

**The Local Costs of Establishing Protected Areas in  
Low-Income Nations:  
Ranomafana National Park, Madagascar**

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**The Local Costs of Establishing a Protected Area:  
Ranomafana National Park, Madagascar**

**Abstract**

Over the last twenty years, governments and influential donor organizations have come to realize that the long-term integrity of protected areas in low-income nations depends critically upon the support of rural communities that live adjacent to them. Despite the recognized need for understanding the opportunity costs of conservation borne by rural communities adjacent to protected areas, there exist few quantitative analyses of the local effects of protected area establishment. Using a unique household data set from southeastern Madagascar, I estimate the opportunity costs borne by residents resulting from the establishment of the Ranomafana National Park in 1991.

I conservatively estimate the present value of the opportunity costs to be \$3.37 million. The costs are not distributed evenly across households around the park. The average present value of costs per household in four zones around the park ranges from \$353 to \$1,316. These values translate into annual costs per average household of \$19 to \$70 over a sixty-year horizon. The paper also characterizes other costs that were not amenable to empirical estimation. Relative to household incomes in the region, the opportunity costs of conservation are substantial. Relative to the national and global benefits from protecting the rain forests of Ranomafana, however, the costs are quite small and the analysis offers hope that government agencies and international donors can design conservation plans that benefit both endangered ecosystems and the welfare of local communities.

**Key Words:** Conservation; Opportunity Costs; Protected Area

## I. Introduction

In the 1980s, governments and influential donor organizations came to realize that the long-term integrity of protected areas in low-income nations depended critically upon the support of rural communities that lived adjacent to them (Anderson and Grove, 1987; Kiss, 1990; West and Brechin, 1991; Brandon and Wells, 1992; Ryan, 1992). Field observations from conservation projects throughout the developing world suggested that the establishment and management of protected areas had substantial negative effects on the livelihoods of residents who lived in and around protected areas and thus undermined local support for conservation (e.g., West and Brechin, 1991; Hough, 1991; Kiss, 1990; Anderson and Grove, 1987; Sahama, 1984).

Many academics and practitioners have therefore argued that detailed *ex ante* assessments of the local impacts of protected area establishment are a critical missing component in the debate over international conservation policies (Garrat, 1984; Dixon and Sherman, 1990; Ghimire, 1991; Hough, 1991; Winterbottom 1991; Brown and Wyckoff-Baird, 1992; Geisler, 1993). Without such assessments, it is impossible to discuss the costs and benefits of ecosystem protection in a global context. As Kramer and Sharma (1997) have noted, just as the failure to measure the total benefits of biodiversity protection can lead to suboptimal development policies, the failure to measure the full costs of protection may lead to unworkable conservation strategies.

Scientists and practitioners have written hundreds of articles and books documenting the costs of environmental regulations in high-income nations (recent examples include Berman and Bui (2001) and Lovell and Sunding (2001)). In the context of ecosystem protection in low-income nations, however, relatively little has been written on the nature and magnitude of the costs of protected area establishment. Most of what has been written has been anecdotal or non-

quantitative with an emphasis on social impacts (e.g., Gordon, 1985; Croft, 1991; Agrawal et al., 1981; Bunting et al., 1991; Schoepf, 1983; Freeman and Frey, 1986; Schelhas, 1991; Payne et al., 1992; Novellino, 1998). There is a dearth of quantitative data on the costs borne by local residents when protected areas are established in low-income nations.

Ruitenbeek (1992) used survey data to estimate the opportunity costs to local residents from the existence of a national park in Cameroon. Azzoni and Isai (1994) used secondary data sources to estimate the opportunity costs of conservation in Sao Paulo, Brazil over a sixty-year time horizon. Norton-Griffiths and Southey (1995) used coarse aggregate data to estimate the opportunity costs of ecosystem conservation in Kenya for a single year. Shyamsundar and Kramer (1996) used contingent valuation techniques to estimate local resident willingness-to-accept restricted resource access associated with the establishment of a national park in Madagascar. Kremen et al. (2000) used simple assumptions (based on extensive practitioner knowledge) to estimate the opportunity costs of foregoing industrial logging and hillside agriculture inside a newly designated protected area in Madagascar.

My analysis contributes to this sparse literature in several important ways: (1) I use a combination of household surveys and semi-structured interviews to acquire detailed data on resource use and management that existed prior to the establishment of a protected area;<sup>1</sup> (2) I use data on forest use for agriculture and for timber and nontimber forest products (e.g., Norton-Griffiths and Southey had data on foregone agricultural benefits only); (3) I estimate the opportunity costs over time, not just for one year; and (4) I characterize costs both quantitatively and qualitatively.

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<sup>1</sup> Most protected area impact assessments have been conducted post facto with no “pre-park” baseline data (see Geisler (1993) for survey).

The next section describes the study site. Section III describes the data collection methods. Section IV develops the basic conceptual model that provides the analytical basis for the quantitative and qualitative analyses of later sections. Section V describes the assumptions made in the empirical analysis. Section VI presents the results of the empirical analysis. Section VII describes the other costs, as well as some potential benefits, that I was unable to quantify given the data available.

## II. Study Area

Madagascar provides an appropriate context in which to study the local impacts of protected area establishment. The country is a high priority for global biodiversity protection (Mittermeier et al., 1998), it has experienced high rates of deforestation and resource depletion (Green and Sussman, 1990), and it has recently completed the first two phases of its ambitious fifteen-year National Environmental Action Plan, which has led to a substantial increase in the number of strictly protected areas.<sup>2</sup>

Biological species diversity in Madagascar is concentrated primarily in the eastern rain forests (Rakotozafy et al., 1987), of which only one-third of the original area exists (Green and Sussman, 1990). The human communities of the eastern rain forests are rural and almost exclusively agricultural. Residents depend upon forest resources for subsistence and commercial activities. In particular, the forests provide land and biomass for a system of swidden agriculture called *tavy*, as well as providing myriad timber and non-timber forest products.

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<sup>2</sup> Before 1989, there were only two national parks in Madagascar. In 2001, there were twelve. The recent emphasis on “eco-regional conservation” in Madagascar encourages protection of even larger areas from extractive activities (Freudenberger and Freudenberger 2000).

Madagascar's Environmental Action Plan gave highest priority to the preservation of the Ranomafana rain forest along the southeastern escarpment of Madagascar because of the forest's exceptionally high level of biological diversity and the immediate threat of human activity. In May 1991, the Government of Madagascar established the 41,600-hectare Ranomafana National Park (RNP) in order to conserve the area's ecosystems. The immediate area around the park (within 5 km) is a mosaic of paddy rice fields, hillside agricultural plots, regenerating forest fallow, and, in some areas, relatively intact rain forest. At the time of the park's establishment, there were about 26,000 people living in over one hundred villages within a five-kilometer radius of the RNP's boundaries. About half of the villages were small, containing one-hundred and fifty people or less.

### III. Data Collection<sup>3</sup>

From September 1990 through March 1991, I collected data on natural resource exploitation in 22 villages and towns within three kilometers of the proposed borders of the RNP. A little over 490 households in 17 villages completed an administered questionnaire, while more than 300 people from the region took part in semi-structured interviews.<sup>4</sup> The household questionnaire documented forest use, agricultural activities and socio-economic indicators. The semi-structured interview covered topics such as village history, land tenure, forest use and agricultural activities, among others. The interview was designed to complement the household

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<sup>3</sup> More details of the data collection methodology, including copies of the survey instruments, and the results, including household wealth indicators, measures of input and output value, agricultural practices, socio-political institutions, resource tenure and the specific species of flora and fauna used, can be found at <http://eppserver.gsu.edu/pferraro>. The collection and interpretation of data benefited greatly from the substantial assistance of Basile Rakotondrajaona.

<sup>4</sup> The major difference between a semi-structured interview and a formal questionnaire is that the former uses a list of topics rather than a carefully prepared questionnaire (see Fox (1989) or FTTP (1991)).

questionnaire by putting the quantitative information from the survey into context. It also served as a means to examine the variety of opinions across age, gender, power and economic categories. The total population covered by the questionnaire and interviews was over 2800 individuals. Data collection also included informal discussions with many other residents and visual observations of natural resources collected and traded in the region.

The household survey was part of a larger health and socio-economic household survey administered by a trained non-governmental team of nurses, which was overseen by Dr. Lon Kightlinger, a parasitologist with over twenty years of experience working in Madagascar. In addition to administering the survey, the team, which also included a medical doctor, provided health services. The team's dual role reduced the potential bias in respondent answers that may have been engendered if residents perceived the survey to be a ploy by the government to restrict their rights of resource access. The resource use questions were embedded among other behavioral and consumption questions geared towards health-related research.

The surveyed region was divided into 4 zones (see Figure 1). These zones were chosen to include all areas that were inhabited around the park and corresponded to ecological, economic and cultural divisions in the region. Limited data (one village survey and discussion with local forestry personnel) concerning the heavily deforested region about forty minutes east of Ranomafana by car were also collected in order to make inferences about likely resident responses to resource degradation over time had the park not been established.

#### **IV. Modeling Approach**

Farm households in the Ranomafana region combine features of both consumers and producers. A farm household is assumed to maximize its utility, which is a function of

consumption of market-purchased goods not produced by the household, agricultural goods produced by the household, secondary forest products collected by the households, primary forest products collected by the household, and leisure (see Ferraro (1994) for formal mathematical model).

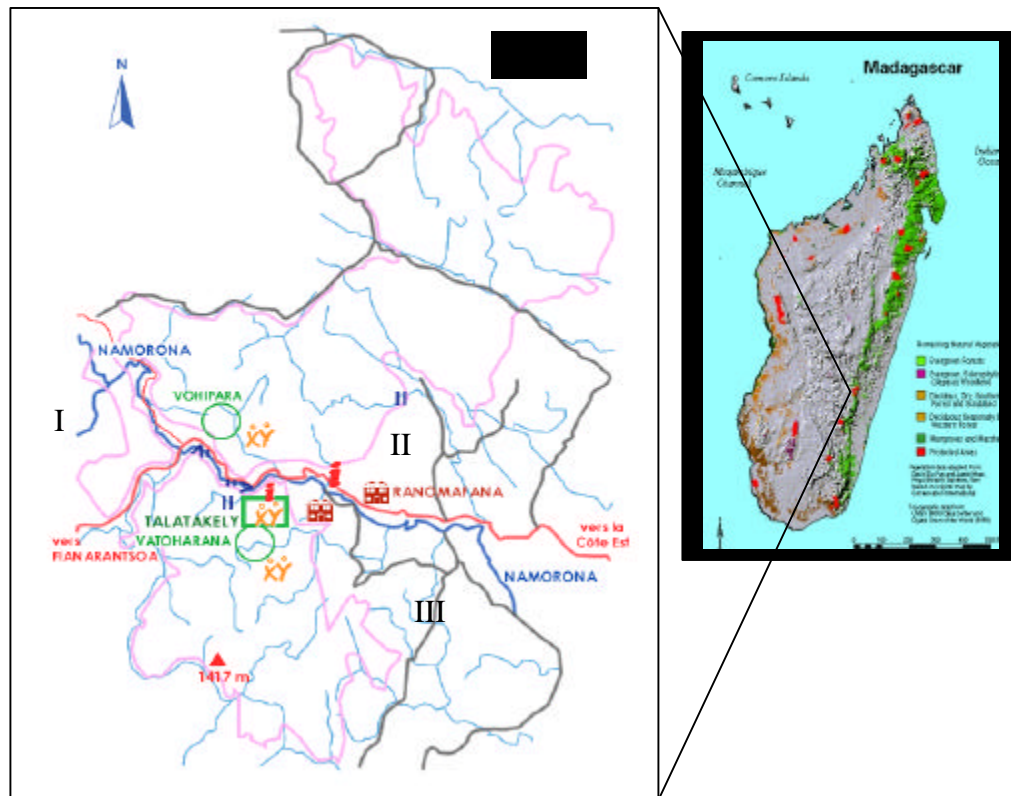


Figure 1 – Ranomafana National Park and Survey Zones (I-IV) (sources: left map, Association de Gestion des Aires Protégées; right map, Center for Conservation Biology, Stanford Univ.).

The RNP’s regulations permit only research and tourism activities within its boundaries and thus lead to a substantial decrease in the amount of forest accessible to local residents for productive purposes. The empirical analysis (Section V) estimates changes in full income that arise because of the RNP’s establishment. Full income is the value of the household’s time endowment plus the value of the household’s production (i.e., agriculture, forest product

collection) less the value of the variable inputs required for production of outputs (Singh et al., 1986). Full income is assumed to equal a household's expenditures on the items it consumes (expenditures include both explicit and implicit costs). A decrease in the availability of forest (a fixed input that is combined with labor to produce outputs) will result in lower full income and hence lower consumption of the variables in the utility function. Lower consumption results in a loss of utility, which will be perceived as a cost by local residents.

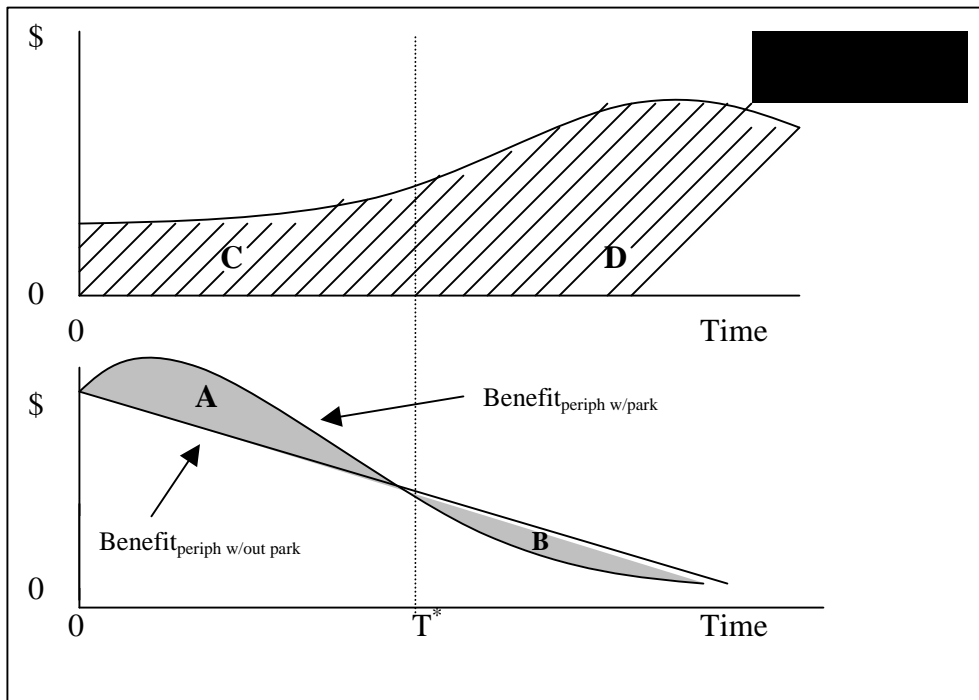


Figure 2 - Net Benefit Flows With and Without the Park

Changes in household full income are approximated indirectly by estimating the foregone net benefits that the households would have derived had the park not been established.<sup>5</sup> The

<sup>5</sup> If a well functioning land market existed in the RNP area, the costs to local residents could be approximated using the price of land. However, there is neither a well functioning land market in Ranomafana nor would such a market necessarily capture the total costs to residents. Given the private property rights regime governing agricultural benefit flows and the common property regimes governing forest product collection, land prices would most likely be based solely upon the stream of agricultural benefits from the land, rather than the combined benefits derived from agriculture and forest products.

empirical analysis assumes that residents are prevented from exploiting the ecosystems within the RNP as the park decree requires. Recent reports from Ranomafana support the validity of this assumption; since the park's establishment there have been few incursions (A. Ralimanana, 2001 per. comm.).

The net benefit streams in the presence and in the absence of the RNP are stylized in Figure 2. The top panel represents the benefit flows coming from the exploitation of the park's resources over time. The curve "Benefit<sub>w/out park</sub>" represents the stream of net benefits coming from the exploitation of the RNP's forest *in the absence of a national park*. These net benefits increase as residents begin to use more of the park's resources to substitute for the declining ability of the peripheral zone (outside the park) resources to meet local needs. Ultimately, the benefits derived from the use of the park would also decline as the park's resources became degraded. The benefits from exploitation of the park's resources *in the presence of the park* are assumed to be zero (see Section VI for discussion of this assumption).

The bottom panel in Figure 2 represents the benefit flows coming from the exploitation of the park's peripheral zone resources over time. The curve "Benefit<sub>periph w/out park</sub>" represents the stream of net benefits coming from the exploitation of the peripheral zone's resources *in the absence of the national park*. These net benefits decrease over time as the resources become more unproductive or depleted (stylized here as a straight line). The curve "Benefit<sub>periph w/ park</sub>" represents the stream of net benefits coming from the exploitation of the peripheral zone *in the presence of the national park*. Residents are assumed to substitute for lost park resources through an intensification of peripheral zone resource use. The shaded region *A* reflects the initial periods of intensification that substitute for lost access to park resources. The shaded region *B* implies that, in the absence of technological change, this intensification results in a

more rapid decline in fertility and loss of secondary forest products and services compared with the no-park scenario (i.e., a more rapid approach to a non-productive state). The assumption of little or no technological change over time is reasonable given: (1) the historically low level of technological improvement in the RNP area, (2) the low level of technological improvement on lands further east that have already undergone a rapid degradation of available resources, and (3) the lack of government extension services in the region. The acceleration of degradation resulting from intensification of lands formerly covered with rain forest is well documented in eastern Madagascar (Razafimamonjy, 1987).

Thus, with the establishment of the RNP, the residents lose the shaded areas of B, C, and D, and gain A in Figure 2. The opportunity costs of establishing the RNP are the present value of  $(C + D + B - A)$ , or  $\int_0^{\infty} e^{-\delta t} \text{Benefit}(t)_{w/out\ park} dt + \int_0^{\infty} e^{-\delta t} \text{Benefit}(t)_{periph\ w/out\ park} dt - \int_0^{\infty} e^{-\delta t} \text{Benefit}(t)_{periph\ w/\ park} dt$ , where  $\delta$  is the discount rate. The first and second integral can be estimated with the data available. Estimating only the foregone consumption of resources within the park (i.e., the first integral) could underestimate or overestimate the total opportunity costs, depending on the residents' ability to substitute for the lost resources (present value of A) and the effect that the intensification of resource use has on the longevity of the peripheral zone resources' productive capacity (present value of B). Estimating the third integral, however, is more difficult. One must predict how resource use in the peripheral zone would change after the park is established. In particular, this calculation requires data on the likely substitutions to take place and the effect that these substitutions will have on the long-term productivity of the peripheral zone resources. Although it has been 10 years since the RNP was established, there has been no comprehensive follow-up survey to characterize the changes in resource use since

the park's establishment. The empirical analysis will therefore not attempt to estimate the second and third integrals. If one were to assume that the sum of the second two integrals is greater than or equal to zero, the cost estimates in Section VI are lower-bound estimates.

## V. Modeling Assumptions

The data consist of (1) the author's point estimates of resource use during the 1990-91 agricultural calendar based on household questionnaires and semi-structured interviews, (2) resident-revealed historical trends, (3) observations of resident behavior across varying gradients of ecosystem disturbance, and (4) observations of residents in areas further east of the RNP that have already undergone almost complete deforestation. The main parameter values used in the empirical analysis are summarized in the appendix.

There is much uncertainty regarding future resource use patterns in the absence of the park. In order to mitigate the effects of uncertainty on the analysis, I use conservative parameter assumptions that likely result in an underestimation of the true costs. I also analyze the sensitivity of the results to changes in the assumed parameter values.

The assumed parameter values take resource use in 1990-91 as the point of reference. During this time, however, much of the forest outside the villages' designated agricultural perimeter was designated as *forêt classée* (classified forest) in which agricultural use and timber harvesting were regulated by a system of permits (the degree to which the regulations were enforced varied spatially and temporally). Given the existence of forest use regulation prior to the RNP's establishment, it could be argued that if the purpose of the empirical analysis were to estimate the **full costs of conservation** to local residents, then one must also consider the

additional costs that were created through the existing system of forest regulation. The empirical analysis in the next section only measures the costs of changing the status of the regional forest from *forêt classée* to national park (i.e., the costs of replacing a system of limited protection with a system of total protection).

## VI. Empirical Results

### a. Costs Per Average Household

The cost estimates in Malagasy francs (FMG) and in U.S. dollars (\$) for the population in each zone within a 5 km belt around the RNP are presented in Table I. I assume a 5% discount rate, a 1900 FMG/\$ exchange rate (May 1991 nominal rate), a sixty year time horizon, the deforestation rates presented in Table A1 in the appendix and a 2.5% population growth rate (see appendix for justification of these parameter values). The present value of the opportunity costs to residents around the RNP is estimated at 6.4 billion Malagasy francs, or \$3.37 million. The average costs per household are \$39/year.<sup>6</sup>

Although there is no one item in the forest whose loss would significantly affect the average household, the sum total of the value of all the products is substantial. Readers from high-income nations may not consider the costs reported in Table I to be high, but one must view them in the context of the low incomes in the RNP region. In 1990, the average annual GNP per capita in Madagascar was \$200 (UNICEF, 1992). Historically, the region around the RNP has had lower than average incomes in comparison with other regions in Madagascar (Francois et al. 1967, cited in Pryor, 1990). If it were assumed that annual full income per capita for the

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<sup>6</sup> My estimate is close to the \$50/year mean willingness-to-accept estimate obtained by Shyamsundar and Kramer (1996) using contingent valuation in communities around a park north of Ranomafana. The 95% confidence interval on their estimate ranged from \$10 - \$90.

average resident in the RNP region was \$200, the average annual costs per capita (\$6.70) account for over 3% of the annual full income per capita. The range varies across zones from 1.5% to almost 6%.<sup>7</sup> Shyamsundar and Kramer (1996) estimate that annual *household* full incomes in an area of rain forest north of Ranomafana were \$279, which would imply costs equal to 14% of household full income on average (range = 7% - 25%).

**Table I - Total Costs**

Zone	Population	Total NPV (FMG)	Total NPV (\$)	Annual Costs Per Household
Western	6879	735,724,880	387,224	\$19
Central	5219	1,977,433,762	1,040,755	\$64
Southeastern	1858	769,435,924	404,966	\$70
Northern	11,646	2,923,696,037	1,538,787	\$35
<b>All Zones</b>	<b>25,602</b>	<b>6,406,290,602</b>	<b>3,371,732</b>	<b>\$39</b>

• Based on a 5% discount rate, a 60 year time horizon, and a 1900 FMG/\$ exchange rate. Figures are rounded up to avoid decimals.

Samuel and Rambelolon (1991) estimate that annual cash revenues to the average household in the *firaisina* (county) of Ranomafana amounted to \$50 - \$60/ year (1900 FMG/\$). If \$50/year were assumed to be the cash revenues for the average household around the park, the annual opportunity costs for all zones combined, which are full income values, vary from 37% to

<sup>7</sup> If an individual were to find full employment at peak wages (2400 FMG/day) in the region, s/he would receive about \$325/year (1900 FMG/\$). Given that few adults in the region, much less children, could find such steady work, \$325 is an upper bound on annual per capita income.

139% of total household cash revenues. Thus, it appears that although the costs may be small in an absolute sense, they are not negligible relative to current incomes in the region. Given that many residents currently are at or near their minimum full income requirement, and that the costs in Table I are likely to be underestimates, the RNP is more detrimental to resident welfare than the values in Table I suggest.

Table I does not include one other quantifiable cost stream that is incurred by local residents after the establishment of the RNP. The establishment of the RNP resulted in the cessation of new timber concessions in the park, which caused a loss of future employment opportunities for residents, estimated at \$23,685 in annual salaries.<sup>8</sup> The cessation of concessions also generated a loss of profits to concession owners, many of whom live in the region, estimated at \$842,105.<sup>9</sup>

The results in Table I indicate that the magnitudes of the opportunity costs vary across zones. Households in the central and southeastern zones incur more costs than households in the northern and western zones. The composition of the opportunity costs also varies. In some zones, like the west, lost forest products make up the majority of the costs. In other zones, like the southeast, lost access to biomass for tavy makes up most of the costs. Variations across zones are a function of variations in market and wage opportunities (e.g., good market access in central zone), access to primary forest (e.g., good access in southeastern zone), ecosystem characteristics (e.g., lower biomass for tavy in west) and cultural characteristics. Regional

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<sup>8</sup> Residents were paid approximately 1800 FMG to carry each beam out of the forest. If commercial operations were to cut 500 ha/year, and it is assumed that 50% of the carriers are residents, approximately 50,000 beams would be cut and about 45 million FMG in salary would be paid annually to residents.

<sup>9</sup> It is assumed that 10,400 ha of the park (25%) is exploitable. The net benefits per hectare are calculated using a gross benefit per hectare of 1,000,000 FMG for the exploitation of only two genus (*Dalbergia spp.* and *Ocotea spp.*; based on documents obtained from the national office of the Département des Eaux et Forêt). Costs are estimated at 850,000 FMG/ha (an average of costs for regions close to the road and for those far from the road). A 0% discount rate is used because the timing of the exploitation is unknown.

differences in opportunity costs and their composition may indicate priorities for internationally-funded conservation and development activities around the RNP.

### b. Sensitivity Analysis

In this section, I examine the degree to which the results presented above are dependent on the assumptions made. As in most empirical analyses, the choice of the discount rate has an important effect on the calculated values. Decreasing the discount rate to 3% increases the costs by 75%. Increasing the discount rate to 8% lowers the costs by 45%. Increasing the discount rate to 10% lowers the costs by 61%. If one assumed that an appropriate discount rate lies between 3% and 10%, the total opportunity costs to residents would lie between \$1.39 million and \$5.87 million. The discount rate also plays a large role in determining the relative contributions of forgone tavy benefits and forgone forest product benefits to the total costs. As the discount rate increases, the relative importance of the foregone net benefits from forest product collection increases.

The choice of the exchange rate does not affect the value of costs as measured in Malagasy francs, but it does affect the dollar value of the costs. I chose to use the 1991 *nominal* exchange rate of 1900 FMG/\$ in order to be able to interpret the results as the actual transfer necessary to compensate residents in 1991 for their losses. AIRD (1992) used a 2000 FMG/\$ exchange rate to approximate the *real* exchange rate in Madagascar in 1991, which would decrease costs by only 5%. Kramer et al. (1994) used an exchange rate of 1111.8 FMG/\$ based on a conversion that accounts for differences in the purchasing power of residents in Madagascar and the U.S. Using the Kramer et al. exchange rate increases the cost in dollars by 71%.

Decreasing the population growth rate to 1% decreases costs by 12%. Increasing the growth rate to 3% increases costs by 10%. Given historical population growth rates and the fact that more than 50% of the current population is under the age of 18 years old, it is very unlikely that the annual population growth rate used in this analysis (2.5%) is too low.

Changes in the deforestation rate or the value of net benefits to tavy production affect the cost estimates in the same way. If the deforestation rates were cut in half, the opportunity costs for all zones combined would decrease by 34%. If the rates were increased by 50%, the costs would increase by 26%. Forest product collection levels within the RNP were held constant in the analysis, but if collection levels were to increase at the rate of population growth, then the total opportunity costs for all zones combined increases by 27%. If it were assumed that only the population in a 3 km belt around the RNP (16,839) would be affected by the park's establishment, the opportunity costs decrease by 29%. Extending the time horizon to 2075 A.D. increases the total costs by 8%. Reducing the time horizon by 25 years, decrease the total costs by 19%.

The value of labor was calculated based on the timing of each activity. If one were to value all labor allocated to tavy agriculture in each zone at the peak wage rate (2400 FMG/day), the total costs decrease by 26%. If one also were to use peak wages to value the labor allocated to the collection of forest products, the total costs decrease by another 28%. If one lowered the wage rate for both tavy and forest production collection to the lowest observed wage of 650 FMG/day, the opportunity costs increase by 32%.

If the estimated crop yield under tavy production were increased or decreased by 25% in each zone, the opportunity costs would change by 23%. If the estimated quantities of forest products collected inside the RNP were increased or decreased by 25%, the opportunity costs

would change by 11%. If all crop prices were reduced or increased by 25%, the opportunity costs would change by 23%. If all forest product prices were reduced or increased by 25%, the total value for all zones combined would change by 18%.

In addition to the sources of error examined above, the manner in which the data were collected may also have affected the cost estimates. For example, in the northern zone, no villages less than two kilometers from the park were surveyed. Residents of villages closer to the park were more likely to use park resources. Given the large number of residents in this zone, underestimation of these costs may significantly affect the overall results. For example, an increase of 0.001 ha/capita in the northern zone deforestation rate and a 10% increase in the net benefits from forest product collection increase the total costs in the northern zone by 21% and the total costs for all zones combined by 10%. Other sources of bias are described in Ferraro (1994) and, in general, suggest that the opportunity costs presented in Table I should be interpreted as underestimates of the true opportunity costs to residents from the establishment of the RNP. The next section examines potential costs that are more difficult to quantify, but which ought to be considered when examining the effects of the RNP.

## **VII. Other Costs and Benefits**

### **a. Distributional Aspects of Costs**

The results in Section VI demonstrate that the costs to residents vary across zones. Residents within these zones, however, are not a homogenous group. Within each zone, there are variations in resource use and thus, there will be variations in costs. There may be intra-zone, intra-village and intra-household differences in the costs incurred by residents, and these

variations should be noted. For example, there are two villages in the western zone, Vohiparara and Sahavondronana, whose residents are heavily involved in the commercial sale of crayfish and eels. The value of their losses is more like that of residents in the central zone than that of their neighbors in the western zone. The average household in these two villages loses a net present value of \$1,014 or \$54/year. The total cost for these two villages is \$59,815, 93% of which is derived from the use of forest products. Thus the values presented in Table I mask substantial variations in the costs to residents in each zone.

The focus on average households in the analysis also conceals the distributional aspects of the RNP's effects within villages. Some residents depend substantially on the collection of forest products from the park area for income generation during the food deficit period. During this period, households will become more dependent on high-interest consumption loans while their means to repay the loans declines. The establishment of the RNP will particularly hurt poorer households and their descendants because they have little or no access to irrigated rice paddies and hillside land that can substitute for restricted access to park resources. These households and their descendants depend heavily on the "frontier" outside the agricultural perimeter for their survival. The household data also suggest that wild sources of food and income typically account for a larger share of household income among the poor than among rich.

The costs are also likely to be spread unevenly across age classes. Older residents (50+ years) often prefer to engage in tavy because it involves less labor investment and because the work effort is not as strenuous as irrigated paddy work. Households led by younger residents often depend on tavy outside the agricultural perimeter to meet their income need because they

have not yet received land through inheritance. Thus even within a village, different groups of residents will be affected in different ways.

In the empirical analysis, the household is the unit of analysis. However, studies have shown that, for many decisions, the household should not be treated as a homogenous unit. Dianzinga and Yambo (1991) have shown that the loss of access to forests affects men and women in different ways. Few data exist on individual preferences and the allocation of resources within households in the RNP region. Anecdotal observations, however, suggest that intra-household effects may be important. For example, men tend to be involved in tavy and forest product collection deep in the forest. In order to compensate for the loss of access to forest resources in the park, households will need to invest more in irrigated rice paddies and gardens near villages and in the production of homemade crafts, activities in which women are the primary laborers.

#### b. Health Costs

The establishment of the RNP will affect resident health by affecting the nutritional composition of their diet. For example, the loss of wild protein sources (e.g., 67% of households reported collecting crayfish) will affect health negatively since residents already consume minimal amounts of protein (Hardenbergh, 1993). Samisoa (1992) found that residents in the Ranomafana region depended on cash income to purchase supplemental staples, oils and fats. The loss of income from commercial sale of forest products (e.g., 16% of households reported selling crayfish) will make it more difficult for households to make these purchases.

Changes in cropping patterns in the peripheral zone will also affect nutrition in the area. First, residents will substitute irrigated rice for tavy rice. This substitution is being encouraged

by development initiatives associated with the RNP (RNPP 1996). In Madagascar, Ralambofetra et al. (1986) and Ralambofetra and Rakotovao (1985) found that hillside rice had more protein and more calcium than rice from irrigated paddies. Second, intensification without technological change will lead to fertility decline in the peripheral zone over time. As fertility declines, households are less likely to plant nutritious, but nutrient-demanding crops such as rice, and more likely to plant less nutritious, but less nutrient-demanding crops such as manioc or sweet potato. Hardenbergh (1993) has also found that the quality of the diet deteriorates in the RNP region when other staples are substituted for rice because of the ways in which residents traditionally combine foods in meal preparation.

The establishment of the RNP will also affect the residents' health by affecting access to medicinal plants and health services. Indigenous healers obtain many of their plants inside the dense forests. The loss of cash income as a result of the RNP reduces a household's ability to seek medical care from indigenous healers, government clinics and private pharmacies, all of which require payment. Although most medicinal plants used for self-treatment come from the secondary forest and scrub, there are some plants that come from dense forest in the park. More importantly, the intensification of agriculture and forest product collection in the peripheral zone will tend to increase the scarcity of the desirable medicinal plants for self-treatment.

### c. Social and Cultural Costs

Residents in the RNP region are very concerned with the fostering of *firaisina* (union), *fihavanana* (family) and *firaisankina* (solidarity). Community harmony is extremely important to because it fosters mutual assistance and security. Any breakdown in social relations can lead to economic losses if households are no longer able to work together to take advantage of

economies of scale or risk-pooling behavior. In some regions of the world, traditional patterns of authority, reciprocity and social bonds break down in the presence of a protected area that deprives residents of significant resources (Calhoun, 1991). In semi-structured interviews, residents noted that such changes were already occurring in some villages before the RNP's establishment, and it is likely that the RNP's establishment will only exacerbate the changes (e.g., frequent borrowing from richer neighbors disrupts community harmony).

The increase in resource scarcity from the RNP's establishment may also affect resource tenure regimes in the region. Residents manage forest products coming from secondary forests around the village under a common property rights regime. The establishment of the RNP, and its concomitant decrease in the supply of forest products, will increase pressure towards the privatization of secondary forest benefit streams. Such a change in property rights would negatively impact land-poor households who depend upon the secondary forests of other households to collect needed forest products. In particular, single women with children in the RNP region depend upon resources on other residents' land to meet their income needs.

#### d. Exposure to Risk

For many residents, intensification on irrigated rice paddies will substitute for foregone tavy yields in the RNP. However, one of the main resident-revealed advantages of tavy is the ability to plant several crops with staggered maturation dates in a single parcel. The differences in maturation dates help residents smooth out their intertemporal income flow. Residents are unable to do substantial intercropping on irrigated lowlands.

An increase in residents' dependence on rice paddies also exposes risk-averse residents to greater production risk from cyclones, which affect irrigated rice paddies more than tavy plots.

Cyclones not only reduce income by damaging each household's crops, but they can also negatively impact households by raising prices. Because of the existence of covariate production risk over the southeastern region, one household's poor harvest would be correlated with diminished aggregate supply and subsequent higher prices.

Substitution in the peripheral zone will also take place through more extensive use of hillsides. In the presence of land scarcity, households in southeastern Madagascar use hilltops for agriculture more frequently. Not only is production lower on these parcels, it is also more variable because of the parcels' exposure to the elements (especially wind). The decrease in peripheral zone fertility over time will also increase the demand for planting manioc, which needs fewer nutrients to grow than most other crops. In some regions, like the eastern central zone, the planting of large areas of manioc is risky because of likely destruction by bush pigs.

Resident exposure to risk is compounded by restricted forest access. Typically the forest is a potential resource for substitution when crops fail. The reduction in the regional supply of forest products will increase the risks associated with crop failures, and for poor households, it will increase the probability of falling below the minimum income requirement.

#### e. Benefits to Residents from the RNP

The establishment of the RNP may also result in benefits for resident communities, including benefits from tourism, watershed protection, and micro-climate control. In the decade since the park was established, however, the benefits from tourism have proven to be seasonal and have been captured by a relatively small subset of the population located near the main road, many of whom were not born in the region. Such outcomes from tourism have been shown to occur near many protected areas around the world (Olwig, 1980; Wells and Brandon, 1990;

Woo, 1991; Lindberg et al. 1996; Wallace and Pierce 1996; Campbell 1999). Sharing the revenues from park entrance receipts may be one way to more fully distribute benefits from tourism to residents.<sup>10</sup>

Even if the benefits from tourism were large and widely distributed, there are also possible costs associated with tourism. Rao and Geisler (1993) noted that tourism often encourages migrants to come to the area and out-compete members of the resident population for jobs. Upreti (1985) and Mishra (1982) have documented costs associated with increases in the price of market goods in areas frequented by tourists. Most farmers in the RNP region (~70%) are net buyers of agricultural products and thus price increases are likely to have negative effects on household welfare.

The ecological benefits to local residents from protection of the RNP's forest cover are difficult to quantify. Because many of these benefits are long-term and diffusely distributed, residents may not recognize them as benefits. Moreover, the acceleration in peripheral zone degradation resulting from RNP's establishment may result in a number of localized ecological costs in the region, such as increases in iron toxicity from sediment runoff in irrigated paddies. Thus, although ecological benefits to local communities from the park's establishment benefits should be included in a total cost-benefit analysis, they may not mitigate residents' perceptions of their opportunity costs.

One final potential benefit warrants mention. In 1991, the United States Agency for International Development awarded Duke University and the Government of Madagascar \$3.237 million to begin improving the management of natural resources inside and outside of the RNP. The Government of Madagascar contributed another \$29,000 and other participating

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<sup>10</sup> In 1996 the RNP was one of the most popular parks in Madagascar and received about 6000 tourists (Vieta, 1998), but a majority of visitors were Malagasy nationals who paid less than \$1 to enter the park (foreigners paid 50,000 FMG, which was about \$12 in 1996).

organizations contributed \$654,000 (USAID/Madagascar 1991). The goal of the project was to integrate the economic development of local communities with the conservation of natural resources inside and outside of the park, thereby engendering local conservation support for the RNP (Duke University, 1990). If one were to assume that 5% of the funds money would be spent on administration, \$3.724 million dollars would remain to mitigate the negative effects of the RNP's establishment. Given the cost estimates in Sections V, the funds available would seem to be sufficient for engendering local conservation support.

Unfortunately, reviews of the project's performance do not indicate that the local population realized large benefits. Joseph Peters, former Conservation Technical Consultant with the Ranomafana National Park Project, estimated that less than 2% of the Ranomafana National Park Project's budget went to rural residents around the park; about 55% went to administrative (US-based) overhead and expatriate technical consultants and the rest went to capital expenditures and host-country technical consultants (Peters 1998).

## **VII. Conclusion**

Madagascar's extraordinary wealth of biodiversity is being liquidated rapidly. Strong measures are needed to ensure the preservation of this wealth for the future. These measures will inevitably include the use of protected areas. However, the same ecosystems that are top priorities for conservation provide adjacent resident communities with many valuable goods and services on which their lives depend. Without alternative methods of meeting these needs, restricted access to protected ecosystems will mean diminishing standards of living over time for communities adjacent to protected areas. Diminishing local welfare may generate serious

conflicts between protected area managers and the resident population and thus jeopardize the long-term conservation goals of protected areas. In order to identify and reduce these conflicts, the local costs of protected areas must be estimated.

Using data from southeastern Madagascar, I estimate that the present value (1991 dollars) of opportunity costs to local residents from the establishment of the Ranomafana National Park is \$3.37 million. In addition to these costs, there were other costs that I was unable to quantify, including health, cultural and social costs. Although I was unable to quantify these additional costs, there is no reason to believe that they are inconsequential. Relative to household incomes in the region, the total opportunity costs of local communities from the establishment of the Ranomafana National Park are substantial.

On a national and global scale, however, the benefits from protecting the Ranomafana National Park are likely to be far greater than the opportunity costs of local residents. The park has been characterized as a biological paradise with many endangered and exotic endemic species. As a tourist site, the park has much potential for generating benefits at the regional, national and international level. Furthermore, the Ranomafana National Park protects the watershed of a hydroelectric plant that generates electricity for the entire central southeastern region, including the provincial capital city. Although the outside conservation funds that were invested in the Ranomafana region in 1990s (\$3.92 million) did not mitigate the opportunity costs from the park's establishment, my analysis suggests that, were they appropriately spent, those funds could have indeed encouraged local conservation support.

## Appendix

### A1. Deforestation Rates

In the absence of the park, the amount of forest cleared for agricultural purposes would increase over time as the population grows and lands outside the park become less productive. Some of the forest inside the park had been deforested by 1990, indicating that residents had a need to begin using the park's ecosystem for agriculture. Moreover, 90% of the surveyed households believed that they did not have enough land to meet their household needs.

TABLE AI

DEFORESTATION RATES OF THE RNP BY ZONE		
Zone	Hectares/capita/year	Total cut 1991-92
Western	0.001	7 ha
Northern	0.003	36 ha
Southeastern	0.006	11 ha
Central	0.004	21 ha

The deforestation rates for each zone are listed in Table AI. Deforestation rates in the RNP in the absence of the park's regulations were estimated from a combination of resident-revealed information (e.g., area of cultivation, crop varieties planted, historical reconstructions of agricultural perimeter) and author observation. The details underlying the assumptions of deforestation rates can be found in Ferraro (1994: Appendix J). The assumed rates are lower than estimated rates for comparable areas in eastern Madagascar (Green and Sussman, 1990; Ryan, 1992; Green, 1993; CARE/NYZS, 1993; Kramer et al., 1994).

One could argue that population growth could increase the amount of labor available for agricultural intensification, thereby decreasing the deforestation rate per capita. However, given (1) the low labor productivity on existing land, (2) the expected limited rate of technical change

over time, and (3) the limited ability of Madagascar's urban and non-farm rural sectors to absorb labor, population growth is unlikely to decrease the rate of deforestation per capita in the RNP region. Scientists working in the northeast of Madagascar found that per capita deforestation rates have been increasing since 1957. Although the annual deforestation rate per capita is held constant in the analysis, the population in the Ranomafana region is growing at an estimated rate of 2.5% (based on 1980 and 1990 census data from local *firaisina* offices).

### A2. Tavy (Agriculture) Assumptions

In order to estimate the benefit stream derived from tavy cultivation in the absence of the park, a typical tavy cycle starting with primary forest is assumed for each zone and the net present value of the stream of benefits from the use of that piece of land until 2050 A.D. is estimated (see footnote 3 for details). The net benefits of tavy vary across zones because of differences in land quality, weather, crops grown and prices of outputs and inputs.

### A3. Forest Product Collection Assumptions

In the absence of the park, the demand for forest products, and hence the net benefits, coming from the park's forests will increase over time because of the increasing scarcity of forest products in the peripheral zone. This scarcity is already evident in some villages a few kilometers from the park in the northern zone. On the other hand, increasing levels of tavy in the park's forest will decrease the net benefits from forest product collection over time by increasing the costs to obtain products. Given the relative abundance of forest products, historical movements of settlements following expansion of the agricultural perimeter and the low opportunity cost of time during the seasons when forest products are most often collected, it is

assumed that the net benefits from forest product collection in the park will not begin to decrease at a noticeable rate until well after the demand for forest products in the park has begun to increase. Under the deforestation rate assumptions used, only half of the RNP is deforested by the year 2079 and thus forest products are likely to be available during the time horizon of this paper's analysis. Given the great uncertainty over the potential long-term dynamics in forest product demand and supply, the analysis assumes that the benefits from forest product collection within the RNP's borders remain constant over the period of analysis.

#### A4. Time Horizon and Discount Rate

Typical time horizons used for the analysis of projects with long-term effects are thirty to fifty years (Dixon et al., 1986). At any positive discount rate, the present value of the costs will be quite small after fifty years. The time horizon used in this analysis is sixty years because even small present values are significant to individuals with low incomes.

For the purposes of the empirical analysis, I assume that the social discount rate is 5%. Results from past studies suggest that individuals do not discount at constant rates over different choices and at different stages in their economic development (Thaler, 1981; Houston, 1983; Loewenstein, 1988; Thaler and Loewenstein, 1989; Ben Zion et al., 1989; Lawrance, 1991; Cropper et al., 1992, Weitzman 2001). Researchers have found discount rates to be a function of the type of choice proposed, the magnitude of the values involved, the time horizon of the choice, and whether a cost or a benefit is being discounted. In order to derive the appropriate social discount rate, the context of the RNP's establishment from the point of view of the residents must be examined.

Thaler (1981), Cropper et al. (1992) and others have found a negative relationship between the discount rate and the length of waiting time and the magnitude of the future value. The greater the time horizon and the greater the magnitude of the future value, the lower the discount rate used by the economic agent making the choice. Given the long-term effects of the RNP and the potential magnitude of the costs relative to current incomes, it is likely that the rates of time preference used by residents to discount the opportunity costs of the RNP are lower than residents' personal rates of time preference.

Changes that have intergenerational impacts are generally discounted at lower rates by societies. When residents discussed the impacts of the proposed park in the semi-structured interviews and in public discussions after the park's establishment, they often complained that the real victims of the park were their children and grandchildren who would not have access to the resources that they would need. When heads of households were asked how much land they would need to provide for their families, many responded with figures of about 3 ha of rice paddy and 10 ha of hillside land. When asked why they needed so much land, most stated that they needed extra for their descendants. Norgaard and Howarth (1991) have shown that the discount rate under these circumstances is a function of the way in which current economic agents want to distribute resource rights between generations. The decision is no longer framed merely in terms of an investment decision yielding returns to the current generation, but also as a question of intergenerational equity. In general, if current economic agents believe future economic agents have significant rights to resources, then any proposed changes that would negatively impact future generations access to resources would be discounted at a relatively low rate.

The ratio of land rent to land sale price gives one estimate of long-term discount rates (Cuesta et al., 1993). Limited market data for rice paddies in the western zone suggest that one

hectare of irrigated land sells for about 275,000-300,000 FMG while the annual rental rate is about 20,000 FMG. This would imply a long-term discount rate of 6-7%. However, the few households that are selling rice paddies are those with immediate cash needs (e.g., a family illness), and thus the ratio probably overstates the true long-term discount rate. Cuesta et al. (1993) found that the average rural land rental to price ratio in Costa Rica ranged from 3.95%-4.99% and the median ranged from 4.76%-6.25%. Moreover, Benzion et al. (1989) found that the discount rates used for changes in the timing of costs were lower than those used for the timing of benefits, and psychologists have found that individuals weigh a removal of some part of what they originally had greater than a gain of equal magnitude (Pearce and Turner, 1990: 129). Other studies have shown that the degree of "voluntariness" or "controllability" plays one of the most important roles in personal risk experience (Vleck and Stallen, 1980). Holding the monetary value of the proposed outcome constant, less voluntary or controllable transactions are less desirable. Several countries have added a premium to market-based compensation awards to reflect the compulsion in the loss of an asset (Burrows, 1991).

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