A Tale of Two Communities:
Explaining deforestation in Mexico

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April 2004

Forthcoming in *World Development*

Summary.

Developing policies to mitigate deforestation in Mexico requires recognizing heterogeneity in the management schemes used by communities. In particular, behavior towards land use change is very different in communities that extract wood from the forest for profit and those that gain their livelihoods through other means. In the former, forestry projects generate funds which can be invested in public goods to help increase the value of the standing forest from the perspective of those who do not receive direct dividends from the projects. An increase in investment of forestry profits in public goods helps decrease forest loss. In communities without such projects, deforestation is related to the ability of the community to induce formation of a coalition of members that cooperates in reducing forest clearing. This is easier in smaller communities with more experienced leaders. Data collected in 2002 combined with satellite imagery are used to test these hypotheses. In addition to verifying the predictions of the models, a disturbing result of the analysis is that deforestation is higher when a community engages in forestry projects, even after properly accounting for self-selection into this activity. This suggests that forestry projects as they now exist in Mexico are not sustainable and contribute to the deforestation problem.

Key words: Deforestation, common property, partial cooperation
JEL classification codes: D70, H41, O13, N56, Q23, Q24

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[1] This paper would not exist without the contributions and support of the Instituto Nacional de Ecología (INE), particularly Carlos Muñoz-Piña, Maria Zorilla Ramos, and Josefina Braña. Also indispensable have been Alejandro Guevara and his team at the Universidad Iberoamericana, Juan Manuel Torres and others of the Centro de Investigaciones y Docencias Económicas (CIDE), and the World Bank. Most importantly, we cannot thank enough all of the very patient and kind members of the *ejidos* and *comunidades* we visited.

1. INTRODUCTION

The 1990s saw a flurry of activity in the economic modeling of deforestation, with early efforts focused on cross-country analyses and second-wave models moving to micro-level approaches (Kaimowitz and Angelsen (1998), Barbier (2001)). The current paper is in the latter category, but with a twist: the introduction of behavior, where the unit of analysis for deforestation corresponds to the unit of decision-making. Specifically, the vast majority of the land-use change literature views deforestation through binary response models based upon an individual's profit maximization problem (see Chomitz and Gray (1996)) but applied to a pixel or to an entire municipality (see Cropper et al (2001), Monroe et al (2002), Godoy and Contreras (2001), Vance and Geoghegan (2002), Deininger and Minten (1999)). This study differs substantially from these, in that it recognizes that the decision process comes from the interaction between individual households and authorities in a community. Analyzing the community level interactions reconciles the unit of analysis (community-level deforestation) and the unit at which decisions are made (individual landholders). This approach, combined with the unique situation in Mexico where most forests are held in common property, reveals two different levels at which forest policy can affect deforestation.

First, field experience has shown us that there is a sharp contrast between the deforestation processes in communities in which the forest is mostly removed by individual households to expand their agricultural or cattle activities, and in communities that extract wood as a commercial activity. In the former, demand for socially excessive forest conversion may be reduced by cooperation within the community. In the latter, the distribution of profits can be used as a tool to minimize individual incentives to encroach on the forest. These two mechanisms imply policy responses that are specific to each of these two types of communities.

Second, although a large part of a community's decision to enter the forestry business or not is determined by geophysical variables, there remains room for policies to influence this choice. This is of particular relevance given the observation that communities that enter the forestry business have significantly higher deforestation than those that do not practice forestry. This finding lends particular importance to policies that target communities practicing forestry and give them incentives to manage their business in a sustainable fashion.

The paper proceeds as follows. First, we discuss the Mexican forestry context (section 2), develop two theories of community behavior (section 3), describe the data, and show summary statistics (section 4). We then present the estimation strategy (section 5), the results (section 6), and conclude with possible policy implications (section 7).

2. THE MEXICAN FORESTRY CONTEXT

This study focuses on the Mexican *ejidos*, rural communities resulting from a drawn-out land reform that extended from the end of the 1910 Revolution until the early 1990s. During this time, an area equivalent to half the country was redistributed to peasants organized in communities. *Ejidos* are composed of two different kinds of property rights over land: private parcels and commons. Private land is mostly used for agricultural activities. Within these same communities there also live many people who are not members of the *ejido,* usually descendants of the original members (*ejidatarios*) who were prevented from becoming members by the legal restriction on inheritance to only one child. The non-members do not have voting rights and are not formally given land, but in practice they often farm on *ejido* lands ceded by others or illegally taken from the commons. The commons are mainly dedicated to pasture and forest. Importantly for the case at hand, they harbor 80% of Mexico's remaining forest.

Though there has been much debate regarding estimation of Mexico's annual deforestation rate, there is no doubt that, conservatively estimated at 1.3%, it is among the highest in the world (Torres-Rojo and Flores-Xolocotzi, 2001). The estimated rate in our sample is 1.2% per year. Mexico is among the most biologically diverse countries in the world, with first place in reptilian diversity, third in bird, and fourth in mammal. Its plant diversity exceeds that of the United States and Canada combined (CNF, 2001). In addition, Mexico is a water scarce country, and forests play an important function in regulating stream flows from watersheds. This suggests that there are significant negative externalities to deforestation in Mexico and justifies our focus on measures to mitigate forest loss.

3. TWO THEORIES OF COMMUNITY BEHAVIOR

During fieldwork in 2002, we observed sharp contrasts in deforestation between communities that manage their forests as a business and that which simply have forests in their common land. They are classified here as forestry and non-forestry *ejidos*, respectively. Forestry *ejidos* are those that have received a forest exploitation permit from the government and organize extractive forestry as a business. Non-forestry *ejidos* are those where there is no formal structure for tree extraction aside from what is provided by a set of basic rules approved by the community assembly. Each *ejidatario* works individually subject to these rules and his personal constraints.

(a) Forest conversion in non-forestry *ejidos*

Deforestation in non-forestry *ejidos* is conceptualized in a theory of partial cooperation, which is based on Barrett's (1989, 1994) work on emissions agreements in Europe. Other authors who have expanded this approach include Carraro and Siniscalco (1993) and Petrakis and Xepapadeas (1996). Several authors have used game theory to model deforestation. Among the papers in this vein are Angelsen (2001) and Ligon and Narain (1998) who focus on games between communities and the state. Alston et al. (2000) examine how uncertainty in property rights induces a game between local landholders.

Based upon field interviews, we posit that the driving force behind rapid deforestation in non-forestry *ejidos* is individual incentives that are not aligned with socially optimal behavior as a consequence of the common property nature of the forest. These incentives come from households' land requirements for both crops and cattle, the latter of which are often used for insurance, and from extraction of wood for domestic use. In many villages, one observes a core group of households who seem to work together, setting and obeying rules limiting the amount of cattle in the commons or the wood extracted for domestic use. Moreover, this group exists despite the fact that there often are people around it who are not obeying the rules. This is the concept of a coalition of cooperators.

The intuition of the model is as follows. Households derive benefits from the forest. These benefits may vary across households and include current benefits such as firewood, house-building materials, and non-wood products as well as future benefits. Both current and future benefits depend upon the quality of the forest, accessibility, and its state at time zero. There may also be benefits from cutting the forest, or encroachment, which include profits from agriculture and cattle, or insurance from cattle. These benefits are decreasing with the size of parceled or private landholdings and increasing with family size, population pressure, and the quality of potential agricultural or pasture land. Finally, there is a cost to encroachment that encompasses the work needed to remove forest and the risk of punishment incurred from being caught encroaching. This risk can be increased by strong leadership (see Bianco and Bates (1990)).

The conditions derived from the model sort the households into three distinct groups as a function of land endowments, outside employment options, and the opportunities available on *ejido* land. These characteristics determine in which of three categories a household will derive the highest net benefits: those who have nothing to gain from encroachment, those who will always be better off encroaching than cooperating, and those who, as a group, will be better off cooperating than encroaching, even when others are encroaching. The first group is comprised of households who have a low demand for common land because they either support themselves with outside jobs, have sufficient private land, or the potential agricultural land is too far away to make it worth the effort of going and clearing it. They accrue no gains from cutting down the forest, and potentially benefit from its continued existence. We call them "passive cooperators", as no incentive is needed to induce them to curb their deforestation activities. The second group is composed of households with high cattle to land ratios, or high household size to land ratios, or little chance of accessing future benefits from the forest (e.g., they may not be *ejidatarios*). They are better off cutting down more trees than not. For this reason, we label them "unrestrained encroachers".

The last group is composed of "cooperators." Cooperation gains are equal to the difference between a cooperator's benefits when he is part of the group that does not encroach on the forest (or clears at a lower level), and the benefits he would receive if cooperation broke down and all members of the group were to cut forest at their optimal individual level. These households have access to current and future benefits, with high costs to encroaching. While the structure of benefits makes these households prefer a cooperative solution, it is not sufficient to prevent individual defaulting at the margin on the group's decision. This is the usual incentive that leads to a non-cooperative equilibrium, even in the case of recognized benefits from cooperation. Sustainability of the coalition requires, as in most cooperation cases, an enforcement mechanism. The coalition of cooperators is thus composed of households that have voluntarily given themselves a mechanism of enforcement and punishment that prevents the unraveling of their collective choice. They typically commit to the cooperative encroachment level by a show of hands in the assembly. This type of mechanism is not unusual in developing countries (see Baland and Platteau (1996) for similar examples).

How might the behavior of these three groups affect deforestation? Here, encroachment is equal to forest loss. Therefore, if we know what may increase or decrease the size of a coalition of cooperators, we know what may decrease or increase deforestation.

To formalize the logic, let $B(F-E, z^f, z_i^f)$ represent forest benefits to household i, where F is total forest before encroachment, $E=\sum_i e_i$ where e_i are household encroachment levels, z^f are forest quality indicators, and the vector z_i^f contains household factors that influence benefits from forest products. Household encroachment benefits are given by $b\left(e_i, z^p, z_i^p\right)$, where z^p are indicators of the potential pasture/agricultural quality of the current forest land that is candidate for encroachment, and z_i^p are household factors which make encroachment more attractive. Finally,

$c\left(e_i, z^c, \delta\right)$ are encroachment costs which increase in encroachment level. This function also includes physical characteristics z^c which raise the cost of encroachment, like distance from dwellings and forest type, plus community characteristics δ that make enforcement of rules more difficult, thus decreasing encroachment costs.

The socially optimal level of encroachment is the solution to the problem:

$$(1) \qquad \max_{\text{all } e_i} \sum_i \left(B\left(F - E \ , z^f, z_i^f\right) + b\left(e_i \ , z^p, z_i^p\right) - c\left(e_i \ , z^c, \delta\right)\right) .$$

The first order conditions, $b_i'(\cdot) = \sum_j B_j'(\cdot) + c_i'(\cdot)$ for all i, define the optimal *ejido* level of encroachment: e_i^*. Here $b_i'(\cdot)$, $B_j'(.)$, and $c_i'(\cdot)$ are derivatives of b, B, and c with respect to e_i. The social optimum is thus found where each household's marginal benefit is equal to the *ejido's* marginal losses from deforestation plus the household's marginal encroachment cost.

At the other end of the spectrum, in the non-cooperative equilibrium, household *i* maximizes benefits from encroaching without taking into account the impact on others, a classic tragedy of the commons story (see Hardin, (1968)):

$$(2) \qquad \max_{e_i} \left(B\left(F - E, z^f, z_i^f\right) + b\left(e_i, z^p, z_i^p\right) - c\left(e_i, z^c, \delta\right)\right) .$$

This solution, $\bar{e}_i$, is defined by $b_i'(\cdot) = B_i'(\cdot) + c_i'(\cdot)$, the optimal household encroachment level. Note, however, that the forest benefits function depends upon the size of the forest minus total encroachment, which implies that the household's decision depends upon the decisions $\bar{e}_j$ of everybody else – the less the others encroach, the lower are the marginal forest benefits, and hence the more household *i* encroaches. The solution results in a reaction function that depends on factors that affect individual benefits from forest and pasture, forest and pasture quality, encroachment costs, punishments, and the encroachment choices $\bar{E}_{-i}$ of the other households, which of course depend upon their respective characteristics:

$$(3) \qquad \bar{e}_i = \bar{e}(z_i^f, z_i^p, z^f, z^p, z^c, \delta, \bar{E}_{-i}(.)) \ ,$$

where $\bar{E}_{-i} = \sum_{j \neq i} \bar{e}_j$ is the sum of the other households' encroachment decisions.

Comparing the cooperative solution derived from (1) and the non-cooperative solution (3), we can divide the households between those that would get higher benefits from cooperation and those that would prefer the non-cooperative higher level of encroachment. A partial cooperation equilibrium can emerge if a group of households would prefer the cooperative solution within their coalition, despite the fact that households outside the coalition do not cooperate.[2] The coalition and the individual encroachers play a non-cooperative game. The coalition maximizes its aggregate benefits, given the non-cooperators' encroachment levels, $\tilde{\tilde{e}}_k$:

$$(4) \qquad \max_{\tilde{e}_j, \text{ all } j \in J} \sum_j \left(B\left(F - \tilde{E}_J - \sum_k \tilde{\tilde{e}}_k, z^f, z_j^f\right) + b\left(\tilde{e}_j, z^p, z_j^p\right) - c\left(\tilde{e}_j, z^c, \delta\right)\right), \quad k \in K, j \in J \ ,$$

where J and K denote the respective sets of cooperators and encroachers, and $\tilde{E}_J = \sum_j \tilde{e}_j$ the level of encroachment of the cooperative coalition with each member encroaching $\tilde{e}_j$. The encroachers individually solve an optimization problem similar to (2), taking as given the encroachment levels of the coalition and of the other individual encroachers. The equilibrium solution sets the optimal encroachment level for each of these groups, and hence the partial cooperation aggregate level of encroachment:

$$(5) \qquad \tilde{E} = \sum_{j \in J} \tilde{e}_j + \sum_{k \in K} \tilde{\tilde{e}}_k \ ,$$

where $\tilde{\tilde{e}}$ is encroachment by unrestrained encroachers when there is a cooperative coalition. The three groups are defined by the following conditions:

1. Passive cooperators, $i \in I$, are worse off encroaching than doing nothing for any level of the others' encroachment:

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[2] Note that under this partial cooperation scheme, cooperators' benefit is lower than at the full cooperative level, while encroachers benefit even more than under the full non-cooperative case.

$$(6) \qquad b\left(e_i, z^p, z_i^p\right) - c\left(e_i, z^c, \delta\right) \leq 0, \quad B\left(F - E, z^f, z_i^f\right) \geq 0 .$$

2. Cooperators, $j \in J$, are defined as those who are better off at the cooperative level than they would be if everyone encroached:

$$(7) \qquad \begin{aligned} & B\left(F - \tilde{E}, z^f, z_j^f\right) + b\left(\tilde{e}_j, z^p, z_j^p\right) - c\left(\tilde{e}_j, z^c, \delta\right) \geq \\ & \quad B\left(F - \overline{E}, z^f, z_j^f\right) + b\left(\overline{e}_j, z^p, z_j^p\right) - c\left(\overline{e}_j, z^c, \delta\right) \end{aligned}$$

3. Unrestrained encroachers, $k \in K$, are defined by the opposite inequality.

We modify equation (5) for the empirical analysis to give encroachment per member which, for M members, is:

$$(8) \qquad \frac{E}{M} = \frac{\sum_{j \in J} \tilde{e}_j(\cdot)}{M} + \frac{\sum_{k \in K} \tilde{\tilde{e}}_k(\cdot)}{M} .$$

Since the cooperative encroachment level is less than the individual unrestrained encroacher's level, deforestation decreases with the size of the coalition. The levels of encroachment of the unrestrained encroachers and of the coalition members are a function of the household characteristics that affect their demands for common land, the quality of the land itself, and the characteristics of all other households in the community. The size of the coalition, which is itself endogenous, depends upon forest benefits, the quantity of good agricultural/pasture land, household characteristics that change land demand, and strong leadership, which may increase the cost of not participating in the coalition. It is here that we observe the effects of features traditionally associated with cooperation, such as group size (Olson (1965), Runge (1986)) and inequality in asset endowments (Bardhan et al. (2002)).

(b) Forest conversion in forestry *ejidos*

A forestry management system is one where there is a community "forestry firm" made up of either some or all of the *ejido* members. The objective for these firms is to maximize their profits over the long term. From this point of view, all other things held equal, this management regime should be the most likely to operate like a single, profit-maximizing owner. There are, however, two important differences between the profit-maximizing owner and the *ejido*. First, *ejidos* are given a harvest limit by the government and must follow a management plan that includes reforestation, among other activities. If they exceed this limit, or do not reforest sufficiently, they are threatened by loss of all future profits through removal of their permit. These limits, however, are not necessarily the optimal level that the *ejido* would choose as they internalize national social objectives. Since enforcement is not perfect, *ejidos* will optimally take a certain level of risk in not complying with the limits, hoping to get away with a certain amount of forest loss.

The second complication of the "owner's" problem is the heterogeneous constituency composed of those who receive direct benefits from the forest project, the *ejido* members, and those who receive benefits only indirectly, the non-members. As in the case of the non-forestry *ejidos*, households (both members and non-members) encroach on common lands for grazing animals and planting crops. Conversion of forest for these activities increases the reforestation responsibilities of forest managers. For this reason, forest managers have an incentive to try to reduce the conversion of forested land by individual activities. They do this through a bribe which has to be different for members and non-members.

It is quite easy to bribe members through the division of profits among them; it is bribing the non-members, who often vastly outnumber members, that creates a problem. To solve this problem, one observes many communities that invest heavily in public goods in lieu of dividing up all the profits. There are two possible reasons behind this behavior. First, there are returns to scale in investment in public goods, so that in large communities, public goods may generate more individual benefits than cash distribution. Second, only members are legally owners of the forest product, and it would be very difficult to decide who among non-members could qualify for profit sharing. This suggests that forest managers may be acting to minimize encroachment incentives by "paying off" non-members through investments in public goods. The tradeoff is between penalizing members who see part of their dividends being diverted to non-members, and reducing incentives for non-members to remove trees clandestinely from the forest.

We model the relationship between forest managers and households in a principal agent framework where forest managers choose optimal levels of harvesting, reforestation, and the profit sharing rule, anticipating the behavior of community members.

Consider the households' decisions. Their incentives to encroach depend upon their own costs and benefits, as in non-forestry *ejidos*, and also upon how their actions affect the forest stock in future periods. This turns their problem into a dynamic one, since their actions today affect the size of the forest in the next period, and hence the size of forest profits. Suppose there are *M ejidatarios* and *N* non-members, and that the percentage of profits that go to dividends is γ.[3] The resource constraint is $F_{t+1} = F_t - H_t - E_t + R_t$, where F_{t+1} is the area of forest stock in period *t*+1, and H_t, E_t, and R_t are the total area harvested for forestry, total encroachment, and reforestation in period *t*, respectively. An *ejidatario m* chooses the optimal encroachment level to maximize his net benefit given the division of profits and the current harvest level:

$$(9)\quad V\left(F_t\right) = \max_{e_m}\left[B\left(F_t - H_t - E_t, z^f, z_m^f\right) + b\left(e_m, z^p, z_m^p\right) - c\left(e_m, z^c\right) + \gamma p\frac{H_t}{M} + g\left(\left(1-\gamma\right)pH_t\right) + \beta V\left(F_{t+1}\right)\right],$$

where p is the net revenue per hectare of forest exploitation, $g\left(\cdot\right)$ is the benefit derived from the consumption of public goods, and $\beta V\left(F_{t+1}\right)$ is the discounted value of the maximized future stream of benefits coming from the forested land for the *ejidatario*. The vectors z^f, z_m^f, z^p, z_m^p, and z^c are as in the previous section. The first order condition is:

$$(10)\qquad b'_m\left(\cdot\right) = B'_m\left(\cdot\right) + c'_m\left(\cdot\right) + \beta V',$$

[3] Note that the sum of members and non-members in the forestry model is equal to the sum of the three different groups in the previous model: *M*+*N* = *I*+*J*+*K*.

where $b'_m(\cdot)$, $B'_m(\cdot)$, and $c'_m(\cdot)$ are defined like in the previous model as derivatives of benefits and cost with respect to encroachment e_m. This implies that the benefits from encroaching one hectare today must be equal to the sum of the lost benefits from having the same piece of forest today, the costs incurred in encroaching it, and the discounted value of the decrease in the future forest stock.

The corresponding expression for non-member *n* is the solution to:

$$(11) \qquad W(F_t) = \max_{e_n}\left[B\left(F_t - H_t - E_t, z^f, z_n^f\right) + b\left(e_n, z^p, z_n^p\right) - c\left(e_n, z^c\right) + g\left((1-\gamma)pH_t\right) + \beta W(F_{t+1})\right],$$

where $W(F_{t+1})$ is interpreted in the same way as $V(F_{t+1})$ above. Note that profit dividends do not appear in the non-member's value of the forest. The first order condition is:

$$(12) \qquad b'_n(\cdot) = B'_n(\cdot) + c'_n(\cdot) + \beta W'.$$

Jointly, these expressions define two encroachment reaction functions, which solve for the optimal encroachment levels $\tilde{e}(z, F_t, H_t, R_t, \gamma)$ and $\bar{e}(z, F_t, H_t, R_t, \gamma)$ for *ejidatarios* and non-members, respectively, which gives the total amount of encroachment $E = \sum_{m\in M}\tilde{e}_m(\cdot) + \sum_{n\in N}\bar{e}_n(\cdot)$. The vector *z* includes all characteristics of all members of the community present in equations (9) and (11). Note that non-members unequivocally lose from an increase in the share γ of profits that go into dividends, and one can show that their encroachment increases in response to an increase in γ. For the members, we can make no such statement, as the sign of the marginal effect depends on the initial amount of the public good and their marginal utility from it.

At the *ejido* level, managers know households' reaction functions. Their objective is to maximize forest extraction profits taking into account the fact that if they harvest more than the permit level, or don't reforest enough, it is likely that they will have their forestry permit revoked in the next period. Let $q(H_t + E_t - R_t; z^q)$ denote the probability that a community will be successful in evading detection of poor management and continue harvesting in the second period, with the discount rate β. The vector z^q includes characteristics that increase the probability that excessive deforesting remains undetected. Finally, $k\left(R_t; z^k\right)$ is the forest management cost function which is increasing in reforestation and characteristics z^k that might make these activities more difficult. With *U* denoting the value of the forest, the *ejido* manager's problem can be written as follows:

$$U\left(F_t\right) = \max_{\gamma, H_t, R_t}\left[pH_t - k\left(R_t; z^k\right) + \beta q\left(H_t + E_t - R_t; z^q\right)U\left(F_{t+1}\right)\right] \tag{13}$$

where $F_{t+1} = F_t - H_t - E_t + R_t$, $E_t = E\left(F_t, H_t, R_t, \gamma\right)$, $q(\cdot) < 1$ and $q' < 0$ when $H_t + E_t - R_t > \bar{H}_t$, and $q = 1$ otherwise, and $\bar{H}$ is the deforestation area allowed by the government.

The first order conditions for γ, H_t, and R_t are:

$$\beta\left(q'U - qU'\right)\frac{dE}{d\gamma} = 0\ , \tag{14}$$

$$p + \beta\left(q'U - qU'\right)\left(1 + \frac{dE}{dH}\right) = 0\ , \tag{15}$$

and

$$-k' - \beta\left(q'U - qU'\right)\left(1 - \frac{dE}{dR}\right) = 0\ . \tag{16}$$

The first expression shows that the optimal profit allocation rule γ is the level that minimizes aggregate encroachment. This is obtained where the sum of the marginal encroachment effect of an increase in dividends for members is equal to the sum of the effects of this change on non-members' encroachment. The intuition is that leadership needs to find a level where increasing the public good to the detriment of dividends begins to increase the encroachment of members by more than it decreases that of non-members. If we assume for a moment that all members are identical and all non-members are also identical, then the optimal profit distribution depends on the ratio of members to non-members:

$$\frac{\partial\bar{e}_n/\partial\gamma}{-\partial\bar{e}_m/\partial\gamma} = \frac{M}{N}\ . \tag{17}$$

If all the encroachment demand functions are concave, the proportion of profits allocated to dividends increases as the ratio of members to non-members increases. It is possible that at some point, as membership size increases, it will be optimal to distribute ejido profits through public goods, as the value of the goods to members may exceed the cash value of the dividends when they are divided among many people.

The term $-\left(q'U - qU'\right)$ represents the marginal future benefits of reforestation (or cost of harvesting): the decrease in the probability of losing the permit plus the increase in the future stock of trees to be harvested. Equations (15) and (16) state that current marginal return to harvesting and marginal cost of deforestation must equal the marginal future value of these decisions, respectively. Equations (14), (15), and (16) jointly solve for the optimal area harvested H_t^*, reforested R_t^*, and allocation of profits to dividends $\gamma *$. These three choices define the optimal encroachment level E_t^*, and the total forest loss from one period to the next:

$$F_{t+1} - F_t = H_t^* + E_t^* - R_t^* .$$

To summarize, in this model deforestation depends upon the forestry firm's harvest level, household encroachment level, and the forest manager's reforestation efforts. All three are jointly determined and hence a function of all exogenous variables. However, the specific variables associated with deforestation are prices, characteristics that affect the probability of getting caught by the forest service for not complying with the management plan, the size of the forest stock, and the discount rate. Those associated with encroachment are individual characteristics, the quality of available agricultural land, the forest stock, and the division of profits between dividends and public goods. Finally, those affecting reforestation are the cost of forest management, the factors that affect the probability of getting caught, the size of the forest stock, and the discount rate. Table 1 summarizes the variables that affect deforestation in the two models, along with the direction of their expected effects.

TABLE 1 HERE

(c) Which regime?

We assume that the choice of management system results from the community maximizing the sum of their households' expected utility given household and community characteristics. This decision takes into account their expected deforestation in each regime, which implies that all of the characteristics that were considered above are part of the decision process. There are also important fixed costs in entering the forestry regime. Hence, only *ejidos* that have a forest of sufficient value (size, quality, and accessibility) to sustain a large operation and the human capital (qualified workers and entrepreneurship) required by this demanding activity will choose the forestry regime. In addition, forestry will only be chosen if the potential value of the land in agriculture or pasture is not too high.

Figure 1 summarizes the sequence of decisions leading to deforestation in ejidos.

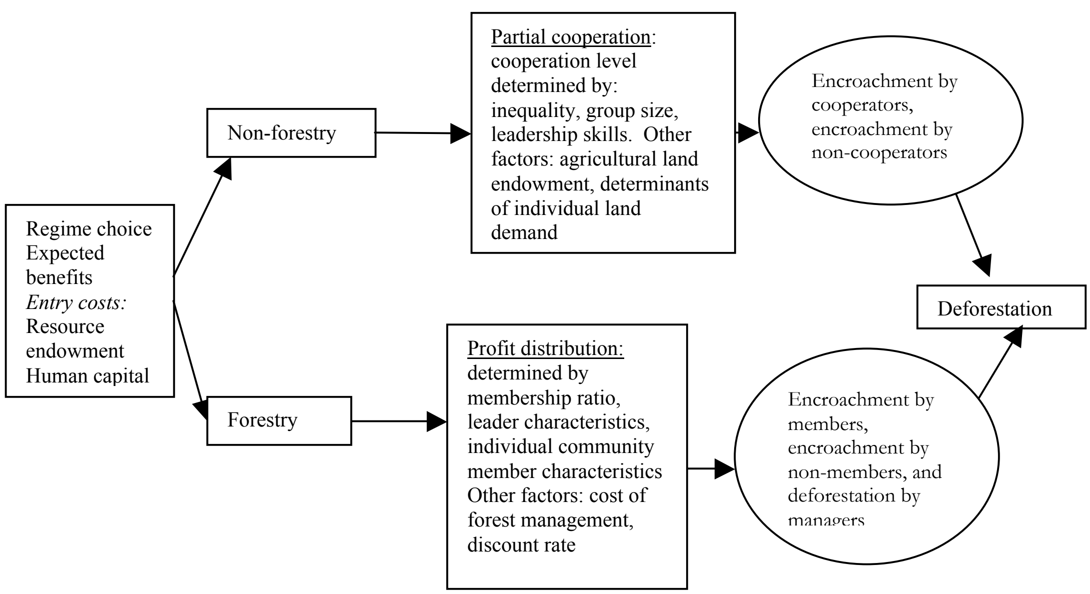

Figure 1. Determinants of deforestation in *ejidos*

4. DESCRIPTION OF THE DATA

The data come from a survey of 450 *ejidos* conducted throughout Mexico in 2002 jointly by SEMARNAT, the University of California at Berkeley, and the World Bank. The survey consisted in two parts, a community questionnaire and an indirect census. In the first part, information on basic characteristics of the community, forest exploitation, and governance was collected, in addition to a sub-set of questions to describe those in leadership positions. There are also data regarding the use of earnings from forestry-related projects in the past year. The second part of the survey was an indirect household questionnaire applied to 50 randomly chosen *ejidatarios* in each *ejido,* where the information was obtained from one key informant. It includes information about participation in government programs, household size, migration, age, employment, land and cattle-holdings, and use of the commons.

The National Ecology Institute (INE) provided the National Forestry Inventories for 1993 and 2000. The inventories are based upon maps of scale 1:250,000 and 1:125,000, respectively. Though initially not comparable, the maps have been reinterpreted for comparability by the Institute of Geography at the Autonomous University of Mexico. The details of this process are described in Velásquez et al. (2002). Slopes and altitudes have been calculated using digital elevation models of scale 1:250,000, and soil maps provided by the National Ecology Institute at the same scale. We have used these two data bases to create an index that indicates good quality agricultural land as land that is both in the low slope category as well as containing soils of high quality. This classification is based upon the FAO's guidelines for defining agro-ecological zones and other soil classification tests (Fisher et al, 2002). Municipal data for 1990 and 2000 come from the National Institute of Statistics and Geography (INEGI).

Table 2 compares characteristics of *ejidos* with and without forestry projects. 20% of *ejidos* in the sample have forest management. Non-forestry *ejidos* are smaller in size. They are also at lower altitudes, indicating superior agricultural potential. As for distance, we see that *ejidos* farther from major markets are more likely to choose a forest management scheme. This may be because they do not have many other employment options, or it may be that *ejidos* nearer to markets have already been largely deforested. Finally, forestry *ejidos* have more good agricultural land per capita and their individual parcels are significantly smaller, suggesting pressures for deforestation. They also have less households with at least one member with secondary schooling.

Deforestation by regime is also reported in Table 2. Area deforested is larger in forestry *ejidos*. While they represent only 20% of all *ejidos*, their deforestation accounts for 34% of total forest loss in the sample. In terms of per capita forest loss, the difference is not significant, but it is suggestive of higher loss per capita in forestry *ejidos*. The nature of the models dictates that the analysis be done on a per capita basis; therefore, deforestation from this point on will refer to forest loss per *ejidatario* between 1993 and 2000.

TABLE 2 HERE

Because we do not observe encroachment behavior, we must design an approximation for this activity. To do so, we appeal to the household questionnaire, where we asked the informant if households used the commons for any activity, be it pasture, agriculture, or forestry. The assumption is that those that do not use the commons are not encroaching, since all of the forest is located within the commons. Users and non-users were further divided into those with more than one hectare of land per adult and those with less. Table 3 shows these four groups, plus the total number of non-members in the community (for whom there is no household data) into possible upper and lower bounds for the cooperating groups. Passive cooperators I are those who possess more than one hectare of land per adult and *do not* use the commons, as these are *ejidatarios* with little need to venture into the commons to satisfy land needs. At a minimum, cooperators J are those with less than one hectare of land per adult who *do not* use the commons. The cooperating group might also include those who use the commons but are land rich, although these households might also be classified as encroachers (K). Those who use the commons and are land-poor fall into the unrestrained encroacher group K. Non-members are also classified as unrestrained encroachers.

This categorization suggests that a proxy upper bound for the number J is the sum of the land-scarce non-users plus the land-rich users, while the land-scarce non-users can be used as a lower bound. Similarly, an upper bound for the encroachers (*K*) is the sum of the land-scarce users, the land-rich users, and the non-members, while a lower bound is just the group of land-scarce users. Because the estimation is of forest loss per member, we will be using the ratio of these totals to membership. Table 3 gives the percentage distribution of these groups by three classes of ejidos in terms of deforestation levels (reforestation or no change, ≤ 2 hectares of deforestation per *ejidtario*, and > 2 hectares per *ejidatario*). It is interesting to see that deforestation per member increases as the percentage of members in the unrestrained encroachers category rises. Also notable is the decrease in "active cooperators", those who don't use the commons but have small land holdings, between the high and low deforestation categories. Finally, we see that deforestation increases as the percentage of members who are land rich users of the commons, categorized as unrestrained encroachers or cooperators (potential upper bound of cooperators), decreases steadily.

TABLE 3 HERE

5. AN EMPIRICAL STRATEGY

As the choice of forestry vs. non-forestry regime is endogenous, the estimation model includes this decision. The variables affecting this choice, including fixed costs and factors affecting the profitability of forestry, are contained in the vector *W*. We assume that the decision of entering a forestry regime is derived from a linear net benefits S^* as follows:

$$S^* = W\alpha + u$$
$$S = 1 \quad \text{if } S^* > 0, \ = 0 \quad \text{otherwise,}$$

where α is a vector of parameters to be estimated. The deforestation equations are written:

$$\Delta L_F = X_F \beta_F + \varepsilon_F \qquad \text{if } S = 1,$$
$$\Delta L_{NF} = X_{NF} \beta_{NF} + \varepsilon_{NF} \qquad \text{if } S = 0,$$

where the subscript *F* indicates a forestry *ejido* and *NF* a non-forestry one, ΔL are hectares of forest loss per member between 1993 and 2000, X are vectors of variables identified in the two models as determining the level of deforestation, and β are vectors of parameters. The error terms *u* and ε are all assumed to have zero mean. The selection process creates correlation between *u* and each of the ε in the sample used for estimation. We estimate these equations as a system using maximum likelihood.

Two variables that appear in the land change equations require instrumentation due to endogeneity: the numbers of cooperators and of unrestrained encroachers. While we know who uses the commons and who does not, and there is information on land ownership and commons use for the households in the survey (used for the classification given in Table 3), commons use is endogenous to the process of deforestation. The use of predicted values in the main regression requires that we bootstrap the entire estimation process, which is done 1000 times for each estimated equation. The results are discussed in the next section.

6. RESULTS

The predictive regression of the use of commons for agriculture or pasture by households in non-forestry *ejidos* is presented in Table 4. As expected, the probability that a household uses the commons decreases with its parcel size (the effect is negative for parcels up to 50 hectares, far above the observed range). Those who have previously held leadership positions are more likely to use the commons. With regards to *ejido* characteristics, we see that the probability of use increases with total *ejido* size, though not by very much. The aggregate leadership variable suggests a negative effect of leader education on land use, suggesting the role of quality of leadership in devising and imposing restrictive rules.

In order to create the group size proxies, we calculate the average of the predicted probabilities among households with plot size larger or smaller than one hectare per adult in each *ejido*. We then tabulate the upper and lower bounds of the cooperating and encroaching groups as described above. Since the dependent variable of the regression is deforestation per member, these average probabilities reflect the percentage of members who are predicted to be in each of the groups of interest. We observe that older *ejidatarios* are more likely to use the commons, as are those who have previously held leadership positions. In addition, larger parcel sizes have a generally negative effect on the probability of commons use. We justify inclusion of these household level variables, collected in 2002, in this and other regressions by the fact that the characteristics that we use are quite structural in the communities that we sample – most ejidos have maintained the same membership they had at founding.

TABLE 4 HERE

The equation of land use change in each regime is then estimated simultaneously with regime choice. In the regime choice equation, explanatory variables include the entry costs variables as well as the characteristics included in the land use change regressions. Table 5 reports partial results, focusing on the entry cost variables. Variables that represent the potential value of a forestry project include *ejido* size, forest type and stock size, hectares at high altitude, and distance from nearest market. *Ejidos* formed at a later date (later than 1975) are more likely to have found themselves endowed with already degraded forest as the land reform was extended to increasingly marginal land, so this variable is a proxy for forest quality. Competition with livestock and agriculture is represented by good agricultural land per capita. Also included are variables that describe the leaders in 1990: their age, education, and previous leadership experience.

We find support for the hypotheses stated in the regime choice section. Being a young *ejido,* which suggests low forest quality, decreases the probability of choosing forestry by 18 percentage points. *Ejidos* found in tropical zones are much less likely (20 percentage points) to enter into forestry. The initial forest area and land at high altitude increase the probability of forestry. Holding these two variables constant and increasing the overall size of the *ejido* decreases the likelihood of entering into forestry, probably because it increases the distance to the forest. Finally, leadership is important: having leaders ten years younger increases the probability of choosing forestry by nearly 10 percentage points.

TABLE 5 HERE

Table 6 shows the estimates for deforestation in non-forestry *ejidos*, following the classification of variables introduced in Table 1.[4] Because our theory describes individual behavior within a community, we use average deforestation per *ejido* member as the dependent variable in the deforestation regressions. The key variable of the theory, the size of the group of cooperators, has the expected significant negative effect. Both upper and lower bound variables reveal a similar effect. An increase of .10 in the proportion of cooperators among members may decrease forest loss by approximately 2.7 hectares per capita. Compared to the average forest loss per capita of 4.4 hectares, this is quite important. In the case of the unrestrained encroaching group, the point estimate for the upper bound is positive but imprecise. As the lower bound of encroacher is just one minus the upper bound of the cooperators, we do not use this variable. Among physical characteristics of the *ejido*, an increase in good agricultural land per capita, reflecting an increase in the opportunity cost of the forest, increases deforestation. The number of households with small plots per adult and population pressure captures the demand for land. For *ejidos* with more than a few parcels smaller than 1ha/adult (beyond 18 to 32% when the average is 36%), an increase in the number of small parcels increases deforestation. The population pressure effect, as reflected in municipal population growth over the period, is consistently positive. The non-significance of the estimated covariance between the error terms indicates no evidence of unobservable characteristics of the *ejidos* that would both condition the choice of regime and the deforestation level.

INSERT TABLE 6

In order to estimate deforestation in forestry *ejidos*, we use the variables identified in the two models of community behavior representing physical, community, and household characteristics. Here, we exclude the variable used to describe forest quality due to the fact that there is not sufficient variation in it for this part of the sample – only 3 of the forestry *ejidos* are less than 25 years old.

[4] Among the expected community variables, we omitted the number of members, as it was not significant and could cause spurious correlation with the endogenous variable of deforestation per capita. Inequality is captured by the proportion of small parcels. Aggregate variables for the household individual encroachment levels are share of small parcels, municipal growth rate (as a proxy for population pressure in the *ejido*), and education as a proxy for employment opportunities.

Because of the small number of degrees of freedom and their lack of significance, the number of members and municipal population growth rates are not included either. Including these variables does not significantly affect the sign, magnitude, or significance of the other exogenous variables. Since profit allocation is an endogenous choice, we instrument for it using the ratio of members to non-members, the difference in age between leaders and *ejidatarios*, and the age of leaders.

Table 7 shows the results, following the classification of variables reported in Table 1. Most of the estimated parameters have very large standard errors, probably due to the small sample size. We see, however, that the key variable in the theory, the share of profits in dividends per *ejidatario,* has the predicted positive sign and is significant in both estimates. The point estimates imply that if we increase each *ejidatarios'* share of dividends by .5 (doubling the mean), deforestation increases by 1.2 to 2.1 hectares per capita. The negative covariance with the error term of the selection equation indicates that the unobserved factors that induce *ejidos* toward choosing to undertake a forestry project contribute to lower the deforestation rate.

Finally, one can simulate the effect of incorporating as members some of the current non-members, a solution to commons management problems suggested by Muñoz-Piña et al. (2003). If all of the forestry communities were to incorporate 100 new members from among the non-members, then the average predicted deforestation per capita would decrease by 2.8 hectares. This results from both a change in the predicted amount of dividends and in the amount of land per capita. Because the effect of the membership ratio is highly non-linear, an increase of 100 members actually decreases the amount of profits allocated to dividends by nine percent.

According to the analysis, high deforestation in *ejidos* with forestry projects results from the dilemma posed by the presence of non-community members living in the *ejidos* and from the prevailing high discount rates associated with poverty. A disturbing fact is that *ejidos* with forestry projects have higher deforestation rates than non-forestry *ejidos*. We observed this in the descriptive statistics. This is also confirmed by the regression analysis in which we control for self-selection into forestry. The predicted average deforestation for *ejidos* in forestry is 6.8 hectares per capita over a seven year time period. Using the model of deforestation for non-forestry *ejidos*, and properly correcting for self-selection into the forestry regime, their predicted level of deforestation if they were non-forestry instead of forestry would be 7.1 hectares per capita. For non-forestry *ejidos*, the predicted average deforestation per capita is 4.5 hectares, lower than that of the forestry *ejidos, even if they choose not to do forestry*. Should all of the non-forestry communities suddenly begin forestry projects, their predicted average deforestation per capita would increase to 16.2. These results are shown in Table 8. This table also shows the decomposition of the difference in predicted deforestation for *ejidos* in and out of their own regimes. Non-forestry ejidos have higher deforestation when they are put in forestry regimes as a result of observables (more non-members and less hectares in forest) and unobservables. Similarly, forestry *ejidos* are predicted to have higher deforestation in non-forestry regimes due to their higher agricultural land per capita and large proportion of population with small parcels (observables), as well as the same large differences in the unobservable characteristics that make them choose forestry. This could indicate that as currently managed and regulated, the forestry projects are not sufficiently profitable for *ejidos* to maintain their resource and ensure its long term sustainability.

INSERT TABLE 8

7. CONCLUSIONS

The main conclusion of our analysis is that deforestation is affected by the institutional choices that communities make – whether to choose forestry or not – as well as the dynamics within these different regimes, and policies must be tailored to address this heterogeneity. We have developed two theories to describe deforestation in communities with and without forestry projects, where the former is a story of conflict management and the latter of partial cooperation. We find that large *ejidos* from non-tropical ecological zones with more area at high altitude and younger leaders are more likely to have a forestry project. Younger *ejidos,* however are much less likely to exploit their forest, probably because they have inherited low quality forest. For *ejidos* that choose not to have forestry exploitation, we show that deforestation is largely related to the ability of the community to induce as large a group of households as possible to cooperate in not encroaching. The members of that coalition are more likely to be younger households with sufficient private land, but not having exercised a leadership position. The coalition is also larger in small *ejidos* with experienced leaders.

When *ejidos* with non-members present in the community choose to enter forestry, the main determinant of their deforestation is their choice of how to divide up profits between dividends and public goods. Holding all else constant, a larger investment in public goods helps reward non-members for not encroaching and decreases forest loss per member. In addition, incorporation of new members into forestry *ejidos* can help decrease deforestation. We are also presented with a puzzle with regards to productive forestry. While it is true that forestry *ejidos* would deforest more even if they did not do forestry, we also find that non-forestry *ejidos*, were they to enter into forestry, would have significantly higher deforestation per member. This suggests that forestry projects as they now exist in Mexico are contributing to the deforestation problem because they are not sufficiently profitable relative to land use in agriculture and pasture. We conclude that serious analysis and reform of the current forestry incentive and regulation systems is imperative.

The findings also shed light on a targeting strategy for the policy that Mexico is currently considering to mitigate their deforestation problem – introduction of payments for environmental services. This is one strategy to raise the profitability of the forest relative to agriculture, and should be given to communities with forests at higher risk of forest loss, namely large *ejidos* with low-sloped land of high quality and leaders with little previous experience in management.

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9. TABLES AND FIGURES

Table 1. Variables included in models and their anticipated effects on deforestation

Variable	Non-forestry *ejidos*	Forestry *ejidos*
Physical		
z^f *Forest quality indicators*		
Forest quality	–	+/–
Forest accessibility	+	+
z^p *Indicators of potential quality of forest land in pasture and agriculture*		
Potential agricultural land: low slope + high soil quality	+	+
z^k , z^c *Physical characteristics that affect the cost of encroachment*		
Ecosystem type	+/–	+/–
z^q *Characteristics that increase the possibility that deforestation go undetected*		
Distance from forest service office	no effect	+
F *Stock of forest in base year*	no effect	+
Community		
δ *Characteristics that make rule enforcement more difficult*		
Number of community members	+	+
Inequality in parcel size	+/–	no effect
Experience & education of leaders	–	no effect
γ *Share of forest profits to dividends*	no effect	+
Households		
z_i^f *Factors that influence benefits from forest products*		
Membership	–	–
Leadership position in community	+/–	no effect
z_i^p *Factors that make encroachment more attractive*		
Size of private land holdings	–	–
Household size/pop. growth	+	+
Employment opportunities	–	–
Remittances	+/–	+/–

Table 2. Contrasting non-forestry and forestry *ejidos*

Characteristic	Non-forestry	Forestry	t-stat for test of difference
Community			
Number of *ejidos* (*n*)	326	79	
Total area of *ejido* (ha)	4512	14,046	–5.60
Distance to nearest market (km)	36.5	46.3	–1.60
Area at high altitude (ha)	759	5,798	–6.56
Number of members in 1990	153	203	–1.02
Ratio of non-members to members	3.1	2.2	1.43
Good agricultural land (ha per capita)	10.5	20.4	–2.68
Households			
Number of households (*M*)	11,350	2,975	
Parcel size (ha per adult)	4.7	2.9	6.56
Cattle (number per ha)	1.3	1.9	–4.77
Household has at least one member with secondary education (rate)	0.48	0.43	5.60
Deforestation			
Forest loss in 1993-2000 (ha)	253	920	-4.47
Forest loss per *ejido* member in 1990 (ha)	3.8	6.6	-1.41
Share of total deforestation (%)	66	34	

Table 3. Membership in cooperation classes by deforestation rates

Cooperation Class	Index	*Ejidos* with reforestation or no change N=119	*Ejidos* with ≤ 2 ha deforestation per capita N=94	*Ejidos* with > 2 ha deforestation per capita N=85
Percentage distribution of members across cooperation classes:				
Unrestrained encroachers	*K*	24	23	31
Unrestrained encroachers or cooperators	*K* or *J*	33	31	19
Active cooperators	*J*	12	14	09
Passive cooperators	*I*	31	33	41
Ratio of non-members (*N*) to members (*M*)		2.7	4.2	2.5

The categories were created as follows: Unrestrained encroachers are users of the commons with parcels ≤ one hectare/household adult. Encroachers or cooperators are users of the commons with > one hectare/household adult. Active cooperators are non-users of the commons with ≤ one hectare of land/household adult and passive cooperators are non-users of the commons with > one hectare of land/household adult.

Table 4. Determining use of the commons in non-forestry *ejidos*
Probit (Dependent variable: agriculture or pasture use = 1)

Variable	Mean of variable	Marginal effect	t-statistic
Household characteristics			
Number of members with secondary education	1.28	–.002	–0.23
Number of members emigrated to U.S.	.64	–.01	–1.2
Age of household head	51.7	.001	1.6
Parcel size (ha per adult)	4.7	–.01	–2.1**
(Parcel size)^2	263	.0001	2.2**
A household member has held leadership position	.41	.07	2.7**
***Ejido* characteristics**			
Total area of *ejido* (1000 ha)	5.287	.02	2.25**
Area of *ejido* at high altitude (1000 ha)	0.598	–.003	–.19
Good agricultural land (ha per capita)	10.7	.0007	0.2
Number of members in 1990	172	–.0002	–1.7
Proportion of leaders with primary education in 1990	.31	–.19	–1.9**
Proportion of leaders with previous experience in 1990	.41	.02	.23
Average age of leaders in 1990	53.4	.003	1.1
Inequality in parcel size (Gini coefficient)	.67	.21	0.80
Proportion of parcels ≤ 1 ha/adult	.38	.49	1.5
(Proportion of parcels ≤ 1 ha/adult)^2	.27	–.21	–0.6
Community is not an indigenous community	.88	.09	0.61
Municipal characteristics			
Municipal population growth rate	.02	.48	.20
Endogenous variable: Household uses the commons	.52		
Number of observations		8,418	
Pseudo R-squared		.11	

** indicates significance at the 5% level.

Table 5. Regime choice probit
(Dependent variable: forestry = 1)

Variable	Mean of variable	Marginal effect	t-statistic
Total area of *ejido* (1000 ha)	6.3	-.04	-2.2**
Area at high altitude (1000 ha)	1.6	.02	2.4**
Forest area, 1993 (1000 ha)	6.0	.05	2.6**
Good agricultural land (ha per capita)	12	.7	0.76
Ejido is in tropical zone	.70	-.20	–3.4**
Ejido is younger than 25 years	.14	-.18	–2.6**
Distance to nearest market (km)	39	-.0001	–0.22
Average age of leaders in 1990 (years)	52	-.01	–3.5**
Proportion of leaders with primary education in 1990	.29	-.03	–0.4
Proportion of leaders with prior experience in 1990	.37	.03	0.54
Endogenous variable: forestry *ejido*	.19		
Number of observations		400	
Pseudo R-squared		.23	

** indicates significance at the 5% level. These are partial results. Also included are the following variables: community is an *ejido*, proportion of households with secondary education, proportion of households with less than one hectare of land per capita, and its square, ratio of non-members to members, number of non-members and municipal population growth rate.

Table 6. Deforestation in non-forestry *ejidos*
(Dependent variable: hectares deforested per member)

Variable	Mean of variable	(1)	(2)	(3)
Physical				
Ejido is younger than 25 years	.16	4.4 (-.8, 9.1)	4.7 (-.66, 10.0)	5.1 (-.37, 9.8)
Distance to nearest market (km)	36.5	.01 (-.02, .04)	.01 (-.02, .04)	.01 (-.02, .03)
Good agricultural land (ha per capita)	10.5	.17 (.02, .36)**	.15 (-.02, .33)	.16 (.01, .36)**
Ejido is in tropical zone	.77	.62 (-1.8, 4.4)	1.2 (-1.8, 5.9)	1.1 (-1.1, 5.3)
Forest stock size, 1993 (1000 ha)	17.4	.1 (-.2, .2)	.1 (-.2, .4)	.2 (.01, .5)**
Land at high altitude (1000 ha)	.60	-.3 (-1.5, .3)	-.2 (-.8, 1.1)	-.3 (-1.3, .5)
Community				
Community is not an indigenous community	.91	5.3 (.01, 10.7)**	5.6 (-1.8, 13.0)	7.9 (2.3, 13.0)**
Proportion of leaders with prior experience in 1990	.39	-.25 (-4.8, 2.0)	1.4 (-1.7, 4.5)	1.0 (-2.0, 3.4)
Households				
Upper bound for cooperators per member	.43	-26.8 (-59.3,-12.4)**		
Lower bound for cooperators per member	.10		-21.6 (-90.0, 8.0)*	
Upper bound for unrestrained encroachers per member	3.8			.03 (-.11, .23)
Proportion of households with secondary education	.50	-2.3 (-6.7, 2.1)	-2.7 (-7.9, 2.0)	-4.0 (-8.5, .06)
Proportion of parcels ≤ 1 ha/adult	.36	-1.6 (-12.5, 26.5)	-8.4 (-24.3, 21.2)	-16.1 (-26.2, -4.0)**
(Proportion of parcels ≤ 1 ha/adult)^2	.26	6.8 (-20.1, 20.0)	23.4 (5.4, 41.4)**	25.6 (10.2, 39.4)**
Municipal				
Municipal population growth rate	.02	88.8 (-10.4, 184.6)	106.8 (9.4, 205.5)**	106.1 (19.4, 201.8)**
Covariance with the error term of the selection equation		-.09 (-.39, .21)	-.09 (-.38, .20)	-.11 (-.37, .17)
Endogenous variable: deforestation per capita	3.8			
Number of observations		297	297	297
Log likelihood		-1346	-1348	-1348

95% bootstrapped confidence intervals in parentheses. ** indicates significance at the 5% level, * at 10%

Table 7. Deforestation in forestry *ejidos*
(Dependent variable: hectares deforested per member)

	Mean of variable	OLS (1)	IVº (2)
Physical			
Distance to nearest market (km)	46.3	-.01	-.01
		(-.06, .05)	(-.09, .07)
Good agricultural land (ha per capita)	20.4	.05	.05
		(-.01, .12)	(-.09, .22)
Ejido is in tropical zone	.44	-.13	.62
		(-6.1, 5.8)	(-9.3, 8.4)
Stock of forest in 1993 (1000 ha)	17.4	-.02	-.03
		(-.08, .03)	(-.02, .02)
Land at high altitude (1000 ha)	5.9	.006	.02
		(-.3, .3)	(-.2, .4)
Community			
Share of dividends in profits per member	.56	2.4	5.2
		(.07, 4.8)**	(-.24, 19.0)*
Households			
Proportion of households with secondary education	.46	-4.3	-2.4
		(-14.3, 5.6)	(-13.4, 7.1)
Proportion of parcels ≤ 1 ha/adult	.49	-2.2	-.10
		(-31.2, 26.9)	(-21.7, 29.8)
(Proportion of parcels ≤ 1 ha/adult)^2	.37	-.43	-2.0
		(-27.9, 27.0)	(-28.5, 18.5)
Covariance with the error term of the selection equation		-.43	-.52
		(-.75, .05)	(-.80, -.05)
Endogenous variable: deforestation per capita	6.6		
Number of observations		79	79
Log likelihood		-425	-426

º Dividends instrumented by the ratio of members to non-members, the difference in age between leaders and members, and the age of leaders.

Table 8. Differences in predicted deforestation (ha per capita) in different regimes

Regime	Forestry *ejidos* N=79	Non-forestry *ejidos* N=297	Difference in predicted deforestation	Explained by observables	Explained by unobservables
Forestry	6.8	16.2	9.4	3.2	6.2
Non-forestry	7.1	4.5	2.6	1.0	1.6