Payments for Environmental Services:
To whom, where and how much?

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Abstract: In this paper we consider different strategies for implementing a payment for environmental services (PES) program to mitigate deforestation in Mexican common property forests (ejidos). We begin by discussing the policy context within which PES programs find themselves, highlighting other possible interventions to help preserve environmental amenities in Mexico. We then discuss some basic principles of environmental payment schemes, formalizing these into three that we simulate: payment of the opportunity cost for forests at risks; payment for environmental benefits provided by forests at risk; a flat payment scheme with a cap on allowable hectares, similar to the type of program often applied in developing countries; and a program of opportunity cost payments for forest at risk with highest environmental benefit per dollar paid. We find that, of these three, the last is most efficient and the second most egalitarian. We also repeat a simulation of the third scheme using predicted, rather than actual risk, which circumvents the problem of strategic behavior on the part of recipient communities but introduces some error into the targeting process. Finally, we consider the characteristics of communities that receive payments from the most efficient program, finding that larger and more remote ejidos receive the lion's share of the budget, but that payments to them are not necessarily more efficient. This scheme also gives more, though smaller on a per capita basis, payments to poor and indigenous communities, where they are more efficient than those to non-poor and non-indigenous ejidos.

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1. Introduction

Though few experts agree on the exact figure, the consensus is that Mexico has the second highest deforestation rate in the world. In addition, it suffers from decreasing soil quality and increasing water scarcity, problems both associated with forest loss. Furthermore, it is among the most biologically diverse countries in the world, with first place in reptilian diversity, third in bird, and fourth in mammal diversity. Its plant diversity exceeds that of the United States and Canada combined, and survival of both the flora and fauna is importantly associated with protection of existing forest (CNF, 2001). This combination of facts has thrust Mexican environmental policy into center stage both at home and abroad, and is the motivation for the paper at hand.

According to the Mexican National Forestry Commission (CNF), 80% of the country's forests are located in ejidos, communities resulting from the post-Revolution land reform, which hold their forestry and grazing lands in common property. Their large forest holdings make them an essential place where to begin addressing the deforestation problem. The policy proposed by the government to slow deforestation, and the main subject of this paper, is a payment for environmental services (PES) scheme, where communities receive cash in exchange for an agreement to manage forest, reforest, or implement other conservation-friendly resource management schemes. PES programs are currently in place in Costa Rica and the United States and are being piloted in Colombia, Costa Rica, and Nicaragua, among other countries (World Bank, 2003).

The purpose of this paper is not to explain why deforestation happens, but rather to discuss steps towards introducing conservation programs and to analyze the effects of program design for nationwide payment schemes. To this end, we begin by putting the preservation of environmental services in a general environmental policy context and summarize the data used in this paper. We follow this with a brief discussion of steps towards deforestation mitigation, continue with an analysis of alternative designs for payment programs, consider the characteristics of the recipient communities, and conclude with a discussion of possible challenges to program implementation.

We find that a scheme of flat payments for all forest with a cap, similar to those being implemented in Mexico and Costa Rica, is very egalitarian, but highly inefficient. A scheme based on paying the opportunity cost only for forest at risk generates more than three times the benefits at the same price as the flat payments program. Simulation of a program which maximizes the environmental benefits per dollar spent increases efficiency over the opportunity cost program by nearly ten times. When we use predicted rather than actual risk to implement the last program, we find that there is some error in targeting, but that the efficiency is still much greater than a traditional flat payments program.

2 Description of the Data

In this section we briefly describe the data used in the calculations. In the summer of 2002, Mexico's National Ecology Institute (INE) , together with the Iberoamericana University, the Center for Economic Education and Research (CIDE), the University of California at Berkeley, and the World Bank, conducted a survey of Mexican ejidos. The purpose of the survey was to understand the deforestation process in these communities in order to inform the design of a PES program. The study randomly sampled 450 ejidos larger than 100 hectares located in the forested regions of the country. Surveys were completed for 407 ejidos. The total universe of forested ejidos is 7,679. The total amount of forest covered by our sample is 2,106,592 hectares of primary and secondary forest. Communities surveyed are not dispersed evenly across the country, as we can see from Table 1, which describes their distribution by region.

Table 1. Distribution of forest ejido universe by region*

Region	Ejidos	% of population	Sample	% of sample
Peninsula	745	9.7	39	10.0
Gulf	795	10.4	37	9.5
South	2,152	28.0	110	26.8
Central	2,488	32.4	122	29.6
North	1,499	19.5	99	24.2
Total	7,679	100	407	100

*Table provided by the Instituto Nacional de Ecología

The final sample included ejidos in all states with the exception of Baja California, Coahuila, Guanajuato, Zacatecas, Morelos, and Aguascalientes. It should be considered a representative sample of the existing forest-holding ejidos of Mexico. In order to calculate forest cover, we use the Forest Inventories of 1993 and 2000, which were constructed by visual interpretation from satellite images with pixels of 30 meters at a scale of 1:250,000 (Velázquez et al., 2002). In addition, we calculate slopes from digital elevation models with 90 meter pixels, and the soil quality from digital soil maps available from the Mexican government. The geographical distribution of the sample of ejidos is shown in Map 1.

Map 1: Distribution of ejidos surveyed, 2002

2.1 Stock of forest in our sample

Overall, 86% of the ejidos in our sample currently have primary forest. The area of primary forests is largely related to ejido size, which varies considerably across ejidos. Total ejido area ranges from 180 to 170,143 hectares in our sample. The average percentage of a given ejido in primary forest is 34.7%. On a per capita basis, the distribution of the forest is quite skewed. Though the average number of hectares per capita is 37, the median is 6.5 and the Gini coefficient .83. This suggests that any payment program disbursed on a per hectare basis will be similarly unequal in its distribution across communities and individual members.

2.2 Changes in the forest from 1993-2000

The next question of interest regards trends in forest change. We calculate total deforestation rate over our sample to be about 1.2% per year, which is comparable to what Torres and Flores (2001) term the "conservative estimate" of 1.3% per year. In our sample, the average ejido deforested about 1.3% per year over the period 1993-2000. For our purposes, deforestation is defined as the change of primary or secondary forest to agriculture or pasture.

3. Putting PES in context

There is a clear consensus on a national and international level that the rate of deforestation in Mexico is too high relative to the social optimum and that something needs to be done. The current policy of choice, now being piloted, is a national level payment for environmental services program financed through Federal fiscal revenues. There is a sense, however, in which this should be the last step in a series of policies to conserve environmental services. There are at least two less expensive interim policies that could be effective initial steps in addressing deforestation: liberating "win-win" solutions and local environmental services agreements.

3.1. Liberating "win-win" solutions

Liberating "win-wins" implies addressing existing inefficiencies within the agencies responsible for forest regulation and other agencies whose policies may indirectly encourage forest misuse. They are "win-wins" because they encourage forest conservation and are aligned with private incentives. This means analyzing current policies and assessing whether they help or hinder deforestation. For example, is the forest permit system so complicated that it creates an inordinately high transactions cost, pushing forest owners into illegality? Why is it that so few of the communities with forestry potential have actually obtained permits?

Although it is difficult to clearly identify all of the the sources of forest loss, particularly illegal ones, we did discover that in 2002, about 20% of the ejidos sampled stated that they had experienced theft of trees from their land. An effective policy to address this activity could do much to slow down deforestation in Mexico. It is also important to keep in mind that tree-stealing is a symptom of some larger incentive problem, usually associated with ill defined and inadequately enforced property rights.

Even within the realm of legal forest management, it would appear that there is room for improvement. In ejidos that extract wood for profit, around 36% do not actively reforest afterwards in spite of the investment made in obtaining a permit. Among those that reforest, the average survival rate of the hectares reforested is only around 58%. The correlation between lack of reforestation effort and deforestation at the ejido level is –0.05, suggesting that higher deforestation is associated with not reforesting post-harvest. The correlation between hectares successfully reforested and deforestation is also negative (–0.09), which implies that improvements in the quality of the reforestation effort is also important in lowering net deforestation.

We currently have no way of telling if forestry ejidos are exceeding their permit levels, although there is some anecdotal evidence that permits are, indeed, enforced. We also do not know if this is the optimal policy for managing a forest. What we can tell is that the process of forest management within the permit system is far from systematic and that technicians in some regions are insufficiently engaged. Introducing more uniformity in technical assistance, monitoring post-harvest activities, and keeping track of illegal wood sales could do much to reduce forest loss, expectedly at a lower cost than compensating for ill-devised or ill-applied policies through PES.

3.2. Local markets for environmental services

The second option to reducing deforestation is to look for self-sustaining markets for environmental services at the local level. There is at least one case of this type of activity in Mexico related to forestry: in the coastal state of Veracruz, lowland communities are paying those higher up in the watershed to conserve the remaining forest cover (SEMARNAT, 2003). There are surely more opportunities for this sort of local trade, particularly through the existing regional water districts. Many environmental externalities, especially water-related ones, are highly localized within specific watersheds. Unless coordination problems across states are extremely difficult, it makes sense to have a watershed-specific transfer to pay for these services. Payments for well-defined local services are also easier to administer than a nationwide program and less exposed to the instability of the federal political process.

Another small-scale environmental services market that is quite active in some places is the international environmental market. Many environmentalists in industrialized countries perceive and are willing to pay for the international negative externalities of the loss of carbon sequestration capacity and biodiversity. The Nature Conservancy has long been a purchaser of lands for environmental services in other countries, and even Formula One race car drivers in the US are now buying amounts of forest corresponding to the quantity that would be needed to mitigate the CO2 emissions of their activities (FIA, 2003).

Once all of the 'win-wins' are taken advantage of and the localized environmental services markets are active, there remain two options for conserving the environmental services still at risk: coercion and incentives. A nationwide PES program falls in the latter category. Mandating conservation by law (and enforcing that mandate) can be just as effective as a payment scheme for forest conservation. However, the legality of coercion depends on property rights, and it may be quite costly to enforce both monetarily and politically. When services are provided freely by legal owners of the resource, putting into place a payments system based on fiscal revenues can be effective. The remainder of the paper explores the different ways one can design an environmental incentive program and the effects that design can have on efficiency and equity.

4. Alternative payment schemes – theoretical considerations

There are many possible ways of designing an environmental payment scheme. Any variation in design will change the kind of environmental services obtained and the people who receive them. Conceptually, there are an upper and a lower bound on the "prices" which one can pay per hectare in a PES program – the opportunity cost and the value of the environmental services provided by the land. In this section we discuss some principles to be maintained regardless of the type of program design chosen.

4.1. Basic principles

Two criteria essential for the establishment of a PES program are targeting (what to pay for) and the magnitude of the payments. In theory, these should be jointly defined to maximize environmental benefits at a given budget and therefore the optimal scheme depends upon the response function of the recipients, in this case, the ejidos. To formalize, let $U\left(F_e - \Delta F_e, c_e \Delta F_e; z_e\right)$ be the utility derived from the standing forest, denoted by $F_e - \Delta F_e$. This function depends on the value that ejido e can derive from deforesting a quantity of ΔF_e, where c_e is its opportunity cost per hectare and z_e are ejido characteristics. The optimal deforestation level is thus a function of the initial standing forest, the opportunity cost and the characteristics:

$$\Delta \tilde{F}_e = \Delta F\left(F_e, c_e, z_e\right)$$

The offer from the PES program is to not deforest at all against a total payment of P_e. The ejido will thus accept the contract if:

$$U\left(F_e, P_e; z_e\right) \geq U\left(F_e - \Delta\tilde{F}_e, c_e\Delta\tilde{F}_e; z_e\right)$$

Let $P_{e,\min}$ be the minimum value that satisfies this condition. Given the environmental benefit b_e provided per hectare in ejido *e*, the optimal transfer scheme is the solution to:

$$\max_{P_e} \sum_e 1\left[P_e \geq P_{e,\min}\right] \Delta F\left(F_e, c_e, z_e\right) b_e$$

$$\text{s.t.} \qquad \sum_e 1\left[P_e \geq P_{e,\min}\right] P_e \leq \overline{P}$$

Ideally, one would like to know the monetary value equivalent to the utility that ejidos derive from standing forest. In the absence of such an estimation procedure, one can use $P_{e,\min} = c_e\Delta\tilde{F}_e$ as an upper bound for the acceptability of the scheme to the ejido (this is equivalent to ignoring the loss in utility associated with the decrease in standing forest). Ejidos accept the payment and agree to not deforest if the payment P_e is at least as high as the opportunity cost of converting the land into pasture/crops, and do not accept the contract if the offered payment is below the opportunity cost:

$$\text{If } P_e \geq c_e \Delta F\left(F_e, c_e, z_e\right) \Rightarrow \Delta F_e = 0$$

$$\text{If } P_e < c_e \Delta F\left(F_e, c_e, z_e\right) \Rightarrow \Delta F_e = \Delta F\left(F_e, c_e, z_e\right)$$

4.2 Opportunity cost or environmental benefit?

This section speaks to the quantity of payments offered to communities. Should one pay the minimum value necessary to preserve the environmental benefits, the opportunity cost c_e, or the entire value of the good being purchased, the environmental benefit b_e? In reality, this is a question of property rights. However, two additional facts come to bear here: first, an ejido will only accept a contract that is greater than its opportunity cost, which implies that if a benefits scheme is chosen and the value is not higher than their profits in alternative activities, deforestation will still occur. Second, payments can only be socially justified if the benefits offered by the land are greater than or equal to the value of the land in alternative activities, $b_e \geq c_e$.

4.3 What should we pay for?

If one looks at the formulae above, the optimal contract only pays for the hectares that would otherwise be deforested, i.e, for $\Delta F\left(F_e, c_e, z_e\right)$, which varies with the deforestation rate. In actuality, one frequently observes a flat payment per hectare of currently standing forest F_e with a cap. In many places, this payment varies with quality of forest in terms of benefits, but the point here is that it does not depend on the deforestation rate. An argument in favor of this flat payment is the simplicity of the implementation and the impression of fairness that it gives, as it does not take into account deforestation behavior.

Given that most countries' conservation schemes operate with a limited budget, it is essential to consider the most efficient distribution of these monies. If the goal of the program is to conserve the largest amount of environmental benefits for a given cash outlay, the optimal scheme consists in ranking the ejidos by decreasing ratio of benefit/payment and include those with highest ratio until the budget is exhausted (this is far from a novel result: see also Babcock et al. (1996), Ribaudo (1989)).

4.4 A word about contracts

Regardless of the choice of targeting scheme, the contract must be made over the entire area of the ejido. Neglecting this consideration could lead to "slippage" (a term coined by Wu (2000)), that is, if a contract is incomplete, then deforestation may simply be transferred from a contracted to an uncontracted area of forest. Hence, typically, the contract should specify a payment against no deforestation on all of the hectares that have an opportunity cost below their environmental benefits.

5 Proposed simulations

In this section we discuss the simulations that we will take to the data in this paper. Building from our theoretical considerations, we have chosen 4 payment schemes:

1. A payment for hectares at risk of deforestation at their opportunity cost [Rc].
2. A payment flat payment over all hectares with a cap, at a rate that gives the same aggregate budget as Rc, with the objecting of simulating a scheme similar to those observed [F].

3. The optimum targeting using an index of environmental benefits (as opposed to actual benefits) for a budget arbitrarily set at 2/3 of the budget of the first scheme, to illustrate how the budget constraint could be optimally dealt with [C].
4. A payment equivalent to [C], but implemented using predicted deforestation in lieu of observed deforestation. We will discuss the details of this approach in a later section.

5.1 Rental of hectares at risk

We allow for heterogeneity of environmental benefits within ejidos. Each hectare of forest is characterized by b_j. Ideally, one would prefer an actual monetary value for the environmental benefits offered by a given piece of land. In reality, however, this is quite difficult to establish, so for the purposes of our simulations we establish an index value b_j that allows the ranking of each hectare of forest by its relative environmental value. Note that this does not allow us to exclude lands whose true environmental value is less than the opportunity cost.

Let F_{ej} be the number of hectares with environmental benefits b_j in ejido *e*, with $\sum_j F_{ej} = F_e$. Assume that there is a constant deforestation rate τ_{ej} of forest of category *j* in the ejido. The first year of the program, the unchallenged deforestation would convert $\tau_{ej} F_{ej}$ of forest of quality *j* into pasture. The second year, an additional τ_{ej} of the remaining forest $\left(1-\tau_{ej}\right) F_{ej}$ would be converted, and similarly the following years. The deforested area after *t* years would thus be:

$$\Delta F_{ej}^{t} = \left(1-\left(1-\tau_{ej}\right)^{t}\right) F_{ej}$$

If the program is to prevent deforestation over the years, it should thus "rent" an increasing share of the forest. Payments based on the opportunity cost, assuming that the environmental benefits of all hectares exceed the cost, would be: $P_{e,Rc}^{t} = \sum_j c_e \Delta F_{ej}^{t}$ Because we are paying exactly their opportunity cost, ejidos will always accept the contract. The participating ejidos are those that would otherwise deforest. Note that the contract is for no deforestation on the total initial ejido area with opportunity cost below environmental benefits. Hence the area enrolled in the contract is $\sum_j F_{ej}$. Environmental benefits obtained by contracts in the participating ejidos are: $B^t_{e,\mathrm{R}c} = B^t_{e,\mathrm{R}b} = \sum_j b_j \Delta F^t_{ej}$. In the rest of the paper we will only consider the first year of payment, and leave out the *t* superscript.

5.2 Flat payment

We here assume a flat payment of r per hectare, up to a maximum of $\overline{F}$ hectares: $P_{e,F} = r \min\left[\sum_j F_{ej}, \overline{F}\right]$.

All ejidos are offered a contract, but an ejido will only accept the contract and thus participate in the scheme if the opportunity cost of the area it would otherwise deforest is less than the offer: $P_{e,F} \geq \sum_j c_e \tau_{ej} F_{ej} = P_{e,\mathrm{R}c}$

In order to facilitate comparison of the two schemes, the rate r is established at the level that equalizes the total budget to the budget of the scheme Rc. It thus solves

$$\sum_e 1\left[P_{e,F} \geq P_{e,\mathrm{R}c}\right] P_{e,F} = \sum_e P_{e,\mathrm{R}c}$$

5.3 Constrained program

If the total payment $\sum_e P_{e,\mathrm{R}c}$ exceeds the available budget, the optimum scheme consists in ranking the ejidos by decreasing ratio of benefits over cost: $bc_e = \frac{\sum_j b_j}{\sum_j c_e}$ and paying the opportunity cost $P_{e,C} = P_{e,\mathrm{R}c} = \sum_j c_e \tau_{ej} F_{ej}$ to those with the highest ratio until the budget is exhausted.

6 Empirical results

6.1 Calculation of the opportunity cost

In order to measure the opportunity cost of forested land, we use the rainfed land rental rates reported in the 2002 ejido survey. Because this rate was not reported for all ejidos, we use the value of the rental rate predicted by the following regression equation:

Variable	Coefficient	T-statistic
Average distance to forest in km	-48.9	1.7
Average distance squared	2.1	1.5
Average altitude of forest in meters	-.13	1.3
Average slope of forest	10.8	1.1
Distance*slope	-.45	.53
Distance* altitude	.02	1.3
Total size in 1000 ha	1.2	3.7
State level maiz yield per ha	68.5	2.2
Yield*slope	-4.3	1.5
Yield*altitude	-.02	1.3
Distance to nearest town in kilometers	-.17	.88
Constant	237.5	1.5
Observations	91	
R-Squared	.23	

The average rental rate was $103 US (sd $70) and the Gini coefficient of the per hectare rate is .37. The distribution of per hectare rental rates is shown in figure 1.

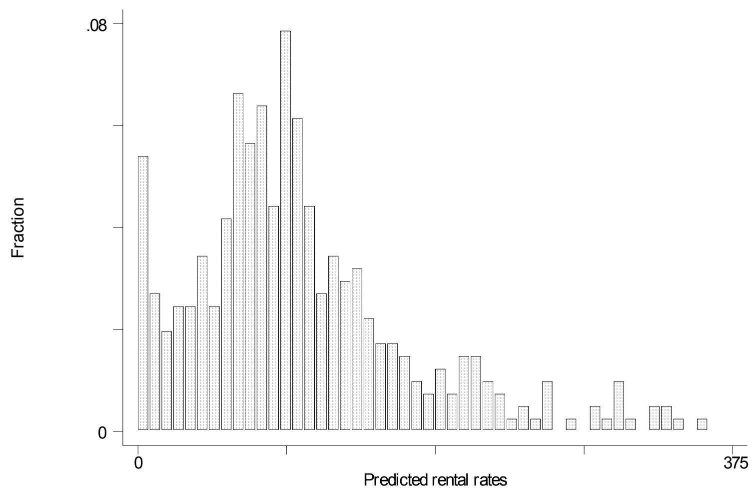


Figure 1: Distribution of predicted rental rates

6.3 Calculation of the environmental benefits index

Ideally, b_j should be expressed in monetary terms. In principle, a team of environmental scientists and economists can establish these values. The research on hydrological benefits remains highly debated, with values for hydrological services ranging from \$20/ha (Chomitz et al, 1998) to \$188 (Hernández, et al., 2003). Still other studies suggest that a mixture of pasture and forest cover generates even higher hydrological benefits that contiguous forest (Aylward and Tognetti, 2002). Hesitant to enter into this valuation debate, we have instead established a set of environmental index based upon both the scale of payments for the existing PES scheme in Mexico and the country's environmental priorities. Given that a major concern in Mexico is water quality, it makes sense to give forests of communities that are closer to major rivers a higher priority than those whose forests do not have this characteristic. Because a detailed river map of the country is not available, we used digital elevation models to establish where the highest flow of water across the landscape would be. Around areas of high flow, we calculated a buffer distance of one kilometer as the area whose erosion would most affect water quality and infiltration, and gave a priority to forest in these areas.

The calculations below should be taken as a first approximation of the total amount of land included. In addition, we give higher values to those communities located in watersheds which have been defined as over-exploited. Over-exploited watersheds have been identified and mapped by INE. Using GIS, we identified those communities which were inside these sensitive areas. We also give differential values to primary and secondary forests, as well as to tropical versus temperate and dry forests. Finally, given that cloud forest is of particular concern because of its status as an endangered ecosystem in Mexico and is thought to produce a higher value of water services, we give them extra value as well. All forest types were calculated according to the classification in the 2000 Forest Inventory.

Table 2 describes one way of ranking the environmental benefits provided by different types of forest in different locations.

Table 2. Constructing an environmental index

Characteristic	Points per hectare
Cloud forest	
Primary	40
Secondary	30
Temperate or dry forest	
Primary	30
Secondary	20
Added to each hectare of above:	
Overexploited watershed	5
Within ½ mile of a river	
Primary	20
Secondary	10

The average benefits per hectare are 30.6 (sd 5.3), a Gini coefficient of .11, and the distribution shown in figure 2.

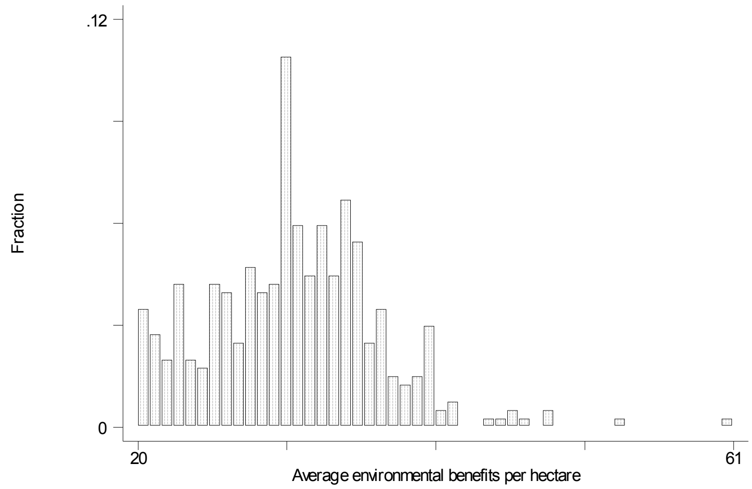


Figure 2: Distribution of environmental benefits scores per hectare

6.4 Observed deforestation rate τ_{ej}

In the first three simulations, we use the observed deforestation rate between 1993 and 2000. In our sample, 61% of the communities have positive deforestation over this time period. The average deforestation rate for the sample is 1.3% and amongst those that deforest it is 2.1%. Figure 3 shows the distribution of the positive deforestation rates. Note the clustering at very low levels of deforestation – payments to these communities will necessarily be quite small.

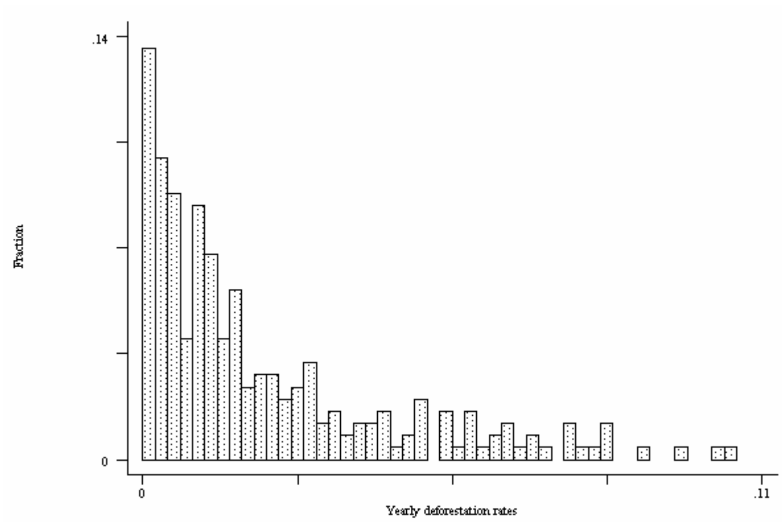


Figure 3: Distribution of positive deforestation rates

5.4 Payments and participation

We simulate our three schemes as if they were put in place in 1993 and we are observing the results one year later. The results are reported in tables 3 and 4. The flat payment here ended up being $5 per hectare with the opportunity costs budget as a constraint. In comparing the first two programs, we see that participation and equity are much higher in the flat payment program than in the opportunity cost program. In the most efficient program, where we use 2/3 the budget of the first program, we have more than 2/3 participation and a slightly lower Gini coefficient.

Table 3. Summary of payments and participants in different programs

Payment rule	Opportunity cost for forest at risk	Flat payment with a cap at 2000 ha	Opportunity cost for forest at risk with highest environmental benefit per $ paid
Percent of ejidos enrolled	61	87	57
Average payment per participating ejido	$10,202	7,341	$7,418
Median payment per participating ejido	$1,744	$7,234	$1,586
Gini coefficient of payments over participants	.81	.32	.77

Table 4 highlights the tradeoff we make between the inequality of the first and third programs and their efficiency. Despite its higher participation, the flat payments program enrolls less than a third of the total hectares at risk of deforestation, and its efficiency is also less than a third of that of the opportunity costs program. This is due to the fact that it enrolls many ejidos that do not have positive deforestation. The optimal distribution of the constrained budget, shown in column three, results in the enrollment of nearly all of the hectares at risk and an efficiency level four times higher than that of the flat payments scheme.

Table 4. Costs and benefits of different payment programs

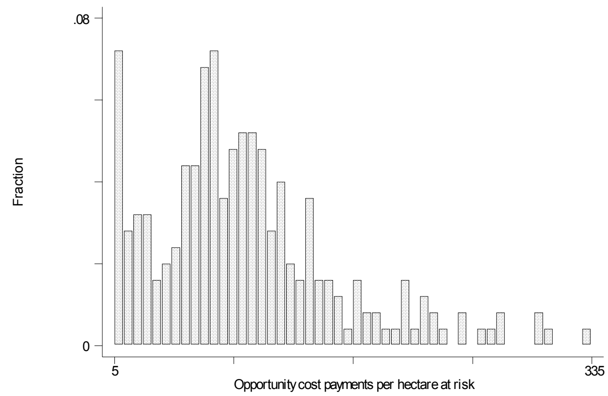
Payment rule	Opportunity cost for forest at risk	Flat payment	Opportunity cost for forest at risk with highest environmental benefit per opportunity cost
Total hectares enrolled	1,836,535	1,022,133	1,534,405
Hectares at risk enrolled	22,667	6,732	19,225
Environmental benefits	682,643	216,378	606,729
Total budget	$2,550,596	$2,598,870	$1,713,509
Efficiency (environmental benefits/opportunity cost)	.27	.08	.35

Table 5 illustrates another measure of efficiency – the dollar amount paid for each hectare at risk of deforestation. Note that this is extremely large for the flat payment schemes (despite the fact that those with zero deforestation cannot be included) and smallest for the optimal strategy.

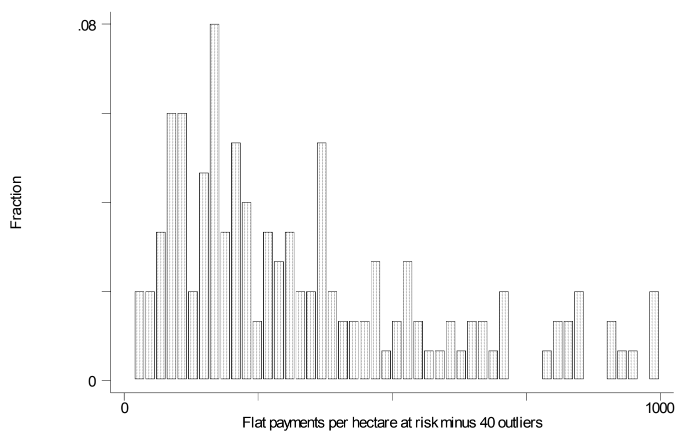
Table 5: Payments per hectare at risk of deforestation

	Opportunity cost for forest at risk	Flat payment	Opportunity cost for forest at risk with highest environmental benefit per opportunity cost
Mean payment per hectare at risk	$96	$7,610	$86
Minimum payment per hectare at risk	$5	$34	$5
Maximum payment per hectare at risk	$331	$654,222	$275

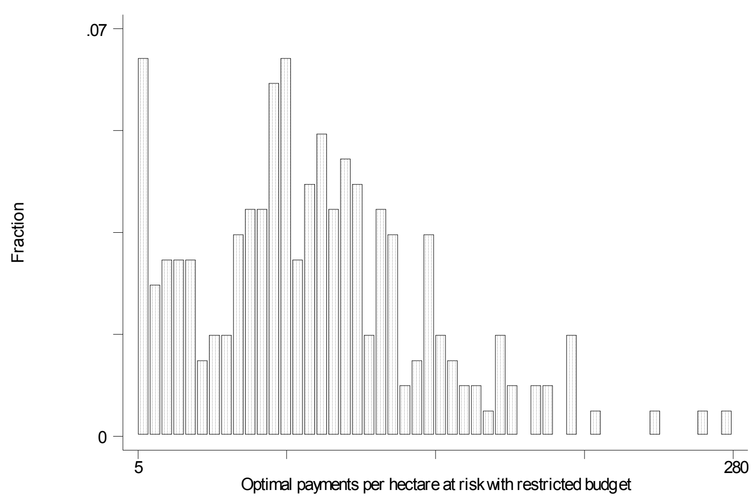
The following three graphs show us the distribution of payments per hectare of forest at risk of deforestation in each of the programs.



Distribution of payments per hectare at risk: opportunity cost program



Distribution of payments per hectare at risk: flat payment program



Distribution of payments per hectare at risk: optimal budget distribution program

6 Implementation – Prediction of the deforestation rate

In order to avoid strategic behavior on the part of ejido communities, it is essential to use the predicted rather than the actual deforestation rate. This section focuses on the application of two predictions of the deforestation rate to the most efficient program. Whatever prediction is chosen, it must be based exclusively on determinants x_e that are truly exogenous to the behavior of the ejido (so that the scheme does not reward bad behavior), i.e., physical endowment of the ejido (area of different types of land, maybe on per capita basis), and structural characteristics such as distance, population, ethnicity, etc. We assume a uniform deforestation rate per ejido (i.e., all categories *j* of forest have the same deforestation rate τ_e), and perform the estimation on the observed sample of ejidos. Although this estimation gives prediction of the expected conditional deforestation rate $\hat{\tau}(x_e)$ in the population of ejidos of characteristic x_e, the actual optimal rate of deforestation of a specific ejido *e* remains unknown to outsiders: $\hat{\hat{\tau}}_e = \hat{\tau}(x_e) + u_e$, where u_e represent the idiosyncratic shock or behavior of the ejido, drawn from the estimated distribution $N(0, \hat{\sigma}^2)$.

Armed with this analysis, we simulate the most efficient scheme based on the predicted deforestation rate $\hat{\tau}_e$ as follows: We first rank ejidos by decreasing ratio of benefits over cost (which is independent of the deforestation rate), as we did above. We then pay the predicted conditional expected deforestation $\hat{\tau}_e F_{ej}$ proportionately to the expected opportunity cost $P_{e,I} = \sum_j c_e (1+\mu) \hat{\tau}_e F_{ej}$ to those with the highest ratio.

A specific ejido will accept the scheme if the payment compares favorably to the opportunity cost of its optimal deforestation rate, i.e., if: $P_{e,I} \geq \sum_j c_e (\hat{\tau}_e + u_e) F_{ej}$ which can also be written: $\hat{\tau}_e + u_e \leq (1+\mu)\hat{\tau}_e$. This shows that if the payment is set at the expected opportunity cost, $\mu = 0$, all the ejidos with higher deforestation rates than the average will not accept the contract. Conversely, all ejidos with predicted rates lower than average are compensated for their "good" behavior. This means that only half of the ejidos will accept the offer. By proposing a higher payment, $\mu > 0$, the program faces a trade-off in paying more than necessary for many ejidos but attracting more of them in the scheme. The expected environmental benefits provided by an ejido that accepts the contract is: $\sum_j b_j\left(\hat{\tau}_e + E\left(u_e \middle| u_e \le \mu\hat{\tau}_e\right)\right)F_{ej}$. It follows that the optimal value for the payment level μ is determined by the overall optimization program:

$$\begin{aligned}&\max_{P_e}\sum_e \Pr\left[u_e \le \mu\hat{\tau}_e\right]\sum_j b_j\left(\hat{\tau}_e + E\left(u_e \middle| u_e \le \mu\hat{\tau}_e\right)\right)F_{ej}\\ &\text{s.t.} \qquad \sum_e \Pr\left[u_e \le \mu\hat{\tau}_e\right]P_{e,I} \le \overline{P}\end{aligned}$$

6.1 Two prediction equations

We present in table 6 two different prediction equations. The first is a parsimonious specification, containing only easily observable, mostly physical variables, while the second includes a range of variables associated with deforestation in common property communities. The former represents a technique suitable for application in policy settings. The intention of presenting both options is to see if any targeting precision is lost in omitting behaviors representing community behavior.

The full specification shows a small increase in the R-squared of the regression over the parsimonious specification – from .38 to .42. This suggests that the second may have superior predictive power to the first. In general, however, an R-squared of .38 is quite respectable for such a cross-sectional estimation.

Table 6: Prediction equations for deforestation
Dependent variable: Hectares of forest lost between 1993-2000

Variable	(1) Parsimonious specification	(2) Full specification
Total area of the ejido in hectares	-0.02	-0.02
	(1.34)	(1.38)
Hectares of forest in 1993	0.13	0.13
	(3.27)**	(3.41)**
Forest squared	-0.00	-0.00
	(2.51)*	(2.62)**
Forest cubed	0.00	0.00
	(2.41)*	(2.47)*
Percentage of total area in forest, 1993	163.55	165.66
	(1.48)	(1.51)
Average distance to forested area	-8.00	-12.87
	(0.70)	(1.11)
Average slope of forested area	-15.75	-16.22
	(1.61)	(1.72)
Hectares of forest*average slope	-0.00	-0.00
	(0.70)	(0.69)
Average altitude of forested area in meters	-0.05	-0.08
	(0.79)	(1.28)
Average distance*average slope	-0.49	-0.52
	(0.54)	(0.59)
Average distance*average altitude	0.01	0.01
	(1.49)	(1.91)
Ejido practices forestry	20.06	9.85
	(0.27)	(0.12)
Number of ejidatarios in 1990	0.03	0.28
	(0.10)	(1.73)
Number of ejidatarios squared	-0.00	
	(0.37)	
Distance to nearest city in kilometers	-0.39	-0.32
	(0.88)	(0.72)
Average number of people per hh with secondary education		-198.26
		(2.38)*
Average parcel size of ejidatarios in hectares		-2.56
		(2.57)*
Number of ejidatarios*Gini coefficient of private parcels		-0.91
		(2.40)*
Membership ratio*forestry ejido		-39.70
		(0.44)
Ratio of members to total population in ejido		-4.75
		(3.04)**
Gini coefficient of private parcels		-226.69
		(1.76)
Predicted proportion of population receiving Progresa		-625.29
		(1.78)
Constant	145.34	704.84
	(1.21)	(2.70)**
Observations	395	395
R-squared	0.38	0.42

Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level

Table 7 compares the payments calculated using both the parsimonious (1) and full (2) specifications. Interestingly, there is not much gain from the considerable expansion of the variable set in (2) – only a .1 (or 7 %) increase in efficiency. The efficiency levels are considerable lower than that of the most efficient program using the actual deforestation rates, at .35, but are still twice as efficient as the flat payments program at .08. As in the actual program, the Gini coefficients of payments for these predicted programs are considerably higher than that of the flat payments program, which has a Gini of .32.

Table 7. Summary of payments and participants in different programs

Payment rule	Specification (1)	Specification (2)
Percent of participating ejidos	50	51
Average payment per participating ejido	\$8,744	\$8,669
Median payment per participating ejido	\$2,058	\$2,591
Gini coefficient of payments over participants	.77	.77
Total hectares enrolled	1,197,210	1,238,791
Hectares at risk enrolled	7,822	8,125
Environmental benefits	265,691	281,402
Total budget	1,757,652	1,768,513
Efficiency (environmental benefits/opportunity cost)	.15	.16
μ	.009	.0085

This leads us to the question of where the misallocation of payments occurs. Table 8 shows the characteristics communities with payments in different error categories. Here we see that specification (2) gives us slightly less type I error and slightly more type II, though these differences are minimal. The type II error comes entirely from deforestation rates that are estimated to be positive for ejidos that in reality had no deforestation. These communities also have very high benefits and low opportunity costs, which means they ranked quite high on our benefits to cost scale. Communities with type I error have very high deforestation rates (and were under-predicted). In addition, their opportunity costs are large relative to the benefits that their land provides.

Table 8: Errors in payment distribution result from predictions

Characteristics	Didn't receive payments but should have (Type I)		Received payments and should have		Received payments and shouldn't have (Type II)	
	(1)	(2)	(1)	(2)	(1)	(2)
Number	121	119	109	111	92	93
Total size in hectares	5,106	4,816	10,872	11,081	2,647	2,670
Hectares of forest, 1993	4,029	3,789	9,567	9,727	1,678	1,710
Average deforestation rate	.031	.032	.010	.010	0	0
Predicted deforestation rate	.014	.014	.014	.014	.016	.016
Predicted proportion of Progresa recipients	.52	.52	.54	.53	.53	.53
Average environmental benefits per hectare	30.2	29	34	35	66	66
Average opportunity cost per hectare	\$105	\$104	\$66	\$68	\$72	\$72

7 Who gets the payments?

In this section we examine the distribution of the most efficient payment program over different structural and social characteristics. The first section considers overall ejido size and distance from the nearest town while the second looks at poverty and ethnic composition.

7.1 Structural characteristics: size and distance

Table 9 shows the distribution of the most efficient payments over size and distance classes. It is interesting to note that in both cases, the lion's share of the budget goes to the most remote and largest ejidos. In the case of distance, these are the less efficient payments, while efficiency over size class is relatively homogenous. Participation rates are also increasing over size and distance classes.

Table 9: Distribution of payments over size and distance

Area and Distance classes	Participation rate	Average payment per community	Efficiency	Percentage of overall budget
Area:				
165 –	43	$1,006	.39	2
1,243 –	50	$3,371	.29	10
2,274 –	67	$4,054	.35	16
5,163 –	71	$17,325	.36	72
Distance:				
0 –	53	$3,668	.40	23
27 –	60	$10,710	.34	77

7.1.1 Social characteristics

This section considers payment distribution over poverty and ethnic composition of recipient groups. Encouragingly, we see higher participation both from the poor and from indigenous communities. In addition, the percentage of the overall budget allocated to these ejidos is quite large and the efficiency of payments to them considerably higher than to the non-poor, non-indigenous communities. We also see, however, that payments per member of these ejidos are much smaller than those in non-poor and non-indigenous communities.

Table 10: Distribution of payments over poverty and ethnic classes

Poverty and ethnic classes	Participation rate	Average payment per capita	Efficiency	Percentage of overall budget
Poverty:				
.37 –	50	$135	.30	39
.53 –	63	$51	.39	61
Percent indigenous population				
0	53	$104	.33	39
>0	62	$68	.37	61

8 Conclusion

In exploring the specification of a PES program for Mexican ejido forests, we have considered the larger context surrounding such payments and some of the details in implementing programs. Before embarking on a national level payment for environmental services scheme, which may be costly to administer and difficult to target, it is important to consider other possibilities for mitigating deforestation. Liberating win-win solutions, which involves getting rid of policies that contradict personal incentives, is the first step in this process. The second is to take advantage of local markets for environmental services. Once these two strategies have been exhausted, the common property forest area still at risk can be targeted for preservation through subsidy. We have simulated four options for program design.

In analyzing these options, we have seen that forests, as well as deforestation, are distributed very unequally across the Mexican countryside, and that in some places forest cover has actually increased over the past seven years. Other regions are in dire need of interventions to mitigate the loss of forests and to preserve the environmental services they provide. Two out of the three program designs simulated use this information in order to target payments at communities with higher risk of converting forest land to other uses.

We used opportunity cost payments as a benchmark, making the assumption that ejidos will reject payments that do not exceed this minimum. Comparing three payment programs, we find that the most egalitarian approach is to pay the rental rate every year but to cap the number of allowable hectares, as currently piloted in Mexico. This is also the least efficient of the three programs in terms of environmental benefits per dollar paid. The highest efficiency comes from maximizing environmental benefits per dollar spent. Payments that incorporate the risk of forest loss – whether the price paid is the opportunity cost or the environmental benefits – are also considerably more efficient than the capped payments. The difference between these two programs is the recipient of the rent – the government in the first case and the ejido in the second.

In applying such a program, one must use predicted deforestation in order to avoid strategic behavior. We show that there is little advantage in venturing beyond easily observable variables in order to make this prediction. There is some efficiency loss in using the prediction as opposed to the actual rate of forest loss, but a program using the predicted deforestation rate is still twice as efficient as a flat payment program.

When we consider the distribution of the most efficient payment program according to characteristics of recipient communities, we find that larger and more remote ejidos receive the lion's share of the budget, although they are not always the most efficient. We also find that poor and indigenous communities have higher participation rates, get a larger proportion of the budget and provide higher benefits per dollar spent that non-poor and non-indigenous ejidos. Unfortunately, however, payments per member to the poor and indigenous are much lower than to their counterparts.

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