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Labor Allocation to Non-Timber Forest Products Extraction: The Case of a Lacandona Rainforest Community

by

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Giannini Foundation of Agricultural Economics

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Abstract

The commercial extraction of non-timber forest products (NTFP) from tropical forests has been considered as a strategy to promote forest conservation and at the same time alleviate poverty. However, recent studies produce conflicting findings regarding the effect of NTFP extraction on conservation and poverty alleviation while highlighting the importance of understanding the economic logic underlying households' decisions to extract NTFPs. This paper analyzes the determinants of household participation in the extraction of *xate* palm, a non-timber forest product, in the Lacandona Rainforest (*Selva Lacandona*). Results show that low opportunity costs and low human capital, two strong correlates of rural poverty, significantly explain individuals' participation in *xate* extraction.

I. Introduction

The commercialization of non-timber forest products (NTFPs) has been considered by many organizations and governments as a strategy that could lead to a win-win situation in which poverty alleviation and forest conservation are simultaneously achieved (Ros-Tonen 2000; Angelsen and Wunder 2003). The attention given to the commercial extraction of NTFPs as a conservation strategy comes from two implicit assumptions: a) Harvesting of NTFPs is less destructive, in terms of biodiversity, than timber harvesting, and, b) Increasing the returns from NTFPs for locals provides incentives to conserve forests. If, in addition, those who extract the resource are poor, then it is argued that an increase in the price (or the quantity demanded) of NTFPs could alleviate poverty while promoting conservation (Neumann and Hirsch 2000; Belcher, Ruíz-Pérez, and Achdiawan 2005). This market-based conservation and development approach assumes that the link between the income of local populations and conservation is positive and that there will be no unintended negative consequences (e.g., an increase in income leading the poor to buy more cattle and thus increase deforestation for pastureland).

Findings from a number of studies suggest that the effects of extraction on forest conservation and poverty reduction are ambiguous or even negative (Browder 1992; Wunder 2001; Lybbert, Barrett, and Narjisse 2002; Angelsen and Wunder 2003). These studies point out that the role that NTFP extraction could play in promoting conservation and poverty alleviation is case specific, and the effective implementation of conservation and development programs in rainforest areas requires an understanding of the microeconomic logic behind activity choice and resource use decisions among heterogeneous households (Coomes and Barham 1997). The case of *xate* extraction in Mexico's Lacandona Rainforest (*Selva Lacandona*) shows that, even in a single village, heterogeneity across households can lead to very different natural resource use decisions.

The main objective of this paper is to understand the determinants behind households' decisions regarding their allocation of labor to natural resource extraction. In particular we address the following questions: When all individuals in a village have access to a natural resource and extraction requires no physical capital, why do some individuals and households participate in extraction and others do not? Is there a negative relationship between the opportunity cost of a day of work and the allocation of labor to NTFP extraction? The next section presents the theoretical and empirical models for labor allocation. Econometric results are presented and discussed in section III. Section IV concludes.

II. Labor Allocation and NTFP Extraction

The empirical literature on the microeconomics of NTFP extraction is relatively sparse. The majority of studies look at firewood (e.g., Bluffstone 1995; Amacher, Hyde, and Kanel 1996; Köhlin and Parks 2001) or include NTFP extraction as part of an aggregate measure of natural

resource extraction (e.g. Takasaki, Barham, and Coomes 2000; Fisher, Shively, and Buccola 2005). A more recent set of studies focus on particular NTFPs (e.g., Lybbert et al. 2002; Escobal and Aldana 2003) or groups of NTFPs (e.g., Coomes, Barham, and Takasaki 2004) that are commercialized outside of the extractor's village and analyze the role of NTFPs in terms of poverty alleviation or resource conservation. The present paper extends that literature. It focuses on a commercial NTFP, which is not consumed by extractors, and on the effect that physical and human capital have on households' extraction decisions. Contrary to past NTFP-specific studies, but similar to firewood studies, we explicitly include the opportunity cost of time as one of the determinants of labor allocation. We also include a variable that partially captures the potential influence of culture or tradition on extraction decisions.

Labor allocation decisions are assumed to take place at the level of the farm household. We allow individual household members to have different productivities or access to employment opportunities. This makes it possible to study the role that individuals' characteristics (like age and education) play in the allocation of labor to NTFP extraction. Our modeling approach yields estimates of the marginal effects of explanatory variables on the supply of labor to NTFP extraction, providing a basis for understanding potential impacts of specific policies interventions (e.g., to promote off-farm employment) on extraction practices and poverty. The data used for the empirical analysis include information on both extractors and non-extractors (contrary to some previous studies, e.g., Escobal and Aldana 2003). Thus, marginal effects can be calculated for the whole population as well as for the subpopulation of extractors.

A. Theoretical Model

The economic analysis of NTFP extraction followed here is based on a household farm model. Each household i is formed by J_i working members and K_i non-working members (to simplify notation the household subscript is omitted whenever possible). Each working member of the households has an endowment of T days per period of time. Households maximize utility subject to an endogenous budget constraint that depends on their decision of how to allocate their working members' labor across different activities.

Households' NTFP extraction decisions are affected by the resource stock available at time t , which in turn is affected by aggregate extraction at $t-1$. The model is therefore initially set up as a multi-period problem in which households maximize utility over time.

Households derive utility from consumption of a composite good (C_t) and leisure of working members (l_{jt}), given a vector F_t of household and individual characteristics that are treated as exogenous. The number of non-working members of the household is included in this vector. The utility function, $U(C_t, l_{1t}, \dots, l_{jt}; F_t)$, is assumed to be strictly increasing in consumption and leisure. Utility is discounted over time by a discount factor r . To maximize utility, households allocate their total time endowments (JT) across three alternatives: leisure (l_{jt}), NTFP extraction work (L_{jt}^{NT}) and work in other productive activities (L_{jt}^O). We allow for members of the same household to have different productivities depending on their individual characteristics (e.g., age, sex or education). Access to a given activity may vary across members of the same household. Hired labor and family labor are not assumed to be perfect substitutes.

The amount of NTFP that an individual can extract at a given point in time is given by

$$q_{jt}^{NT} = q_{jt}^{NT}(L_{jt}^{NT}; S_t, \theta_{jt}) \text{ where } S_t \text{ is the stock of the resource available at time } t \text{ and } \theta_{jt} \text{ is a}$$

vector of household and individual characteristics that can affect the individuals' ability in extraction. The only cost of extraction is the time involved; no inputs or assets are needed. The price of the NTFP, p_t^{NT} , is set by the international market. The growth function of the resource is $S_{t+1} - S_t = g(S_t) - H_t$, where $g(S_t)$ is the density-dependent natural rate of growth of the resource population without extraction, and $H_t = \sum_{i=1}^N \sum_{j=1}^J q_{jit}^{NT}$ is the amount of NTFP extracted by all households at time t .

The composite production function for other activities is $q_t^O = q^O(L_t^O, \dots, L_{jt}^O, L^H; \mathbf{A}_t)$, where \mathbf{A}_t is a vector of physical capital (e.g., land) and other individual- and household-specific characteristics that affect farm productivity and are taken as given by the household.

A budget constraint ensures that consumption expenditures equal the sum of NTFP income, income from other productive activities and exogenous income (E_t). Therefore, in order to maximize utility households solve the following problem:

$$\begin{aligned}
 & \underset{C_t, L_{jt}^{NT}, L_{jt}^O, L_t^H, l_{jt}}{\text{Max}} \quad \sum_{t=0}^{\infty} \left[r^t * U(C_t, l_t, \dots, l_{jt}; F_t) \right] & (a) \\
 & \text{s.t.} \quad p_t C_t = p_t^{NT} \left(\sum_{j=1}^J q_{jt}^{NT} \right) + p_t^O q_t^O - w L_t^H + E_t \\
 & \quad T_j = L_{jt}^{NT} + L_{jt}^O + l_{jt} \\
 & \quad \sum_{j=1}^J T_j = JT \\
 & \quad q_{jt}^{NT} = q_{jt}^{NT}(L_{jt}^{NT}; S_t, \theta_{jt}) \\
 & \quad q_t^O = q_t^O(L_t^O, \dots, L_{jt}^O; \mathbf{A}_t)
 \end{aligned}$$

The NTFP that households extract is located in a common property forest and there are no rules that control extraction by community members. In this setting of unmanaged common

property, households have limited incentives to incorporate future effects of current extraction decisions into their optimization problem. The result is the same as in a situation of open-access: at each period households solve static maximization problems, taking as given and out of their control the time path of the stock of the NTFP as well as those of all exogenous variables (Bluffstone 1995; Damania et al. 2003). Consequently, problem (a) simplifies to maximization of utility on a period-by-period basis.¹ Brooks et al. (1999) have shown that if one can assume that, under sole ownership, the total present value of all future extraction is finite, then the resulting paths of the period-by-period rent dissipation method are equivalent to what one obtains using a game-theoretic analysis.

Given this framework, labor allocation has two important characteristics. The first is that production and consumption decisions are not separable, implying that household characteristics like size and land endowments could affect production decisions. The second is that labor allocation can vary across individuals belonging to the same household. By solving the first-order conditions of the period-by-period version of problem (a) we can obtain individual labor allocation as summarized by the following set of reduced form equations:

$$L_{jit}^{NT} = L_{jit}^{NT}(\mathbf{p}_t, S_t, \mathbf{F}_{jit}, \mathbf{A}_{jit}, \boldsymbol{\theta}_{jit})$$

$$L_{jit}^O = L_{jit}^O(\mathbf{p}_t, S_t, \mathbf{F}_{jit}, \mathbf{A}_{jit}, \boldsymbol{\theta}_{jit})$$

where $\mathbf{p}'_t = [p_t^{NT}, p_t^O, w_t]$. The first equation is the one estimated here; that is, we estimate labor allocation to NTFP extraction at the individual level. In this model, household i decides how much of individual j 's labor, if any, will be allocated to NTFP extraction at time t .

B. Empirical Strategy

As a result of the maximization of utility, some households decide to allocate labor from all or some of their members to NTFP extraction, while the optimal choice for other households is a corner solution where nobody works in extraction ($L_{jit}^{NT} = 0 \forall j$). This implies that labor allocated to resource extraction can assume a value of zero with positive probability, but it is continuous over positive values. In other words, there is a censoring problem when analyzing time allocation to NTFP extraction.

We estimate a model that includes the opportunity cost of time (w_{jit}) as an explanatory variable. This allows us to disentangle the direct effects that exogenous variables have on labor allocation from the indirect effects that occur through the opportunity cost of time. The choice of whether or not to allocate labor to the alternative activity, which is simultaneous with the allocation of labor to NTFP extraction, affects the returns that a given individual can obtain from a day of work in non-NTFP activities. Thus, w_{jit} is endogenous (i.e., u_{jit} and v_{jit} , as defined below, are correlated). To correct for the inconsistency of the estimators implied by the endogeneity of w_{jit} the following instrumental variables tobit model is estimated:

$$L_{jit}^{NT} = \max(0, L_{jit}^{NT*}) \quad (1)$$

$$L_{jit}^{NT*} = \alpha_1 + \rho w_{jit} + \pi'_{jit} \beta_{\pi} + \beta_{\tau} \tau_t + u_{jit}$$

$$w_{jit} = \alpha_2 + \mathbf{z}'_{jit} \gamma_z + \gamma_{\tau} \tau_t + v_{jit} \quad (2)$$

where L_{jit}^{NT} measures the number of days allocated to NTFP extraction by individual j from household i at the time period t . L_{jit}^{NT*} is a latent variable, and the vector \mathbf{z}_{jit} includes the household and individual information contained in \mathbf{A}_{jit} , \mathbf{F}_{jit} and $\boldsymbol{\theta}_{jit}$. More specifically,

$\mathbf{z}_{jit}' = (\boldsymbol{\pi}_{jit}', \boldsymbol{\eta}_{jit}')$, where $\boldsymbol{\pi}_{jit}'$ is a vector of exogenous variables and $\boldsymbol{\eta}_{jit}'$ is a vector of instruments.

This model is estimated using maximum likelihood under the assumption that (u_{jit}, v_{jit}) are distributed as multivariate normal.

The normality assumption is critical. If normality is not satisfied, the tobit estimator not only is inconsistent but also suffers from a problem of incorrect functional form for the expected values of the dependent variables. We test the normality assumption using the conditional moment test with bootstrapped critical values proposed by Drukker (2002). This bootstrap method corrects for a size problem that arises when relying on asymptotic critical values.

Prices (p_t) and the stock of NTFP (S_t) are omitted from the equations to be estimated, although they were part of the reduced form equations derived above. The data available (see next section) come from a single village, and prices do not vary across individuals at a given point in time. The same is true for the stock of the NTFP that is available from common property. A year dummy (τ) is included in the estimation to indirectly account for changes in prices and NTFP stock over time. Unfortunately, this procedure does not allow us to disentangle the effects of changes in prices from changes in stock or other variables that are constant across individuals but may change over time (e.g., weather).

III. Labor Allocation Results

A. Data Set, Descriptive Statistics and Expected Signs

The data to estimate the model come from two household surveys applied by one of the authors in Frontera Corozal, Mexico, during 2001 and 2004.² In the first round of the survey 100 randomly selected households (approximately 10% of the population) were interviewed; these households were visited again during the summer of 2004.³

Frontera Corozal is a village in the *Selva Lacandona* (Lacandona Rainforest) in the Mexican state of Chiapas. The Lacandona Rainforest is a tropical forest characterized by its importance in terms of biodiversity (it encompasses the Montes Azules UNESCO Biosphere Reserve) as well as by its archeological and cultural richness (SEMARNAP, 1996). It sits right at the center of the Mesoamerican Biological Corridor, arguably one of the most ambitious conservation and sustainable development projects in Mesoamerica (Conabio 2003).

The natural resource on which this research focuses is the *xate* palm (*Chamaedorea* spp.), a marketable NTFP that grows under the cover of forests. *Xate* palm leaves are used by the floral industry as a backdrop for flowers in wedding and funeral displays. They are also in demand during Easter season, particularly on Palm Sunday.

Xate extraction is an important income generating activity for rural communities located in or around forests in México and Guatemala (Endress et al. 2004; Sánchez-Carrillo and Valtierra-Pacheco 2003; CEC 2002). *Xate* leaves extracted from these communities have been sold in national markets or exported to Canada, Europe and the United States since the 1950s. Mexico supplies 80% of the world's *xate*, and Guatemala supplies 12% (Rainforest Alliance 2005a). Recently, there have been some concerns about the sustainability of *xate* extraction from wild populations given the degree of extraction in both countries (CEC 2002; Endress et al. 2004; Rainforest Alliance 2005b). In the Lacandona Rainforest *Xate* is the most important NTFP in terms of its contribution to cash income for households (Vásquez-Sánchez, March, and Lazcano-Barrero 1992). Our surveys found that, in Frontera Corozal, *xate* income can represent up to 75% of an individual household's income.

In México the process of transporting *xate* fronds from forests to markets can be summarized as follows: extractors gather palm leaves and deliver them to local collectors; a

regional buyer then picks up the leaves and transports them to a regional collection center; then the leaves are sent to wholesale markets in Mexico and abroad. There are only a few regional buyers in Mexico; they are the ones who set the purchase price that will be paid to local extractors.

Xate has attracted the attention of national and international organizations as a possible means to simultaneously promote development and conservation. Recently, the North American Commission for Environmental Cooperation began to evaluate the possibility of establishing a green market for *xate* under the assumption that it will lead to the conservation of forests and at the same time to the improvement of local economic conditions (Bowman 2003; CEC 2002). A pilot project to purchase *xate* fronds harvested in México and Guatemala took place during March 2005 and April 2006 as part of this effort (CEC 2005; Dean Current, personal communication, 2006).⁴ The efforts of USAID, the Rainforest Alliance, other NGOs, and the national government to promote sustainable *xate* extraction in the Petén Region of Guatemala are another example of the interest in *xate* as a conservation and development tool (Heinzman and Reining 1990; Rainforest Alliance 2005a).

In an effort to evaluate its implications for biological sustainability, *xate* has also been the focus of research on the impact that extraction has on the dynamics of palm populations; this has seldom been done with other NTFPs (Endress et al. 2004). Unlike most NTFP research, these studies could eventually provide the necessary information to incorporate biological aspects of *xate* explicitly into an economic model of extraction.

Community members have exclusive rights to extract natural resources from the contiguous rainforest; nevertheless, there are no community rules on how these resources,

including *xate*, should be managed (Sánchez-Carrillo and Valtierra- Pacheco 2003; Tejeda 2004). *Xate* can therefore be considered as an unmanaged common property resource.⁵

The wild population of *xate* in Frontera Corozal has been characterized as being in a state of deterioration (Sánchez-Carrillo and Valtierra Pacheco 2003; Tejeda 2004). Sánchez-Carrillo and Valtierra Pacheco found that hours of work per day in *xate* extraction increased from 1996 to 2001 while productivity per day decreased. This is consistent with the perceptions of those interviewed in the 2004 survey; 68% of respondents who extracted *xate* thought that *xate* was harder to find than in previous years.

Unfortunately, there is no systematic information about how the stock and quality of wild *xate* around Frontera Corozal have truly changed over time. It is important to clarify that the information required to do this includes the change over time in the availability of marketable *xate* leaves and not only the change in the stock of *xate* palms. This distinction is crucial. As shown by Endress et al. (2004), it is possible that *xate* extraction will lead to a situation in which the leaves produced by the palms are shrinking in size, thus losing their market value.

Table 1 summarizes the variables that are included in the econometric model. The sample consists of 329 individual observations for 2001 and 338 individual observations for 2004 from 86 households. All individuals included in the sample are 13 years of age or older.

Education is expected to positively affect individuals' opportunity cost of time.⁶ Schooling could also decrease individuals' willingness to participate in risky physical activities like *xate* extraction. The number of individuals in the household who have completed elementary school or who have more than 9 years of education is expected to positively affect the opportunity cost of time, due to human capital complementarities. Households with higher

levels of education are expected to have higher returns in activities that potentially involve more than one family member (e.g., agriculture and family businesses).

Xate extraction in the rainforest is a labor intensive and physically demanding activity that involves walking long distances; we therefore expect to find an inverted U-shaped relationship between age and *xate* extraction. Although participation of women in *xate* is higher than in other activities (e.g., agricultural employment), it is still the case that extraction is an activity dominated by men. The effect that the size of the household has on *xate* extraction is not clear *ex-ante*.

Xate extraction does not require capital. However, wealth and physical capital affect the opportunity cost of time through other activities. Individuals in poorly endowed households are constrained from participating in the most remunerative activities requiring capital investments. When access to credit is limited and dependent on endowments or credit markets do not exist, households must self-finance production activities. Proxies for household wealth include cattle holdings, land ownership, and an index of family assets. The index is constructed from dwelling characteristics and ownership of durable goods (including boats or cars) using principal components analysis following Filmer and Pritchett (2001). These three variables are expected to have a positive effect on the opportunity cost of time but are not expected to have any direct effect on *xate* labor allocation.

A dummy variable, “Tradition”, takes on the value of one if the parents of the household head and/or the parents of the spouse ever participated in the extraction of non-timber forest products. It is included as a proxy for the role of culture, tradition or familiarity with extractive activities in the estimation of the *xate* labor allocation equation. A time dummy (1 for 2004, 0 for 2001) is also included in the econometric estimation.

B.. Identification Strategy and Estimation Results

The first potential identification problem that we face is sample selection: not all individuals in the sample participate in *xate* extraction. The surveys provide information on the relevant explanatory variables for all individuals in the sample, regardless of whether or not they worked in *xate*. The best strategy to deal with a censored sample like this one is to estimate a tobit model (Wooldridge 2002).

A second identification concern comes from the inclusion of an endogenous variable, the opportunity cost of time, in the equation for time allocated to *xate* extraction. Controlling for the opportunity cost of time makes it possible to disentangle direct and indirect effects of changes in the other variables on *xate* labor allocation. The identification strategy that we use is to estimate an instrumental variables version of the tobit model. Similar to linear models, identification in the tobit requires that there is at least one variable in the equation for the endogenous explanatory variable (equation (2), the opportunity cost of time equation) that is not in the equation of interest (equation (1), *xate* labor allocation). We use as instruments the variables cattle, land, and assets. None of these variables have a direct impact on *xate* extraction. Extraction from the rainforest does not use any of these as inputs, and *xate* is not used to feed cattle. Therefore, these variables can affect labor allocation only through the effect they have on the opportunity cost of time, via other activities. They do not belong in the NTFP labor allocation equation once the opportunity cost of time is included.

Even though the tobit model with instrumental variables is estimated using maximum likelihood, instead of a two-step procedure, table 3 presents the results of the “first-stage” estimation of the opportunity cost equation to show the relevance of our instruments. Bearing in

mind that the distribution of the opportunity cost is skewed (to the right) we present, in addition to the ordinary least squares (OLS) estimator, results for a robust regression estimator. This estimator is less sensitive to outliers than OLS (Hamilton 1991). The three variables that we use as instruments (cattle, land and assets) are highly significant in both models (the point estimates are very similar as well). As expected, all three have a strong positive association with the opportunity cost of time. Some coefficients that are significant under OLS are not when using robust regression.

Results of the instrumental variables tobit estimation of the *xate* labor allocation equation appear in table 3.⁷ In many empirical applications only the marginal effects on the latent variable mean $\left(E[L^{NT*} | X]\right)$ are reported. Nevertheless, as argued by Wooldridge (2002), in some situations the latent variable might not have any quantitative meaning. This is especially true when the model entails a corner solution, as in our case when interest is on marginal effects on censored $\left(E[L^{NT} | X]\right)$ and truncated $\left(E[L^{NT} | X, L^{NT} > 0]\right)$ means. These alternative measures of the estimated marginal effects of the explanatory variables on *xate* extraction are presented in the table.

It can be shown (see Wooldridge 2002) that:

$$\begin{aligned}
E[L^{NT*} | X] &= X\beta \\
E[L^{NT} | X, L^{NT} > 0] &= X\beta + \sigma_u \left(\frac{\phi(X\beta / \sigma_u)}{\Phi(X\beta / \sigma_u)} \right) \\
&= X\beta + \sigma_u \lambda(X\beta / \sigma_u) \\
E[L^{NT} | X] &= P(L^{NT} > 0 | X) \cdot E[L^{NT} | X, L^{NT} > 0] \\
&= \Phi(X\beta / \sigma_u) X\beta + \sigma_u \phi(X\beta / \sigma_u)
\end{aligned}$$

where \mathbf{X} includes all of the observations for w , π and τ , $\lambda(\mathbf{X}\boldsymbol{\beta}/\sigma_u)$ is the inverse Mills ratio, and $\boldsymbol{\beta}' = [\alpha_1, \rho, \boldsymbol{\beta}'_\pi, \boldsymbol{\beta}'_\tau]$. Consequently, the marginal effect of a change in variable k on the expected value of the latent, truncated and censored variables can be calculated using, respectively,

$$\frac{\delta E[L^{NT*} | \mathbf{X}]}{\delta x_k} = \beta_k \quad (3)$$

$$\frac{\delta E[L^{NT} | \mathbf{X}, L^{NT} > 0]}{\delta x_k} = \beta_k \left\{ 1 - \lambda(\mathbf{X}\boldsymbol{\beta}/\sigma_u) [\mathbf{X}\boldsymbol{\beta}/\sigma_u + \lambda(\mathbf{X}\boldsymbol{\beta}/\sigma_u)] \right\}, \text{ and} \quad (4)$$

$$\frac{\delta E[L^{NT} | \mathbf{X}]}{\delta x_k} = \beta_k \Phi(\mathbf{X}\boldsymbol{\beta}/\sigma_u) \quad (5)$$

These results depend on the normality assumption. The test of normality shows that the conditional moment (8.28) is smaller than the 10% bootstrapped critical value (15.22), which implies that the null hypothesis of normality cannot be rejected at any level below 10%.⁸ In this case, the results obtained will be consistent and the expected values will have the functional forms shown above.

One can interpret these marginal effects as follows: the first marginal effect corresponds to the effect of a change in x_k on the *desired* days of *xate* work, the second to a change in the actual days of *xate* work for *xateros*, and the third to a change in the actual days of *xate* work for *xateros* and non-*xateros*. It is important to note that even though the magnitude of these three marginal effects can differ, the sign will always be determined by β_k , a characteristic that does not hold for other non-linear models (e.g., the Heckman model).⁹

An additional complication is that the marginal effects in a tobit model, like other non-linear models, are not necessarily constant (as they are in an ordinary least squares model), and

they can be different for each observation. Furthermore, the marginal effects need not be linear. This implies that the interpretation of marginal effects is not straightforward, and the information that a single number can convey is limited.

The marginal values for the truncated and censored means can be calculated in at least three different ways: using average values of the explanatory variables; calculating the marginal effect for each observation and then obtaining the average; or calculating the marginal effects for some “typical” observations (Kennedy 2003). To obtain the estimated effects presented in table 3, we replace X with \bar{X} (and β with $\hat{\beta}$) in equation (5), while in equation (4) we replace X with the average values for those individuals who participated in *xate* extraction.

Table 3 shows that the opportunity cost of time is indeed endogenous (exogeneity is rejected) and has a negative and significant effect on the allocation of labor to *xate* extraction. The higher the income that an individual can earn in a day of work in non-*xate* activities, the lower the number of days that he will allocate to *xate* extraction.

The relationship between opportunity cost and *xate* labor allocation is negative and nonlinear. This can be seen clearly in figures 1 and 2, which display the censored and truncated expected values of *xate* labor, $E[L^{NT} | X]$ and $E[L^{NT} | X, L^{NT} > 0]$, respectively, as a function of the opportunity cost of time. These figures permit us to differentiate the impact that a change in the opportunity cost will have on the whole population (combining a change in the probability of participation with a change in days of participation) from the impact that it will have on those participating in the activity before the change.

Figure 1 shows that if the opportunity cost is equal to 40 pesos (approximately US\$4) per day, the expected *xate* labor supply of the average individual is almost 4 days. If the opportunity cost increases to 80 pesos the expected *xate* labor supply is less than one day. Figure 2 depicts

the expected *xate* labor supply for those who participate in extraction. For this group, the expected *xate* labor supply is above 40 days if the opportunity cost is equal to 40 pesos and close to 30 days if it is equal to 80 pesos.

The indirect effect that the individual and household education variables have on *xate* labor allocation through their effects on income-generating capabilities in other activities is captured by the opportunity cost. The direct effect of the education variables is statistically significant (except for household secondary education). A negative effect of education is consistent with distaste for *xate* work among individuals from relatively educated households.

As anticipated, family history of participation in gathering and harvesting natural resources has a positive impact on wild *xate* exploitation. This variable could be capturing a higher marginal productivity of labor allocated to *xate* extraction due to familiarity with extractive activities, a preference for working in the rainforest, or a combination of the two. The negative sign of the year-dummy coefficient could be the result of decreasing availability of the resource (as claimed by the inhabitants of the community). However, it also could be due to an increase in off-farm employment options, or to other time-varying village variables. The allocation of effort to *xate* extraction follows a concave pattern with respect to age, reminiscent of a Mincerian earnings equation. This and a positive sign of the coefficient on the male dummy variable are in part explained by the fact that extracting *xate* from the rainforest is a physically demanding activity. Nevertheless, it should be acknowledged that females and individuals at either end of the age distribution are less likely to participate in *any* activity.

The second and third columns of table 3 report the marginal effects of a change in each explanatory variable on the number of days allocated to *xate* extraction for everybody and for *xateros*, respectively. Results show that the average male (*xatero* or not) works six days more

per-year in *xate* extraction than the average female (column 2). An average *xatero* from an “extractive family” (i.e., Tradition=1) works five more days per-year in *xate* than an individual from a non-extractive family (column 3).

Although these results provide useful information, with the aid of graphical analysis we can gain a better understanding of how the marginal effects change depending on the values of the explanatory variables. In particular, the marginal effects might be statistically different from zero for some values of the dependent variables but not for others (see for example the marginal effects of age). Figures 3 to 6 illustrate how the marginal effects of age and education change depending on the initial value of these variables. Similar figures could be presented for all variables in table 3; however, for the sake of brevity we concentrate on only these two. The marginal effects implied by changes in opportunity cost can be inferred from the slopes of figures 1 and 2. In figure 3, the marginal effect of a change in age is positive and increasing for individuals below 20 years of age but decreasing and even negative for those over 35 years. Figure 4 shows that the marginal effect is positive but decreasing for *xateros* younger than 35 years of age and negative thereafter. Figures 5 and 6 show that, although an additional year of education decreases *xate* labor supply, the direct effect of schooling decreases as education levels increase.

IV. Conclusions

This paper identifies some of the basic factors shaping the allocation of labor to non-timber forest product extraction using data from a sample of village households in Chiapas, México. The opportunity cost of time, which is partially explained by human and physical capital, is negatively related to participation in NTFP extraction. In addition, even when accounting for the

indirect effects of human capital on labor allocation to NTFP via the returns in other activities, individual and household education both have a negative effect on *xate* labor allocation. This suggests that individuals with high levels of education have a distaste for *xate* extraction work, and other things (including the wage) being equal, would prefer to work in alternative activities.

Policies that increase off-forest employment alternatives and thus the opportunity cost of time are likely to result in decreases in labor allocated to *xate* extraction. Nevertheless, it is likely that access to these new opportunities will not be homogenous. In particular, those with low levels of education might not be able to participate in other activities. New employment opportunities might still indirectly benefit those who extract NTFPs if they lower pressure on the resource (by diverting labor to non-*xate* activities) and if this is reflected in increases in NTFP harvest rates.

On the other hand, while an increase in the price of the NTFP will lead to a short-run improvement in the economic condition of extractors (see López-Feldman, Mora, and Taylor 2007), it might have a neutral or even negative effect on welfare in the long-run. An increase in price implies a reduction in the differential between the opportunity cost of time and the revenue from a day of work in extraction activities, increasing the optimal amount of labor that some households allocate to extraction. An increase in the supply of NTFP labor could then result in lower harvest rates per unit of effort for each and every participant in the activity. In the long run, the income and poverty effects of policies that increase off-forest employment or the price of the NTFP will depend upon interrelationships between the NTFP labor supply and the growth rate of the resource.

V. Appendix: Estimating the Opportunity Cost of *Xate* Labor

Jacoby (1993) and Skoufias (1994) developed a general methodology to estimate the supply of labor for agricultural households whose members do not work for wages. The methodology that they propose does not require the imputation of a value of time from a small group of wage laborers to a larger group of self-employed. The main steps of the procedure are as follows: 1) an agricultural production function for the household is estimated (Cobb-Douglas is the preferred production function in both papers); 2) based on the estimates of the agricultural production function the marginal product of labor is estimated, and; 3) total labor supply at the individual level is estimated using shadow wages as one of the regressors.

A similar methodology is used in this paper as the basis to estimate the opportunity cost of a day of work in *xate*. In the theoretical model presented in section II households decide how to allocate labor between *xate* extraction and all other possible productive activities. This distinction is used when estimating the opportunity cost of a day of work in *xate*. The value of households' production in all the non-*xate* activities ($Q_{it}^O = p_t^O * q_{it}^O$) is used to estimate a Cobb-Douglas production function. All of the households in the sample participate in non-*xate* activities; therefore, there is no selectivity problem when estimating this aggregate production function.

We account for the potential endogeneity of inputs resulting from correlation with time-invariant unobserved factors by using panel data methods. Using the balanced panel of households (86 observations for two periods) three models were estimated: OLS, fixed-effects and random-effects. A Hausman test of the random versus fixed-effects specification fails to reject the random model which results are presented in table 4.

The household-level opportunity cost of a day of work was derived using the following expression:

$$\hat{w}_{it} = \frac{\hat{Q}_{it}^o}{L_{it}^o} \hat{\beta}_{L^o}$$

where \hat{Q}_{it}^o denotes the fitted value of non-*xate* production by household i in year t , L_{it}^o is labor allocated by the household to the non-*xate* activity, and $\hat{\beta}_{L^o}$ is the coefficient on the log of labor (0.74 from table 4).¹⁰

Table 5 shows the mean of the estimated opportunity cost for both *xateros* and non-*xateros*. The difference in means illustrates that those who extract *xate* have a lower opportunity cost of time than those who do not.¹¹ The mean values estimated are similar to the average agricultural wage in the community, 44 pesos per day.

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Table 1. Descriptive Statistics

Variable		Description	Mean	(std. dev.)
Dependent Variable	Xatewk	Days of work in <i>xate</i> extraction	6.054	(20.283)
Individual Characteristics	Head	1= Individual is head of household	0.258	
	Male	1= Male	0.526	
	Age	Age in years	30.307	(15.007)
	Educ	Years of education	4.790	(3.667)
Household Characteristics	HH-elem	Number of household members (except individual) with elementary school completed (6 years)	1.520	(1.448)
	HH-sec	Number of household members (except individual) with at least 9 years of education	1.094	(1.220)
	HH-size	Number of household members older than 2 years old	6.628	(2.323)
	Cattle	Number of animals owned (at beginning of the period)	3.819	(10.688)
	Land	1 = Owns land	0.925	
	Assets	Index of dwelling characteristics and assets (Principal Components Analysis)	0.536	(0.214)
	Tradition	1 = Parents of household head and/or spouse have a history of non-timber forest products extraction	0.451	
	Year	1= 2004	0.507	
N		Pooled observations	667	

Table 2. Opportunity Cost of *Xate* Labor

First Stage (OLS)		
	Coefficient	
	OLS	Robust Regression
Head	4.31* [2.32]	0.33 [1.58]
Male	-3.65** [1.69]	-0.16 [1.21]
Age	-0.001 [0.282]	0.14 [0.17]
Age ²	-0.001 [0.003]	-0.001 [0.002]
Educ	0.06 [0.35]	0.13 [0.19]
HH-elem	-1.79*** [0.54]	-1.48*** [0.42]
HH-sec	2.36** [1.19]	-0.14 [0.46]
HH-size	-1.15*** [0.38]	-0.42 [0.29]
Tradition	-0.45 [1.49]	3.08*** [0.90]
Year	-6.34*** [1.11]	-4.01*** [1.07]
Cattle	1.39*** [0.07]	1.52*** [0.06]
Land	5.10** [2.13]	4.81** [1.82]
Assets	56.43*** [5.39]	44.74*** [3.31]
Constant	17.17*** [6.48]	9.62** [3.62]
R ²	0.64	0.79
N	667	

In brackets cluster robust standard errors for OLS and bootstrapped standard errors for robust regression

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. *Xate* Work
Instrumental Variables Tobit

	β_k	$\delta E[L^{NT} X]$ δx_k	$\delta E[L^{NT} X, L^{NT} > 0]$ δx_k
Opportunity Cost	-1.08*** [0.38]	-0.10*** [0.03]	-0.28*** [0.09]
Head	0.93 [18.86]	0.09 [1.83]	0.24 [4.93]
Male	60.83*** [15.82]	6.00*** [1.87]	13.76*** [3.22]
Age	4.88** [2.48]	0.06** [0.07]	1.28** [0.64]
Age ²	-0.07** [0.03]		-0.02** [0.01]
Educ	-6.06*** [1.88]	-0.58*** [0.19]	-1.58*** [0.48]
HH-elem	-9.85** [4.43]	-0.94** [0.44]	-2.57** [1.16]
HH-sec	-3.73 [5.77]	-0.36 [0.57]	-0.98 [1.52]
HH-size	0.02 [2.94]	0.00 [0.28]	0.00 [0.77]
Tradition	20.70** [10.39]	2.05* [1.23]	5.29** [2.67]
Year	-20.25*** [7.58]	-1.96** [0.82]	-5.16*** [1.81]
Constant	-93.51** [43.38]	-	-
Observations		667	
χ^2 (Exogeneity test)	7.96		

Cluster robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Cobb-Douglas Non-*Xate* Production Function
Random Effects

	RE
Non- <i>xate</i> work	0.58*** [0.06]
Inputs	0.06*** [0.02]
Cultivated Area	0.25*** [0.07]
Cattle	0.18*** [0.05]
Educ	0.07 [0.06]
HH-elem	-0.12 [0.09]
HH-sec	0.01 [0.10]
Assets	1.11*** [0.27]
Constant	5.02*** [0.35]
Observations	172
R^2	0.5
$\chi^2(8)$	10.52
Prob> χ^2	0.23

Note: The dependent variable is the natural logarithm of the value of non-*xate* production. The explanatory variables, except assets are also natural logarithms.

* significant at 10%; ** significant at 5%; *** significant at 1%

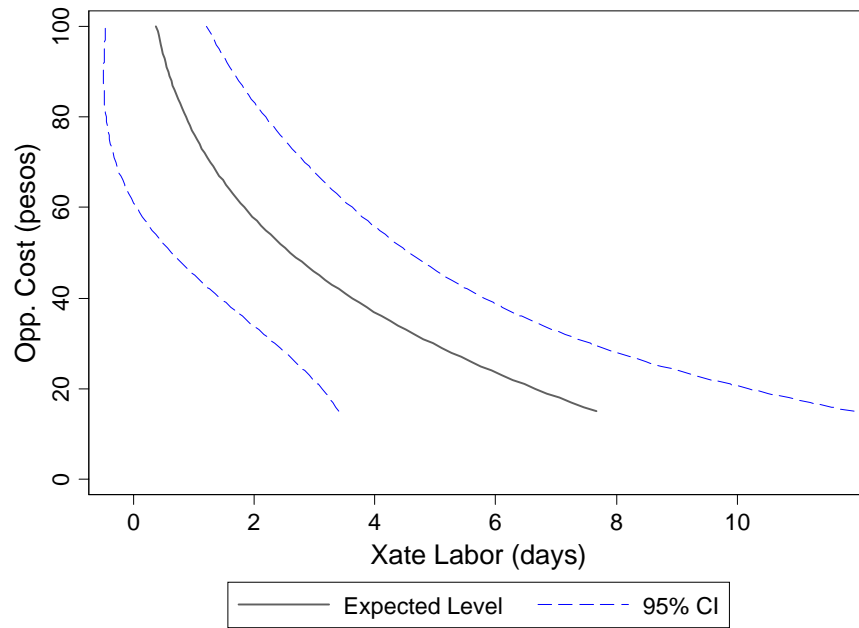
Table 5. Differences in Opportunity Cost

	Mean
Non-Extractors (pesos per-day)	46.14
Extractors (pesos per-day)	37.17
Difference	8.97**

** significant at 5%

Figure 1. *Xate* Labor Supply for *Xateros* and Non-*xateros*

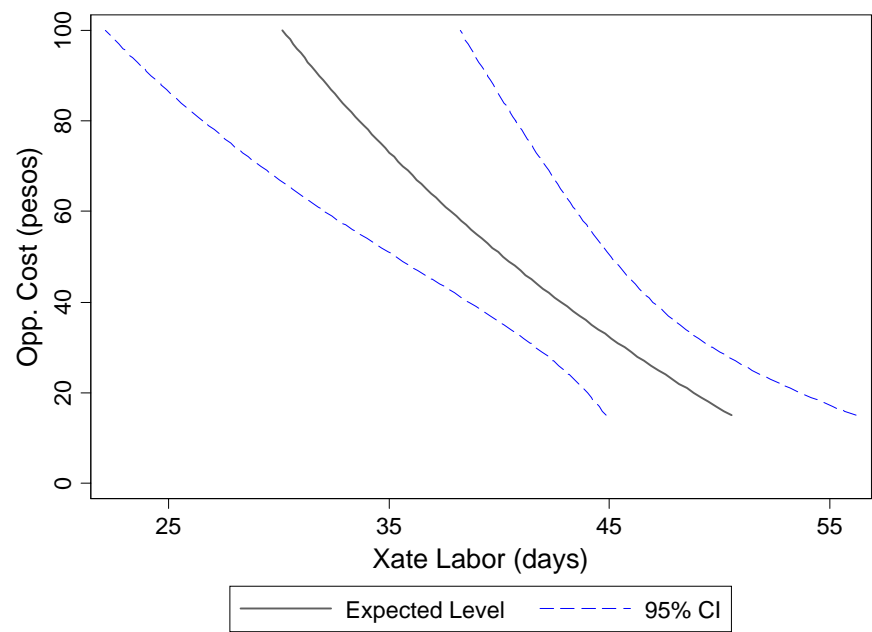
$$\left(E\left[L^{NT}|X\right]\right)$$



Note: All variables except opp. cost are set at mean values

Figure 2 *Xate* Labor Supply for *Xateros*

$$\left(E\left[L^{NT}|X,L^{NT}>0\right]\right)$$

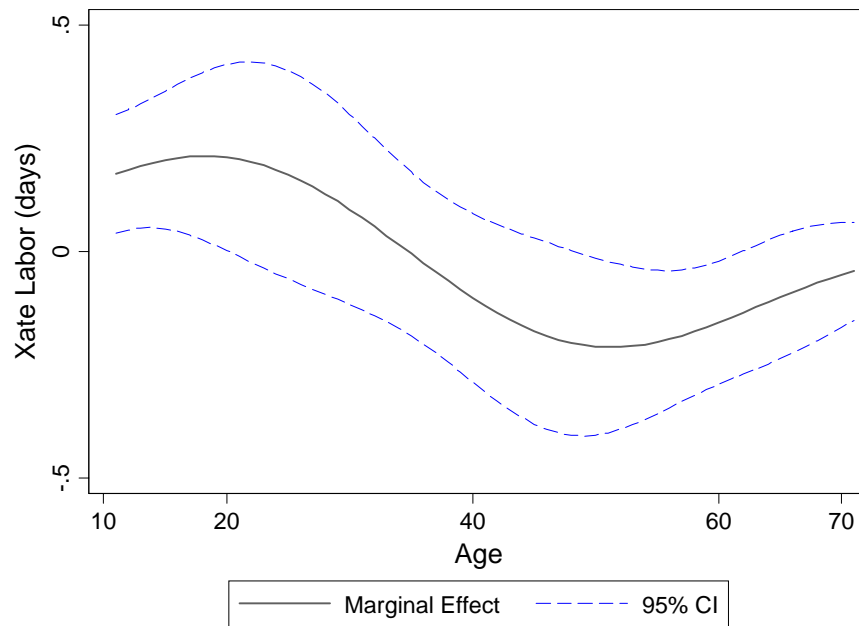


Note: All variables except opp. cost are set at mean values for xateros

Figure 3. Marginal Effect of Age on the Expected Level of *Xate* Work for *Xateros* and Non-

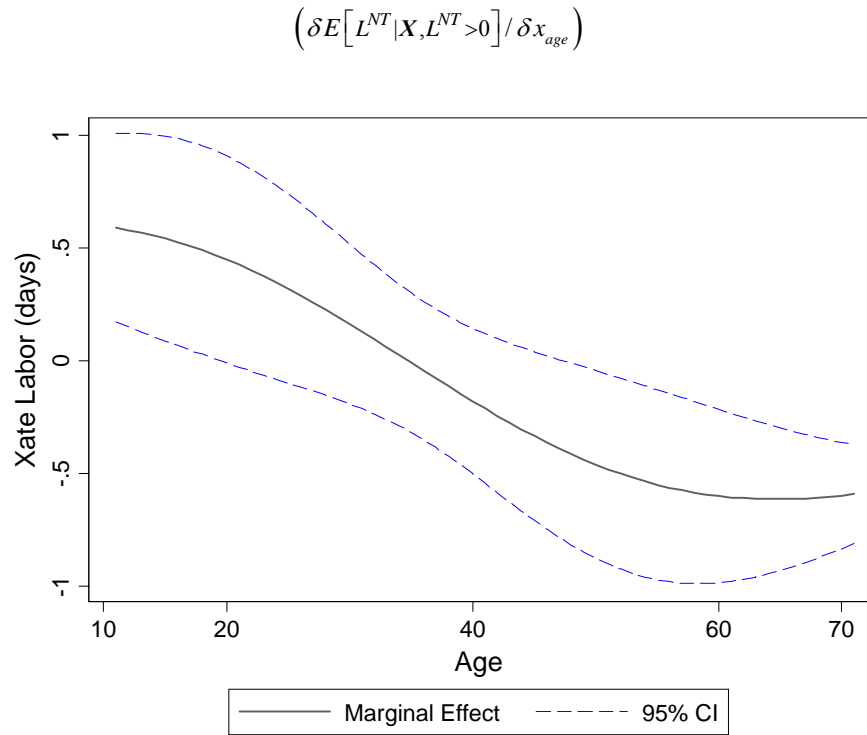
Xateros

$$\left(\delta E[L^{NT}|X] / \delta x_{age} \right)$$



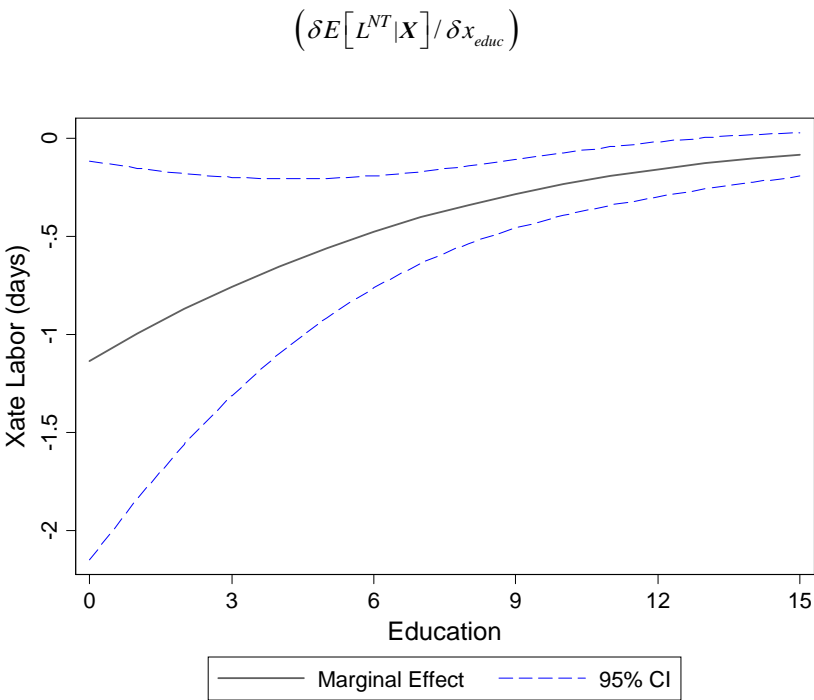
Note: All variables except Age are set at mean values

Figure 4. Marginal Effect of Age on the Expected Level of *Xate* Work for *Xateros*



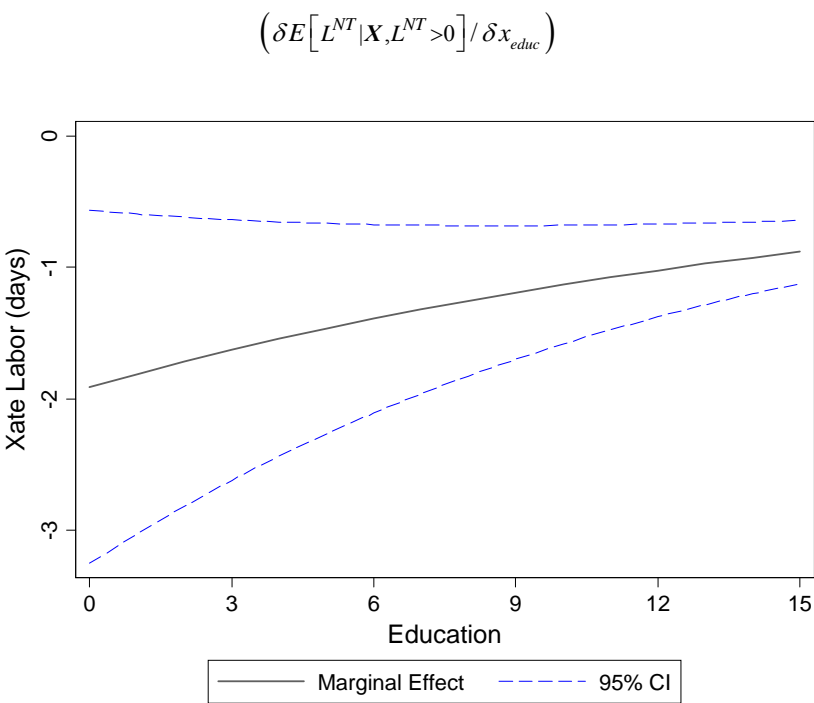
Note: All variables except Age are set at mean values for *xateros*

Figure 5. Marginal Effect of Education on the Expected Level of *Xate* Work for *Xateros* and Non-*Xateros*



Note: All variables except Education are set at mean values

Figure 6. Marginal Effect of Education on the Expected Level of *Xate* Work for *Xateros*



Note: All variables except Education are set at mean values for *xateros*

Notes

¹ Implicitly we are also assuming that there are no savings possibilities and that physical capital is taken as given by the household; otherwise this simplification is not possible. These assumptions are not unrealistic in poor regions of developing countries where saving mechanisms are not readily available and where access to credit is highly dependent upon endowments.

² The information collected refers to the periods September 2000-August 2001 and September 2003-August 2004. For ease of exposition we will refer to the first twelve-month period as 2001 and the second as 2004.

³ During the second survey 14 households were lost from the sample, 6 due to migration and 8 because they refused to be re-interviewed. The lost households are not statistically different in observable variables from those that remained in the sample. It was decided, therefore, that sample bias due to attrition was not a concern, although we must admit that it is still possible that those households have different unobservable characteristics compared to those that remained in the sample. The econometric analysis for this paper uses the 86 households that were enumerated in both surveys.

⁴ During the first year of the pilot project Lutheran, Episcopalian and Unitarian churches in the U.S.A. bought 5,000 palm fronds to be used during Palm Sunday. In 2006 the amount of sales increased to 80,000. The plan for 2007 is to include Canadian churches and to sell as many as 1 million fronds (Dean Current, personal communication, 2006). During a normal Palm Sunday 30 million palm fronds, including *xate*, are used in the U.S.A. and Canada (CEC, 2005).

⁵ The term common property resource, as employed here, refers to a resource that is owned by a well-defined group whose members have the right to use the resource and exclude non-members from using it (Ciriacy-Wantrup and Bishop, 1975; Ostrom, 1990).

⁶ See the appendix for an explanation of how the opportunity cost was estimated.

⁷ As a way to test the robustness of the results the model was also estimated using a trimmed sub-sample of the data. The sub-sample excluded those observations for which the values of the opportunity cost were below (above) the percentile 1 (99) or for which the values of the number of days of work in *xate* extraction were above the 99th percentile. The results obtained using this sub-sample are very similar to those presented in table 3. The significance levels of the coefficients presented in table 3 were confirmed using bootstrapped confidence intervals.

⁸ The normality test was performed using a regular tobit instead of an instrumental variables version as we are not aware of a statistic available to test the null of multivariate normality of the errors in the instrumental variables tobit model. The results reported are for a tobit model with the opportunity cost included as explanatory variable; normality is not rejected either if this variable is excluded from the model.

⁹ These result holds because it can be shown that the adjustment factor in the marginal effects of the truncated and censored mean will always be non-negative (Wooldridge, 2002).

¹⁰ Jacoby (1993) and Barrett et al. (2005) report that when using this method they find negative marginal products for some individuals. As emphasized by Barrett et al (2005) solving this problem (either by dropping those observations or by assigning a value to them) introduces an unknown bias in the subsequent estimations. Fortunately in our case all the estimated marginal products of labor are positive.

¹¹ The difference in means was tested using a bootstrapping approach because the normality assumption is rejected for the distribution of the opportunity cost and a t-test requires the normality assumption.