Economic Impacts of Tropical Forest Conservation: The Case of Logger Households around Ruteng Park

David T. Butry
Subhrendu K. Pattanayak

WORKING PAPER 01_01   JANUARY 2001

RTI International's* Environment and Natural Resource Economics Program circulates these working papers to convey information and entertain discussion. The papers may not have undergone formal peer review. Contact Subhrendu Pattanayak (subrendu@rti.org) if you have any questions or concerns. <www.rti.org/enrepaper/>

*RTI International is a trade name of Research Triangle Institute.

Economic Impacts of Tropical Forest Conservation: The Case of Logger Households around Ruteng Park

David T. Butry and Subhrendu K. Pattanayak♣

JEL Classification: O13, Q12, Q23, Q28
Keywords: tropical deforestation, logging profits, local costs, profit functions, contingent valuation, economic instruments

ABSTRACT

The debate over tropical forest conservation remains contentious in the absence of quantitative evidence on the local benefits or costs of protection. We surveyed logging households in the buffer zone of Ruteng Park in Manggarai, Indonesia to develop micro-level measures of forest dependence as forest profits and to correlate it with wealth, forest size and prices by estimating a profit function. Regression analysis reveals that there are differences in forest use behavior across rich and poor households. Rich households are sensitive to changes in prices of forest products, while poor households are sensitive to wages. We also find that merely designating greater areas of 'protected' forests will have serious regressive effects. Calculated profits show that representative logging households can lose between $340 to $460 of annual profits from a policy that completely bans forest uses. We conclude that complete restriction on forest use will be politically difficult and will require compensation. Moreover, mere designation of forest protection creates the twin problems of hurting the poorer local households and furthering local deforestation by rich households. Instead, the government should consider economic instruments such as permits and taxes/subsidies. Contingent valuation data shows that regulating forest use by a permit scheme is a viable alternative because it enjoys the support of the local people. Economic instruments can help developing country governments design forest protection policies that distribute benefits more evenly and that pay attention to the people living at the forest margins.

♣ The authors are Economist, USDA Forest Service and Senior Economist, RTI International. Senior authorship is not assigned. All correspondence should be addressed to Subhrendu K. Pattanayak, Research Triangle Institute, Research Triangle Park, NC 27709; subrendu@rti.org. We are grateful to Randy Kramer for access to the data and would like to thank two anonymous reviewers and participants at SOFEW 1999 and Camp Resources 1999 for their comments.

1. INTRODUCTION: LOCAL COSTS OF TROPICAL FOREST PROTECTION

The debate over tropical forest conservation is contentious in part because there is little or no information on whether or how tropical forest conservation affects local economic development. This study takes a quantitative approach to fill this policy gap by estimating models and testing hypotheses regarding local use and reliance on tropical forests in the Manggarai region of eastern Indonesia. The goal is to provide some policy information on the highly charged debate regarding the unequal distribution of costs and benefits of environmental conservation in tropical developing countries. Critics of tropical forest protection contend that it generates largely global benefits, such as biodiversity conservation, recreation, and ecological services, while it imposes sizeable opportunity costs on local people who are denied access to or use of forest resources (Kremen et al., 2000). Local benefits of biodiversity, recreation, and ecological services are typically indirect and latent, in contrast to seemingly transparent and sizeable opportunity costs of protection borne by local economies. We use microlevel data from a survey of logging households in the buffer zone of Ruteng Park to estimate welfare effects of forest conservation. Quantitative estimates of this nature can provide the starting point for policy discussions about compensation or charges.

We have three specific objectives. First, we address how an effective timber ban affects the well being of logger households, measured in terms of gains or losses in forest profits. Regression analysis allows us to determine how prices of timber products, forest policies, and wealth influence households dependence on forests. Second, we test for differences in the extent of welfare changes across two wealth groups and for extent of correlation between forest profits and forest conservation (measured by the level of protected forest cover). These allow us to simulate welfare changes that would result from different levels of forest conservation. Third, we explore the potential use of policy levers to more effectively conserve forests and mitigate economic impacts. Measures of price responsiveness from the profit analysis and contingent valuation data on willingness to pay (WTP) for timber permits is used to investigate the potential for 'green market initiatives' as alternatives to total restrictions on forest use.

The rest of the paper is organized as follows. Section 2 presents background on Ruteng Park and on the socio-economic conditions of the logging community living around the park. In Sections 3, 4 and 5 we describe the theory, data and empirical model for our analysis. Results are presented in Section 6. We discuss the policy implications in Section 7 and conclude in Section 8.

2. BACKGROUND: RUTENG PARK IN MANGGARAI, INDONESIA

Ruteng Park was created in 1993 in Manggarai, Indonesia as part of the global and national concern regarding tropical deforestation. It was designed along the lines of an integrated conservation and development project (ICDP) with the twin goals of protecting tropical ecosystems while promoting local economic development. The park is 32,246 hectares, with a 56,000 hectare buffer zone, an area in which sustainable levels of forest product collection, agroforestry and small-scale agriculture are permissible, as long as they are consistent with the ICDP design principle (Blomkvist, 1995; Moeliono, 1995). The area is mainly a sub-tropical forest that is rich with biodiversity, including Komodo rats, monkeys, wild boar, civets, cobra, and vipers. The terrain is extremely steep, as the park is located on the tops of several volcanic ridges and is the source of many rivers and streams. Previous research has found evidence of ecotourism potential (Eisen-Hecht, Kramer, and Sills, 1999) and watershed protection benefits for farming (Pattanayak and Kramer, 2001) and domestic use (Zurita, 2000).

Although many Manggarai people are farmers, approximately 2000 households—sizeable subset of the local population—rely on timber logging.[1] These households process timber into boards and beams, and sell them as construction lumber to local government agencies, churches, and private builders. Timber comes from the forests managed or owned by villages, the buffer zone, and the reserve section of Ruteng Park. In 1989, the government banned concessionaire logging for timber in government forests, including Ruteng Park in 1993. Our field research shows, however, that local inhabitants have continued to log limited amounts of timber from the in and around the park. They also collect a variety of non-timber forest products (ntfp) such as rattan, herbs, and textile coloring agents. Park managers can allow sustainable logging and ntfp collection in the buffer zone since the ICDP recognizes the rights of local people. However, forest conservation policy is an evolving process, as national and local policy makers continue to ponder alternatives for forest conservation, including tougher enforcement and participatory conservation that can be reconciled with local development goals. Because inadequate information on the economics of controlling logging stymies current forest conservation efforts (Blomkvist, 1995), we focus on investigating the magnitude and distribution of the economic impacts of restricted forest use.

While we do not support or argue for a complete ban on forest logging, we wish to examine the effects of various degrees of forest protection, including an effective ban on logging by local households. There are many benefits and cost of different levels of restricted forest use. The ecotourism industry will benefit by accruing amenities and profits (Eisen-Hecht, Kramer, and Sills, 1999), and downstream farming communities will realize watershed protection benefits (Zurita, 2000; Pattanayak and Kramer, 2001). Carbon sequestration and biodiversity preservation will be among the major global benefits (Kremen et al., 2000; WRI, 2000). On the cost side, clearly consumers in the region will be deprived of timber products. Moreover, loggers will gain little and instead stand to lose substantially (Blomkvist, 1995; Moeliono, 1995). Although a majority of loggers surveyed in the region expressed concern for the forest deterioration, 26% felt that the logging restrictions were not warranted. In this paper, we focus on costs to local loggers.

---

[1] Background information on the logging in the Park region are available in Blomkvist (1995), Ministry of Forestry (1995), and Moeliono (1995).

3. CONCEPTUAL FRAMEWORK: A PROFIT FUNCTION APPROACH

In order to determine a representative logging household's level of welfare, we use a profit function approach (Garcia et al., 1986; Sadoulet and de Janvry, 1995). A logging household's reliance on forests is positively related to quantity of timber harvested and, thus, to logging profits, which measure economic welfare. Because we are interested in characterizing the nature of household use of and reliance on the forests, we estimate profit functions instead of describing point estimates of forest profits. Forest profits are calculated as revenues (derived from timber and other forest products) less costs (of inputs such as labor). Within an economic framework, logging households would choose levels of forest outputs, labor inputs, and, thus, their profits, based on the prices that prevail in local markets. Thus, profits are modeled as a function of output and labor prices and exogenous variables described below (Sadoulet and de Janvry, 1995):

$$\pi = p'q(p,w;\ z,f(b,\ j)) - w'x(p,w;\ z,f(b,\ j)) \qquad [\mathbf{1}]$$

where p and w are the output and input prices, q is the vector of output quantities, x is the vector of input quantities, and z is the vector of fixed factor quantities. f(b, j), a particular type of fixed factor, is the amount of accessible forest which depends on the extent of conservation (b) and the logger households access opportunities that are conditioned by its wealth and status (j).[2] Given these exogenous factors, household choose optimal levels of forest outputs, q(p,w; z,f(b, j)) and inputs, x(p,w; z,f(b, j)). Thus, their profits from forest use can be described by a function with the following properties:

$$\pi = \pi\ (p,w,z,f(b,\ j)) \qquad [\mathbf{2}]$$

$$\partial\pi/\partial p > 0;\ \partial\pi/\partial w < 0;\ \partial\pi/\partial z > 0;\ \partial\pi/\partial f = ?$$

$$(\partial\pi/\partial f)*(\partial f/\partial b) < 0;\ (\partial\pi/\partial f)*(\partial f/\partial j) = ?;\ (\partial\pi/\partial f)*(\partial^2 f/\partial b\partial j) = ?$$

The partial effects of individual exogenous factors are summarized above: consistent with theory, higher output prices, lower input prices and higher fixed factors increase profits. An increase in accessible forest size, which is equivalent to an increase in a fixed public input, increases profits. However, accessibility is a function of the extent of conservation and its interaction with household characteristics. By itself, an increase in conservation will decrease the amount of effective forest size and therefore decrease profits. Because of political clout or socio-cultural factors, the wealthier and the more powerful may realize greater access under 'forest conservation' because now they do not compete with the poor households for products of the

---

[2] We use the term 'access' more broadly to mean abilities and opportunities, not merely opportunities related to the physical logistics of use. Various social scientists have maintained that socio-economic status affects the opportunities or abilities and the consequent choices made by individuals presumably because status—measured by wealth in our case—proxies for several factors. For example, wealthier households may possess information and/or technology that give them a comparative advantage in using the forests. Likewise, wealthier households may live closer to the forests.

protected forests. We cannot apriori sign the forest cover variable and allow this question to be resolved by the empirical analysis.

Total forest profits measure the upper bound of the extent of welfare loss from a policy that effectively restricts all forest uses (Equation [3]). In such a scenario the amount of accessible forest and therefore of forest profits are zero.

$$\pi(p,w,z,0) - \pi(p,w,z,f) = \text{welfare loss.} \qquad [\mathbf{3}]$$

4. DATA: SURVEY OF LOGGER HOUSEHOLDS IN MANGGARAI, INDONESIA

We implement the conceptual model by using data that were collected by researchers from Duke University and the Indonesian Ministry of Forestry in 1996 as part of study on the economics of protected area management.[3] A socioeconomic household survey was implemented in approximately 100 households from five *desas* (villages) in the Manggarai district of Western Flores, including Carep, Golo Dukal, Pau, Tenda, and Waso, which together contain the bulk of the logging population (Moeliono, 1995). Surveys were administered by two teams from the Universitas Nusa Cendana (West Timor) in February of 1996. The questionnaires were organized into several sections including household characteristics, logging and farming activities, non-timber forest products, and attitudes about Ruteng Park and the forest ecosystems.

On the average, a household head is 39 years and has resided in his village for 37 years. The majority of those surveyed have some primary school level education or less (77%). The average family size is six. About half of our sample households have been logging and selling timber for 13 years. The best quality or Class I timber (*ajang, ngancar, wuhar, dalo, pinis, lumu, worok*) is the most frequently logged of the four qualities or classes of timber. In addition to logging, many households collect dead wood for fuel from nearby fields and roadways.

Labor is the primary input and axes, manual hand saws, and machetes are the preferred tools for logging. Of those surveyed, 34% own at least one axe, 30% own a manual saw, and 98% own at least one machete. Households reported prices for various classes of timber as the price per unit of timber sold.[4] Wages in farming and logging crews are used as the cost of labor in logging. We created a capital cost for logging tools as a geometric function of the tool, the tool's age, its value when originally purchased, and the quantity of each tool (Klemperer, 1995).[5] These prices are used to compute household specific forest profits as total revenue (price multiplied by quantity of

---

[3]See Kramer et al. (1997) for a detailed description of the project and the data collection.

[4]For those households that did not specify a price per unit of product an average, the village average price is used as a reasonable proxy for the market opportunities for that timber.

[5]$C = (P^*r)\ ((1-r)^t)$ where C is the current year equipment cost, P is the initial purchase price, r is the discount rate, and t is age of the equipment. The discount rate was set at 15%.

forest products) less total costs (capital costs plus the product of wage rate and labor). In Table 1, we present the average profit measures, categorized by the watersheds described below.

We created a wealth dummy variable to determine whether forest access and forest dependency varies across wealth groups. Accumulation of consumer goods, such as radios, appliances, motorcycles, watches and jewelry are measures of status and well-being in Manggarai, Indonesia. Cluster analysis of the count of consumer durables identified two wealth groups: 66% 'poor' and 34% rich, or those who own at least one good. A Students t-statistic of 11.73 shows that the groups are statistically different populations. This cluster dummy was positively correlated with other wealth measures, including home quality.

The five villages lie in four watersheds. As shown in Table 1, these watersheds are covered with different proportions of forests that are designated as "protected forests" by the Ministry of Forestry. The protected status of these forests does not necessarily imply that the forests do not provide forest products to all people. Instead, as argued in the previous section, accessibility (and enforcement) is probably a function of local politics and culture. We use a dummy variable to test for this difference.

5. MICRO-ECONOMETRIC MODEL OF FOREST DEPENDENCE

Our empirical model, represented by a Cobb-Douglas profit function, serves as the means to test the theory of Section 3 with the data described in Section 4. The Cobb-Douglas function, a first order approximation of any profit function, is used to establish the relationship between economic welfare, as measured by forest profits, and exogenous factors including prices, forest size, and wealth. We use a censored regression model, following Heckman's (1979) two-step procedure, to account for a sample selection bias. That is, we first estimate a probit model to calculate λ_i, the probability of positive forest profits. In the second stage we include λ_i as an additional model regressor to accommodate self-selection bias.

Equation [4] presents the empirical counterpart of the profit function developed in Equation [2].

$$\ln \Pi = \beta_0 + \beta_{Ti} \ln P_{Ti} + \beta_L \ln P_L + \beta_F F + \beta_\lambda \lambda + \epsilon \qquad [\mathbf{4}]$$

P_{Ti} is the price of harvested timber products, P_L is the wage rate of labor, and F is the amount of protected forest in the watershed. λ is the selection parameter estimated in the first step of a 2-step Heckman estimation.

In our sample, non-zero forest profits are observed for 49 out of the 97 observations, suggesting the existence of sample or self-selection. Forest profits are known for the actively logging households, but the "reservation" profit, or the minimum profit that non-logging household require to harvest, is not known. Among the various methods for analyzing zero-inflated data of this nature, we choose Heckman's (1979) two-step estimation technique that produces efficient and consistent estimators. (See Deaton [1997] and footnote [6] for further discussion of two-stage models).

The probit regression is defined in Equation [5] as

$$\text{Prob}(q_i>0) = \beta + \beta_{Ti} \ln P_{Ti} + \beta_L \ln P_L + \beta_K K + \beta_F F + \epsilon \qquad [\mathbf{5}]$$

In addition to variables described for the forest profit function, K represents a vector of socio-demographic characteristics and opinions that influence the zero/non-zero profit levels. These include the education level of household head, age of the household head, size of household, and whether the respondents believe that loggers are often fined or their products confiscated for logging within the protected forests. We include socio-demographics and opinions only in the selection model (and not in the substantive model) because these variables are likely to influence the decision to log and not the substantive logging profits.[6]

In order to test for wealth effects, we interact the wealth dummy with all explanatory variables to implement the cross-sectional version of the Chow-test. Differences across wealth groups can be evaluated by testing the significance of the F-statistic for the hypothesis that coefficients on all interaction variables are collectively equal to zero. The interaction variables can accommodate different size and sign coefficients across groups, and the effect for the rich households is measured as the sum of the coefficient on the variable and the variable interacted with the wealth dummy. However, determining the precise political, cultural, or socio-economic process by which different households use the forest is beyond the scope of this paper.[7] We use the idea to motivate the idea of heterogeneous use and leave it to the empirical analysis to provide evidence.

6. TWO-STAGE HECKMAN MODEL RESULTS

We begin with a discussion of the results of the Heckman selection model. The overall model is significant, explaining 76% of the binary choice of whether or not a household harvests. The results of the probit model, reported in Table 2, offer several insights. Product and input prices weakly influence this decision, although they seem to influence the amounts of profit (see 2nd stage results below). As discussed previously, demographic characteristics, such as age and education, influence the participation choice. Younger and less educated households are more likely to log. Moreover, households living in watersheds with greater amounts of protected forests are less likely to log. Coefficients of the probit model are used along with household specific

[6]We understand that identifying the general model is a delicate matter (Deaton, 1997). Recognizing this, we have implemented alternatives such as the Cragg, Tobit and Two-part models and find that our results are reasonably robust to these 3 alternative specifications.

[7]Godoy and Bawa (1993) hypothesized that richer households depend less on forest products, spending less time to collect fewer products that comprise a smaller part of their income. Several studies have found that in general forest use behavior is different among poor and rich households (Godoy, Brokaw, and Wilkie, 1995; Wickramasinghe, Pérez, and Blockhus, 1996; Gunatilake, 1997).

observation on all variables in the model to calculate household specific probability of participation, which is used as an explanatory variable for the 2nd stage profit model.

The profit model is statistically significant as shown by a F-statistic of 3.68 and has an adjusted R^2 of 0.36. Importantly, the signs and size of the statistically significant coefficients, described in Table 3, add theoretical credibility to the model. This result and the significance of the coefficient of λ, with a probability value < .001 and a log ratio $\chi^2(1)$ statistic of 16.3, show the relevance of the 2 stage Heckman approach. The joint and individual significance (measured by F and t-statistics) suggest that forest profit function varies across poor and rich households.

First, we discuss the results for the poor households. Their profits, or their forest uses, are not sensitive to prices of class I and II or the better quality timber. This could be because these households have few or no credible production alternatives and continue to harvest irrespective of timber price levels. They are, however, sensitive to changes in wages and to the opportunity costs of their labor, their most important resource. The estimated labor demand elasticity of –1 suggests that increases in wages cause households to seek the alternative income opportunities. The coefficient of the class III timber price is negative and statistically significant. One interpretation of this result is that poor households use this timber as a production input. A key result is the negative coefficient of the protected forest variable. This suggests that designating greater amounts of protected forests reduces forest access for the poorer households.

For the rich households, the statistical significance of the variables is determined by the joint significance of the coefficients of the variables by themselves and the variables interacted with the wealth dummy. Rich households' profits, or their forest uses, are positively sensitive to the class I timber price. In contrast to poor households, the rich may have credible production alternatives and can respond to changes in prices of forest products. The price elasticity for class I timber is 2.5. The coefficient of the class II and III timber price is negative and significant. Profits of richer households, however, are not sensitive to changes in wages. This change in sign and statistical significance of price coefficients across household groups (*i.e.,* from poor to rich) suggest heterogeneity in using forests and responding to market signals.[8] The positive coefficient of the protected forest variable indicates that protection indirectly makes available greater amounts of forest to the rich households. As we emphasized earlier, accessibility is likely to be a condition of wealth and political status; the sign switch of the coefficient on forest size offers evidence that this is true.

7. WELFARE ANALYSIS: SIMULATING COSTS AND BENEFITS

The data and analysis above shows that forest protection in Manggarai region will effect the economic welfare of several logging households living in and around the forests. Consider the

[8] A referee has pointed out an intriguing possibility that different households face different effective prices because socio-cultural status allows them to somehow negotiate or bargain differently.

extreme conservation policy of an enforceable complete ban on logging all forest products. Based on Equation [3], we see that the representative household will lose $400 of forest profits annually, where a representative household is characterized as having the statistical mean characteristics. The 90% confidence interval for loss in logging profits is $340 – $460.[9] These represents the upper bound of welfare loss because 100% enforceability is impossible and the households will continue to harvest products from forests that they collectively and individually own and manage (as opposed to state owned forests, including Ruteng Park). Nevertheless, such an estimate can be the starting point for any policy discussions regarding compensation for the logging households, if a total ban on forest extraction is deemed optimal and viable. The form of such compensation would need to include a variety of non-monetary strategies such as promoting fast-growing species on private and village forests.[10] We return to these strategies later in the paper.

An important finding from the regression analysis is that any forest policy that merely designates greater areas of ‘protected’ forests will have serious regressive effects. The different signs on the forest size coefficient indicate that poor households will bear losses while the richer will realize gains. We use the regression coefficient of the protected forest variable to simulate this regressive effect. We estimate the effect on profits of increases in designated protected forests by 10%, 25% and 50% (or the maximum watershed area). For households in each wealth group, we calculate baseline and policy induced profit levels. The average change in profits for each wealth group and for each policy level is reported in Figure 1. For example a 25% increase in forest size will decrease profits by $52 for the poor households, and increase profits by $313 for the rich households. The bottom line is, that in its current form, simply designating greater amounts of forest cover will create losers and gainers in a distinctly regressive manner. In addition, continued forest extraction by rich households will deplete existing forest stocks and further deforestation.

8. ECONOMIC INSTRUMENTS AS POLICY LEVERS

The previous section shows the magnitude and distribution of economic losses from a forest conservation policy that either completely restricts forest use or merely designates greater protection on paper. Since such policies will be politically difficult and inequitable, park managers could use permits and tax-subsidy schemes to conserve forests by modifying the intensity and magnitude of forest use. The Ministry of Forestry believes that instead of a complete

[9]Given the small size of the data, the 90% confidence interval for the population mean is computed using bootstrap procedures that comprised of drawing 100 observations, recording the mean profit, and repeating the process 1000 times (Hamilton, 1992).

[10]As pointed out by a referee, the actual compensation policy would be a dynamic process. Determining the actual time path of payments to compensate for restricted use is beyond the scope of our paper. Instead, our utility-profit maximizing framework can be used to estimate the maximum income loss of different household types. Our estimates provide a starting point for a dialogue between the park officials and the logging community regarding the size of compensation. For a discussion of compensation programs see Ferraro and Kramer (1997). Blomkvist (1995) and Moeliono (1995) discuss logging compensation issues in the Manggarai region.

ban, logger cooperatives could engage in controlled selective harvests (Blomkvist, 1995). In addition, 76% of the logger households support some form of regulated forest use. 71% households said that they did not expect their children or grandchildren to be loggers, given current resource use trends. Below we discuss the permit and tax/subsidy schemes, which are examples of economic instruments proposed in previous assessment of the logging in Manggarai (Moeliono, 1995).

Logging Permits

A permit or license system would conserve forests by restricting forest use to permit holders[11]. Although such a scheme will impose transactions and operational costs, perhaps the greatest uncertainty and potential impediment lies with the local people's willingness to buy into such a scheme. In the case of Ruteng Park, however, there is evidence of local support for logging permits, as measured by peoples' stated willingness to pay (WTP) for permits. Logger households were directly questioned to elicit their WTP for the logging permits using contingent valuation (CV). In this methodology, values are elicited by first describing a proposed service, and its market to the survey respondents, and then asking them directly to state their WTP for the proposed service (Whittington, 1998; Shyamsundar and Kramer, 1996). All households in the sample were asked about their WTP an annual logging permit to cut trees in the government forests and buffer zone forests. The median and mean for WTP are $4.55 and $5.50. We emphasize that this does not represent exact measures of local people's value of the forests of Ruteng for logging. Instead, the WTP data provides a referendum of support for the permit scheme and that the policy signal lies in the direction rather than the magnitude of WTP. The referendum argument is further supported by the expected correlation of the WTP amount with economic factors and opinions as documented in regression results reported in Table 4. For example, households who had higher incomes and fewer adverse experiences with park officials were willing to pay more for permits. Although this parsimonious specification is not a comprehensive model of WTP, it allows us to investigate and verify the credibility of the WTP estimates. We conclude that regulating forest use by a permit scheme is a viable alternative to a complete ban on forest use because it enjoys the support of the local people.

Price Policies—Taxes and Subsidies

Some household's sensitivity to prices, as illustrated by the profit model results, suggests that logging pressures could be alleviated via a tax or subsidy system. Taxing ecological sensitive timber classes would decrease the real price received by loggers, thus making them less

[11] Critics of permitting systems for environmental conservation may argue that it is essentially an academic concept that has only recently gained policy recognition and use in the developed countries. In many parts of the developing world, including Indonesia, however, licensing and permitting schemes are fairly common in the case of rationed goods and services.

profitable. For example, a tax on class I timber will decrease extraction by rich households.[12] By similar logic, price subsidies (or premiums) could be provided for more abundant timber classes making them more attractive to extract. Similar tax breaks could be provided for timber from sustainable logging operations and from private lands (Moeliono, 1995). Perhaps the best use of government funds would be to invest in non-timber sectors and improve income alternatives (Blomkvist, 1995; Moeliono, 1995), which will raise the opportunity cost of labor. The sensitivity of poorer households to wage rates suggest that they will respond to income alternatives by reducing their logging activities. Any such tax-subsidy proposal, however, must carefully weigh the ecological gains against the administrative and political costs.

Previous assessments have also recommended other policies to reduce logging pressure on the forests within the Park. Blomkvist (1995) and Moeliono (1995) have argued in favor of government subsidies to promote plantations of fast growing species on private and common lands. In the short run, they suggest educating the consumer (including the local governments and church) about using non timber substitutes in construction such as bamboo in scaffolding. Blomkvist (1995) also recommends spatial targeting of conservation efforts in order to channel logging away from core areas. Long run schemes include promotion of agroforestry, which can produce timber and fuelwood, and intensive agriculture.

9. CONCLUSION/SUMMARY

Few studies use household level data to quantitatively examined the role tropical forest conservation has on the local economy. The debate over tropical forest conservation remains contentious in the absence of quantitative evidence on the local benefits or costs of protection. Rigorous micro-econometric studies can serve two purposes. First, they can produce reliable estimates of the degree and distribution of local compensation for scenarios in which locals bear the costs of policies that generate largely global benefits. Second, they allow analysts to examine a range of conservation alternatives, including partial forest protection implemented with permits, taxes and subsidies. We surveyed logging households in the buffer zone of Ruteng Park in Manggarai, Indonesia to develop micro-level measure forest dependence in terms of forest profits and correlate it with prices, wealth and forest size by estimating a profit function. Regression analysis reveals differences in forest use behavior across rich and poor households. Rich households are sensitive to changes in prices of forest products, while poor households are sensitive to labor wages. We also see that merely designating greater areas of 'protected' forests will have serious regressive effects. Calculated profits show that representative logging households can lose as much as $340-$460 of the annual income from a policy that completely bans forest uses.

[12]This policy has some 'regressive' effects because the poorer households (lower wealth group), are insensitive to prices. Therefore, in the interest of distributional fairness, taxes could be levied on those sensitive timber classes mainly targeted by the wealthier group.

We conclude that complete restriction on forest use will be politically difficult and will require compensation. Moreover, simple designation of forest protection creates the twin problems of hurting the poorer local households and furthering local deforestation by rich households. Instead, the government should consider economic instruments such as permits and taxes/subsidies. Contingent valuation data shows that regulating forest use by a permit scheme is a viable alternative because it enjoys the support of the local people, as measured by the WTP data. The household's sensitivity to prices, as illustrated by the profit model results, suggests that logging pressures could be alleviated by taxing class I timber and raising the opportunity cost of labor through employment opportunities. The governments of developing countries have taken substantial strides towards tropical forest protection. Economic instruments can help them design forest protection policies that distribute benefits more evenly and pay attention to the people living at the forest margins.

REFERENCES

Blomkvist, L. 1995. *Forestry and Silviculture Specialist Report on Ruteng.* Directorate General of Forest Protection and Nature Conservation, Ministry of Forestry. Jakarta, Indonesia.

Deaton, A. 1997. *The Analysis of Household Surveys: A Micro-econometric Approach to Development Policy.* Johns Hopkins University Press. 479 p.

Eisen-Hecht, J., R.A. Kramer, and E.O. Sills. 1998. "International Backpacker Tourism in Indonesia." Working Paper. Durham, NC: Duke University.

Ferraro, P., and R. Kramer. 1997. "Compensation and Economic Incentives: Reducing Pressure on Protected Areas." Chapter 9 in R.A. Kramer, C. van Schaik, and J. Johnson (ed.), *Last Stand: Protected Areas and the Defense of Tropical Biodiversity*, Oxford University Press.

Garcia, P., B. Dixon, J. Mjelde, and R. Adams. 1986. "Measuring the Benefits of Environmental Changes Using a Duality Approach: The Case of Ozone and Illinois Cash Gain Farms." *Journal of Environmental Economics and Management* 13(1):69-80.

Godoy, R., N. Brokaw, and D. Wilkie. 1995. "The Effect of Income on the Extraction of Non-Timber Tropical Forest Products: Model, Hypotheses, and Preliminary Findings from the Sumu Indians of Nicaragua." *Human Ecology* 23(1):29–51.

Godoy, R., and K.S. Bawa. 1993. "The Economic Value and Sustainable Harvest of Plants and Animals from the Tropical Forest: Assumptions, Hypotheses, and Methods." *Economic Botany* 47(3):215-219.

Gunatilake, H. 1997. "The Role of Rural Development in Protecting Tropical Rainforests: Evidence from Sri Lanka." *Journal of Environmental Management* 53:273–292.

Hamilton, L. 1992. "Computer Intensive Methods." In *Regression with Graphics: A Second Course in Applied Statistics*. Duxbury Press, California.

Heckman, J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1):153-162.

Klemperer, W. 1995. *Forest Resource Economics and Finance*. McGraw-Hill College Divison, New York.

Kramer, R.A., S. Pattanayak, E. Sills, and S. Simanjuntak. 1997. *The Economics of the Siberut and Ruteng Protected Areas*. Final Report submitted to Directorate General of Forest Protection and Nature Conservancy, Ministry of Forestry, Indonesia. Nicholas School of the Environment, Duke University, Durham, NC.

Kremen, C., J. Niles, M. Dalton, G. Daily, P. Ehlrich, J. Fay, D. Grewal, and R. Guillery. 2000. "Economic Incentives for Rainforest Conservation Across Scales." *Science* 288(5472):1828-1832.

Ministry of Forestry, Directorate General of Forest Protection and Nature Conservation, *Ruteng Nature Recreation Park Integrated Conservation and Management Plan*, Volume 1-3, Biodiversity Conservation Project in Flores and Siberut, ADB Loan No. 1187-INO (SF), Jakarta, Indonesia, August 1995.

Moeliono, M. 1995. *Wood Use in the Manggarai*. Intercooperation. Ruteng, Flores, Indonesia.

Pattanayak, S., and R. Kramer. 2001. "Worth of Watersheds: A Producer Surplus Approach for Valuing Drought Control in Eastern Indonesia." *Environment and Development Economics* 6:123-145.

Sadoulet, E., and A. de Janvry. 1995. *Quantitative Development Policy Analysis.* John Hopkins University Press, Baltimore.

Shyamsundar, P., and R. Kramer. 1996. "Tropical Forest Protection: An Empirical Analysis of the Costs Born by Local People." *Journal of Environmental Economics and Management* 31:129-144.

Whittington, D. 1998. "Administering Contingent Valuation Surveys in Developing Countries." *World Development* 26(1):21-30.

Wickramasinghe, A., M. Pérez, and J.M. Blockhus. 1996. "Nontimber Forest Product Gathering in Ritigala Forest (Sri Lanka): Household Strategies and Community Differentiation." *Human Ecology* 24(4):493-519.

WRI. 2000. "Taking Stock of Forest Ecosystems." In *People and Ecosystems: The Fraying Web of Life. World Resources 2000-2001.* World Resources Institute: Washington D.C.

Zurita, P. 2000. Ecosystem Valuation: Concepts, Theories and Empirics. Unpublished M.E.M Thesis. Nicholas School of the Environment, Duke University, Durham.

Table 1. Watershed Specific Descriptive Statistics

Watershed	Size of Watershed	Size of "Protected Forest"	Average Forest Profit ($US)
1	420	315	178
2	1270	240	436
3	1707	815	421
4	1287	500	153

Table 2. Results of Probit Model of Zero/Non-zero Profits

Variable Name	Estimated β	P-Value
Ln (Wage)	0.332	0.470
Ln (Price of Class I Timber)	0.894	0.282
Ln (Price of Class II Timber)	–0.308	0.790
Ln (Price of Class III Timber)	2.098	0.007
Ln (Price of Class IV Timber)	–14.718	0.001
Age of household's head (*years*)	0.004	0.882
Average age of household (*years*)	–0.032	0.069
Household size	–0.028	0.773
Education (*years*)	–0.302	0.147
Size of Protected Forests (*hectares*)	–0.002	0.027
Familiar with fines /confiscation for logging in protected forest (0=*no*; 1=*yes*)	–0.207	0.536
Constant	78.642	0.002

Table 3. Profit Function Estimates: 2nd Stage Heckit Model

Variable Name	Estimated β	P-Value
Ln (Wage)	–2.00	0.002
Ln (Price of Class I Timber)	–1.04	0.291
Ln (Price of Class II Timber)	–0.09	0.947
Ln (Price of Class III Timber)	–1.52	0.015
Ln (Wage) * Wealth Dummy	–0.77	0.615
Ln (Price of Class I Timber) * Wealth Dummy	4.46	0.007
Ln (Price of Class II Timber) * Wealth Dummy	–6.33	0.001
Ln (Price of Class III Timber) * Wealth Dummy	2.37	0.007
Size of Protected Forests	–0.002	0.092
Size of Protected Forests * Wealth Dummy	0.006	0.031
Constant	49.75	0.000
Inverse-Mills Ratio	1.11	0.134

Table 4. Robust Regression* of Ln (WTP) for Logging Permits

Variable Name	Estimated β	P-Value
Natural Logarithm of Annual Profit from Logging Outputs (Rupiah)	0.066	0.018
Size of Protected Forest in Watershed (hectares)	0.001	0.086
Size of Protected Forest in Watershed (hectares) * Wealth Dummy	0.002	0.075
Experience with fines or confiscation for logging in protected forest (0=no; 1=yes)	0.358	0.321
Experience with fines or confiscation for logging in protected forest * Wealth Dummy	–2.180	0.036
Constant	7.902	0.000

*corrected for watershed specific heteroskedasticity

Figure 1. Forest Profits and Policies