustain life: (1) as a source of the raw material vital for all human activity; (2) as a sink for waste and residue generated by human activity; and (3) as a means of maintaining essential life support functions (Munasinghe 1992). Tropical forests constitute an important natural system that fulfills these services through a multitude of functions and products; there is, therefore, an urgent need to conserve these ecosystems.

In terms of source functions, the products and services derived from tropical forests are diverse and benefit people at the local, national and global levels. Indigenous peoples and communities that live on the fringes of forests rely on the forest resources for most of their consumption goods, such as food, shelter, and even clothing. Their well-being depends extensively upon the forests. At the national level, forest resources are considered a source of foreign exchange and energy. Forest lands are regarded as "new" land for expansion of food production and settlements. Forests also ensure a regular supply of fresh water, prevent flooding, protect crops from wind damage, and also prevent soil erosion and siltation of river beds downstream. In all, about 2.5 billion people in the tropics rely either directly or indirectly on forest resources for consumption goods. The global community relies on tropical forests to stabilize global climate conditions, protect the diversity of biological species, support natural ecological systems, and provide recreational benefits. People at all levels derive benefits from the amenity value of forests and the knowledge that forests continue to existence.

Forest-related exports generate about US $100 billion (1989 dollars) worth of foreign exchange, amounting to an average 2.7 percent of GDP in developing countries (Sharma et al. 1992)· In certain countries they account for a higher percentage of the GDP; for instance, about 5 percent in Malaysia, 5 percent of GDP from value added in the forestry sectors of Liberia and the Ivory Coast, and 4 percent in Cameroon and Tanzania. The forestry sector is a significant source of government revenue in some countries--about 70 percent in Sabah (Malaysia), for example. Nevertheless, the potential rent from the forestry sector is grossly underestimated and goes uncaptured in most developing countries.

By far the most valuable economic product from tropical forests is wood, which accounts for about half of all forest-related revenue. The two main wood products are roundwood and fuelwood. Roundwood is wood in its natural state which is processed into sawnwood, pulp, panels, plywood and paper. Tropical hardwoods, the major industrial timber export of the tropics, accounts for just over 10 percent of the total international trade in timber (Sharma et al. 1992). In total, about 31 percent of the entire volume of industrial timber produced in the developing countries is exported in the form of roundwood or wood products (London Environmental Economics Centre 1992). Nevertheless, this constitutes only about 4 percent of the total tropical wood supply (Federal Republic of Germany 1991). Thirteen percent is consumed nationally as timber and the rest is consumed in the form of fuelwood (Vanclay 1993). At present, 33 tropical countries are net exporters of timber. That number is expected to drop to 10 by the end of the century, however, as the domestic demand in many countries catches up with the surplus that was previously exported.

Fuelwood is produced primarily to meet national consumption needs. About 83 percent of all wood extracted from tropical forests is consumed as fuelwood. In Africa as much as 91 percent of all wood supplies is used as a source of energy (Vanclay 1993). An estimated 3 billion people in developing countries rely on fuelwood as the primary source of energy (Sharma et al. 1992). Nevertheless, only about 20 percent of the total energy demand in developing countries is met by fuelwood. Along with increasing scarcity of wood, especially in areas severely denuded of forest cover, the cost of fuelwood has tended to increase significantly. Households, especially poor urban households, may spend up to 20 or 30 percent of their income on fuelwood alone (Rowe et al. 1992).

Forests are the source of many nonwood products as well. These include extractives (such as bark, dyes, fibers, gums, incense, latexes, oils, resins, shellac, tanning compounds and waxes); parts of plants and animals for medicinal, ceremonial or decorative purposes; and food (such as bush meat, flowers, fruits, honey, nuts, leaves, seeds and spices) (Sharma et al. 1992). Most nonwood products are consumed locally (i.e., nationally). Nevertheless, they constitute a valuable resource, and their commercial value per hectare of land can exceed that of wood products. Certain nonwood products have considerable international markets as well. Rattan, latex, palm oil, cocoa, vanilla, nuts, spices, gum and ornamental plants are commodities for which markets exist and are expanding in developed countries. Several countries earn considerable revenue from exporting nonwood products. Gum exports in Sudan generate about US $60 million annually and Madagascar earns about as much from exporting vanilla. Indonesia is one of the world's largest exporters of tropical nonwood products. Rattan, resin, essential oils, kapok and cinchona bark (quinine) exports in 1986 generated US $134 million in foreign exchange.

In terms of other (nonsource) functions, the considerable array of environmental services generated by forests is sufficient justification for protecting natural tropical forests. Tropical forests and forest soils serve as a vast storehouse for carbon due to their high density of biomass. Up to three times the amount of carbon found in the atmosphere is contained by tropical forests (Sharma et al. 1992). The Intergovernmental Panel on Climatic Change (IPCC) estimates that tropical deforestation contributes about one-sixth of the total global emission of carbon into the atmosphere. The increasing levels of atmospheric carbon cause the buildup of greenhouse gases, believed to result in a rise in earth's surface temperature, the "greenhouse effect." Although the resulting increase in temperature is elusive to estimate or predict, it is believed that a 3 (+1.5) degree Celsius rise in global temperatures can be expected in about 50 years, if the level of atmospheric carbon doubles.

Primary tropical forests support about one-half of all known surviving species. The species and genetic diversity, as well as the diversity of ecosystems found in the tropics, are vital for maintaining the balance of natural ecosystems. Loss of genetic diversity can cause maladaptation of species to changing environmental conditions and increase susceptibility to diseases. The diversity of species also has tremendous medicinal value to humans. There is ample evidence of benefits to humans from the rich species and genetic diversity found in the tropics:

- One gene from a single Ethiopian barley plant now protects California's barley crop, worth US $160 million annually, from yellow dwarf virus;
- Globally, medicines from wild products are worth approximately US $40 billion a year;
- In 1960, a child suffering from leukemia had only a 20 percent chance of survival; today, a child has an 80 percent chance of survival due to treatment from a drug containing active substances from the rosy periwinkle, a tropical-forest plant from Madagascar (Munasinghe 1992).

Forests serve the important function of protecting watersheds and ensuring perennial supplies of fresh water. By mitigating erosion due to winds and surface runoff, forests reduce sedimentation and bed-loading of streams, reservoirs and rivers downstream. The role of forests in preventing floods is quite evident in certain regions. Widespread destruction of forest along the Himalayan foothills is linked directly with devastating floods in the Ganges and Brahmaputra river basins. Forests have a significant role in stabilizing regional climate and hydrologic systems, particularly by affecting rainfall patterns. Forests also have a role in improving air quality as well as in enriching soils through nitrogen fixation.

The recreational value of tropical forests has largely been underestimated thus far. Ecotourism is an emerging economic activity with tremendous potential to generate foreign exchange for tropical countries. Local urban dwellers also derive recreational benefits from visiting tropical forest reserves, but their willingness to pay for this activity is generally lower than that of international travelers. The mere existence of tropical forests constitutes a stream of benefits to people, most of whom may never intend to visit a forest reserve. In several economic valuation studies that have been conducted to quantify these benefits, the "existence value" of tropical forests constitutes a significant percentage of the total economic value.

## Depletion of Forest Resources

At present, 36 percent of the tropics is covered by natural forests, an area amounting to about 1,715 million hectares. Based on an estimate of 1,882 million hectares believed to have been under forest cover in 1980, the average annual rate of tropical deforestation during the 1980s was about 0.9 percent. However, the rate of forest loss in countries endowed with small areas of forest cover has been much higher: 6.5 percent in Ivory Coast, 5 percent in Nigeria, 4 percent in Costa Rica and 4.7 percent in Paraguay, for example. In terms of area, the largest extent of loss is incurred by Brazil (3.2 million hectares annually) and Indonesia (1.3 million hectares annually). By region, Africa loses 5 million hectares per year and tropical America loses 8.3 million hectares per year. If present trends continue unabated, all remaining tropical forests may well be lost during the next century. Africa could lose all existing forests in just 60 years (United Nations-FAO 1992).

The term deforestation is used in a rather broad context to imply the wasteful destruction of forest resources, especially primary forests, but this is not always the case (Rowe et al. 1992). "Disturbance deforestation" refers to human activities that seriously alter the natural habitat of forest systems. "Conversion deforestation" is the process of converting forest lands into alternative uses, such as agriculture and resettlement. Not all human activity results in complete destruction of forests. Certain human-induced disturbance or conversion deforestation practices leave the actual area under forest cover intact, although some of the forest related services and functions may be significantly affected. Well-managed plantation forests that allow secondary forests to regenerate after each harvest, and sustainable agricultural practices that allow the land to be left in fallow for several seasons following a harvest, are considered to be less destructive uses of forest lands. Wasteful deforestation occurs when forests yielding high valued goods and services are clearcut and replaced with land uses that yield lower returns.

This latter type of deforestation is what poses a significant environmental problem and has local, national and global implications. Wasteful deforestation is to a great extent an irreversible process. Secondary forests do regenerate quite rapidly if the land is left fallow after a season of cultivation or if deliberate reforestation efforts are undertaken. However, the biological diversity found in natural tropical forests can take many decades to regenerate and in some instances could be lost forever.

The real causes of tropical deforestation are often confused with the symptoms of the problem. Misdirected forest management policies that address the symptoms rather than the causes, are likely to fail (Vanclay 1993). Distinguishing between the causes and symptoms of deforestation can be tricky, particularly since some of the causes lie beyond the borders of the forests.

Population pressures, combined with poverty and landlessness, are one cause of deforestation in the tropics. Governments of developing countries are driven to harvest forest resources and convert land into agricultural use simply to meet the increasing demands of a growing population base. By the year 2000, the world population is expected to increase by 1 billion, and about 60 percent of this growth will be concentrated in the developing countries. Faced with the challenge of providing basic necessities, these governments see tropical forests as an invaluable source of new land and raw material. While low-lying forests are treated as potential agricultural lands, highland forests are used for extracting timber, fuelwood and other raw material. Approximately 10 million hectares of forests will have to be cleared each year simply to continue providing the growing population with the current intake of nutrient content, assuming that present yields are maintained.

It is believed that 60 percent of all deforestation is due to expansion of agricultural settlements (World Bank 1992). The remainder is divided among various other activities such as logging, ranching and mining. In some regions, however, the extent of deforestation due to the expansion of small-holder agricultural settlements is modest in comparison with these other activities. In the Amazon region, for example, the most prominent form of deforestation is by conversion of land into livestock ranching. In Brazil alone, subsidized cattle ranching accounted for about 70 percent of deforestation--an area amounting to some 12 million hectares by 1980 (Rowe et al. 1992). Similarly, in tropical east Asia, industrial logging constitutes the major form of deforestation.

Uncontrolled profiteering and corruption motivate politicians, forestry officials, timber merchants and rich landowners to exploit forest resources. The influence of corruption is not often evident in the routine proceedings of business and administration. However, occasional inquiries into illicit dealings between government officials and logging companies may reveal the extent of racketeering that takes place in the forest industries. In Papua, New Guinea, during the late 1980s, political turmoil led to an independent inquiry into the activities within the forestry sector. The report following the inquiry revealed that many politicians, community leaders and logging companies were engaged in bribery, money laundering and other illicit activities.

Governments of developing countries are also largely preoccupied with rectifying urban and social problems and often do so at the expense of environmental degradation. These problems have a direct effect on human well-being, whereas the welfare effects of environmentally unsound policies are less clear. Furthermore, governments prefer to address highly visible issues, which upon resolution constitute political victories. Consequently, environmental issues have typically received relatively low priority on government policy agendas. Lately, however, the ecological consequences of extensive environmental degradation and the resulting economic consequences are receiving recognition, particularly due to efforts by nongovernmental organizations. People of developing countries are now more aware of the need to reconcile economic development with conservation of environmental resources, and governments are increasingly held accountable for environmentally sound policies.

The mismanagement of forest resources is also due to the inefficiency of administrative and regulatory institutions. Forestry sectors are typically characterized by centralized administrative structures in which authority and power are concentrated at the top. Administrative staff at the local levels do not have much authority over the decision-making process. Furthermore, forestry institutions are understaffed and lack both training and equipment to implement proper management practices. Forestry officials must often rely on timber companies to provide transportation to logging sites in the interior of forests. Hence, their ability to perform random inspections is severely limited. Furthermore, officials lack incentives to perform duties with diligence and efficiency. Institutional reform measures and proper incentive structures need to be adopted to rectify some of these problems.

A related issue is the tendency to exclude local communities and indigenous people from the planning process for long-term forest management (Hanna and Munasinghe 1995a, 1995b). Traditional claims to forest lands held by these groups are often disregarded as well. All too often, forest management policies that have attempted to prevent entry to, and the extraction of products from, forest reserves have ended in failure. The main lesson has been that the participation and support of local communities are imperative for successful management of forest resources.

A clear manifestation of poor enforcement capacity within institutions is the irregularity or inability of forestry agencies to collect royalties, fees and reforestation taxes from logging firms. As a result, governments bear the loss of a significant source of revenues. Developing country governments typically collect less than 50 percent of due revenues from the forestry sector (Rowe et al. 1992). In the Philippines only 16 percent of all timber harvesting rents were collected between 1979 and 1982. The loss of revenue to the government amounted to about US $850 million. Consequently, private timber firms which capture a large percentage of the rent from timber harvesting are encouraged to exploit forest resources for private short-term gains.

Various forms of market failures constitute a significant threat to the sustainability of forest management as well. Of particular significance is the disparity between the private and social costs of timber harvesting. Timber prices are generally based on the stumpage value; that is, the value of products derived from the timber less the processing costs. However, timber harvesting imposes considerable social costs in terms of opportunity costs, or foregone benefits from other forest-related good and services. The loss to local communities of forest-related consumption goods, loss of services rendered by forest ecosystems (such as flood control, fresh water supply, prevention of erosion and soil degradation, and carbon sequestration), the loss of biodiversity, and foregone recreational benefits are all factors that must be taken into consideration when determining the social cost of timber harvesting. Only then can the socially efficient level of harvesting be determined. Other factors that cause market failures are the open-access nature of forest resources, incomplete information and uncertainty of forest systems, and imperfect competition.

Market failures are often complemented by policy failures that further aggravate the deforestation problem. Over 80 percent of tropical forests are essentially publicly owned. Government policies therefore have a considerable effect on the management of forest resources, and the distribution of benefits and costs from forest related industries. Policies such as encouraging timber harvesting by granting concessions and subsidies to logging companies, or providing infrastructure support to promote nonforest land uses, have a direct and negative impact on forests. Macroeconomic policies that distort prices of forest-related goods can also result in increasing deforestation. Examples include artificially lowering the price of fuelwood to subsidize domestic energy costs, or setting high taxes on imported timber products in order to encourage local industries. For instance, the tax policy in Indonesia has distorted prices to the extent that domestic industries can incur operating costs 2.5 times higher than competing industries in other countries and still remain competitive. As a result, the Indonesian plywood industry consumes 15 percent more raw material in processing plywood than other countries in the region (Rowe et al. 1992).

The combined impact of market and policy failures is that private, profit-driven firms are encouraged in the "mining" of forests for short-term gains rather than practicing sustainable harvesting. The remedy often involves some form of public intervention by establishing regulations, providing economic (i.e., market-based) incentives, or making institutional changes that ensure sustainable management of forest resources (London Environmental Economics Centre 1992). Logging firms must also be charged rent that more accurately reflects the opportunity cost of harvesting timber.

## The Need for Valuation of Tropical Forests

This leads to an issue that requires urgent attention with regard to proper forest management: the valuation of tropical forest resources. There are several economic techniques to estimate the value of natural resources such as forests. These include the contingent valuation method, travel cost method and opportunity cost method. Forest resources pose several difficulties with regard to the estimation of total economic value. Examples are the absence of markets for many forest products and services, the difficulty of placing a monetary value on all resources, the lack of knowledge regarding the value and utility of some forest functions, and the difficulty in isolating the benefits of interrelated functions. In spite of such limitations, economic valuation methods can be useful to estimate values which are accurate at least within an order of magnitude.

Environmental functions that cannot be valued in monetary terms can be examined using other techniques such as multicriteria analysis. This may require the development of additional biological and physical indicators of sustainability (Munasinghe and Shearer 1995). The objective is to integrate environmental concerns into the conventional economic decision-making process by providing policy analysts with better information upon which to base decisions involving alternative land uses. Traditional economic analysis often only accounts for the commercial value of forest resources. Disregarding the nonmarket value of forest resources--including amenity value--may cause certain alternative land uses to appear more desirable.

Correcting market and policy failures can be complicated and sometimes lie beyond the capabilities of sovereign governments. Internalizing the cost of wasteful deforestation can be undertaken to some extent by identifying benefits derived by local and national communities. There are considerable global externalities from tropical forests as well. Estimating the value of global externalities and internalizing them must be done at a global level.

Finally, a nation's land use policy is established to conform with political and social objectives and is not based simply on economic criteria. The institutional structure that underlies a nation's land use policy dictates the outcome of forest management practices. It overrides the effect of market signals and influences the tone of policies. Indeed, when the national land use policy is based on legitimate political, social and economic concerns, the outcome is desirable. If the policy is influenced by self-serving political motives and driven by corruption, then the process may be in need of reform.

# 2. Tropical Forests and Sustainable Development: A Framework for Analysis

*Mohan Munasinghe*

By the early 1980s there was mounting evidence that environmental degradation had a direct and negative impact on economic development. Several ecologists pointed out that the open dynamic socioeconomic subsystem within which all human activity occurs is engulfed within a larger ecosphere (Odum 1973, Odum 1975, Costanza 1991, Folke and Janssen 1992). As human activity increases due to population growth and economic development, so does the scale of the socioeconomic subsystem relative to the finite extent of the ecosphere, thereby endangering the latter's capacity to provide essential environmental services that support the subsystem. The aim of sustainable development is to keep the scale of the socioeconomic subsystem within these reasonable limits. While the overall objective is to improve the quality of life, this objective is constrained by the need to diminish the intensity of resource use, in order to maintain or even enhance environmental assets and services for the future.

It is unreasonable to expect that all tropical forest resources can be maintained intact, especially given the projections for population growth in the developing countries. If alternative uses of forest land yield higher returns than intact forests, then conversion is warranted. It is imperative, however, that such decisions first take into consideration the totality of goods and services provided by forests, all affected communities, and the impact on sustainability of environmental systems supported by forests. Economic development has to be reconciled with environmental concerns in order to strike a healthy balance between forest conservation and development. This is the recipe for sustainable development.

## Dimensions of Sustainable Development

Three main dimensions are essential to achieving development practices that are sustainable: economic, ecological and sociocultural (Munasinghe 1993a). These are mutually reinforcing concepts that must be addressed with equal emphasis to ensure sustainability.

The economic approach to sustainable development is based on the Hicks-Lindahl concept of maximizing the flow of net benefits from a stock of resources. In so doing, the stability of the resource base must be maintained. Identifying the critical resource base that must be maintained to ensure sustainability and determining the substitutability between different resources are difficult tasks. They are further exacerbated by the irreversibility and uncertainty of some environmental processes, and the tendency of natural systems to experience catastrophic collapse. Finally, valuation of resources, particularly noncommercial resources, poses a challenge as well.

Maintaining the stability of natural (biophysical) systems is a key objective of ecological development. Central to this effort is the task of protecting the diversity of species, of genetic structures and of ecosystems. Biodiversity protection is important for three reasons. First, the viability of ecosystems upon which current life forms and production processes are dependent requires sufficient biological diversity. Second, the needs of future generations are unknown. Species required for critical processes in the future may now be unknowingly and wastefully driven to extinction. Finally, knowledge is limited concerning the intricate relationships among ecological processes that constitute natural systems. Destroying seemingly insignificant species may cause irreversible and even catastrophic imbalances in these natural systems.

The sociocultural approach to sustainable development focuses on protecting all social and cultural systems, particularly those of indigenous peoples. There are 6,000 cultural groups worldwide that speak as many different languages. Compared with national state cultures, indigenous cultures constitute 90 to 95 percent of the cultural diversity of the world (Gray 1991). Among the main objectives to achieve when promoting sociocultural development are: a) protecting cultural heritage; b) ensuring equity (both intra- and intergenerational); and c) empowerment of less dominant groups in societies.

The formidable task confronting policy makers is to reconcile all three approaches and to operationalize policies that achieve sustainability. A practical approach would be to maximize the net benefits from economic and social development subject to the constraint of maintaining the stability of services from, and the quality of, natural resources over time (Munasinghe 1993b). There must be a balance between the use of natural resources and the natural capacity for regeneration. Particular precautions must be taken when the resource is already scarce or nearing extinction. Then the rate of extraction must be less than the rate of natural regeneration until a critical stock of the resource has been rebuilt. Similarly, the discharge of pollutants must be maintained in balance with the natural capacity for assimilation. Fortunately, most major types of pollutants can be assimilated by environmental systems, to a certain extent. In the case of persistent pollutants such as CFCs, policies must be designed to ensure that they are eventually phased out of use.

The existence of tropical forests is essential to achieving sustainable development on all three fronts: economic, ecological and sociocultural. Goods and services derived from forests support economic development. When forest resources are managed sustainably, a continuous flow of goods and services can be ensured. Indeed, there is significant potential to expand the economic benefits from tropical forests and also ensure a more equitable distribution of these benefits. Previously untapped benefits such as recreational use can be identified and utilized. Ecotourism and other recreational uses constitute a series of benefits from forest resources that are mutually compatible with conservation, but if tropical forests are allowed to degenerate, these services may never be realized.

## Effects of Deforestation on Sustainable Development

The effects of deforestation on sustainable development can be extremely detrimental. Denuded mountain slopes lose the ability to retain water, resulting in extensive flooding along riverbeds. The devastation from wide-scale flooding includes crop damage; loss of livestock and other animals; damage to human dwellings, infrastructure and equipment; displacement of people; and the spread of disease. Countries such as Bangladesh, Thailand and Madagascar frequently experience such disasters. Deforestation also decreases the soil retention capacity, allowing the erosion of fertile topsoil and reducing the productivity of the land. Furthermore, the siltation of riverbeds and reservoirs downstream impedes hydroelectric projects, fisheries and other industries; causes destructive flooding; and poses a threat to constructed dams. Overall, the estimated economic loss due to depletion of forests is about 4 to 6 percent of GNP in the major timber exporting countries--the same order of magnitude as the gains from timber export (Rowe et al. 1992).

Tropical forests play a vital role in maintaining natural environmental systems, thus contributing to ecologically sustainable development in many different ways. By acting as a storehouse of carbon, tropical forests help to maintain the balance of carbon in the atmosphere, consequently influencing global climatic conditions. The biomass-rich tropical forests may retain up to 55 percent of the total organic carbon stock (Rowe et al. 1992). Since the atmosphere has only a limited capacity for absorption, excess carbon contributes towards the buildup of greenhouse gases. Currently, deforestation releases between 1 and 3 billion metric tons of carbon into the atmosphere, due to the release of carbon during the burning of forests and the subsequent absence of biomass to sequester atmospheric carbon. Fossil fuel combustion, particularly from developed countries, accounts for the release of about 5.6 billion metric tons of carbon into the atmosphere annually. During recent years, the buildup of greenhouse gases attributable to the burning of tropical forests has increased the cause for concern. Although the existence of a greenhouse effect lacks scientific validation, conclusive evidence may come too late to prevent the effects of global warming. Preemptive measures are therefore warranted.

When forest resources come under extreme pressure of human activity, the result may be eventual desertification of the land. Loss of forest cover affects the capacity of land to retain water and may also cause changes in rainfall patterns. This results in changing patterns of vegetation. Less dense shrubs and bushes may replace the rich biomass which required more moisture. If the pressure on land due to human activity continues unchecked, the surviving vegetation may gradually disappear until the surface is virtually bare. Beyond a certain stage, the process of desertification may be difficult to reverse.

Forests also have a significant role in maintaining watershed systems. The capacity to retain water within forest soils enables watersheds to remain active even during periods of low rainfall or drought. Denuded of tree cover, soils lose the retention capacity and most rainfall disappears rapidly as surface runoff. The role of forests in providing fresh water may not be apparent. But the destruction of watersheds can be devastating, especially to rural poor communities that rely on natural sources for even their basic requirements. Trees also affect rainfall by permitting evapotranspiration. In the Amazon it is estimated that about one-half of the rainfall is the result of evapotranspiration (Rowe et al. 1992). The loss of forest cover thus affects the hydrogeologic cycle as well.

Finally, tropical forests have a significant role in protecting biodiversity. The 1992 Convention on Biological Diversity defined biological diversity as the "variability among living organisms." There are three categories of biological diversity: species, genetic and ecosystem. The categories simply provide a convenient method to define different types of diversity and facilitate measurement, but they are not mutually exclusive (Aylward and Barbier 1993). It should be noted that the concept of biodiversity is distinct from the biological resources themselves. But the literature tends to consider efforts to conserve biodiversity and to conserve biological resources (or natural habitats) as being one and the same objective.

Tropical forests cover 9 percent of the earth's surface but support about one-half of the 1.4 million named species found among the entire world biota (Schucking and Anderson 1991). Yet, it is believed that less than 5 percent of the biodiversity of rain forests is known to science. The total number of species in the world is estimated to range between 5 and 30 million. One study revealed that just 10 hectares of rain forest in Borneo contained some 700 tree species, the total number of species found in all of North America (Botkin and Talbot 1992). More typically, a hectare of South American tropical rain forest may contain 40 to 100 species, or, in Amazonian Peru, as many as 300 species. In contrast, a typical hectare of eastern North American forest may contain 10 to 20 species, while boreal forests could have as few as one to five (Botkin and Talbot 1992).

Some conservation biologists believe that 25 percent of all species may become extinct during the next 20 to 30 years (Botkin and Talbot 1992). The extinction and evolution of species is an inevitable natural process, although during some periods the rate of extinction or evolution has reached significant proportions. For example, about 65 million years ago the last mass extinction is known to have wiped out all dinosaurs, most marine invertebrates and marine plankton. Except during such periods, the rate of evolution has generally been slightly higher than the rate of species extinction, thus causing biological diversity to increase over time. At present, however, due mainly to increased human activity, species are disappearing at an unprecedented rate. According to one estimate, the rate of extinction is 40,000 times higher than the natural rate of species evolution! Some authors suggest that as many as 50 species may be driven to extinction each day (Schucking and Anderson 1991).

Protecting biodiversity is important for several reasons. First, there is intrinsic value to biodiversity in and of itself. Tropical forests are complex ecosystems with intricate dependencies among various species of plants and animals. The extinction of a single species can drive several others to endangered status or extinction.

One attractive aspect about biodiversity protection for the developed world may be the potential medicinal value of various species found in tropical forests. Pharmaceutical prospecting is a growing industry in which plant and microbial organisms are screened for compounds active against disease agents such as cancer and AIDS. The U.S. National Cancer Institute is currently engaged in a five year program involving the screening of some 3,000 plants active against cancer cells, of which some 70 percent are tropical (Munasinghe and McNeely 1994).

Finally, tropical forests are important to fulfill the sociocultural dimension of development, mainly by serving the basic needs of numerous indigenous and tribal groups. There are some 300 million indigenous people around the world who live in 70 countries and inhabit some 20 percent of the land mass (Martin 1993). The preservation of this unique social and cultural diversity is dependent upon maintaining forest resources intact. With proper emphasis, indigenous communities can be protected from the barrage of outside pressures which they are not accustomed to handling. Along with increasing economic pressure, many indigenous groups have lost their traditional claims to forest lands and have been displaced by ranchers, loggers and settlers.

The objective is not to preserve these cultures and societies to meet some ideal standards of "indigenousness." Indeed, as the world's finite resource base becomes increasing constrained due to rising demands of the growing population base, these indigenous communities are likely to encounter external economic, cultural and political pressures sooner or later. Indigenous communities often feel the external pressure when they come in contact with religious missionaries, mass media networks, and market-oriented economic forces. Frequently, these influences strain relationships between the older generation and younger members within the community. Older members strive to maintain traditional customs and rituals while the youth are more open to external influences.

The policy analyst's challenge is to learn how to communicate with groups speaking different languages, holding different world views, and having different cultural characteristics. In acknowledgment of the presence and importance of indigenous communities, policies must be designed and based on the notions of development that are important to each individual community, rather than a superimposed, or preconceived, notion of development. Doing so enables these communities to adapt to external environments gradually and in a nonthreatening manner, while ensuring the continued maintenance of their cultural heritage. But if the proper measures are not adopted, many cultures may vanish. During the past 150 years, 87 indigenous groups have disappeared in Brazil alone. These are simply the cases that have been recorded; the actual number may be higher.

The developed world is well aware of the asset constituted by indigenous peoples' knowledge of different animal and plant species, their behavior and uses, and the intrinsic functions of forest ecosystems. A fundamental difference between indigenous and nonindigenous peoples arises from their respective views of nature. Nonindigenous societies generally perceive human beings as an entity separate from nature; hence, the main focus is to establish the proper relationship of human beings with nature. The natural environment is perceived as an entity to be "managed" or controlled to better serve human needs. Indigenous peoples, in contrast, generally believe that humans are an intrinsic part of nature. The relationship is therefore one of coexistence with nature. Their knowledge base reflects this perception and contains both material and spiritual information (Gray 1991).

Indigenous knowledge of the medicinal value of plant and animal species has been particularly attractive to the developed countries. About one-fourth of all western prescription drugs contain elements of rain forest plants. Information from indigenous groups has contributed to the development of about three-fourths of these drugs. For instance, information on quinine and curare were provided by the Shuar of Ecuador and Peru (Gray 1991). The pharmaceutical industry based on rain forest-related drugs generates about US $43 million in annual revenues. Unfortunately, very little of this economic benefit is returned to the indigenous communities.

Policies that recognize and incorporate indigenous communities will most likely be successful if sufficient authority and power are delegated to the local level. Empowering these communities instills within them the direct responsibility for management and protection of the forest resources. Equally important is the need to educate local communities on the effects of forest destruction and the benefits from well-managed forest resources. Once aware of such benefits, communities are more apt to adopt conservation methods and to ensure that such methods are adopted by other communities and groups as well.

In this respect, the concept of biosphere reserves is a promising approach. A great emphasis is placed on involving local communities in research, education and training programs. Local people are integrated into the management system and their indigenous knowledge of forests is utilized in designing management practices. The reserves comprise use and nonuse zones, known as buffer zones and strict zones, respectively (Kemf 1993).

This leads to the final objective of sociocultural development: the issue of equity. The typical scenario in many developing countries is rampant profiteering by logging firms and corrupt politicians at the expense mainly of local communities that are deprived of even the most fundamental requirements such as food and shelter. Under proper forest policies, there should be a more equitable distribution of the benefits from harvesting forest resources. Local communities that suffer most of the externality effects are rightfully due a greater share of the revenue. Likewise, logging firms must bear the costs equivalent to the extent of damage caused by their activities. Holding logging firms more accountable for the cost of destructive forest uses will eventually result in their adopting less destructive measures and also in their considering the efficiency and effectiveness of harvesting forest resources. It is then likely that the extent of forest destruction will decrease significantly.

## Framework for Analysis[1]

The environmental impacts of human activity can be traced using techniques of environmental assessment (EA). For example, deforestation of a primary moist tropical forest may be caused by hydroelectric dams (energy sector policy), roads (transport sector policy), slash and burn farming (agriculture sector policy), mining of minerals (industrial sector policy), land clearing encouraged by land-tax incentives (fiscal policy), and so on. The task of environmental assessments is to distinguish and prioritize among these multiple causes and their impacts. These procedures are carried out by engineers, biologists, social scientists and other experts to the best extent possible. An important step is the identification of the "with" and "without" project scenarios.

Once the impact of human activities has been identified by an environmental assessment, environmental economic tools help to map these results into conventional decision making. These methods include economic valuation of environmental impacts (at the local/project level), natural resource management (at the sector/regional level), environmental macroeconomic analysis and environmental accounting measures (at the economywide or multisectoral level) and global/transnational environmental economic analysis (at the international level). However, there is considerable overlap in the techniques used at different levels.

### *Valuation of Environmental Costs and Benefits*

The total economic value (TEV) of an environmental resource is made up of use value (UV) and nonuse value (NUV). Use values can be further divided into direct use value (DUV), indirect use value (IUV) and option value (OV). Nonuse value comprises primarily existence value (EV). Bequest value is sometimes classified as a component of NUV as well. Therefore, total economic value can be stated as:

TEV = UV + NUV; or

TEV = [DUV + IUV + OV]
+ NUV

Care must be exercised to avoid the possibility of double counting. This may occur if the value of indirect supporting functions as well as the resulting direct uses are counted. A brief description of each of the above components is presented below:

*Direct use value* is determined by the contribution that an environmental asset makes to current production or consumption;

*Indirect use value* includes the benefits derived basically from functional services that the environment provides to support current production and consumption (e.g., ecological functions like natural filtration of polluted water or recycling of nutrients);

*Option value* is basically the premium that consumers are willing to pay for an unutilized asset, simply to avoid the risk of not having it available in the future;

*Existence value* arises from the satisfaction of merely knowing that the asset exists, although the valuer has no intention of using it; and

*Bequest value* reflects the desire to conserve environmental assets for the benefit of future generations.

Although total economic value (TEV) is a well-defined concept, the breakdown by components often introduces ambiguity and potential for overlap. Particularly elusive to measurement are the categories of OV and NUV. Since the primary objective is to measure TEV, the distinction between individual components of value is not strongly emphasized. The individual components are considered primarily as an indicative guide.

Several empirical techniques have been developed to measure the monetary value of environmental assets and impacts. The results from implementing some of these techniques have been controversial even in developed market economies, and they must be interpreted with caution and sound judgment.

The basic concept underlying all valuation techniques is the willingness to pay (WTP) of individuals for an environmental service or resource. This corresponds to the area under a demand curve derived for the consumption of the particular environmental service or resource. Alternatively, the change in value of an environmental asset could be defined in terms of the difference between the values of two expenditure (or cost) functions. This provides a value for the minimum amount necessary to achieve a desired level of utility (for a household) or output (for a firm) before and after varying the quality of, price of, and/or access to the environmental resource in question, holding all other aspects constant.

Another measure of economic value is what people are willing to accept (WTA) in the way of compensation for environmental degradation. Empirical evidence shows that WTA compensation for being deprived of an environmental amenity yields higher values than corresponding WTP estimates to retain the same amenity. While there is no explanation for such a discrepancy based on economic theory, several behavioral and psychological explanations have been proposed. People are less willing to spend actual income or wealth as opposed to "opportunity" income or wealth--money they do not yet have but may obtain (Knetsch and Sinden August 1994). People may also be more cautious about changing the status of assets as opposed to experiencing no change. Generally, WTP is considered to be a more consistent and credible measure than WTA.

Nevertheless, there may be valid justification for the use of WTA in developing countries. Money values placed on environmental goods and services are typically low, especially in low-income areas. Income disparity between regions and different groups has been addressed in traditional cost-benefit analysis by using income weights, but difficulty in obtaining accurate income or consumption estimates of concerned groups hinders this approach. In such situations it may be possible to measure benefits of environmental improvements in terms of willingness to accept income for loss of amenity, as opposed to willingness to pay for the improvement.

A variety of methods have been proposed for empirically measuring changes in the economic value of environmental resources. These methods rely on actual behavior in conventional markets, implicit markets, and constructed markets. Several of these methods are used in the case study that follows.

## Note

1. For more details on this section, see Munasinghe 1993a.

# *PART B: MADAGASCAR CASE STUDY*

# 3. An Overview

*Randall Kramer, Priya Shyamsundar, Evan Mercer and Mohan Munasinghe*

This study focuses on environmental valuation of a forestry development and conservation project in Madagascar. The study is important for several reasons. First, discussions at the World Bank have included an emphasis on the need for improved valuation methods for natural resource projects. Second, forests produce a number of nontimber outputs that cannot be valued with traditional net revenue analysis often used in project analysis. Third, there is tremendous public and political interest in tropical forestry issues, which in turn has created a demand for improved quantitative information on the benefits and costs of protecting and using tropical forests.

## Introduction

Although there is some lively debate on this view among economists, ecologists and environmentalists, we assume that meaningful assignment of economic values to many environmental goods and services is possible and can improve policy and public decision making (Smith 1990). Environmental economics emphasizes human preferences in assigning values to nonmarket goods and services. This is admittedly an anthropocentric approach, but one that recognizes the importance of the noncommercial value of air, water, forests, and other environmental resources. Environmental economics assigns values based on individuals' willingness-to-pay for improved environmental quality. The measurement of environmental benefits and costs facilitates their use in a benefit-cost framework to supplement the more conventionally measured benefits and costs.

As lawmakers and the public devote an increasing share of national income to environmental programs, they need evidence of the economic benefits resulting from these significant investments. Furthermore, valuation studies such as this one can shed light on questions such as: Is the value of a park with a buffer zone greater than one without? What is the appropriate level of compensation for local people unable to continue their forest extraction activities because of a reserve? How much are foreign tourists willing to pay to visit national parks in developing countries?

This research project has the objective of adapting several valuation methods for use in economic analysis of a conservation project. In particular, the objective is to examine the use of several valuation tools for assessing the benefits and costs of establishing a new national park. The results of the study should have implications for future economic analysis of forestry and other environmental projects.

## Madagascar and the Mantadia National Park

Comprising 587,000 square kilometers, Madagascar is an island located 400 kilometers off the southeast coast of Africa. With a per capita income of about $300, 80 percent of the 11 million inhabitants live in rural areas and 85 percent work in agriculture. Only 14 percent of the 12 million hectares of forest in Madagascar is classified as nondegraded, high-density forest (World Bank 1988). The island has one of the highest rates of deforestation in the world, losing an estimated 200,000 hectares of forest per year. More unique plants and animals have evolved in Madagascar than probably anywhere else in the world--at least 150,000 of Madagascar's 200,000 species are found nowhere else. This high level of endemism, large number of species, and relatively small geographic area have led the major conservation organizations to declare the island to be one of the most important global reservoirs for biological diversity.

Madagascar is potentially an important tourist destination. Tourism in Madagascar centers on two major activities: beach and nature tourism. Nature tourism is among the fastest growing subsectors of the tourist industry even in the face of minimal promotion, high access costs, and poor infrastructure. Of the 28,000 tourists who visited Madagascar in 1987, 8,000 came specifically for nature tourism, compared to only 4,000 in 1985 (World Bank 1990).

The World Bank, along with other donor agencies and nongovernmental organizations (NGOs), are providing funding to the government of Madagascar (GOM) to establish a network of over 45 protected areas covering 1.4 million hectares as part of a National Environmental Action Plan (NEAP). The objectives of the protected area network include conserving the country's biodiversity and establishing a vibrant nature tourism industry. The Bank justified funding projects for this program on the assumption that increased tax revenues from nature tourism would cover operating costs[1] and that by the fifth year of the project the growth in nature tourism would add $12.5 million per year to the economy (World Bank 1990).

In 1988, the Madagascar Forests Management and Protection Project (FMPP) was approved by the World Bank. The project had three objectives: (1) to strengthen the forestry department; (2) to prevent further degradation of natural forests; and (3) to promote private sector involvement in reforestation and wood processing. The project was budgeted at $22 million over seven years.

Mantadia National Park was established as a part of the natural forest protection objective.[2] The park is located near the popular Perinet Forest Reserve in the Andasibe region east of Antananarivo, the nation's capital. It can be reached in approximately 3 hours from the capital by paved roads and is also accessible by rail. The park extends over an area of 9,875 hectares which is representative of the eastern rain forests. The park varies in altitude from 850 to 1,250 meters and is characterized by steep terrain and dense undergrowth. A mixture of different species of trees and plants characterize the land and forests in the park. The park is thought to contain possibly 11 species of lemurs, four of which are endangered, two are rare and two vulnerable. Most important, the park contains the habitat for the Indri,[3] one of the largest known lemurs in Madagascar (Harcourt and Thornback 1990).

The combination of the Perinet Reserve's global reputation as one of the last remaining habitats for the Indir lemurs, the easy accessibility, and the planned training and visitor facilities for the new park suggest large potential benefits from nature tourism recreation. In approving the FMPP, however, the Bank did not include the national park component in its benefit-cost analysis because the benefits were considered "long-term in nature and difficult to quantify" (World Bank 1988, p. 43). Rather, it was simply assumed that cost recovery through tourism activities would be large enough to support the operation and maintenance of the reserve.

## Environmental Valuation Methods Used in the Study

The total value of a moist forest in Madagascar consists of a number of component values. These can be broadly categorized as use and nonuse values. The use values include value to individuals who extract timber, food, medicine, and other products from a forest, as well as those who consider the forest a source of nutrients by means of slash-and-burn agriculture. Use values also include the value to foreigners and Malagasies who use an intact forest for recreation, locals who use it for religious and cultural purposes, and scientists who use the forest as a laboratory. In addition, there may be significant existence values. Because of the diverse habitat provided by forests in Madagascar, many people may value preservation even if they never plan to visit or use the forest.

The creation of a national park can enhance or diminish several components of the total forest value (Dixon and Sherman 1990). If residents are prohibited from extracting minor forest products, this will diminish the residents' use values. On the other hand, to the extent to which the park has attributes that are desirable to tourists or to preservationists, there may be offsetting increases in recreation or existence values.

It is challenging to attach economic values to many of the benefits of environmental projects because no corresponding market price data are available. Although public goods such as biodiversity, wildlife reserves, and national parks are often available to consumers at a zero price and may not affect private goods markets in a measurable way, many people are willing to pay significant sums to insure their continued availability. Environmental economists have devised ways to measure this existing, but not directly observable, willingness-to-pay for such environmental assets (Smith 1990; Whittington et al. 1990). Four methods are used in this study for empirically measuring the change in environmental values resulting from the park: (1) contingent valuation method; (2) recreation demand analysis; (3) opportunity cost analysis; and (4) productivity analysis.

### *Contingent Valuation Method*

The contingent valuation method (CVM) uses survey techniques to establish the value of goods and services that are not exchanged in markets and, therefore, do not have any prices associated with them. Within this framework, demand for nonmarket goods is established by first describing a simulated market to the respondents and then asking them directly to reveal their preferences in terms of some common denominator. The advantage of using the CVM is that it is suitable for valuing a wide range of nonpriced environmental goods and services.

CVM question formats have several variations.[4] In this study, the referendum style of contingent valuation questions is used. Referendum CVM questions divide the sample into a discrete number of subsamples. Each subsample is asked whether or not they would be willing to pay a specified amount for the particular nonmarket good, and they respond either "yes" or "no."

In this study, CVM was used in both the village survey and the tourist survey. In the village survey, household members were asked about their willingness-to-accept compensation for having lost access to the forest contained in the park. The questions referred to compensations which would make the household as well off with the park as they would have been if they had continued to have access to the forests in the park. The measure used for the compensation mechanism was units of rice.

In the tourism survey, the CVM was used (as an alternative method to the recreation demand method), for estimating the total value of the park to tourists. These questions were phrased in terms of how much more the foreign tourists would have been willing to pay for their trips if the new park were available for them to visit.

### *Recreation Demand Analysis*

Recreation demand models use the amounts of time and money visitors spend traveling to a site, as price proxies together with participation rates and visitor attributes, to estimate the recreational value of the site. Most studies portray the problem in terms of a single-purpose, single-destination, day trip to a site that affords some particular recreation experience of typical quality that can be substituted for those available at many similar sites. Recreation in Madagascar's national parks contrasts sharply with these assumptions. Recreators in Madagascar can be divided into two groups consuming distinct goods: local recreators who make day trips to national parks to view the local natural environment, and international nature tourists who undertake lengthy trips to experience unusual natural settings and cultures.

Demand by international tourists requires a reformulation of the traditional travel cost models. This study focuses on international tourists. A theoretical model of international nature tourism is presented in a paper by Mercer and Kramer (1992). It is based on the assumption that individuals travel to a single country such as Madagascar and engage in a variety of activities. The activities consist of traveling to specific natural areas for recreation and travel enjoyment. Estimating this model requires specific data on how each household distributes its time across activities during the time horizon of the model, and a specification of the features of the activities. Ideally, this implies collecting full trip itinerary data as well as travel cost data for foreign visitors. The itinerary data include the distribution of time among activities for each individual and the costs of pursuing the activities.

### *Opportunity Cost Analysis*

The opportunity cost approach uses standard economic analysis of market values to determine the net economic benefits associated with the alternative uses of one or more resources. In this study, the opportunity costs of interest are those associated with alternative land uses by people living in and near the park. Given the dependence of the villagers on the forests for a significant portion of their livelihood, creating a national park out of a large tract of forest and imposing restrictions over future use imposes a considerable economic burden on local villagers. By determining recent land use in and around the park and projecting future land use changes in the absence of the park, one can estimate the cost to villagers from losing the opportunity to exploit the park area for agricultural or forest products.

Although there are no human settlements within the Mantadia National Park boundaries, several villages lie in proximity. These villages depend upon the forests within and immediately around the park for forest products and food. A primary use of the forest is swidden agriculture. For several hundred years, the eastern Malagasy have practiced a form of shifting cultivation known as "tavy." About 200,000 hectares of land is cleared every year because of shifting cultivation in Madagascar (Andriamampianina 1985).

Villagers in this area are also dependent upon the forests for a number of other reasons. Fuelwood is collected from the forests on a regular basis, a wide variety of fish and animals are foraged for consumption, and several types of grass are harvested and used for assorted purposes. Forest plants and herbs also serve as important sources of medicine.

The application of opportunity cost analysis requires that cash flow analyses be conducted for villages around the park to determine the inputs and outputs of the households' production functions. In addition, a determination must be made of how much of the agricultural and forestry activities is occurring inside and outside the park boundaries. This is accomplished with the use of remotely sensed data.

### *Productivity Analysis*

Productivity analysis is used in this study to measure the benefits to farmers of reduced flooding from reduced deforestation resulting from the establishment of the park and buffer zone. Productivity analysis is a valuation method suitable for examining the effects of environmental quality on products that enter into market transactions. This approach has been used in other studies to value the effects of various types of environmental change on agriculture, forests and fisheries (Freeman 1993). The basic premise is that changes in environmental quality can reduce (or increase) the quantity and quality of products being marketed. Once those physical changes are identified and estimated with the help of natural scientists, the productivity changes can be valued through economic analysis.

The productivity analysis for this study proceeds by first estimating deforestation rates in the Mantadia area using remote sensing. Deforestation rates for the future are projected based on the historical analysis. These land use changes are then used to project effects on flooding. Finally, the predicted reductions in flooding brought about by the park and buffer zone are used to predict reduced crop losses which are estimated and valued in economic terms.

## Notes:

1. This assumption is based on an expected increase in the number of tourists from 30,000 to 200,000 by the year 2000.

2. Recently, the World Bank has discontinued its involvement with the Mantadia National Park. However, the U.S. Agency for International Development is working with an NGO to implement the park plan.

3. Madagascar is the only place in the world where lemurs occur in the wild. Lemurs are prosimian primates. Of the 54 species of lemurs on the island, the Indri is the largest and in acute danger of extinction (Jenkins 1987).

4. Mitchell and Carson (1989) describe the pros and cons of the referendum and alternative CVM question formats.

# 4. Impacts on Villagers

*Priya Shyamsundar, Randall Kramer, and Narendra Sharma*

Development projects in which large forest areas are protected or converted to other land uses, such as agriculture or grazing for livestock, have often failed to take into account the impacts on people with traditional rights to forests. The failure to adequately compensate or involve people in the establishment and management of protected areas has resulted in poor performance of many projects dealing with reserves and natural parks. In many instances, these parks and reserve areas are vulnerable to problems related to access by local populations. This component of the study analyses the economic and social impacts of establishing the park in Madagascar on village households living adjacent to the protected tropical rain forests (Kramer, Sharma et al. 1994).

## Approach

Household production models have been used by economists to study a number of issues pertaining to farm households (Singh, Squire and Strauss 1986). These include labor supply, transportation, intrahousehold decision making, etc. (Gronau 1977). The same framework can be used to study the impact of the establishment of a national park on Malagasy villagers in terms of their demand for forest and agricultural products and their land use practices (Shyamsundar 1993).

Households are assumed to consume a vector of market goods $X_m$, a vector of subsistence goods $X_a$, and a vector of minor forest products $X_f$. Two of these, $X_a$ and $X_f$ are both produced and consumed by the household. Furthermore, households obtain utility from the consumption of leisure $X_l$.

The household utility function is given by:

$$U = U(X_m, X_a, X_f, X_l) \qquad (1)$$

The household uses the surplus from the production of the agricultural goods and the minor forest products to buy market goods. It therefore faces the following income constraint.

$$p_m X_m = p_a(A - X_a) + p_f(F - X_f) - wl_h - p_k k + I - c \qquad (2)$$

where

- $X_m$ = a vector of market goods purchased by the household
- $A$ = a vector of quantities of the different agricultural goods produced by the household
- $F$ = a vector of quantities of forest products harvested or processed by the household
- $p_m$ = a vector of prices of market goods
- $p_a$ = a vector of prices of agricultural goods
- $p_f$ = a vector of prices of forest products
- $l_h$ = hired labor used in the production of agricultural goods
- $k$ = a vector of capital goods used in the production of agricultural output
- $w$ = the market wage
- $p_k$ = a vector of prices of capital goods
- $I$ = other income available to the household.
- $c$ = costs of clearing primary forests for swidden agriculture

Thus, the right hand side of the above expression represents household net surplus. It is the income available to the household after consuming a portion of its produce and purchasing the inputs used in home production. This income is used to purchase a vector of market goods $X_m$, which are available at market prices $p_m$. The household also faces land and labor constraints, as well as agricultural and forest production constraints.

The establishment of the park will result in a change in the total area to which the household has access, both for agricultural purposes and for obtaining forest products. Initially, i.e., without the park, the average household is assumed to have access to T hectares of land. With the establishment of the park, the household loses access to some land, retaining access to only T′ hectares of land ($T' \leq T$). Thus, with the establishment of the park, the household loses access to $\Delta T$ hectares ($\Delta T \geq 0$) of land. Some of this land is under primary forest cover ($T_p$), and the rest under secondary forest cover ($T_s$).

$$T - T' = \Delta T = \Delta T_p + \Delta T_s \qquad (3)$$

The loss in accessible land has a direct impact on household production and, thereby, on household income and consumption. The change in production and consumption behavior in turn affects household welfare. The loss to household welfare as a result of the park can be estimated in a number of different ways.[1]

The welfare loss can be estimated *indirectly* by estimating the opportunity cost borne by the household because of the establishment of the park. Opportunity costs are defined as "the benefit foregone by using a scarce resource for one purpose instead of using it for its next best alternative use" (Gittinger 1982, p. 489). As long as the household is using optimal and positive quantities of land in its production activities, a decline in land availability results in a decline in household benefits because of a decrease in household profits. The cost the household bears equals the change in profits as a result of the change in access to land.

An alternate method for establishing the welfare loss to the household as a result of the park is based on the household's expenditure function. The expenditure function is used in standard welfare economics to link income and utility through the indirect utility function (Varian 1984). It is the minimum expenditure required to obtain a given level of utility. The contingent valuation method can be used to estimate changes in the expenditure function by asking people directly about perceived changes in welfare.

## Data Collection and Analysis

In order to estimate the opportunity costs associated with foregoing these economic activities on park land, a survey was conducted of 351 households in 17 villages. These villages lie within 7.5 kilometers of the park boundary. A local nongovernmental organization, well versed in rural survey techniques, assisted in administering the survey. The survey was undertaken following a reconnaissance visit to the villages, several focus group interviews, conversations with various people who were well acquainted with the area, and a pretest which covered about 25 households. The survey was administered in Malagasy, the national language.

The questionnaire focused principally on (1) establishing the extent of dependence of the local villagers on forests near their villages and on forests within the park boundaries for obtaining a variety of forest products; (2) establishing the extent to which villagers used the forests within and immediately around the park for shifting cultivation; and (3) assessing local attitudes toward conservation of forests. Questions were also asked related to socioeconomic variables, land use, time allocation, and household production activities. The final section used the contingent valuation method. The CV question required respondents to provide "Yes" or "No" responses (a referendum format). The question referred to compensation which would make the household as well off with the park as they would have been if they had continued to have access to the forests in the park. The measure used for the compensation mechanism was units of rice.

A separate questionnaire was administered to the village leaders. It focused on issues pertaining to general agricultural patterns, markets and prices of goods sold, village history and migration patterns, forest-related cultural issues, and details concerning shifting cultivation practices.

The opportunity costs of establishing the Mantadia National Park to the local populations were determined by considering: (1) the income generated from forests by the locals in terms of forest products (both timber and nontimber) harvested; (2) the income generated by locals from slash and burn agriculture on the forest lands; (3) the extent to which the area included in the national park includes forests used by the villagers; and (4) the extent to which villagers continue to have access to the area within the national park for harvesting of forest products and for swidden agriculture.

The income generated by villagers from harvesting forest products was established by using primary data obtained in the village household survey. The most important data used were the frequency and quantity of different products harvested. Price data on forest products and data on labor expended were obtained from a number of different sources, including interviews with villagers, shop owners, household and village leaders, and published reports.

Agricultural income was estimated by considering data obtained from the village household survey on area planted, crop yields, and annual costs incurred. Price data on agricultural products were farm gate prices obtained by interviewing various people operating within the village economy. Data on labor expended in agricultural production were obtained from a comprehensive study undertaken on the costs of agricultural production (MPASSA 1987).

Three cash flows were developed based on the geographical groupings of the surveyed villages and an estimate of the populations that were losing access to lands and forest products as a result of the park. The three cash flows refer to sets of villages that lie northeast, southeast, and southwest of the park. In each of these cash flows, the net loss from the establishment of the park to the average household in the subgroup of villages was estimated.

Each cash flow consists of two sets of estimations:

1. 1991 (single year) estimates of the net cash flow to the average village household from the harvesting of forest products and the net cash flow accruing as a result of swidden agriculture; and
2. the final cash flow, which extends from 1991 to 2010. This cash flow is based on the initial year's flow of benefits and costs, but also incorporates certain adjustments in benefits and costs over time (e.g., it is assumed that without the park, deforestation would proceed in the park area at a 3 percent annual rate).

Each of the three cash flows measures the economic benefits from the forests within the park to the locals if they continued to have access to the park. The cash flows, therefore, estimate the value of land to the average household assuming a "without park" scenario. This value is equivalent to the opportunity cost of establishing the park to the average household. Therefore, the net present value figures in each of the three cash flows represents the present value of the opportunity costs from the establishment of the Mantadia National Park to the average village household in each of the three different village groups.

## Results

The household survey covered a total of 17 villages lying to the east and south of the Mantadia region. The total population covered by the household survey is 1,598, and the average household size in this region is 4.6 persons (Table 4.1). Most of the villages do not have access to any medical facilities, running tap water, or electricity. The village children in general suffer from malnourishment. Malaria, chest congestion-related illnesses, and venereal diseases are other significant health problems affecting this population. In general, most of the villages surveyed either had, or were within 4 to 5 kilometers of, primary school facilities. However, the survey indicated the average number of years of education per person to be only 2.4 years.

Rice production is the primary economic activity in the area. The average household produces 487 kilograms of paddy rice per year, worth about US $128 (Table 4.2). Most households also engage in shifting cultivation. Eighty percent of the households surveyed said that they would add to existing land for cultivation. Other crops grown are maize, beans, manioc, sweet potato, taro, sugar cane, ginger, banana and coffee. Fuelwood is the most economically important forest product obtained by the households.

**Table 4.1 Socioeconomic Characteristics of the Surveyed Households**

| *Variable* | *Range* | *Mean* |
|---|---|---|
| Number of household members (N=351) | 1 - 13 | 4.55 |
| Age (years) (N=335) | 0.5 - 100 | 17 |
| Proportion younger than 10 years of age (N=593) | ---- | 0.37 |
| Education (years) (N=1542) | 0 - 14 | 2.35 |

**Table 4.2 Value of Agricultural and Forestry Activities**

| *Activity* | *Number of observations* | *Total annual value for all villages* | *Mean annual value per household* |
|---|---|---|---|
| Rice | 351 | $44,928 | $128 |
| Fuelwood | 316 | $13,289 | $38 |
| Crayfish | 19 | $220 | $12 |
| Crab | 110 | $402 | $3.7 |
| Tenreck | 21 | $125 | $6 |
| Frog | 11 | $71 | $6.5 |

Based on the data collected on agricultural and forestry inputs and outputs, the cash flow models were used to estimate the opportunity costs borne by the villages as a result of lost access to the forests in the park. Averaging over the results obtained from the three cash flow models, the mean value of losses was $91 per household per year (Table 4.3). Aggregating over all households living in the vicinity of the park and using a 10 percent discount rate and 20-year time horizon, the net present value of the opportunity costs was estimated to be $566,000.

**Table 4.3 Estimates of Economic Losses to Local Villagers from Establishment of Mantadia National Park**

| *Method Used* | *Annual Mean Value per Household* | *Aggregate Net Present Value* |
|---|---|---|
| Opportunity Cost | $91 | $566,000 |
| Contingent Valuation | $108 | $673,000 |

The contingent valuation responses were analyzed with an econometric model. The discrete choice responses were used to estimate a bid function in a logistic regression framework (Table 4.4). The estimated bid model revealed that a number of socioeconomic variables were systematically related to the probability of accepting offered bids. The bid level itself was a positive and significant explanation of responses. The coefficient on the dummy PREFDUM is positive, as would be expected. Respondents who found buffer zones acceptable were more likely to agree to the offered bid. Several of the dummy variables for village groups have significant coefficients. These variables likely reflect village level differences not captured in other variables.

The logit model correctly predicted 75 percent of the responses, clearly indicating that the elicited bid responses were nonrandom. From the estimated bid function, a mean willingness-to-accept compensation was calculated. The responses to the contingent valuation questions indicate that, on average, a compensation of rice equivalent in value to $108 per year per household would make households as well off with the park as without (Table 4.3). Aggregating over the population in the park area, this implies a necessary one-time compensation of approximately $673,000, assuming a 10 percent discount rate and 20-year time horizon.

**Table 4.4 Maximum Likelihood Estimates for Village Contingent Valuation Analysis**

| *Variable* | *Coefficient* | *Std. Error* | *t-ratio** |
|---|---|---|---|
| Constant | -3.0012 | 0.766 | -3.917 |
| BID | 0.15887 | 0.08 | 1.987 |
| HHMEM | -0.0400 | 0.075 | -0.531 |
| PREFDUM | 1.6577 | 0.3935 | 4.212 |
| RTOT | -0.0005 | 0.0004 | -1.337 |
| Group 1 | 1.8473 | 0.6146 | 3.006 |
| Group 2 | -0.1833 | 0.7186 | -0.255 |
| Group 4 | 2.6515 | 0.6242 | 4.248 |
| Group 5 | 1.3421 | 0.5927 | 2.265 |
| Maximum Log Likelihood | -121.999 | | |
| n | 240 | | |
| McFadden's $R^2$ | 0.25 | | |
| Percent Correctly Predicted | 0.75 | | |

WTA = Yes/No responses to the bid (the dependent variable); BID = offered bid (ranging from 1 to 7 vata of rice); HHMEM = number of household members; PREFDUM = a dummy representing preference for buffer zones over forests (Buffer Zones = 1 Forests = 0); RTOT = annual household rice production; GROUP 1 - GROUP 5 are dummy variable for geographical groupings of villages.

## Discussion

The Mantadia National Park has been established with the intention of preserving Madagascar's unique biological heritage. While the benefits of conserving the fauna and flora and the biological diversity within the park are large (and are presented later in this report), some very significant opportunity costs must be considered, as a necessary condition, to avoid open access problems that will threaten the existence of the park in the long run.

Approximately 3,400 people in three sets of villages will be negatively affected by the park. The results suggest that an annual compensation of approximately $100 per household would be required. Such compensation could be made in the form of education, health facilities, alternative income-earning enterprises in the buffer zone, or other development activities.

These compensation costs appear to be a significant part of the true cost of implementing protected area projects and should be built into project design at an early stage. Without adequate compensation and active cooperation of local residents, natural resource management projects are more likely to fail.

The opportunity cost approach was used to provide baseline estimates of the economic losses to villagers from the establishment of the park. The analysis relied on cash flow models constructed from detailed input and output data collected from the 350 village households. This approach provided considerable insight into differential impacts in the various regions around the park. It potentially could be used in involving people in the management of programs. It is also a powerful tool in understanding the interrelationship among microeconomic factors relating to use and management of parks.

Nonmarket valuation techniques, which have been extensively used in developed countries to directly measure the welfare changes occurring from a given change in a public good, have been underutilized in developing countries. In this study, contingent valuation was used to estimate the welfare change perceived by local residents as a result of loss of access to lands currently within the Mantadia National Park.

The analysis indicates that CVM, rigorously applied, can be effectively used in the developing country context. The econometric analysis undertaken indicates a systematic association between various socioeconomic variables of interest and the expressed willingness-to-accept compensation. The results show that responses to the CVM question were decidedly nonrandom. Also, the opportunity cost (or market based) approach and the contingent valuation method provided strikingly comparable estimates of costs borne by villages. All of this is encouraging evidence to support the use of the contingent valuation method in such a context, but further research is required to improve its widespread applicability.

## Note

1. If a market for land existed, the loss in welfare could be fairly simply approximated by considering land prices. However, because of the lack of trade in land, the value of land, and thus the welfare loss because of loss of access to land, is established by considering the *returns* to land holdings.

# 5. Impacts on Tourism

*Evan Mercer, Randall Kramer and Narendra Sharma*

When environmental conservation projects increase nature tourism[1] activities, economic valuation techniques can be used to measure the associated benefits. Despite the fact that international nature travel has become "big business" (Laarman and Durst 1987), only a few attempts have been made to estimate the economic value of tourism to national parks in developing countries[2] Most studies have focused on the value to domestic tourists. The objective of this study component is to help fill this gap by examining the potential benefits that accrue to international nature tourists from the creation of Mantadia National Park (Mercer, Kramer and Sharma 1993).

## Approach

The decision by foreigners to pursue nature tourism in Madagascar is more complex than the models presented in most recreation demand studies to date. Foreign visitors fly great distances and utilize various modes of travel to visit numerous sites and enjoy many different activities in Madagascar. Few foreign tourists plan trips solely to visit a particular national park in Madagascar. More commonly, they decide to take a trip to Madagascar to view nature. Then, they decide on an itinerary that may include several parks, cultural sites, and other attractions.

Assume that households (or individuals) travel to a single country such as Madagascar and engage in a variety of activities which consist of traveling to specific natural areas to enjoy the vegetation, wildlife, scenery, water features, etc. Households considering international nature tourism attempt to maximize utility as a function of recreation service flows ($Z_R$) and nonrecreation service flows ($Z_{NR}$), i.e.,

$$U = U(Z_R, Z_{NR}) \quad (4)$$

Nonrecreation service flows are produced by combining the composite market commodity ($X_{NR}$) with time ($T_{NR}$). Recreation service flows are produced by combining market travel services ($XT_i$) and time to travel to country *i* ($T_i$) with nature tourism trip experiences in country *i* ($V_i$). Therefore, the household production functions for $Z_R$ and $Z_{NR}$ are:

$$Z_R = z_R(V_1 \ldots V_i, T_1 \ldots T_i, XT_1 \ldots XT_i) \quad (5)$$

$$Z_{NR} = z_{NR}(X_{NR}, T_{NR}) \quad (6)$$

Nonhomogeneous nature tourism trip experiences in country *i* ($V_i$) are produced by choosing a bundle of *j* activities ($A^j_i$) and utilizing in-country market services ($Xt^j_i$) and time ($t^j_i$) to travel to the locations of the activities. The $A^j_i$ can be thought of as either single destinations within the country or groups of destinations. Activities in Madagascar, for example, might include traveling to the proposed Mantadia National Park to view the Indri lemurs and to a specific beach to swim and sunbathe, or to a group of parks for bird watching and a group of beaches for snorkeling. Therefore, the production function for $V_i$ is expressed as:

$$V_i = v_i(A^1_i \ldots A^j_i, t^1_i \ldots t^j_i, Xt^1_i \ldots Xt^j_i) \quad (7)$$

where

$A^j_i$ = activity *j* in country i and is a function of the site's environmental services ($s^j_i$), market goods ($Xr^j_i$), and on-site time ($tr^j_i$)

$t^j_i$ = travel time to location of $a^j_i$

$Xt^j_i$ = market goods used to travel to location of $a^j_i$.

The household's problem is to maximize its utility (equation 4) by choosing nature tourism trips ($V_i$) and market goods ($X_{NR}$) subject to production constraints (equations 5, 6, and 7) and a full income constraint. This decision problem is examined with two different empirical models: (1) a Typical Trip Model, and (2) a Random Utility Model (RUM).

## Data Collection and Analysis

To conduct the empirical analysis of recreation benefits, questionnaires were prepared and translated into French. The questionnaires consisted of a series of questions on the costs of the current trip to Madagascar, details on previous international nature tourism related trips, the decision process in determining trip destinations, contingent valuation questions for willingness-to-pay for visiting the Mantadia National Park, and a series of socioeconomic and demographic questions.[3]

The questionnaires were tested in Philadelphia with a focus group of previous visitors to Madagascar. Focus group participants were recruited by the Wildlife Preservation Trust, a conservation organization that has organized several tours of Madagascar. Draft questions were presented to the participants for their comments and feedback. The final questionnaire was revised based on the focus group comments. In Madagascar, the questionnaires were revised again following pretests with a small sample of visitors to the Perinet Special Reserve and discussions with our local Malagasy collaborators. Two local Malagasy research consultants (trilingual in English, French, and Malagasy) were hired to administer the questionnaires to visitors to the Perinet Special Reserve.

Data were collected during the summer of 1991. Interviews were completed with 94 tourists. The number of tourists available to survey was limited by a political strike which made transportation difficult. Additional data were obtained from an expert opinion survey administered to 27 US and European organizers of nature tours.

## Results

Summary statistics from the collected data are presented in Table 5.1. Income for the total sample of visitors ranged from US $3,000 to $300,000, with a mean of $59,156. The average tourist was 38.5 years old and had completed 15 years of education. Visitors came from 14 countries (primarily from Europe). Trips ranged from three to 100 days in length (mean of 26.6 days) with one to eight days spent at Perinet (mean of two days). Total expenditures ranged from $335 to $6,363 with the average trip costing $2,874. Italy, Great Britain, and France were the most common countries of origin.

For the econometric models, incomes and travel costs to Madagascar were taken directly from the tourist survey. The tourist survey responses were also used to select the seven most important destinations that serve as substitutes for Madagascar. Average values given by the travel agents for each of the destinations were used as the quality variables in the econometric analyses. Travel costs for the substitute destinations were calculated by adding the cost of round trip airfare from the capital city of the respondents' country of residence to the capital city of the destination country. The average additional in-country cost of a two-week developing country nature tourism trip was calculated from the responses of travel agents and tour operators in the expert opinion survey. In the CVM section of the tourist survey, tourists to Perinet were provided with information about the new park and then asked if they would be willing to pay $C more for their trip to Madagascar to include a visit to the new national park if: 1) they saw twice as many lemurs and birds as they saw at Perinet; and 2) if they saw the same number of lemurs and birds as they saw on the current visit to the P-erinet Reserve (where C = $50, $100, $150, $200, $300, $400, $600, or $800). The tourists responded "yes" or "no" to the randomly assigned bid levels.

**Table 5.1 Summary Statistics for Tourists by Country of Origin**

| *Country* | *% of sample* | *Average Expenditure ($US)* | *Average Number Days in Country* | *Average Number Days in Perinet* | *Average Age (yrs)* | *Average Education (yrs)* | *Average Income ($US)* |
|---|---|---|---|---|---|---|---|
| Britain | 20.2% | $3332 | 18 | 1.6 | 45 | 17 | $39,545 |
| Italy | 21.4% | $2357 | 21.4 | 1.9 | 34 | 15 | $63,214 |
| France | 15.5% | $3171 | 36 | 1.9 | 34 | 15 | $37,785 |
| Germany | 11.9% | $3270 | 24.8 | 1.8 | 40 | 16 | $32,935 |
| Switzerland. | 11.9% | $3200 | 37.6 | 2.3 | 36 | 17 | $50,717 |
| USA | 4.8% | $3097 | 18.5 | 2.75 | 49 | 17 | $70,000 |
| Belgium | 3.6% | $2921 | 23 | 1.3 | 47 | 16 | $35,896 |
| Holland | 3.6% | $2572 | 26.5 | 5.3 | 30 | 14 | $41,666 |
| Austria | 1.2% | $2000 | 21 | 1 | | 15 | $65,000 |
| Denmark | 1.2% | $1750 | 28 | 2 | 35 | 18 | $75,000 |
| Kenya | 1.2% | $6363 | 35 | 4 | 39 | 11 | $25,000 |
| New Zealand | 1.2% | ___ | 60 | 3 | 26 | 12 | $5,000 |
| Reunion | 1.2% | $335 | 9 | 1 | 68 | 14 | $45,000 |

**Table 5.2 Maximum Likelihood Estimates for Recreation Demand Analysis**

| *Independent Variables* | *Typical Trip Model°* | *RUM Model°°* |
|---|---|---|
| INTER | 3.7089* (2.43) | 0.78318* (7.891) |
| UNUS | -1.49* (-4.281) | -0.4096* (-8.698) |
| ACCOM | -0.94190 (-0.183) | -0.5381* (-7.040) |
| COST | -0.000499 (-0.889) | 0.00046 (0.772) |
| EDYRS | 0.0849 (0.781) | |
| INCOME | 0.000006 (1.091) | |
| ED*COST | | -0.0000168 (-0.536) |
| INC*COST | | -0.0000121** (-1.793) |

° : Log-likelihood = -195.2669

°° : Log-likelihood = -656.45

* : significant at the .05 level

** : significant at the .10 level

INTER = index of quality of local guides, educational materials and facilities for interpreting natural areas; UNUS = index of the possibility of seeing unusual animals; ACCOM = index of quality of accommodations and transportation services; COST = roundtrip airfare plus in-country costs; EDYRS = years of formal education; INCOME = total household annual pretax income; ED*COST = number years of education multiplied by COST; and INC*COST = household income multiplied by COST. T-ratios are in the parentheses below the coefficient estimates.

Table 5.2 presents the maximum likelihood regression results from the Recreation Demand Models. The dependent variable in the Typical Trip model is the sum of the number of trips each individual has made or plans to make within the next five years to eight developing country nature tourism destinations. The dependent variable in the RUM model is the probability of visiting site *j*. The independent variables are listed in the left column of Table 5.2. Following Feenberg and Mills (1980), the income (INC*COST) and education variables (ED*COST) in the RUM multinomial logit model were combined with the cost variable. A tobit maximum likelihood estimator was applied to the typical trip model and a multinomial logit maximum likelihood estimator was applied to the RUM discrete choice model.

The quality variables[4] INTER and UNUS were significant at the .05 level in both models, while ACCOM was significant in only the RUM model. Only the INTER variable exhibits the correct sign. The COST variable was not significant in either regression and had the correct negative sign only in the Typical Trip model. The income variable was significant at the .10 level in the RUM model but has the incorrect negative sign. While not significant in the Typical Trip model, the INCOME variable exhibits the correct positive sign. The incorrect signs may be a result of a mis-specified model or faulty data due to the small sample size collected during an unusual tourist season (i.e., during the general strike).

For the contingent valuation analysis, the bid amounts and respondents' answers (yes or no) to the bid amounts formed the dichotomous choice variables for estimating a logit function of willingness-to-pay. A number of functional specifications suggested by Bishop, Heberlein and Kealy (1983), Boyle and Bishop (1988), and Hanemann (1984) were tested with the logit analysis. The linear specification, which provided the best fit with the data, is presented in Table 5.3. The values represent the estimated coefficients for each independent variable regressed against the probability that the respondent is willing to pay the specified bid amount for a visit to Mantadia National Park if the respondent sees the same number of lemurs and birds as during his or her trip to the Perinet Reserve.

Despite the small sample, the CVM method produced significant results for estimating the willingness-to-pay of tourists to visit the new national park during their trips to Madagascar. Variables that influence the probability of being willing to pay for visits to the park include the price (bid amount), the national origin of the tourist, type of pay, number of vacation days, and whether or not they subscribe to nature magazines (differential significance between the regressions). The bid amounts (CV1AMT and CV2AMT) are highly significant (at the .01 level) in both regressions. Variables that are significant at the .05 or .10 level include the dummy variables for national origin for French, Germans, and British (FREN, GERM, BRIT), the dummy variable for salaried vs. hourly or self-employed respondents (PAYTYPE), the number of annual vacation days (VACDAYS), and annual household income (INCOME). The difference in significance of the variables between the two regressions, while troublesome at first glance, also provides some interesting researchable hypotheses.

The sign on the CV1AMT and CV2AMT variables is as expected; as the price increases, "yes" responses become less likely. However, the sign on the INCOME variable would be expected to be positive rather than negative, again indicating problems with the small sample size or a mis-specified model (INCOME coefficients were negative in all specifications tried). The coefficient on the INCOME variable, however, is very small (-.000006 and -.000012). Given the relatively high income levels of the respondents (mean income = $59,156), this might be interpreted to mean that income levels had little impact on probability of a "yes" response.

**Table 5.3 Maximum Likelihood Estimates for Tourism Contingent Valuation Analysis**

| *Independent Variable* | *Dependent Variable (Pr(Yes))* | |
|---|---|---|
| | *Same # of Lemurs* | *Twice # of Lemurs* |
| Constant | 1.258<br>(0.961) | -0.19263<br>(-0.178) |
| CV1AMT | -0.0058*<br>(-3.128) | |
| CV2AMT | | -0.0039*<br>(-2.655) |
| BRIT | 1.6154***<br>(1.8564) | 1.9833**<br>(2.026) |
| ITAL | -1.6425<br>(-1.118) | 1.2527<br>(2.026) |
| FREN | -13.643<br>(-0.070) | -1.7917***<br>(-1.795) |
| GERM | 1.5353***<br>(-1.732) | 0.44743<br>(0.041) |
| PAYTYPE | -1.7194***<br>(-1.732) | 0.0292<br>(0.041) |
| MAG | 0.40732<br>(0.531) | 1.462**<br>(2.350) |
| VACDAYS | 0.02980<br>(1.466) | 0.0327***<br>(1.642) |
| INCOME | -0.000006<br>(-0.0889) | -0.000012**<br>(-2.153) |
| McFadden's $R^2$ | 0.352 | 0.443 |

*Significant at the .01 level. **Significant at the .05 level. *** Significant at the .10 level.

CV1AMT=bid amount for same number of lemurs, CV2AMT=bid for twice as many lemurs, BRIT=dummy variable (1=British, 0=other), ITAL=dummy for Italian, FREN=dummy for French, GERM=dummy for German, PAYTYPE=dummy (where 1=salaried 0=other), MAG=dummy for nature magazine subscriber, VACDAYS=number of vacation days/year, INCOME=total household annual pre-tax income.

The significance and signs of the national origin variables are quite interesting. In both regressions, the British and Germans are more likely than the non-British and non-Germans to be willing to pay to visit the new national park in both cases (i.e., whether or not they see more lemurs and birds). However, the GERM variable is not significant in the second regression. The negative signs on the French variables indicate that the French are less likely than other nationalities to be willing to pay to visit the new park no matter how many lemurs and birds they see, whereas the Italians appear to be willing to pay to visit the park only if they see more lemurs and birds. These results fit with expectations following discussions with tour operators and travel agents who indicated differential attitudes toward protected areas and tourism among nationalities.

**Table 5.4 Estimates of International Tourists' Benefits from Establishment of the Mantadia National Park**

| *Method* | *Mean increase in consumer surplus per tourist* | *Total annual increase in consumer surplus* | *Discounted present value (10% discount rate)* |
|---|---|---|---|
| Typical Trip | $45 | $174,720 | $1.7 million |
| RUM | $24 | $93,600 | $936,000 |
| CV | $65 | $253,500 | $2.53 million |

Table 5.4 presents a summary of the benefits estimates for international tourists based on the above econometric models. The first column represents the average increase in consumer surplus per tourist. The second column is an estimate of the annual aggregate benefits of the park for foreign tourists using a conservative assumption that the total number of visitors to the Mantadia National Park will remain the same as the number that visited the Perinet Reserve in 1990.[5] The final column provides the discounted present value of the aggregate annual benefits assuming that they will remain the same in perpetuity (another conservative assumption). It is obvious that the tourism benefits of the park would be substantial, ranging from about $1 million to $2.5 million.

In comparing the estimates in Table 5.4, the Typical Trip and RUM models only measure the willingness-to-pay for the increased quality of local guides, educational materials, and facilities for interpreting natural areas assuming no increased possibility of viewing lemurs or improvements in accommodations. The CV estimate is comparable, although it also assumes some improvements in accommodations, and it may reflect some existence values.

## Discussion

When conservation projects provide increased opportunities for nature tourism activities, nonmarket valuation techniques can provide estimates of potential economic benefits. This study component has demonstrated the utility of recreation demand models and contingent valuation methods for assessing the economic impacts of conservation projects. After developing appropriate conceptual frameworks for analyzing international nature tourism activities, the researchers used surveys to collect needed data from tourists in Madagascar and from tourism operators in the USA and Europe. Despite the limited sample size, the regression results indicate considerable success in explaining variation in trip choices and willingness-to-pay for enhanced tourism opportunities. These models were then used to generate estimates of aggregate tourism benefits associated with creating the Mantadia National Park.

The park valuation estimates were based on expected increases in the quality of nature tourism opportunities in Madagascar. The two recreation demand models generated fairly close estimates of increases in consumer surplus. For both models, it was assumed that the new park would lead to a 10 percent increase in an index of the quality of guides, educational materials, and facilities for interpreting natural areas. The Typical Trip model resulted in an annual benefits estimate of $174,720 for all tourists, while the random utility model generated an estimate of $93,000 annual willingness-to-pay. It may be that Typical Trip models are more appropriate for situations in which recreators are making numerous trips to a variety of sites within a season, for example, Madagascar residents visiting the park. RUM models are probably more appropriate for the choices of international nature tourists for whom there are a limited number of choice occasions. Hence, the valuation estimated based on the RUM model inspires more confidence.

The contingent valuation approach generated estimates of the value of the park under two different scenarios. The estimate most comparable to the RDM estimates is based on a question about willingness-to-pay for the park if tourists were able to see the same number of lemurs and birds as currently viewed in the Perinet Reserve. This estimate aggregated over all tourists is $253,000 annually.

Studies of this type bode well for both ex-ante project evaluation efforts as well as project planning, implementation and management. Although the estimated tourism benefits are only one part of the total value of the new national park, the results show that tourism can be a significant source of benefits when parks are created in a tropical country, even one with a modest level of international visitors. Clearly, the potential nature tourism benefits should be included in any reasonable benefit-cost analysis for project evaluation. Nonmarket studies of this kind, however, may prove even more beneficial in maximizing project revenues and benefits through improved planning and management efforts. Governments may wish to use tourism taxes, user fees, and similar revenues to capture some of this willingness-to-pay in order to finance conservation activities.

## Notes

1. Nature tourism (also known as nature-oriented tourism, natural history tourism, and ecotourism) is defined as "tourism based directly on the use of natural resources in a relatively undeveloped state, including scenery, topography, water features, vegetation, and ecosystems" (Healy 1988, p. 1).

2. See Abala (1987), Brown and Henry (1989), Dixon and Sherman (1990), Durojaiye and Ikpi (1988), Edwards (1991), Eutriak and Grandstaff (1986), and Tobias and Mendelsohn (1991).

3. For additional detail on the survey, see Mercer, Kramer and Sharma (1993).

4. Estimations were performed with the LIMDEP econometric software package (Greene 1992), INTER = index of quality of local guides, educational materials, and facilities for interpreting natural areas; UNUS = index of the possibility of seeing unusual animals; and ACCOM = index of the quality of accommodations and transportation services.

# 6. Spatial Dimensions of Environmental Impacts

*Randall Kramer, Daniel Richter and Subhrendu Pattanayak*

There is mounting concern that increasing rates of deforestation are causing greater flooding on the eastern half of the island of Madagascar where the monsoon rains are particularly severe. This is because forests have a strong impact on the dynamics of floods. This impact involves two processes: regulating the rate at which water moves into streams, and regulating the total water runoff (Richter, Noble and Kramer 1992). It is generally believed that deforestation increases the frequency and severity of floods, yet there is limited empirical work to demonstrate these effects (Courtney 1981). A study in a temperate setting showed that forest soils are several times more permeable to rainfall than are pasture soils and have much lower discharges for 50-year floods (Clark 1987). A larger-scale analysis, which focused on deforestation in the upper Amazon basin, found a significant increase in the annual crest of the Amazon during a period in which extensive deforestation took place (Gentry and Lopez-Parodi 1980).

It is important, however, to distinguish between localized and more regional impacts. After a careful analysis of worldwide evidence from forest watershed research, Hewlett (1982) concludes that there is no cause-effect relationship between forest cutting in the headwaters and floods in the *lower* basin. Flooding may increase close to the area cut, but as water flows through a major river basin, this effect becomes insignificant amid other important ones such as the nature and intensity of precipitation, the direction in which water moves across the basin, and the size and geomorphology of the basin (Hamilton 1988). Yet, if the more *immediate* downstream has a sizable amount of agricultural activity, flooding may result in significant economic losses in terms of diminished crop yields. Anecdotal evidence suggests that the incidence and magnitude of flooding has increased in Madagascar in recent years as deforestation has expanded. Major floods have occurred in 1959, 1972, and 1986, and crop loss is an increasingly regular phenomenon. In addition, research conducted in the Mantadia area shows evidence of increased runoff in watersheds cleared for swidden agriculture. If current rates of deforestation continue, flooding may further increase and cause greater economic losses. This analysis focuses on the local effects of floods.

To the extent that the Mantadia National Park and other aspects of the Environmental Action Plan reduce deforestation, one benefit of these conservation activities will be the prevention of flooding. The purpose of this study component is to estimate the economic benefits of reduced flooding that may arise from the establishment of the Mantadia National Park. This component represents the combination of ecological and economic information to better understand interactions between humans and a rapidly changing environmental system (Kramer, Richter et al. 1995).

## The Productivity Analysis Approach

The productivity analysis proceeds by examining the history of deforestation in the Mantadia area using remote sensing.[1] Data from aerial photos taken in 1957 and satellite images recorded in 1976 and 1984 are combined with topographic information to describe the deforestation history of the area

(Green 1993). These deforestation rates are projected into the future to capture the effect on flooding. The relationship between deforestation and flooding is examined using two different data sets: one based on monitored small watersheds in the Mantadia area, and one based on weather data and flow rates of the Vohitra River. Finally, the predicted reductions in flooding brought about by the creation of the park and buffer zone are used to predict reduced crop losses which are valued in economic terms. All of these predictions are in a "with and without park" framework. In the "without park" case, the flooding damages would have amounted to a sizable economic loss. In the "with park" case, these losses are considerably diminished. Thus any estimation of the benefits of the park creation must include the prevention of loss.

## Deforestation History of the Study Area

Remote sensing was used to construct a deforestation history of the study area (Green 1993). The technique made use of (1) a set of eight 1:50,000 scale topographic maps, and (2) 1:1,000,000 scale negatives of Landsat satellite images. The eight topographic maps encompass an area roughly 88 kilometers (N-S) by 63 kilometers (E-W), a total of approximately 550,000 hectares, which includes the entire watershed of the Vohitra River. Forest cover is depicted on the topographic maps by overlaying information of the 1:50,000 scale aerial photographs acquired in 1957 (based on a photo interpretation). These overlays form the base maps of the forest extent in 1957, upon which subsequent information about the changes in forest cover from the Landsat images of 1976 and 1984 is further overlaid. Thus, this multiple overlaying enables the depiction of the chronological path of deforestation. From these maps it was possible to examine the impact of topography, slope and elevation, in particular, on deforestation in this area.[2]

Elevation within the study area increases from east to west from a low of approximately 100 meters in the southwest, through intermediate elevations (1,000 meters) on the Central Plateau to the Andrabetany Mountains (1,500 meters) in the north. Comparing the deforestation history of the study area with elevation reveals important correlations. In general, progressive destruction of forest cover proceeds from lower to higher elevations and from east to west through time. Deforestation as a percent of original forest lost at a given elevation and for a given slope is shown in tables 6.1 and 6.2, respectively.

Deforestation has proceeded generally from areas of low to high elevation, with deforestation fronts moving faster through terrain of low and moderate slope, becoming stabilized in areas of high relief, most notably along the eastern escarpment of the plateau. While deforestation between 1976 and 1984 virtually eliminated all large tracts of lowland forest in the study area, forests of the plateau had been largely spared up to 1984. Three centers of deforestation pose the greatest threat to the forests of the plateau. Two areas in which active deforestation fronts are moving up the escarpment on moderate slopes are the valleys of the Lakato River in the south and Rianila River in the north. A third active area of deforestation is centered on the town of Andasibe and the road that runs though it., connecting Antananarivo and Toamasina. This latter cutting threatens much of the plateau because no topographic barriers exist to "naturally" slow the rates of clearing in this area.

Deforestation in this region has already isolated the forests of the Special Reserve and the Forestry Station and has penetrated into the southwest and southeast corners of Mantadia Park. Steep slopes within Mantadia will probably limit deforestation in the southwest and along the northwest portions of the park, yet forests that remain on the relatively flat land in the southeast portion of the park may be threatened with clearing. Probably less than 10 percent of Mantadia National Park had been cut by 1984; however, large tracts of forest on moderately flat portions of the plateau are threatened to the west and northwest of Mantadia. Cutting near Andasibe and Lakato may eventually fragment the formerly continuous forest cover to the north and south, thereby limiting future migrations of plants and animals on a large scale, just as species within the Special Reserve and Forestry Stations are now isolated.

Clearing, especially during the period 1976 to 1984, has removed much of the forest cover from the watersheds of the region. Using the values in tables 6.1 and 6.2, it is possible to ascertain that deforestation has proceeded at an annual rate of 2.17 percent for the area at an elevation of 800 to 1,200 meters and a slope of 0 to 12 degrees[3]. Given this rate, in a "without park" scenario, the park and the buffer zone will lose all of their primary forest cover in approximately 45 years (Kramer, Richter et al. 1995).

**Table 6.1 Forest Extent vs. Elevation***

| *Elevation in meters* | *Original* | *1957* | *1976* | *1984* |
|---|---|---|---|---|
| > 1200 | 13375 ha | 12652 ha | 12652 ha | 12636 ha |
| | (100%) | (95%) | (95%) | (95%) |
| | | {100%} | {100%} | {99%} |
| | | | | |
| 800-1200 | 223800 ha | 171900 ha | 166320 ha | 151240 ha |
| | (100%) | (77%) | (74%) | (68%) |
| | | {100%} | {97%} | {88%} |
| | | | | |
| 400-800 | 175280 ha | 90652 ha | 78011 ha | 46906 ha |
| | (100%) | (52%) | (45%) | (27%) |
| | | {100%} | {86%} | {52%} |
| | | | | |
| 100-400 | 126730 ha | 45839 ha | 29389 ha | 3211 ha |
| | (100%) | (3%) | (23%) | (3%) |
| | | {100%} | {64%} | {7%} |
| | | | | |
| Total | 539170 ha | 321040 ha | 286370 ha | 21399 ha |
| | (100%) | (60%) | (53%) | (40%) |
| | | {100%} | {89%} | {67%} |

* Note: Forest extent is depicted in hectares, (percent of original), and {percent of 1957}.

**Table 6.2 Forest Extent vs. Slope***

| *Slope in degrees* | *Original* | *1957* | *1976* | *1984* |
|---|---|---|---|---|
| > 17 | 1150 ha | 834 ha | 819 ha | 694 ha |
| | (100%) | (73%) | (71%) | (60%) |
| | | {100%} | {98%} | {83%} |
| | | | | |
| 12 - 17 | 11950 ha | 7958 ha | 7425 ha | 5577 ha |
| | (100%) | (67%) | (62%) | (47%) |
| | | {100%} | {93%} | {70%} |
| | | | | |
| 8 - 12 | 106900 ha | 65756 ha | 59328 ha | 42900 ha |
| | (100%) | (62%) | (55%) | (40%) |
| | | {100%} | {89%} | {67%} |
| | | | | |
| 4 - 8 | 353580 ha | 215780 ha | 192700 ha | 145190 ha |
| | (100%) | (61%) | (55%) | (41%) |
| | | {100%} | {89%} | {67%} |
| | | | | |
| 0 - 4 | 80800 | 36266 | 31059 | 23284 |
| | (100%) | (45%) | (38%) | (29%) |
| | | {100%} | {86%} | {64%} |
| | | | | |
| Total | 554380 ha | 326590 ha | 291330 ha | 217650 ha |
| | (100%) | (59%) | (53%) | (39%) |
| | | {100%} | {89%} | {67%} |

*** Note: Forest extent is depicted in hectares, (percent of original), and {percent of 1957}.**

## The Effect of Deforestation on Flooding

To determine whether these forest conversions have had a detectable impact on flooding, a review was made of hydrologic experiments conducted on the Perinet Experimental Watersheds, which lie within this river basin. These watersheds are a remarkable research facility from which the scientific results have been prodigious, yet the results are not widely known. Second, long-term discharge data from the Vohitra River were analyzed to examine whether trends indicate increased flooding in recent years.

Since the early 1960s, small watershed studies near Perinet have tested effects of land uses on flooding. Land uses studied include primary forest (foret naturelle), secondary forest (savoka), traditional rice agriculture with burning (tavy), and agriculture with terraces and other conservation practices (cultures). Watershed data are reported by Bailly et al. (1973) and Sarrailh and Rakotomanana (1978) in detailed technical reports. These reports quantify how conversion of primary forest to agricultural uses and secondary forest affects flood dynamics in highland watersheds of eastern Madagascar.

An eight-year experiment at the Perinet Experimental Watersheds suggests that flooding differs considerably between primary and secondary forest. Annual storm flow from a 30-hectare secondary forest savoka watershed was about three-fold more than from a similar-sized primary forest catchment. The increased stream flow from savoka may be attributable to several factors, such as reduced infiltration capacity due to soil compaction, decreased evapotranspiration, and less extensive rooting. The length of time during which a savoka may re-acquire the hydrologic attributes of a primary forest was not reported.

Two agricultural land uses were compared with savoka in their effects on flooding in a nine-year experiment at Perinet. Substantially greater volumes of quick storm flow were produced when savoka watersheds were converted to tavy or to cultures. Year-to-year variation was substantial but, on average, tavy produced about 154 percent more storm flow than savoka forest, whereas the carefully cultivated catchment produced 58 percent more runoff than savoka. Though forest conversion increased rate and volume of runoff over the nine year period for all floods, land use appears to have its greatest effects on small- and medium-sized floods.

In addition to the above studies, the stage of the Vohitra River at Andekaleka has been monitored, generally twice daily, since 1952. A 27-year record of monthly discharge (1953 to 1979) was available to analyze for flood frequency and time-trend analyses, thus providing a second perspective on the problem of hydrologic changes in the area.

The primary objective of these Vohitra data analyses was to determine whether peak discharges have increased in the Vohitra River over nearly three decades. Two time series of river discharge data were used to address this objective: the series of annual maximum monthly discharges (n = 27, 1953-1979), and the complete series of monthly discharges over the same period (n = 285).

It was necessary to remove variation in precipitation from each time series so that trends could be examined that were free of variations in precipitation inputs. Monthly rainfall data for this 27-year period were taken from three stations in or adjacent to the Vohitra River basin: Antananarivo, Andekaleka and Tamatave. An arithmetic mean monthly rainfall was estimated from the three stations for the rainfall-runoff regression model. Log transformed monthly precipitation and monthly discharge were used in two regression analyses to predict discharge from precipitation. Residuals (observed minus predicted discharge) were determined for the two equations and were plotted against time. These residuals data were taken as the time series of river discharges with variation due to rainfall removed. Since residuals tend toward zero throughout the time series, there was no graphical evidence to suggest that flooding of the Vohitra River increased in frequency or severity.

Several important caveats are offered at this point. First, the time series tested ranges from 1952 to 1979. This series could potentially be extended if the complete Vohitra River discharge data could be obtained but, despite several attempts, the authors were not able to obtain data from years more recent than 1979. It seems obvious that a more definitive statement might be made about the Vohitra River basin, but only if detailed daily river data were available for the entire record (1952 to the present). Second, the fact that there is no detectable trend leads to one of two conclusions: either no trend in flooding existed prior to 1979 (i.e., forest conversion of the river basin had not yet affected flooding) or alternatively, no trend is detectable with the monthly data sets used in this analysis.

In summary, flooding generally becomes more frequent and more destructive as a result of converting forests to other uses. This potential is amply demonstrated by the studies of forest clearing at the Perinet Experimental Watersheds. In apparent contrast, analysis of the flooding data from the large Vohitra River basin indicates no increasing trend in storm flow over the period of 1952 to 1979. As stated above, these results do not necessarily indicate that effects of deforestation on flooding have not occurred; rather, they indicate that the monthly discharge data do not show a trend in increasing flood frequency or severity. More than any other conclusion, the analyses indicate that more work is needed. A comprehensive time series analysis of the Vohitra River data should be undertaken using more complete records of discharge and rainfall than were accessible for this study. The results would be of great interest to natural scientists, policy analysts and economists throughout the world.

Even with the partial data, using the results from the experiments in the Perinet Watershed and the rates of deforestation estimated earlier, it is possible to predict a "without park" effect on the annual discharge in the major rivers in the watershed (Kramer, Richter et al. 1995). Moreover, since land use has differential effects on floods of different intensities, it is possible to fit a diminishing function on flooding intensities.

## Estimating the Value of Flood Damages: The Dose-Response Effect

At the time of this writing, rice paddy destruction in the Mantadia area is not extensive according to local experts (Ferraro 1993). Many of the hillsides are still under at least some forest cover and many people are able to harvest most of their rice production before the heavy rains at the end of the rainy season. Further, floods primarily affect the paddy rice, as opposed to tavy, which is on the hillside. Although about 5 percent of the agricultural production is lost due to flooding annually, in years of major storms, which are not very rare, the destruction can be sizable.

Using a simplified productivity analysis, it is possible to use a dose-response effect (dose = flooding; response = damage) to estimate losses due to flooding. In a "with park" scenario, this amount would equal the benefits from averting flooding damages. It is necessary to ascertain several characteristics of floods as parameters that enable estimation of flood damage. These parameters are: area of inundation, depth, duration, seasonality, intensity and frequency (United Nations 1991).

Paddy, the principal crop that grows in the valley bottoms, lies in the area inundated; it can be damaged by submersion and the force of the water overspilling the river banks. The floods happen in the rainy months of February and March, however, by which time most of the paddy is already harvested. This restricts the yield damages. Thus the "area of inundation" and "seasonality" parameters help focus the calculation to a percentage of paddy yields only, as opposed to a much larger basket of all Malagasy agricultural production.

Regional studies and anecdotal evidence provided data on the range and destructive capacity of the two smaller (two- and five-year) floods (Ferraro 1993). The assumption is made that the 100- and 200-year floods will damage all of the paddy in the effective flood plain, an area of 654 hectares. For the floods of the intermediate magnitudes, a logarithmic function was fitted that used the above information. This functional form incorporates the depth, duration and area inundated. The logarithmic nature of the function indicates that the destructive potential of the floods increases, but at a decreasing rate, over a range of increasing flood magnitudes.

To determine the economic value of the effect on human use, calculations used the average annual net return on a hectare of paddy ($453), a discount rate of 10 percent, and an exchange rate of 1,110 Malagasy francs per US dollar. As shown in Table 6.3, the first year total (across floods of all magnitudes) expected loss is $51,691. Over a 20-year life of the project, the aggregated expected loss amounts to $547,176.[4]

**Table 6.3 Net Present Values of Flooding Damage**

| | *Net Present Value of Year 1 Total Expected Loss* | *Aggregate Net Present Value of Total Expected Loss* |
|---|---|---|
| Growth in damage | $51,691 | $547,176 |
| No growth in damage | $50,787 | $475,620 |

The establishment of the protected area is projected to prevent deforestation on 26,787 hectares. The effect of this on flooding incidence, and thereby on crop damage, will be realized through the elimination of the growth in the amount of storm flow, and thereby of the growth in damage potential of the various flood magnitudes. This "with park" scenario does not imply that floods will not happen and there will be no loss to crops; rather, it implies that crop losses will be lower since the floods will not increase in their potential to cause damage. In other words, once the park and the buffer zone are in place, assuming that protection for the forests they encompass is assured, the floods will not grow in intensity and range because land will not be converted from its present primary-secondary forest combination to tavy. Table 6.3 reports the "no growth in damage" scenario (with park), the first year total expected loss, and the aggregate impact. This was essentially a repetition of the previous (without park) calculation with the only difference being the use of a much lower 'dose' (flooding) factor.

Thus, for the "with and without park" comparison, the net present value of the aggregate watershed protection benefits, over the 20-year life of the project, is $71,556. This amount is the simple difference of the aggregate total expected loss associated with the "with and without growth in damage" (equivalent to the "without and with park") scenarios.

## Discussion

The Vohitra River is part of a much larger river basin that flows easterly to the Indian Ocean. As the topography flattens to the east, there is more irrigated area. This area can also be affected by upstream watershed degradation, which can cause increased sedimentation. A recent report on irrigation investments in Madagascar considered the effects of watershed degradation on downstream irrigation systems (Metzel and Baird 1990). However, the area protected by the Mantadia National Park and associated buffer zone is such a small part of the larger watershed that the downstream benefits are likely to be quite small.

Because of the interest in measuring the benefits of the park, only crop losses from changed flooding in the vicinity of the park and buffer zone are analyzed. As evidenced in Table 6.3, these impacts are modest, but this analysis may underestimate the total watershed protection benefits of the project. It is important to note that the benefits and costs of watershed protection are not borne by the same individuals. While reduced flooding benefits farmers who grow paddy rice in river bottoms immediately downstream, the costs of establishing the park are borne by residents living around the park who formerly used the area for collecting forest products and practicing swidden agriculture.

To apply the productivity analysis, a variety of scientific concepts have been used, including tools from remote sensing, hydrology, forestry, agronomy and economics. A large amount of secondary data were compiled and reanalyzed by the study participants to shed light on the necessary physical, biological and economic interrelations. This has represented a rather uncommon integrated analysis, and illustrates the range of data and skills necessary to apply productivity analysis to examine the watershed protection benefits of tropical forests.

Notwithstanding the data limitations, it can be argued that this study component has resulted in a reasonable estimate of watershed protection benefits. It is recommended that future research projects be designed to shed further light on these complex and important interrelationships, and on the human-ecosystem interface. Productivity analysis is suggested as the best analytical tool to employ in such research. Furthermore, this study illustrates the need for building national capacity to establish geographic information systems and carry out long-term hydrologic assessments. Such data bases are necessary to understand the dynamics of ecological systems that are subject to major human pressures.

## Notes

1. Productivity analysis has been widely used in economics to value the effects of various types of environmental change on agriculture, forests, and fisheries (Freeman 1993).

2. See Greene (1993) for details.

3. The deforestation rate (d) is defined as the mean annual percentage loss in forest cover.

4. Other components of this study assume a 20-year life for the project. Thus, for an estimation of the flood prevention benefits under the "with park" scenario, only the first 20 years of the expected life of the forest area are taken into account.

# 7. Existence Values

*Randall Kramer, Evan Mercer and Narendra Sharma*

Evidence for substantial public support for biodiversity protection can be seen in public opinion polls and voluntary contributions to conservation organizations. Another means to gauge this support is the use of the contingent valuation method. This section summarizes another study component that uses contingent valuation in a national mail survey to assess the value that residents of the United States place on rain forest protection (Kramer, Mercer and Sharma 1993). The purpose of the survey was: (1) to measure the willingness-to-pay of residents of the United States for preserving a portion of the world's tropical forests, and (2) to determine the attitudes toward issues concerning tropical rain forest preservation and management (such as compensation). Of course, as many of the benefits of biodiversity protection occur in other countries, especially in Europe, this survey provides a pilot study to explore whether or not the CVM is workable for valuing a global good of this type.

## Approach

This empirical effort to measure the existence value of rain forest protection is based on welfare concepts of environmental economics. It is assumed in the study that households maximize utility subject to an income constraint by choosing a bundle of market and nonmarket goods. If one of the nonmarket goods is a public good called rain forest protection, then willingness-to-pay will be a function of the price of rain forest protection, prices of other goods, income, and household tastes. The hypothesis is that these tastes will be conditioned by a variety of socioeconomic characteristics, including household size and age distribution, education, political party affiliation, and environmental attitudes.

A survey respondent should be willing to pay the requested donation of $W for the protection of tropical rain forests if his or her level of utility with protection and lower income (Y-W) is at least as great as his or her utility without protection. That is, when

$$U(0,Y;A) \leq U(1,Y-W;A)$$

where 0 = no additional rain forest protection
1 = additional rain forest protection
Y = income
A = a vector of attributes that may affect the WTP for rain forest protection.

Since the underlying utility function, U(•), is unknown to the researcher,[1] it is viewed as a random variable with a given parametric probability distribution and an observable mean value. Assuming a logistic cumulative probability density function for the random variable, the probability that the respondent's willingness-to-pay is greater or less than the offered bid amount can be estimated with a logit regression model.

## Data Collection and Analysis

The empirical CVM model used in this study component is based on two different approaches. Given the lack of consensus in the literature about the question format for CV questions (Mitchell and Carson 1989), an experiment was conducted. The sample was randomly divided into two groups for experimental treatment. Half of the sample was presented with a referendum style question. The application of referendum CVM questions requires a discrete number of subsamples. Each subsample is asked whether or not they would be willing to pay a specified amount for the particular nonmarket good and they respond either "yes" or "no." The probability that an individual's willingness-to-pay is greater or less than the offered bid amount is estimated with a logit regression model. The logit model creates a function that depicts the probability that WTP values will exceed offered bid amounts. The total WTP is then estimated as the area under the probability function.[2] By including other explanatory variables in addition to the offered bid in the logit model, one determines how income and other explanatory variables influence the demand for rain forest protection.

The other half of the sample was presented with a "payment card" question format (Mitchell and Carson 1989). With this approach, each respondent is presented with an array of different dollar amounts starting with zero and asked to circle the amount closest to their WTP. One way to calculate mean WTP from payment card responses is to take a simple average of the circled amounts. A censored regression model (Cameron and Huppert 1989) is used from which a mean predicted WTP can be calculated. As with the logit analysis of the referendum responses, explanatory variables can be included to identify demand shifters. Willingness-to-pay estimates based on each approach will be presented subsequently.

For this study, three focus groups were conducted. One group was recruited from the staff (nonfaculty) of a university; the other two groups were recruited from among members of church groups. The focus groups were used in part to refine the amount and type of information about tropical rain forests presented in the survey. Exercises were also conducted to define the good to be valued. Most focus group members were comfortable valuing tropical rain forests in general, but not for specific regional or country subcomponents. Thus, without specifying countries or regions, the final good was the creation of parks and reserves to protect 110 million acres (or 5 percent) of the remaining rain forests (in addition to the 5 percent already preserved). The other major use of the focus groups was the testing of alternative payment vehicles, i.e., higher taxes, higher prices, and donations to nonprofit organizations. After extensive discussions with the focus group participants and contingent valuation experts, contribution to a hypothetical United Nations Save the Rain Forests Fund was defined as the payment vehicle. A pretest was employed with a national mail sample of 100 households.

The final version of the survey was mailed to a random sample of 1,200 US residents between April and June 1992.[3] A mailing list was purchased from a commercial marketing firm. The sampling frame was all households with listed telephone numbers. After several follow-up mailings, 542 surveys were returned, for a corrected response rate of 56 percent. The design and implementation of the survey followed the Total Design Method developed by sociologist D. Dillman (1978), including the use of three follow-up mailings.

## Results

Tropical deforestation was a well-known issue among the respondents: 91 percent of the respondents responded affirmatively to the question "Before today, have you ever read, heard, or seen TV shows about tropical rain forests?" and 81 percent claimed to be familiar with reasons for deforestation (see Table 7.1). Two-thirds of the sample answered yes to the question "Should industrialized countries help developing countries pay for preserving their rain forests?" This has important ramifications for the ongoing political debate about the role of industrialized countries in bearing some of the costs of environmental protection in less developed countries. A follow-up question asked what percentage of the costs would be borne by the industrialized world. The median response was 41 percent.

**Table 7.1 Percentage of Respondents Answering "Yes" and "No"" to Questions about Knowledge of, Visits to, and Obligations to Pay for Rain Forests**

| | *YES* | *NO* |
|---|---|---|
| Any knowledge of rain forests | 91% | 9% |
| Knowledge of causes of deforestation | 81% | 19% |
| Previously visited a rain forest | 11% | 89% |
| Plan to visit a rain forest | 8% | 61%[a] |
| Should industrial countries help developing countries pay for preserving their rain forests | 67%[b] | 33% |

[a] 31 percent were uncertain if they would visit a rain forest in the future
[b] For those responding "Yes," the percentage that industrialized countries should pay ranged from 1 to 100 percent, with a median of 41 percent.

The respondents were encouraged to weigh tropical deforestation against other environmental concerns by asking them to rank a variety of environmental problems. The rankings assigned were 1 through 6 with 1 indicating the greatest importance. Highest rankings were given to air (2.63) and water pollution (2.73). This is not surprising since the local effects of these problems are more pronounced than other problems presented, and there may be a perceived greater link with the health of respondents and their families. Next in average order of importance were two international environmental problems that have received extensive media attention: atmospheric ozone depletion (3.47) and global warming (3.65). Considerably lower rankings were given to the other problems on the survey list: tropical deforestation (4.52), acid rain (4.60), and harvesting old-growth forests in the northwestern United States (5.37). It is interesting that deforestation in the tropics was viewed as a more serious problem than deforestation in the US Pacific Northwest.

To examine factors affecting willingness-to-pay for rain forest protection, the CV responses were regressed against a number of socioeconomic and attitudinal variables. Results are given in Table 7.2 for both subsamples. The first column indicates the effects of the variables on the dollar amount selected by the payment card respondents. The second column shows the effects of the independent variables on the probability of saying yes to the offered bid by the referendum format respondents. Although the coefficients have different interpretations for the two different question formats, the results will be discussed jointly in terms of the direction of influence of the independent variables on WTP.

Because of the inherent nature of the question formats, only the referendum model has a variable for the offered bid. The log of the offered bid has a negative and significant effect on the likelihood of bid acceptance. Hence, there is confirmation of the expected negative relationship between price and quantity of rain forest protection. Income has the expected positive effect on the WTP in both models. As incomes rise, there is a shift in the demand for this environmental good. Political affiliation has no significant effect in the payment card model, but in the referendum model Republican affiliation has a negative association (at the 10 percent significance level) with accepting offered bids. A dummy variable for whether or not respondents made charitable contributions has a significant and positive coefficient in both models. A dummy variable which reflects past or planned visits to rain forests increases the WTP in the referendum model.

The ranking given deforestation compared to other environmental problems was also included as an independent variable. As expected, the more important the ranking (1 = most important), the higher the WTP in the payment card model (at the 10 percent significance level). Surprisingly, the importance given to the cutting of old-growth forests in the northwest United States had the opposite effect in the referendum model. One possible explanation is that people who are concerned about old-growth US forests may have more of a national focus and be less concerned about tropical forests, thus having a lower propensity to pay for protection in the tropics. Respondents who said that industrialized countries should help pay for rain forest protection had higher WTP in the payment card model and were more likely to accept offered bids in the other model. Finally, family size had a positive relationship with WTP in the payment card model, perhaps indicating a bequest or intergenerational equity motive.

Estimated willingness-to-pay is shown in Table 7.3. The referendum format yields a mean WTP per household of $24, while the payment card format gives a mean WTP of $31 per household. Aggregating over the 91 million households in the United States gives a total WTP of $2.18 billion and $2.82 billion for the two methods. While this total figure appears quite large, it should be viewed in context. Recall that the CV question asked for a one-time contribution. Hence, the $2.2 billion to $2.8 billion can be thought of as a revolving fund that would be used over a number of years to finance tropical forest programs. If one makes a more conservative assumption that only households with at least $35,000 in annual income would actually donate to the fund, then the aggregate WTP would be $1 billion.

**Table 7.2 Maximum Likelihood Estimates for Rain Forest Contingent Valuation Analysis**

| | *Payment Card Responses*[a] | *Referendum Responses*[b] |
|---|---|---|
| Constant | -3.522 (-1.747)[d] | -15.914 (-2.641)[c] |
| Log of Bid | --- | -1.165 (0.229)[c] |
| Log of Income | 0.379 (1.904)[c] | 1.426 (2.516)[c] |
| Political Affiliation dummy | 0.231 (0.769) | -1.190 (-1.857)[d] |
| Charitable Contributions dummy | 1.04 (3.045)[c] | 2.194 (2.059)[c] |
| Rain Forest Visitor | 0.711 (1.943)[c] | -0.942 (-1.182) |
| Deforestation | -0.151 (-1.817)[d] | -0.230 (-1.015) |
| Old-growth Forests | -0.047 (-0.613) | 0.377 (1.954)[c] |
| Cost-sharing dummy | 1.921 (5.883)[c] | 1.947 (2.464)[c] |
| Family Size | 0.190 (2.088)[c] | -0.018 (-0.083) |
| Number of observations | 173 | 163 |
| Goodness of fit | --- | McFadden $R^2$ = .48<br>Correct Pred. = 89% |

[a] Dependent variable is the log of the amount (ranging from 0 to $1500) which was circled.
[b] Dependent variable is the yes/no response to the offered bid level.
[c] Significant at 5 percent level.
[d] Significant at 10 percent level.

**Table 7.3 Willingness-to-Pay Estimates for Tropical Rain Forest Preservation**

| *Type of Question Format* | *Mean WTP ($/household)* | *Total WTP (all households)*[a] | *Total WTP (income > $35,000)*[a,b] |
|---|---|---|---|
| Referendum | $24 | $2,184,000,000 | $ 780,000,000 |
| Payment Card | $31 | $2,821,000,000 | $1,007,000,000 |

[a] Assuming 91,000,000 million households in the United States in 1989 (US Bureau of Census)
[b] Income distribution in 1989 (US Bureau of Census)

## Discussion

This study component represents one of the few applications to date of nonmarket valuation methods to a global environmental good. Most previous applications of contingent valuation have focused on local or regional environmental goods. The results suggest that US residents are able to respond to valuation questions about the value of tropical rain forest protection and to give consistent responses across two different CV formats.

Perhaps the most interesting policy finding is that two-thirds of the households said that industrial countries should share the costs of protecting the remaining rain forests. The Biodiversity Convention signed by most countries attending the Rio Conference was based in part on a principle of shared costs between beneficiaries in industrial and less developed countries. Results of this study suggest that the US public supports this international financing approach.

For the study sample, tropical deforestation ranked below most other environmental problems, perhaps reflecting a higher priority for domestic environmental issues. Despite this low relative ranking, households are willing to contribute $24 to 31 on average. This could create a substantial global fund if households in other industrial countries are willing to make similar-sized donations.

## Notes

1. The underlying utility function is unknown because many of its components are unobservable.

2. There are a number of different approaches in the literature for empirically estimating WTP for referendum CV questions. In the estimation procedures, this study component takes the approach of assuming that WTP is a non-negative random variable. See Cooper and Loomis (1992) for a defense of this approach.

3. The cover letter, follow-up letters and survey instrument are found in Kramer, Mercer, and Sharma (1993).

# *PART C: CONCLUSIONS*

# 8. Summary and Implications

*Narendra Sharma, Randall Kramer and Mohan Munasinghe*

## Summary

Forests in many areas of the world are vanishing at a rapid rate. In the last several decades, the intensity and scale of forest exploitation have increased significantly. A large number of developing countries experiencing increasing deforestation are also facing acute shortages of fuelwood, fodder, industrial timber, and other forest products for domestic use. Aside from the potential environmental degradation, depletion of forests and trees may exacerbate poverty, displace indigenous populations, and impede agricultural productivity. Deforestation, especially in the humid tropics, has serious regional and global implications (potential climate change, loss of biodiversity, and degradation of large watersheds).

The improved management of forest resources is the subject of considerable attention from local, national, and international organization and agencies. In both developed and developing countries, the amount of forest land set aside as parks and forests is growing, yet economic analysis of these management decisions is rarely conducted, either before or after the fact. Without such analysis, it is difficult to determine whether proposed changes in forest use are economically justified.

To help guide decision making on the variety of options available to improve management of the world's forests, improved valuation is needed. Accurate valuation of forest resources is essential to the appraisal of both forestry and nonforestry projects affecting forests. This study has examined the use of a number of different nonmarket valuation techniques.

In the village component, a paired comparison of the use of opportunity cost analysis and the contingent valuation method found $100 annual costs to village households resulting from foregone access to land set aside for the park. The opportunity cost approach was a relatively simple, but data intensive, form of analysis with practical applications for conceptualizing development programs and for involving people in the management of programs. It is also a powerful tool in understanding the interrelationship among microeconomic factors relating to use and management of parks. The contingent valuation method required the collection of less village data but was challenging to implement because of the need to carefully refine the method for use in village settings where there was little formal education and few cash transactions. The results were encouraging for the use of CVM in such settings.

The tourism component developed an approach to valuing parks for international nature tourists. Both the recreation demand method and the contingent valuation method were used to estimate the benefits of the new park for these visitors. There were some differences in estimates for the two methods ($24 vs. $65 per trip), but the disparity may be due to the possible influence of nonuse values on the higher estimates of the CVM approach. Nevertheless, both methods appeared to be quite workable for valuing recreational demand for national parks in the developing world. One practical application of the results would be the setting of user fees.

The deforestation-flooding component illustrated the complexities of combining several disciplinary approaches to implement the productivity method for valuing environmental changes. A remote-sensing expert conducted extensive analysis of maps and satellite images to estimate deforestation rates in the study area. A hydrologist/soil scientist analyzed data on small watershed runoff and river basin flow rates to provide input on the effects of deforestation on flooding in the Mantadia area. Finally, the information about flooding was combined with agronomic information on crop yields and flooding to estimate the agricultural impacts of additional deforestation in the absence of the park. This interdisciplinary effort provided a useful illustration of the application of productivity analysis, but it could have been expanded into an extensive research project of its own. Although, due to data constraints, a certain degree of subjectivity exists in the estimation of the effect of deforestation on discharge and agronomic damages, the estimates of the economic impacts of flooding are believed to be conservative.

The first three components of the study focused on use values associated with a protected tropical forest. Given the strong interest in tropical forestry issues among environmental groups and politicians in industrialized countries, it is widely thought that nonuse values must be important motivators of current concerns. Yet, little empirical work has examined the importance of nonuse values associated with tropical forest conservation. The fourth component of the study analyzed such economic values for a sample of U.S. residents. This study was one of the first applications of CVM to a global environmental good. The results suggested that the CVM can be used in such a context if care is taken to provide balanced and detailed information to respondents about the transboundary effects of protecting tropical forests. Respondents indicated a strong demand for rain forest protection, although a significant minority were not willing to "purchase" this good.

## Policy Implications

This study has examined the economic impacts of a new national park on a variety of stakeholders. The work suggests that, with proper tailoring to local conditions, environmental valuation methodologies can be useful in assessing resource value changes in developing countries. Other researchers are encouraged to engage in valuation studies to improve the information base for designing new environmental policies and projects.

The results from such valuation efforts can be incorporated more fully into benefit-cost analysis of projects, including conservation components, to determine the project's economic viability. Further research of this type has implications for policies, investment decisions, resource mobilization, and project design and management. Such information can help governments decide how to (1) allocate scarce capital resources among competing land use activities, and (2) choose and implement investments for natural resource conservation and development. Results can also be used in determining, or influencing, pricing, land use, and incentive policies. At the local level, the findings can be used to determine appropriate compensation for local villagers for foregone access to forest areas designated as national parks. In addition, the research findings can show the value of a park as a global environmental asset to foreigners, thus influencing external assistance for conservation programs at the local level.

At the same time, the findings indicate future issues that need further exploration. Reliance on willingness-to-pay is fundamental to the economic approach to valuation, but tends to highlight the value ascribed to richer foreign visitors (because ability to pay is also a key element). If conflicting claims to park access were to be determined purely on this basis, Malagasies (especially the poor local villagers) are likely to be excluded. Therefore, other aspects of sustainable development (especially social elements like distributional equity) would need to be considered to protect the basic rights and needs of local residents.

This study has shown the potential of several valuation methods for improving the economic analysis of projects. While a study of this scope is impractical for every environmental or natural resource project, a carefully planned research program conducted on a variety of project types in a variety of geographical and socioeconomic settings would begin to establish a database of values that could be used for benefits transfer to other projects. Development institutions like the World Bank can play an important role in refining sound and practical valuation techniques for the environmental benefits and costs of forestry and other environmental projects. The Bank could even become a leading center in the development and application of resource valuation techniques, much as it has been for benefit-cost analysis. Much of the development of valuation to date has been done by economists from developed countries and most of the applications have been in developed, temperate climate settings. A multiyear program of Bank involvement in research and application would rapidly increase the use of environmental valuation in developing countries. The Bank could also play an important role in training development economists in resource valuation, spreading technologies and ensuring their wider application.

# References


Abala, D. O. 1987. A theoretical and empirical investigation of the willingness to pay for recreational services: A case study of Nairobi National Park. *Eastern Africa Economic Review* 3:111-119.

Andriamampianina, J. 1985. Traditional land use and nature conservation in Madagascar. In *Culture and Conservation: the Human Dimension in Environmental Planning*, ed. J. McNeely and D. Pitt. London: Croom Helm.

Aylward, B. A., and E. B. Barbier. 1993. The economic value of species information and its role in biodiversity conservation. In *The Economic Value of Species Information and Its Role in Biodiversity Conservation: Case Studies of Costa Rica's National Biodiversity Institute and Pharmaceutical Prospecting*, ed. B. A. Aylward et al. A Report to the Swedish International Development Authority Prepared by the London Environmental Economics Centre and the Tropical Science Center in Collaboration with the National Biodiversity Institute of Costa Rica.

Bailly, C., G. Genoit de Coignac, C. Malvos, J. M. Ningre and J. M. Sarrailh. 1973. Estude de l'influence du couvert naturel et de ses modifications: experimentation en bassins versants elementaires realisees a Madagascar. 1 ere Partie. Tananarivo, Republique Malgache: Centre Technique Forestier Tropical, Ministere du Developpement Rural.

Becker, G. S. 1974. A theory of social interactions. *Journal of Political Economy* 82:1063-93.

Bishop, R. C., T. A. Heberlein and M. J. Kealy. 1983. Contingent valuation of environmental assets: Comparisons with a simulated market. *Natural Resources Journal* 23:619-633.

Botkin, D. B., and L. M. Talbot. 1992. Biological diversity and forests. In *Managing the World's Forests: Looking For Balance Between Conservation and Development*, ed. Narendra P. Sharma. Dubuque, IA: Kendall/Hunt Publishing Company.

Boyle, K. J., and R. C. Bishop. 1988. Welfare measurements using contingent valuation: A comparison of techniques. *American Journal of Agricultural Economics* 70:20-28.

Brown, G., and W. Henry. 1989. The economic value of elephants. Paper No. 89-12. London: London Environmental Economics Centre.

Cameron, T. A., and D. D. Huppert. 1989. OLS versus ML estimation of non-market resource values with payment card interval data. *Journal of Environmental Economics and Management* 17:230-246.

Clark, C. 1987. Deforestation and floods. *Environmental Conservation* 14(1): 67-69.

Cooper, J., and J. Loomis. 1992. Sensitivity in contingent valuation models. *Land Economics* 68(2):211-224.

Costanza, R., ed. 1991. *Ecological economics: The Science and Management of Sustainability*, New York: Columbia University Press.

Courtney, F. M. 1981. Developments in forest hydrology. *Progress in Geography* 5(2):217-241.

Dillman, D. A. 1978. *Mail and Telephone Surveys: The Total Design Method.* New York: John Wiley and Sons, Inc.

Dixon, J. A., and P. B. Sherman. 1990. *Economics of Protected Areas: A New Look at Benefits and Costs*. Washington, DC: Island Press.

Durojaiye, B. O., and A. E. Ikpi. 1988. The monetary value of recreational facilities in a developing economy: A case study of three centers in Nigeria. *Natural Resources Journal* 28:315-328.

Edwards, S. F. 1991. The demand for Galapagos vacations: Estimation and application to wilderness preservation. *Coastal Management* 19:155-199.

Eutrirak, S., and S. Grandstaff. 1986. Evaluation of Lumpinee Public Park in Bangkok, Thailand. In *Economic Valuation Techniques for the Environment*, ed. J. A. Dixon and M. M. Hufschmidt. Baltimore: Johns Hopkins University Press.

Feenberg, D., and E. S. Mills. 1980. *Measuring the Benefits of Water Pollution Abatement*. New York: Academic Press.

Federal Republic of Germany. 1991. *Tropical Forest Report*. Bonn: Press and Information Office of the Federal Government.

Ferraro, Paul. 1993. Personal communication, Ranomafana National Park Project, Madagascar.

Folke, C., and A-M Jansson. 1992. *The Emergence of an Ecological Economics Paradigm: Examples from Fisheries and Agriculture.* Beijer Reprint Series No. 9. Stockholm: Beijer International Institute of Ecological Economics.

Freeman, A. Myrick. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, DC: Resources for the Future.

Gentry, A. H., and J. Lopez-Parodi. 1980. Deforestation and increased flooding of the Upper Amazon. *Science* 210:1354-1356.

Gittinger, I. P. 1982. *Economic Analysis of Agricultural Projects*. Baltimore: Johns Hopkins University Press.

Gray, A. 1991. The impact of biodiversity conservation on indigenous peoples. In *Biodiversity: Social and Ecological Perspectives*, ed. V. Shiva. London: Zed Books.

Green, G. M. 1993. Remotely sensed determination of deforestation history and topographic controls: Manatady National Park and surroundings. Durham, NC: Center for Resource and Environmental Policy Research, Duke University.

Greene, W. H. 1992. LIMDEP Users Manual Version 6.0. Bellport, NY: Econometric Software, Inc.

Gronau, R. 1977. Leisure, home production and work: the theory of the allocation of time re-visited. *Journal of Political Economy* 85:1099-1124.

Hamilton, L. S. 1988. Forestry and watershed management. In *Deforestation: Social Dynamics in Watersheds and Mountain Ecosystems*, ed. J. Ives and D. C. Pitt. London: IUCN, Routledge.

Haneman, W. M. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. *American Journal of Agricultural Economics* 66:322-341.

Hanna, S., and M. Munasinghe, eds. 1995a. *Property Rights and the Environment: Social and Ecological Context*. Stockholm and Washington, DC: Beijer Institute of Ecological Economics and The World Bank.

Hanna, S., and M. Munasinghe, eds. 1995b. *Property Rights in Social and Ecological Context: Case Studies and Design Applications*. Stockholm and Washington, DC: Beijer Institute of Ecological Economics and The World Bank.

Harcout, C., and J. Thornback. 1990. *Lemurs of Madagascar and the Comoros*. The IUCN Red Book. Gland, Switzerland: IUCN.

Healy, R. G. 1988. Economic considerations in nature-oriented tourism: The case of tropical forest tourism. Forestry Private Enterprise Initiative Working Paper No. 39. Research Triangle Park, NC: Southeastern Center of Forest Economics Research.

Hewlett, J. D. 1982. Forests and floods in the light of recent investigation. Proceedings of Canadian Hydrological Symposium, June 14-15, pp. 543-560, Frederiction.

Jenkins, M. D. 1987. *Madagascar: An Environmental Profile*. Gland, Switzerland: IUCN.

Kemf, E. 1993. In search of a home: People living in or near protected areas. In *Protecting Indigenous Peoples in Protected Areas: The Law of the Mother*, ed. E. Kemf. San Francisco: Sierra Club Books.

Knetsch, J. L., and J. A. Sinden. 1984. Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. *Quarterly Journal of Economics* 99(3):507-521.

Kramer, R. A., R. Healy, and R. Mendelsohn. 1992. Forest valuation. In *Managing the World's Forests*, ed. N. Sharma. World Bank Natural Resources Development Series. Arlington, VA: Kendall Hunt.

Kramer, R. A., N. Sharma, P. Shyamsundar, and M. Munasinghe. 1994. Cost and compensation issues in protecting tropical rainforests: Case study in Madagascar. Environment Department Working Paper No. 62. Washington, DC: World Bank.

Kramer, R. A., D. Richter, N. Sharma and , S. Pattanayak. 1995. Ecological and economic analysis of watershed protection in eastern Madagascar. Durham, NC: School of the Environment, Duke University.

Kramer, R. A., E. Mercer and N. Sharma. 1993. Valuing tropical rain forest protection as a global environmental good. Durham, NC: Center for Resource and Environmental Policy Research, Duke University.

Laarman, J. G., and P. B. Durst. 1987. Nature travel in the tropics: Is this growing enterprise a trend in wildlands management? *Journal of Forestry* 85:43-46.

London Environmental Economics Centre. 1992. The economic linkages between the international trade in tropical timber and the sustainable management of tropical forests. Main report to the International Tropical Timber Organization. London: International Institute for Environment and Development.

Martin, C. 1993. Introduction. In *Protecting Indigenous Peoples in Protect Areas: The Law of the Mother*, ed. Elizabeth Kempf. San Francisco: Sierra Books.

Mercer, E., R. A. Kramer and N. Sharma. 1993. Estimating the nature tourism benefits of establishing the Mantadia National Park in Madagascar. Durham, NC: Center for Resource and Environmental Policy Research, Duke University.

Mercer, D. E., and R. A. Kramer. 1992. An international nature tourism travel cost model: Estimating the recreational use value of a proposed national park in Madagascar. Paper presented at Allied Social Science Associations Annual Meeting, January 5, New Orleans.

Metzel, J., and K. Baird. 1990. Assessment of environmental issues relating to irrigation investments in Madagascar. Cambridge, MA: Associates for International Resources and Development.

Ministere de la Production de l'Agriculture et Systeme des Statistiques Agricoles (MPASSA). 1987. Etude methodologique de determination des couts de production (le cas de paddy). Projet Recensement National de l'Agriculture et Systeme Permanent des Statistiques Agricoles. Madagascar.

Mitchell, R. C., and R. T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington, DC: Resources for the Future.

Munasinghe, M. 1992. Biodiversity protection policy: Environmental valuation and distribution issues. *Ambio* 21(3):227-236.

Munasinghe, M. 1993a. *Environmental Economics and Sustainable Development.* Environment Paper No. 3. Washington, DC: World Bank.

Munasinghe, M. 1993b. Environmental economics and biodiversity management in developing countries. *Ambio* 22(2-3):126-135.

Munasinghe, M., and J. A. McNeely, eds. 1994. *Protected Area Economics and Policy.* Washington, DC: World Bank.

Munasinghe, M., and W. Shearer, eds. 1995. *Defining and Measuring Sustainability: The Biogeophysical Foundations.* Tokyo and Washington, DC: United Nations University and The World Bank.

Odum, H. T. 1973. Energy, ecology, and economics. *Ambio* 2:220-227.

Odum, E. P. 1975. *Ecology: The Link Between the Natural and Social Sciences.* 2nd ed. New York: Holt-Saunders.

Rowe, R., N. Sharma and J. Browder. 1992. Deforestation: Problems, causes, and concerns. In *Managing the World's Forests: Looking for Balance Between Conservation and Development,* ed. N. P. Sharma. Dubuque, IA: Kendall/Hunt Publishing Company.

Sarrailh, J. M., and J. L. Rakotomanana. 1978. Bassins versants de perinet: Resultats et interpretation de douze annes d'estudes. Report No. 431. Antananarivo: FOFIFA - Departement de recherches forestieres et piscicoles.

Schucking, H., and P. Anderson. 1991. Voices unheard and unheeded. In *Biodiversity: Social and Ecological Perspectives,* ed. V. Shiva. London: Zed Books.

Sharma, N., et al. 1992. World forests in perspective. In *Managing the World's Forests: Looking for Balance Between Conservation and Development,* ed. N. P. Sharma. Dubuque, IA: Kendall/Hunt Publishing Company.

Shyamsundar, P. 1993. Economic implications of tropical rain forest protection for local residents: The case of the Mantadia National Park in Madagascar. Ph.D. dissertation. Durham, NC: School of the Environment, Duke University.

Singh, I., L. Squire and J. Strauss. 1986. *Agricultural Household Models: Extensions, Applications and Policy.* Baltimore: John Hopkins University Press.

Smith, V. K. 1990. Can we measure the economic values of environmental amenities? *Southern Economic Journal* 56(4):19-32.

Tobias, D., and Mendelsohn, R. 1991. Valuing ecotourism in tropical rain forest reserve. *Ambio* 20:91-93.

United Nations. 1991. Mitigating natural disasters: Phenomena, effects and options. A manual for policy makers and planners. New York.

United Nations - FAO. 1992. The Forest Resources of the Tropical Zone by Main Ecological Regions. Forest Resources Assessment 1990 Project. Rome.

Vanclay, J. K. 1993. Saving the tropical forest: Needs and prognosis. *Ambio* 22(4):225-231.

Varian, H. R. 1984. *Microeconomic Analysis.* 2nd ed. New York: W. W. Norton and Company, Inc.

Whittington; D., J. Briscoe, X. Mu, and W. Barron. 1990. Estimating the willingness to pay for water services in developing countries: A case study of the use of contingent valuation surveys in southern Haiti. *Economic Development and Cultural Change* 38(2):293-311.

World Bank. 1988. Forests management and protection project - Staff appraisal report. Democratic Republic of Madagascar. Report No. 6994-MAG. Washington, DC: World Bank.

World Bank. 1990. Democratic Republic of Madagascar environment program - Staff appraisal report. Washington, DC: World Bank.

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