Using referenda to improve targeting and decrease costs of conditional cash transfers*

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Abstract

Cost-effective allocation of conditional cash transfers (CCT) requires identifying recipients with low opportunity costs who might change behavior. This paper develops a low-cost approach for improving program implementation by using a stated preference, referendum-style survey question to calculate willingness to accept (WTA) for CCT contracts. We illustrate this in the context of Mexico's Payments for Ecosystem Services Program, and find that the estimated social cost based on WTA is substantially lower than actual payments. Simulation of three geographic targeting approaches shows that joint selection using deforestation risk and WTA could increase program impact under the same budget. We also simulate modified payment schedules based on predicted WTA and demonstrate that these could reduce program cost.

Keywords: targeting, conditional cash transfers, payments for ecosystem services, stated preference

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1. Introduction

Designing voluntary programs that induce behavioral change can be fraught with problems of self-selection: some households who would have sent their children to school without incentives are compensated for enrollment (De Janvry and Sadoulet, 2006), investors who were already building low-income housing receive tax benefits intended to induce them to do so (Sinai and Waldfogel, 2005; Gyourko, 2009), energy efficiency programs enroll individuals who would already have adopted energy-efficient technologies (Joskow and Marron, 1993; Boomhower and Davis, 2014), or producers who did not intend to deforest are paid for forest conservation efforts (Alix-Garcia et al., 2008; Ferraro, 2008). While conditional cash transfer programs (CCTs) usually benefit the voluntary recipients, they often fall short on the behavior-change goals, and thus can result in inefficient allocation of scarce resources. One of the important lessons from this literature is that effective targeting requires being able to predict which potential beneficiaries are most likely to engage in the targeted behavior (truancy, pollution, deforestation, etc.). Yet obtaining the information necessary to identify where transfers are most effective and determining the appropriate levels of compensation can be immensely difficult and expensive in practice. Practical strategies that successfully allow policy-makers to do this are scarce (Johnson and Lipscomb, 2017; Allcott and Kessler, 2019).

In this paper, we study CCT design in the context of a major environmental cash transfer program in Mexico. We propose that adding a simple stated preference referendum-style willingness to accept (WTA) question to occasional surveys of potential recipients could be used to improve program additionality and cost-effectiveness as well as to generate estimates of program social cost. Specifically, we illustrate two strategies to refine program design for conditional cash transfers: re-targeting based on the WTA estimates and a constructed risk index using observable geographic covariates, and changing the program's schedule of payments based on geographic zones and WTA estimates.

The conditional cash transfer we study is focused on reducing deforestation. Tropical deforestation threatens biodiversity, carbon storage, watershed function and rural livelihoods, and policymakers continue to struggle to find effective strategies to combat it. More than eight countries have adopted large payments for ecosystem services (PES) policies, which compensate landowners for conservation activities. Payments for forest conservation have in multiple cases led to preserved forest[1]. Quasi-experimental evaluations of PES programs in Costa Rica, Mexico, Ecuador, and Brazil (Alix-Garcia et al., 2012; Arriagada et al., 2012; Robalino and Pfaff, 2013; Robalino et al., 2014; Alix-Garcia et al., 2015; Jones and Lewis, 2015; Sims and Alix-Garcia, 2017; Simonet et al., 2018) have found avoided deforestation impacts as well as neutral or positive livelihood impacts. An RCT of a pilot program in Uganda also demonstrated high absolute additionality of PES (Jayachandran et al., 2017). However, many important questions remain about the opportunity costs of PES programs and practical approaches to maximize the environmental and social net benefits of such programs. Concern about high enrollment of non-additional properties has been salient in the literature on PES from the very beginning (Jack et al., 2008; Alix-Garcia et al., 2008; Wünscher and Engel, 2012). Strong program additionality at low cost depends on targeting payments to areas where the risk of deforestation is high,

[1] For reviews of the literature, see Alix-Garcia and Wolff (2014); Miteva et al. (2015); Börner et al. (2017).

yet WTA is low. Although risk of deforestation and WTA are often correlated, opportunities to improve targeting exist using the risk/WTA ratio, as long as these dimensions are not perfectly correlated and information can be collected about both.

We begin by estimating and examining the distribution of willingness to accept for conservation incentive payments among a representative population of common property applicants. Landowners in Mexico can apply voluntarily to the program on an annual basis, responding to published rules on eligible zones, available payments, and prioritization of applicants. The program currently accepts applications, then ranks these according to multiple criteria reflecting national environmental and social goals. Applicants with the highest scores within each state are offered 5-year contracts until the available budget is exhausted. Program payment levels are differentiated by ecosystem type and risk of land cover change and the majority of payments go to common property landowners, who own more than half of all land in Mexico (Fox, 2007). We focus on payments to these landowners, who make decisions about program enrollment and land management through an assembly of members and an elected council.

The willingness to accept analysis is based on answers to a question within a survey we designed and supervised in 2016 of 862 community leaders and over 8,000 household heads across communal properties. We included a referendum-style stated preference question designed using best practices within the stated preference literature (Johnston et al., 2017). Specifically, leaders and household heads were offered a randomly programmed payment amount and asked whether they would vote in favor of program enrollment given that payment or not. If leaders vote in ways that reflect the aggregate WTA for the community, their responses will correspond to standard measures of WTA. In the Mexican context, leaders are mandated to represent the community and are more familiar with program details than the households, making this a reasonable assumption. However, to further assess whether the leader responses are actually representative of community preferences, we also derive the payment levels under which the median voter would vote in favor of contracts and estimate these amounts using individual household responses. We find that actual leader votes are largely consistent with these stated preferences of community members. Given this, we use leader responses to estimate the community-level opportunity cost of program participation.

Our analysis first finds that for Mexico's PES program, estimated WTA is substantially lower than current program payments. Given that the potential bias in these estimates is, if anything, upwards, this indicates that environmental benefits from the existing program could be realized at lower budgetary cost. We then illustrate how to use the WTA estimates in combination with observable covariates to increase environmental benefits and decrease social costs by re-targeting to areas at greater risk of deforestation. To clarify tradeoffs between possible social objectives, we simulate the implications of three different targeting schemes on four indicators of CCT program success: total area enrolled, payments above WTA, land area at high risk of deforestation enrolled, and wealth of beneficiaries. We find that targeting the program based only on the costs of participation (WTA) is likely to result in an inexpensive but ineffective intervention, while targeting only based upon the possibility of behavioral change (deforestation risk) increases potential program impact but at a higher cost. A targeting strategy that integrates both components – the ratio of risk per unit of WTA (risk/WTA) – is likely more cost-effective, as it enrolls land with higher risk of deforestation and at a lower opportunity cost. We find that the schemes that incorporate deforestation risk also enroll poorer communities on

average than the current approach.

Driven by the observation that estimated WTA is generally lower than actual payments, we also propose a modified set of differentiated payments based upon simulated willingness to accept. Here we decrease the payment levels within the current program payment categories, using the WTA function to predict enrollment. We demonstrate that the new payment scheme would enroll most properties with high deforestation risk while costing dramatically less.

Broadly speaking, this paper is related to the discussion of lowering targeting costs for social programs. Work on this topic ranges from poverty mapping (e.g., Davis, 2003; Elbers et al., 2004) to geographic targeting (Bigman and Fofack, 2000), and user-led methods for identifying appropriate program beneficiaries (Alderman, 2002; Galasso and Ravallion, 2005; Alatas et al., 2012). However, our paper speaks most directly to the general literature on program design for conditional cash transfers by offering a test of stated opportunity costs relative to actual program payments and practical suggestions for improved design. Studies focused on how much to compensate participants for enrolling in schemes that promote behaviors that may be costly to them are rare, usually because measuring these opportunity costs is non-trivial[2]. While many environmental mechanisms are structured to help set payments at the level of the opportunity cost – for example, through emissions trading – land conservation programs in developing countries tend to operate based on best guesses about prices, yields, and production costs from a few surveys.

In principle, one could use second-price auctions to help set prices in a way that would be fully incentive-compatible. Auctions are used in the U.S. Conservation Reserve Program (Kirwan et al., 2005; Hellerstein, 2017) and have been run for tree-planting programs on a small scale in Tanzania (Jindal et al., 2013), Malawi (Jack, 2013) and Indonesia (Jack et al., 2008), but have not yet been implemented for avoided deforestation contracts. This is because auctions have not been politically feasible in the regions with the most deforestation, due to concerns that their complexity might disadvantage communities with less connectivity or knowledge of market mechanisms. A key contribution of our paper is therefore to present an alternate strategy to improve program cost-effectiveness based on stated preference from a simple referendum question and an index of risk characteristics. Stated preference methods have been developed and extensively studied by environmental and resource economists for more than 30 years (Hanemann, 1984; Cameron and James, 1987) but rarely applied to problems of CCT targeting. These approaches have been previously examined in the PES literature (Southgate et al., 2009; Yu and Belcher, 2011; Cacho et al., 2014), but used to estimate possible payment levels rather than to re-target CCTs. Our study is also unique in that we use a representative sample from a national level program, directly link our estimates to the current payment scheme, use both individual and community level responses to the WTA question, and simulate both changes in targeting as well as adjustments to payment levels. Our approach is also unique in that it uses household responses to inform our interpretation of the community aggregate response. Although best practices are used to minimize bias, to the extent that there is remaining bias due to strategic responses, it will result in upward-biased WTA estimates and thus an underestimate of the potential from re-targeting that could be achieved.

[2]In Mexico's pioneering educational conditional cash transfer program (now called Prospera), payments were originally set at 40 percent of an approximation of what children of school age earn when they work, but this proxy does not take into account the myriad other reasons why children might not attend school, and the true opportunity costs varied widely depending on context (De Janvry and Sadoulet, 2006).

Finally, our work also contributes to the discussion surrounding the social costs of land conservation programs. Estimating the costs of environmental policies is essential to understanding the welfare gains from a particular intervention. Yet measuring such costs is difficult due to the fact that individuals and firms may not wish to reveal costs, are not fully aware of all components of cost, or have very heterogeneous production functions for pollution abatement (Pizer and Kopp, 2005)[3]. Most prior work uses estimates of production revenues for alternate crops or livestock uses to estimate opportunity cost (e.g., Börner et al., 2010; Sims and Alix-Garcia, 2017; Boerner et al., 2016; Börner et al., 2017) but these do not give true cost measures. It has previously been assumed that the potential costs of payments for ecosystem services in developing countries could be quite low – an assertion that has partially justified the expansion of the policy (Landell-Mills, 2002). We confirm in the context of a major program that the social costs of ecosystem services could indeed be low with appropriate targeting mechanisms.

2. Program description

2.1. Contracts, assignment, and payment structure

Mexico's PES program is one of the oldest and largest environmental conditional cash transfer programs. To respond to deforestation and degradation threatening Mexico's water supply and biodiversity, the National Forestry Commission (CONAFOR, for its acronym in Spanish) introduced its first program of payments for ecosystem services[4] starting in 2003. The program is designed to encourage the conservation of land cover and maintenance of intact ecosystems through payments to owners of environmentally valuable land. The program has two major modalities that pay landowners to maintain hydrological services or biodiversity conservation and is currently unified under the Programa Nacional Forestal – Pago por Servicios Ambientales (PSA). Since its creation, the program has grown substantially, adding between 400,000 and 600,000 hectares of land annually. At the end of 2014 (the most recent year of enrollment of the recipients that we survey), over 2 million hectares of forests were enrolled in PSA and it had an annual budget of around US $60 million. The majority of the land enrolled in the program are holdings that operate under collective land tenure arrangements (called ejidos and comunidades indigenas) but it is also open to individual households. Between 2011 and 2014, 62% of recipients and 90% of area enrolled were from common properties. Because of the dominance of the communal tenure area in the program, we restricted data collection and analysis to that group.

Mexico's program has three main mechanisms to target participants in accordance with program goals: geographic eligible zones, a priority points system of ranking applicants, and differentiated payment levels. Over our study period, Mexico had approximately 30 million hectares eligible for PSA. The eligible zones are determined mostly by geographic features – presence of vegetation, deforestation risk, and other environmental characteristics – and are shown in Appendix Figure A1. Individuals and communities living within eligible zones may submit applications,

[3] Whittington and Pagiola (2012) review CV in the PES context. However, this review focused on the demand for environmental services (willingness to pay) rather than producer costs, as we do in this study.

[4] Text in this section is similar to the description of the survey and program in a paper on the social capital impacts of the program (Alix-Garcia, Sims, Orozco-Olvera, Costica, Medina and Monroy, 2018) and a report to CONAFOR/CONEVAL outlining findings from the overall impact evaluation of the program between 2011-2014 (Alix-Garcia, Sims, Orozco-Olvera and et al., 2018).

which include geo-referenced boundaries of parcels they would like to enroll, along with a land management plan. Community applicants to the programs must submit evidence of a community vote in favor of enrolling in the program, a process described in more detail below. From these submitted applications, the federal office of CONAFOR selects new beneficiaries every year based on a point system, and pays them according to the area of each property falling within different categories of ecosystem type and risk of loss. Applications are evaluated along multiple dimensions including environmental criteria (e.g. high risk of deforestation, within a protected area, high biomass density, high water scarcity, percent in forest cover) and social characteristics (e.g. within a municipality with high degree of marginalization or majority indigenous, etc.). The full set of selection criteria for PSA for the years that we examine is shown in Appendix Table A1. CONAFOR ranks all applications according to the sum of these points and awards payments to those with the highest points within each state and sub-program. New beneficiaries are enrolled until the state budget is exhausted. During the years that we examine (2011-2014), there were approximately 2,000 applications for the program each year, of which one-third were awarded payments.

Beneficiaries sign five-year contracts that are conditional on maintaining existing land cover and having completed voluntary forest or biodiversity conservation management activities according to the submitted plan. CONAFOR verifies forest cover through satellite imagery and with audits in the field. A loss of forest cover or a change in land use can result in either contract cancellation (if changes were intentional) or a decrease in payments proportional to the reduction in area (if changes were due to natural causes or illegal encroachment by outsiders)[5].

Table 1 displays current per hectare payments set by CONAFOR, which vary by ecosystem type and level of deforestation risk. If a property has land in more than one payment class, the payment per hectare is a spatially weighted average of the land types. Although the payment levels in principle have a wide spread, there is little land that qualifies for the two highest payment classes, so average payments are below the average of the classes.

Program funds are deposited into the community bank account, which is managed by the ejidal leaders. The magnitude of the total payments given to communities is relatively large compared to wages but has a high variance across communities. In our sample, the average annual per capita payment for common property households (if it were distributed as lump sum payments) is $340 USD, around one month of minimum wage salary. The actual allocation of payments received within the community varies significantly, and depends upon decisions taken within the community assemblies. In our sample, half of the communities chose to invest in materials for forest care and pay wages for labor in the forest (Table A2). Many communities also gave cash distributions to members and invested in village infrastructure. When distributions to community members (called ejidatarios or comuneros) or wages for forest labor are chosen as investments, they tend to use up more than half of the allocated funds. Community leaders manage all funding that comes into the ejidos, and organize community work efforts associated not just with PSA, but with the variety of other government support programs targeted to ejidos. For this reason, community leaders tend to be more familiar with the specific details of effort and investment into activities associated with the PSA.

[5] We do not have quantitative information on the number of contracts reduced or cancelled. Conversations with officials at CONAFOR suggest that cancellation and reduction do happen but have affected only a small percentage of properties. Costedoat et al. (2015) address this issue in Chiapas.

Table 1: Payment schedule 2011-2014

Modality	Zone	Ecosystem	Deforestation risk	Payment per ha in pesos	% eligible area
Hydrological					
	1	Cloud forest	Very high	1,100	0.13
	2	Cloud forest	High, medium, low	700	2.9
	3	Pine, oak, semi-deciduous tropical	All risk levels	382	11.6
Biodiversity					
	4	Rainforest	All risk levels	550	39.7
	5	Dry tropical forest, Mangroves	High & very high All risk levels	382	8.9
	6	Dry tropical forest Arid and semi-arid	Medium, low, very low All risk levels	280	36.8

Payment levels extracted from program rules of operation provided by CONAFOR and forest types verified through discussion with CONAFOR. Deforestation risk is set according to spatial layers from the Mexican National Institute for Ecology and Climate Change (INECC). Modalities refers to the type of ecosystem service being targeted, and percent eligible area is the percent of the area within which applications are accepted that are found in each of the listed payment zones.

2.2. Communal properties

As noted above, our analysis focuses on commonly-held agrarian properties. Collective tenure in Mexico dates back to before the Spanish conquest (Knight, 1986). However, its current form is shaped by the land reform that began after the Mexican Revolution, with land redistributions occurring between 1917 and 1992, and additional "regularization" of holdings occurring even today. Mexico's Agrarian Reform was one of the largest land transfer schemes in history, and included both the expropriation and transfer of land from large "haciendas" to peasant villages as well as the formalization of holdings held by indigenous communities for centuries. It transformed the landscape and the politics of the country (Sanderson, 1984; Knight, 1991; Markiewicz, 1993) – today over half of the country's land area is held in agrarian communities, where approximately half of the rural population lives (De Janvry et al., 1997; Fox, 2007).

Property rights can vary significantly by community. Comunidades indigenas, for example, often hold all land within their boundaries as common, while many ejidos have individually-titled parcels. Despite this variation, communities share important institutional features. First, forest lands are legally property of the federal government, and cannot be officially divided or logged without permits. Therefore, although in practice some communities allocate spatial forest rights to households, most of the lands enrolled in the PSA program are officially managed as common property. The second important feature of the ejidal sector in the context of this paper relates to governance. All ejidos have the same minimal administrative structure: a president, secretary, oversight committee, and treasurer are elected by vote for three year terms, and are not allowed to serve consecutive terms in the same position. Many villages also

maintain committee structures beyond this basic arrangement. Communities hold regular assemblies to make decisions on a variety of issues, such as enrollment in government programs that affect the entire ejido, including the PSA. In all of the communities that we interviewed, decisions are made based on majority voting. Evidence of a vote to participate in the program is required along with the other application materials. In order that there be a formal vote for participation in a PSA (or other government) project, a clear sequence must occur. First, a general announcement of a meeting must be made. When the meeting is held, there must be 50% plus 1 in attendance. In the case that attendance is insufficient, the meeting ends and there is another meeting announcement. In the second meeting the assembly is held, with a formal vote, even if attendance does not reach 50%. The vote is validated by the National Agrarian Registry (RAN).

In the surveys used for this study, we asked a series of questions about these meetings. Participation in community meetings is mandatory, although not all communities sanction lack of attendance – 59% do have some kind of punishment for non-attendance, and within the past year, 70% have applied these sanctions. Attendance rates tend to be fairly high; we asked leaders the number of members attending the most recent assembly, and find the median attendance to be 62%[6].

3. Data

3.1. Survey data

The data come from surveys of households and leaders implemented in 12 Mexican states in 2016. In total, we surveyed 862 communities and 8,413 households. The data were collected in order to evaluate social and environmental impacts of the PSA program for cohorts enrolled between 2011 and 2014 (Alix-Garcia, Sims, Orozco-Olvera and et al., 2018). To determine the sample, we divided the country into zones (North, Center, South and Yucatan Peninsula) and selected the states with the highest number of applicants. The sample was stratified by "medium" (2011-2012) and "short-term" (2013-2014) cohorts, although for the purposes of this paper we combine all cohorts, as the program rules and deforestation pressures were substantially similar in all these years. Because the design of the impact evaluation exploits a threshold in the enrollment criterion for the program – based upon the point score assigned by CONAFOR – sampling of accepted and rejected applicants occurred around the acceptance threshold for the point score. The basic sampling strategy was to select treatment and control communities with scores adjacent to the cut-off for each cohort year and state, and continue selecting farther away from the cut-off until arriving at a sample size that represented the proportion of program applicants for that state and cohort. Figure A2 shows the spatial distribution of all applicants to the program between 2011 and 2014, and highlights the states in which interviews took place. The survey instrument was field-tested by project PIs and then interviews were

[6]For the random sample of households to whom we administered the household survey, we also asked how many assemblies a household member was sent to within the last year. Across our more than 8,000 households, less than 3% did not send a representative to a single assembly with in the past year. While households were asked about all assemblies, the leaders were responding about the most recent assembly, so these numbers are not necessarily inconsistent. Although this is quite a small number, we run a basic probit regression with non-attendance as the dependent variable and the available household characteristics as covariates (results shown in Table A4). Broadly speaking, non-attendance is greater for older and less educated households.

conducted by a team of enumerators from Chapingo University in Mexico. While CONAFOR facilitated access to all communities, no CONAFOR employees were present for interviews and enumerators clearly identified themselves as coming from an independent third party.

An individual was defined as a leader if they were currently in a leadership position within the ejido – i.e., they were in one of the main elected positions of president, secretary, treasurer, or oversight committee. Surveyors asked first to speak with the president, but if the president was absent, they would speak with his designated representative. Community leaders are accustomed to such interactions and generally have systems in place for other council members to stand in for the president when necessary.

For the household survey, 10 households were randomly selected to be interviewed for the program, based on lists of members obtained in advance, with responses given by the household head. We chose to sample equal numbers of households within each community because one goal was to obtain a community average effect on socioeconomic indicators (not weighted by population). Characteristics of the respondents are given in Table A3. The primary reported economic activity of over half of the respondent households was agriculture or livestock, most household heads have not completed secondary school, and 72% of respondents understood the survey questions "very well" (as assessed by the enumerator).

The sample is representative of the universe of possible applicants. When we compare the communities sampled with the universe of possible applicants in all states during these years, we find few differences in observable covariates. Table 2 shows the means and normalized differences in means across the sampled versus the not sampled applicants between 2011 and 2014. Most of the normalized differences are quite small (less than a quarter of a standard deviation). The covariate for which there is a substantial difference is percent indigenous in the municipality, which is larger for applicants in the sample both for beneficiary and non-beneficiary communities[7]. Sampled beneficiaries are also somewhat farther from major cities.

Leaders and households were surveyed separately, with some questions overlapping across the instruments. Leaders responded to questions about the PSA program, including the location of the parcel and its characteristics, a referendum question regarding how they would vote on program participation at different prices (see description below), the way in which payments were divided within the community, the types of forest management, and use of the PSA parcel. In addition, they responded to a battery of questions on community characteristics (infrastructure, productive activities, common property size, etc.). A significant number of questions were also asked with the intention of measuring social capital for use in a complementary study (Alix-Garcia, Sims, Orozco-Olvera, Costica, Medina and Monroy, 2018).

The household survey also began with questions about the PSA program, including the same referendum question asked to the leaders (though with different random prices) and household use of the PSA parcel. A basic household roster and demographic characteristics were also elicited, along with the main in-

[7]When we test within our sample for a difference in estimated WTA between those with above 50% indigenous and those below, we find a difference of 3 pesos on average, and a t-test of this difference across subsamples yields a p-value of 0.61. This assuages concerns about possible bias from a high presence of observations from majority-indigenous municipalities.

Table 2: Sample versus universe of PSA applicants, 2011-2014

	Not sampled		Sampled			
	(1)	(2)	(3)	(4)	(5)	(6)
	Non-ben	Ben	Non-ben	Ben	Norm diff (1) v (3)	Norm diff (2) v (4)
Ln(ejido area, ha)	8.41	8.07	8.12	8.28	-0.19	0.14
Ln(common property area, ha)	7.87	7.60	7.59	7.98	-0.11	0.17
Ln(ejidatarios)	4.63	4.57	4.64	4.56	0.01	-0.00
Ln(non-ejidatarios)	1.25	1.65	1.41	1.31	0.07	-0.14
Ln(area submitted, ha)	6.76	6.61	6.56	6.80	-0.16	0.16
Average slope (deg)	12.22	12.36	11.02	10.98	-0.12	-0.13
Average elevation (m)	1410.45	1357.59	1358.32	1271.73	-0.04	-0.06
Ln(km to any road)	7.86	7.65	7.61	7.67	-0.17	0.02
Ln(km to major city)	4.49	4.34	4.60	4.59	0.13	0.30
Ln(km to city $>$ 5,000)	3.30	3.12	3.20	3.25	-0.11	0.11
Mean canopy cover	41.38	43.96	47.37	53.64	0.14	0.23
% indigenous in municipality	0.13	0.21	0.26	0.38	0.26	0.27
Deforestation risk (INE)	0.05	0.06	0.06	0.05	0.05	-0.10
Obs	1169	808	375	487		

Table shows mean values of variables for communities that were sampled versus those that were not sampled, and breaks these down by beneficiary and non-beneficiary communities. The last two columns show the normalized differences in means between sampled and non-sampled non-beneficiaries (column (5)) and sampled and non-sampled non-beneficiaries (column (6)).

come sources of the household. Households then responded to a series of social capital questions. In addition, the household survey asked questions about both housing characteristics and small assets. We used these to generate wealth indices that help shed light on the socioeconomic effects of the program generally (Alix-Garcia, Sims, Orozco-Olvera, Costica, Medina, Romo-Monroy and Pagiola, 2019) and the distributional consequences of changing targeting approaches in this paper[8]. We examined a variety of methodologies for aggregation, including simple summation of the presence or absence of characteristics, principal components, polychoric principal components (which takes into account categorical variables), and inverse proportion weighting (which applies higher weight to very scarce items). Our analyses use the village level averages of the simple asset indices, though the other more complicated aggregations of the household data yield similar results.

3.2. Deforestation risk

In order to conduct targeting exercises below, we create a measure of deforestation risk[9]. We would like this measure to be specific to the risk affecting the types of properties that apply for the program. To this end, we use the national level program data to examine deforestation behavior within the polygons that were submitted for consideration during the study period (2011-2014) but were rejected from the program. We analyze polygons with unique histories – that is, if an applicant submitted different pieces of overlapping land in different years, we separate the submitted parcel into multiple non-overlapping units in order to avoid double-counting of areas.

To ensure that the deforestation index is exogenous to program participation during the period that we analyze and simulates an ex-ante information set, we create the index using measured deforestation between 2005 and 2010, prior to application. The deforestation data come from Hansen et al. (2013). This dataset provides information on annual forest loss beginning in 2000 and has been updated yearly[10]. The underlying satellite imagery is a combination of Landsat (30m) and MODIS (250m resolution). We aggregate total deforestation within each polygon between 2005 and 2010, and assign an indicator equal to one for polygons where deforestation over this period was greater than 2 hectares, and that had a baseline forest cover of greater than 10 percent.

We estimate a probit model with the binary deforestation variable as an outcome and include only exogenous covariates (geographic features, ecosystem indicators, baseline forest, and distances to small and large cities) with coefficients shown in table A5. These variables are strongly correlated with returns to agriculture and livestock production, which are the main sources of deforestation in Mexico. These variables also correlate with accessibility, which may drive illegal timber extraction, a secondary source of deforestation. When households in our survey were

[8]Housing characteristics included brick or wooden walls, concrete, metal, fiber, cement, or tile roof, cement, wooden, mosaic or marble floor, number of rooms. The housing index also includes measures of access to public services, including existence of water and sewage connections, and amount of water and electricity availability. The assets index is composed of responses to questions on the presence or absence of the following items: television set, refrigerator, blender, microwave oven, laptop, car, truck, motorbike, bicycle, gas or electrical cooker, telephone landline, and mobile phone.

[9]The Mexican government has its own deforestation risk index ("Index of Economic Pressure") which is used for targeting the PES program and setting payment levels (Table 1). We do not use this index due to the fact that it does not have complete coverage of the entire country, is not specific to the types of land that are of interest for the current study, and is not limited to the specific, pre-treatment years that we use to create our index.

[10]This dataset has important limitations. It was created for global analysis, and the accuracy of the algorithm has been shown to vary across countries and ecosystems (Burivalova et al., 2015). In Mexico, it is thought to underestimate forest cover loss.

asked what their enrolled PSA land might be used for, the most common potential uses (when they could be specified) were agriculture and livestock. These responses are consistent with other research on the causes of deforestation in Mexico (Kolb and Galicia, 2012). Table A5 shows two prediction strategies, without and with state fixed effects. We use the estimated coefficients from column (1) to generate a probability of deforestation risk for each parcel of land. In order to assign a single value to the submitted land from each ejido, we aggregate the parcels using the mean. Results are nearly equivalent using predicted risk from column (2), which includes state fixed effects, and/or to using the maximum risk for polygons within an ejido.

4. Measuring willingness to accept

We are interested in measuring communities' underlying willingness to accept payment for enrolling common property land in the PSA program, in order to understand the program's opportunity costs and to construct supply curves for predicting responses to counterfactual payments and enrollment criteria. Payments in the PSA program are set administratively, and so provide only an upper bound on applicants' WTA. In lieu of an auction, we exploit a standard methodology in environmental and resource economics, whereby survey participants receive a referendum question on a program at a randomly chosen price, and are asked to vote yes or no for the program, at that price. As described above, we observe votes from our sample of leaders, whose job is to represent their village, and a subsample of individuals within the village, who vote their own preferences. We use responses to the referendum to estimate each community's collective minimum willingness to accept payment for enrollment, based on leaders' responses, and the payment that would induce the median household member to vote yes, based on the household data.

4.1. The question

The following question, based on standard stated preference methodology (Phaneuf and Requate, 2017), was presented to all of the leaders and households in our sample:

> Suppose that your ejido/community were voting another time to decide if they wanted to participate in the program. The decision would be taken according to the normal voting rules of your village. If the community were to receive an amount of [X] per hectare, equivalent to [X x number of hectares in total], would you vote in favor of or against participating?

Here [X] refers to an amount between 80 and 770 pesos ($\sim$ US $4 and $41). Values offered in the referendum question were randomized, with a higher proportion of values offered below the actual payment received (or that would have been received in the case of the non-beneficiaries). This distribution was chosen because we assumed that true opportunity costs were likely to be less than the payments, given that all surveyed communities had already voted once to participate at these rates. The question was asked in reference to the specific parcel of land that was submitted in the most recent PSA application. After answering, a follow up question was offered at a higher (lower) value in the event that the respondent said no (yes) to the first value.

4.2. Minimizing strategic response

The referendum-style question was used, rather than an open ended or checklist format, because prior research has shown that the referendum format can induce truthful preference revelation in specific contexts[11]. Vossler et al. (2012) and Carson et al. (2014) provide theory and experimental evidence related to willingness to pay (WTP) referendum questions for stated preference. They show that a single issue, binary choice referendum over a public good that individuals care about – i.e. is 'consequential' (Carson and Groves, 2007) – is incentive compatible if the payment mechanism is enforceable, and the probability of implementation is increasing in the proportion of yes votes. Carson et al. (2014) further show that an advisory referendum preserves incentive compatibility. Both studies verify their predictions using field experiments that compare real and hypothetical payment scenarios. There is now general agreement that binary choice referenda are a preferred choice for WTP public good studies, based on their attractive incentive properties and familiar context for respondents, who respond to a posted price (Johnston et al., 2017, p.345).

There is comparatively little research on the incentive properties of WTA formats. This is because stated preference practice has generally emphasized the WTP format due to perceived challenges in implementing the WTA format. These include the potential for scenario rejection given the unfamiliar context for many respondents of being offered payment, rather than buying at a posted price, and concerns about incentive compatibility. In a recent review of the WTA format, Whittington et al. (2017) nonetheless argue that in contexts such as payment for ecosystem services to landowners, researchers should use a WTA format to accurately represent property rights at the status quo.

The specifics of our study provide several reasons to believe that our WTA format, and stated preference design more generally, will not be substantially affected by hypothetical or strategic bias problems. The referendum presented in our survey mimics the process already undertaken when the ejido votes on government program participation. The scenario itself was familiar to respondents because surveyed communities had applied to (and hence voted on) the program in the past. It was also phrased in reference to the specific piece of land that was most recently submitted to the program. Land areas within communities tend to be identifiable by specific phrasing – e.g. "the part of Bald Hill between the north road and the red river" – and this phrasing was identified in an earlier part of the survey with the ejido leader and used in the referendum context. Participants clearly understood which piece of land was being discussed. The familiarity and specificity of our scenario increases our confidence that the object of the referendum was salient to respondents, and that they were comfortable completing the task.

Our WTA format is also likely to be incentive compatible because it asks about a collective, rather than private good. Lloyd-Smith and Adamowicz (2018) modify the theory in Vossler et al. (2012) to show that incentive compatibility carries through under the same sufficiency conditions when the elicitation format is WTA in a public good referendum. They also show empirically that the WTA format for public goods is preference revealing. This finding is relevant for us because our household survey meets the conditions described by Lloyd-Smith and Adamowicz (2018): the local forest resource is a collective good, and the vote centers on the single issue of the community accepting

[11]The basic understanding of incentive compatibility in stated preference questions is drawn from the public choice literature on voting (e.g., Farquharson, 1969; Gibbard, 1973; Satterthwaite, 1975), which lays out conditions under which voters truthfully reveal their preferences. More recent insights related to information structure are discussed by Carson and Groves (2007). Vossler and Holladay (2018) examine the incentive properties of alternative elicitation formats.

payment for collectively giving up aspects of it. The audience for the vote is the community government, which enters into an enforceable contract if the vote is positive. Thus, the question would be incentive compatible for leaders if they respond to the referendum question with a public good in mind and on behalf of constituents. It is possible, however, that leaders could respond to the question as they might for a private good, in which case for the leaders' survey there could be incentive to strategically overstate WTA. It is possible that leaders could view themselves as acting as a representative of the community selling an asset to an external party, with the audience for their vote the program administrator. Carson and Groves (2007) and Lloyd-Smith and Adamowicz (2018) describe two types of strategic responses in this type of private good stated preference WTA context: for existing goods, there is incentive to respond no to an offer to indicate more price sensitivity, and for new or future goods there is incentive to respond yes to secure a future chance to participate. Since this is an existing program, the former seems more likely in our case. This would cause leaders to be less likely to vote yes, which would cause us to overestimate the costs of program participation.

4.3. Theory and estimation

This subsection describes how responses to the referendum question connect to the community-level willingness to supply conservation and how individual responses relate to the leader responses. We begin by using household expenditure functions to derive a welfare-theoretic measure of opportunity cost. This leverages the fact that expenditure functions are money metrics, and we are interested in a monetary value for program participation. The expenditure function for household i in ejido j is $E(q_j^k, u_i, ; s_{ij}, \varepsilon_{ij})$, where q_j^k denotes the common property forest parcel eligible for enrollment, s_{ij} and ε_{ij} denote observable and unobservable characteristics of preferences, respectively, and u_i defines the utility level. We use $k = 1$ to indicate the parcel is enrolled in the PSA program, and $k = 0$ otherwise, with the understanding that q_j^k reflects both the lost production and required conservation labor aspects of the program that are relevant to the household. The household-level willingness to accept compensation for having the common property parcel enrolled in the program is:

$$WTA_{ij}(s_{ij}, \varepsilon_{ij}) = E(q_j^1, u_i^0; s_{ij}, \varepsilon_{ij}) - E(q_j^0, u_i^0; s_{ij}, \varepsilon_{ij}) = NB_{ij}, \tag{1}$$

where u_i^0 is the baseline level of utility prior to enrollment. Note that $WTA_{ij} > 0$ indicates there is an opportunity cost to the individual household of the community's participation in the program, since a higher expenditure amount is necessary to maintain status quo utility. Since the forest is collectively held, the community-level willingness to accept is the summation of the individual household values:

$$WTA_j(X_j, \varepsilon_j) = \sum_{i=1}^{I_j} WTA_{ij}(s_{ij}, \varepsilon_{ij}), \tag{2}$$

where X_j and ε_j are terms that capture the aggregate of household and community characteristics and I_j is the number of households in the ejido. Equation 2 is the welfare-theoretic opportunity cost concept that we want to understand, using both the leader and household votes.

4.3.1. Leader responses and community WTA

We begin by using the leaders' voting outcomes to measure willingness to accept. If we assume leaders' responses to the referendum reflect their forecast of the community level net benefits from participation – a point to which we return below – then a yes response to the proposed payment B_j implies $WTA_j(X_j, \varepsilon_j) \leq B_j$. That is, the payment exceeds the community's collective opportunity cost. For estimation we assume that the community willingness to accept function is given by

$$WTA_j = exp(X_j\beta + \varepsilon_j), \tag{3}$$

where $\varepsilon_j \sim N(0, \sigma^2)$ reflects unobserved drivers of the opportunity cost of participation, and the explanatory variables include community level characteristics and state fixed effects.

Due to uncertainty represented by ε_j, we are not able to predict the community leader's vote ex-ante. Rather, we can express the probability of a 'yes' vote based on

$$\begin{aligned} Pr(yes_j) &= Pr(B_j \geq WTA_j) \\ &= Pr(lnB_j \geq X_j\beta + \varepsilon_j) \\ &= Pr(\varepsilon_j \leq B_j - X_j\beta) \end{aligned} \tag{4}$$

To estimate these parameters, we normalize by the standard deviation of ε_j, which leads to

$$\begin{aligned} Pr(yes_j) &= Pr\left(\frac{\varepsilon_j}{\sigma} \leq \frac{1}{\sigma} lnB_j - X_j\frac{\beta}{\sigma}\right) \\ &= Pr(\varepsilon_j^* \leq \gamma lnB_j + X_j\theta), \end{aligned} \tag{5}$$

where $\varepsilon_j^* \sim N(0,1)$, $\gamma = 1/\sigma$, and $\theta = -\beta\gamma$. Maximum likelihood estimation produces values for γ and θ, which are then used to recover elements of the willingness to accept distribution. Specifically, since WTA_j is log-normally distributed, the conditional percentiles of the distribution are

$$WTA_j^p = exp(z^p\sigma + X_j\beta), \tag{6}$$

where z^p is the p^{th} percentile of the standard normal distribution. We will present the median as our main summary statistic for community-level willingness to accept because this estimate of "leader WTA" is closest to the welfare-theoretic construct in equation 2.

4.3.2. Household responses and median voter price

Up to this point, our analysis follows standard stated preference theory (Phaneuf and Requate, 2017). Next, to assess the credibility of leader responses as representative of household preferences, we derive and estimate the payment

that would induce the median household to vote in favor of the program. Define the net benefit to household i from participation in the program at a village level payment B_j by

$$NB_{ij}(B_j, s_{ij}, \varepsilon_{ij}) = g(WTA_{ij}, B_j) \tag{7}$$

where WTA_{ij} is the willingness to accept for household i in ejido j, given by equation 1. The function should be understood to reflect both the household's individual opportunity cost as well as its gain – either in services of its share of the payment – from community enrollment. While we cannot observe the net benefit for a household, we do know that a household will vote yes in the referendum if $NB_{ij} > 0$ and no if $NB_{ij} < 0$. Given this, an application to the PSA program will go forward via majority vote if

$$NB_{mj}(B_j, s_{mj}, \varepsilon_{mj}) > 0 \tag{8}$$

where household m has the median net benefit amount among voting households in the community. We use B_j^{50} to denote the payment amount in community j that makes the median voter indifferent to participation in the program. That is, B_j^{50} is the amount that would induce 50 percent of member households to vote yes. We refer to this as the median voter price.

To estimate the median voter price, we specify the reduced form probability that a household votes yes on the referendum by

$$Pr(NB_{mj}(B_j, s_{mj}, \varepsilon_{mj}) > 0) = Pr(y_{ij} = 1) = \frac{exp(\alpha_j + \phi lnB_{ij})}{1 + exp(\alpha_j + \phi lnB_{ij})}, \tag{9}$$

where $y_{ij} = 1$ denotes a yes vote and $y_{ij} = 0$ indicates a no, and α_j is a community fixed effect. We use this relationship to implicitly define the median voter price for community j according to

$$0.50 = \frac{exp(\alpha_j + \phi lnB_{ij}^{50})}{1 + exp(\alpha_j + \phi lnB_{ij}^{50})}, \tag{10}$$

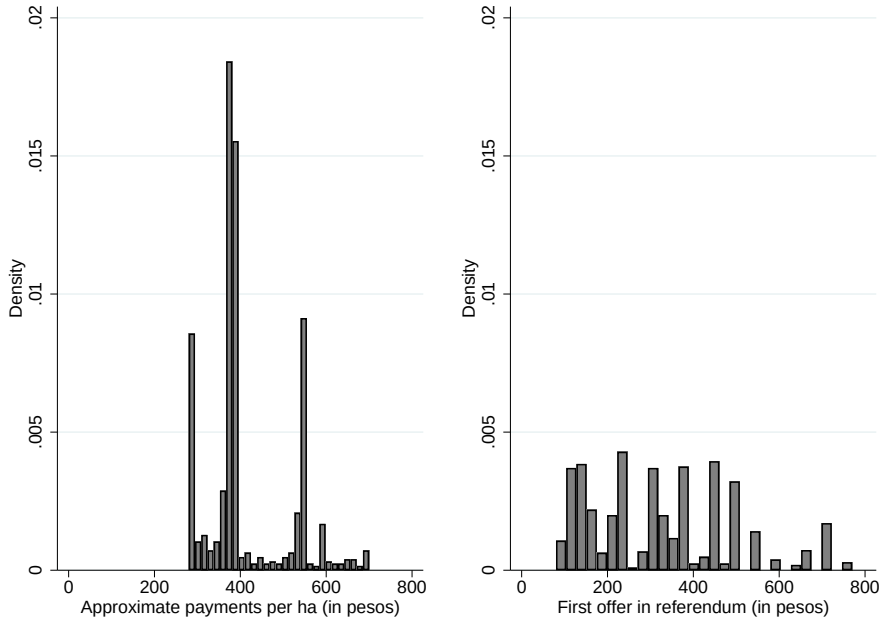
To recover values for the median voter prices we first estimate ϕ in equation 9 using a fixed effects binary logit model. The estimator recovers a consistent estimate for ϕ by concentrating the fixed effects out of the likelihood function. To recover values for the fixed effects we implement a contraction mapping that calibrates each α_j so that the observed fraction of yes votes in community j matches the average predicted probability of a yes vote for sampled community members. With values for ϕ and α_j in hand, we then implement a numerical routine based on equation 10 to recover B_j^{50} for each community in our sample. Details on these steps are included in Appendix A.1.

4.4. Summary statistics

The left panel in Figure 1 shows the distribution of per hectare payments actually received by beneficiary communities, or calculations of what would have been received by non-beneficiaries. The mean value of these payments is 412 pesos per hectare. The second histogram shows the distribution of the random offers given in the referendum

question. In 65% of the cases, the value offered was less than what the community was or would have been receiving. These distributions are similar for the household survey.

Figure 1: Distribution of actual payments and of first offer in referendum



Left panel shows the distribution of payments per hectare for communities in the sample. Values for beneficiaries are the actual payments received. Values for non-beneficiaries were calculated from program rules. The right panel shows the distribution of the offers in the referendum question for the leaders.

Table 3 shows summary statistics for the actual payments and offered prices, as well as the proportion of 'yes' votes. The acceptance rates for the contract offers overall were high – 72% for leaders and 79% for households. We note that the lower rate of acceptance among the leaders implies that estimates of WTA made from their responses will be higher than those from the household survey, and thus more conservative (i.e., reflect a higher opportunity cost). The rate of acceptance was somewhat lower for those leaders who were offered a contract at a value less than the one that they were supposed to receive; in these cases, 64% of the leaders voted yes, and 78% of households. This rate decreased to 59% among leaders of beneficiary communities, but remained high, at 76%, among beneficiary community households.

With regards to the second offer price, we did encounter switching consistent with a change in the level. For those who voted yes to the first contract price offered, and hence received a lower price for the second question, 27% said that they would not take the lower offer. On the other hand, among the 244 respondents in the leader survey who said no to the first offered price, 83% said yes to the second (see Appendix Tables A6 and A7). The fact that many individuals did change their answer suggests that they were engaged with the interviewer and understood the question.

Table 4 supports the assumption that leader votes are representative of community preferences, which indicates that they are acting as community representatives. The table shows the distribution of calculated median voter prices,

Table 3: Sample actual and offered payments, acceptance rates

	Mean	sd	Max	min
a. Leaders				
Approx. payment per ha	412	98	700	280
First offer in referendum	326	1678	770	80
Actual value - referendum value	86	163	590	-440
Voted yes to first offer	0.72	0.45	1	0
Obs	862			
b. Households				
Approx. payment per ha	412	98	700	280
First offer in referendum	329	171	770	80
Actual payment - referendum offer	84	165	590	-440
Voted yes to first offer	0.79	0.41	1	0
Obs	8413			

Values from leader (panel a.) and household (panel b.) survey.

both for the full sample and for the sample for which there was within village variation in votes (73% of villages). In both cases, the sample average of the predicted median voter price is around 200 pesos – of similar magnitude to what we find using the leader sample to estimate WTA (discussed below). Importantly, it appears that the leaders broadly vote as their constituents would wish: in 77 and 71 percent of the villages, the leader vote was consistent with the median voter price. The majority of the inconsistencies occur in cases where the leader was rejecting a bid that was higher than the estimated median voter price (the leaders only said yes to an offer less than the median WTA 4% of the time)[12]. This may be explained by the fact that the leaders may have a better sense of the true total costs of program participation than do the households. It could also reflect the strategic incentive for leaders to signal higher price sensitivity, though based on the high percentage of yes votes we observe among the leaders, it does not seem that this was an important driver of choices.

5. WTA estimates

Based on the match between leader responses and household WTA, in the remainder of the paper we use the estimates of WTA from the leaders' sample as our preferred prediction for the social costs of the program. In order

[12]The existence of sampling noise around our point estimates of the median voter prices implies a higher proportion of leader votes could be consistent if we compared their votes to confidence intervals, rather than point estimates. One aspect of sampling error that could affect our findings is the potential for unusually large or small community level average offer prices, which would induce some communities to have unusually large or small average yes votes. To examine this, we completed our median voter price analysis on a subsample that excludes communities with average household level offer prices that are larger or smaller than 1.5 standard deviations from the overall average. Our findings using this subsample closely mirror the findings in table 4.

Table 4: Median voter prices and leader votes

	Mean	5th %tile	Median	95th %tile
a. Full sample				
Median voter price	179	3	48	626
Leader vote consistent with median voter price	0.77			
Leader = yes, offer < median voter price	0.04			
Leader = no, offer > median voter price	0.19			
Observations	862			
b. Sample with within-village vote variation				
Median voter price	203	25	93	759
Leader vote consistent with median voter price	0.71			
Leader = yes, offer < median voter price	0.06			
Leader = no, offer > median voter price	0.23			
Observations	625			

Panel a. shows statistics for the full sample and panel b. for the sample that has variation in voting within the village.

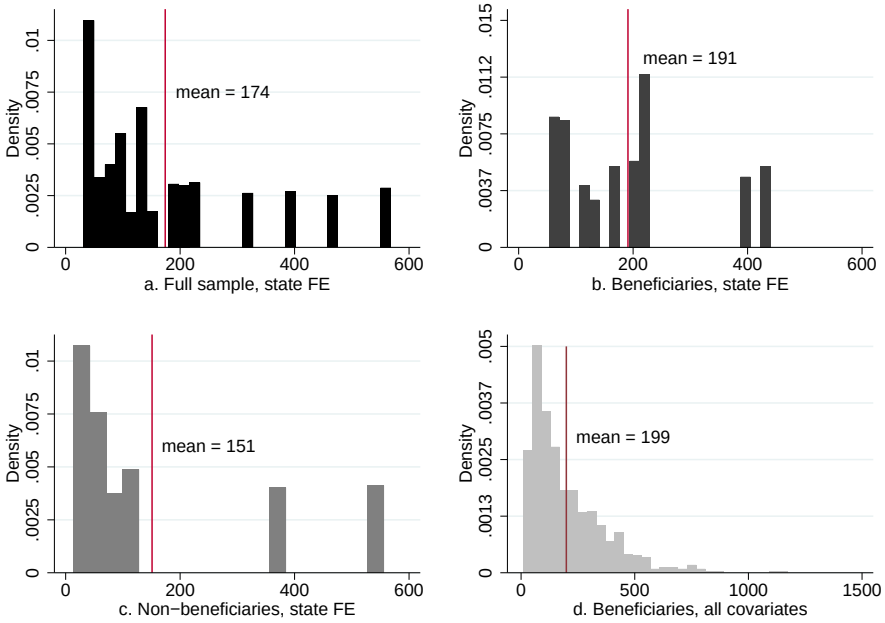
to estimate WTA, we run a series of probit regressions to estimate equation 5 with different configurations of the matrix $\mathbf{X}_j$. Without any covariates, these estimations yield a γ that gives us an estimate of the median WTA across all of the communities. With additional conditioning, we can refine these estimates for subsamples of the population. For example, including state fixed effects produces separate median WTA estimates for each state. Further covariates permit the prediction of median WTA for communities with varying configurations of the covariates.

Table A8 contains the leader sample probit estimations used to predict willingness to accept. These estimates show specifications with no controls (column 1), with state fixed effects (columns 2-5), and with a full set of covariates intended to reflect the opportunity cost of participation, including forest type, ejidal wealth indices, primary economic activities, potential use of PSA land, and geographic characteristics. Beneficiaries seem more responsive to changes in the offer price than non-beneficiaries. The state fixed effects explain a significant amount of the variation in responses (compare columns (1) and (2) in Table A8). We observe this also in a simple graph showing the proportion of yes responses against the difference between the offer and the actual payment (Figure A3), which illustrates a steeper drop for beneficiaries than non-beneficiaries when the net gains (the difference between the hypothetical and the asking price) decrease. This helps justify our use of the coefficient estimates from the beneficiary sub-sample to predict non-beneficiary WTA in our simulations. We use the estimated coefficients from this table (A8) to calculate γ and θ from equation 5 above, and then the median value of WTA as written in equation 6.

Figure 2 shows the averages of the estimated median values of community willingness to accept. These are calculated using both parsimonious specifications (the first three columns of Table A8), and a specification using a large set of relevant covariates to refine the prediction (the last column of Table A8). We also divide the calculations by subsample, showing the full sample, beneficiaries, and non-beneficiaries.

The sample average of the median WTA estimates ranges from 151 to 199 pesos per hectare. The lowest estimate comes from the non-beneficiary population. This could be explained either by the fact that non-beneficiaries have

Figure 2: Averages of estimated median WTA using different specifications

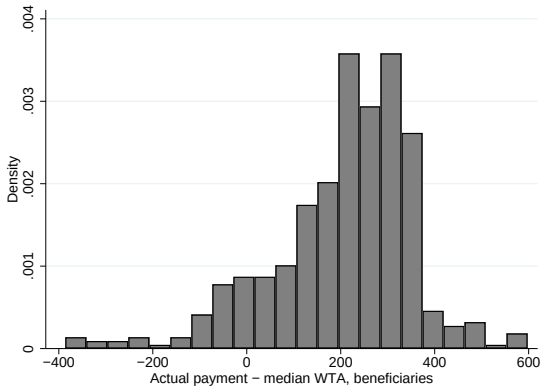


The figure shows the distributions of estimated median WTA using different estimation equations to generate coefficients, as well as different subsamples. The median WTA for each community is calculated using equation A9 with coefficients generated from the estimates shown in Table A8. Panel a. shows results using the full sample of beneficiaries and non-beneficiaries (column (2), Table A8), panel b. uses coefficients from column (3), panel c. from column (4), and panel d. from column (5). All estimations include state fixed effects. Panel a. contains a beneficiary indicator in the estimation, and panel d. includes additional covariates. The vertical lines indicate the mean value within each estimation. The mean, minimum, and maximum are shown in Table A9.

not experienced the extra labor cost of participating in the program, or that the opportunity costs of beneficiaries are higher due to targeting on deforestation risk. Because these differences seem to suggest learning about the costs of participating in the program, and because we prefer the results including the full set of covariates, in later simulations that use non-beneficiary WTA, we use the coefficients from the beneficiary estimates (column (5), Table A9) to predict median WTA for non-beneficiaries. Note that in all cases the average median values are lower than the minimum value actually offered by the program (280 pesos per hectare).

Figure 3 shows the sample distribution of differences between the real payment per hectare received by the community, and the estimated median willingness to accept. In 80% of the cases, the actual payment is higher than the median WTA, which we expect, given that communities are already participating in the program. Of the 10% of the beneficiaries where the median WTA is greater than the actual payment, half are within 50 pesos (about 2.78 USD). In approximately 80 percent of the cases where WTA is less than the actual payment, the estimate of median WTA is more than 100 pesos less than they are actually being paid. This implies there is a substantial transfer in excess of participation costs to communities enrolled in the program[13].

Figure 3: Distribution of the difference between payments and WTA based on leader responses



Difference between the actual payment per hectare for each community and the estimated WTA shown in figure 2, panel d. Negative values indicate estimated WTA greater than what is actually received.

These estimates display a reasonable order of magnitude when compared to available information on agricultural profits in Mexico. Using estimates from a previous paper on locality-level production values (Sims and Alix-Garcia, 2017)[14], the median locality-level revenue for the states in our survey that received some PSA payments is 731 pesos per hectare. Although profit margins are not available for Mexico, for small, family-owned US farms with sales less than $150,000 per year, 76% have profit margins of less than 10%, and only 16% report margins greater than 20% (USDA, 2013). A 10% profit margin on 731 pesos per hectare of revenue suggests profits of less than 100 pesos per

[13] Analysis of household impacts from the 2011-2014 cohorts (Alix-Garcia, Sims, Orozco-Olvera and et al., 2018) suggests no significant gains in household wealth, but does find significant investment in communal assets and substantial increases in local land-cover management activities.

[14] The estimates are derived from municipal level production revenues from principle crops and livestock in 2003 (the first year of the PSA program). We normalize the revenues by non-forested area of the municipality to calculate an average value of production per non-forested hectare. We regress these revenues on municipal averages of geographic covariates and predict the locality-level production values using the locality values of those covariates. These measures therefore provide a village-level approximation of agricultural revenues, but no measure of cost.

hectare – implying both that our WTA estimates display a correct order of magnitude to compensate for the opportunity costs of foregone production, and that these costs are likely small.

6. Estimates of social cost and adjustments to targeting

Under the assumption that the leader WTA estimates represent a combination of foregone production and participation costs, we can use the predictions for median willingness to accept across the beneficiary leaders in the sample to establish an estimate of the social cost of the program for participant communities. To do this, we first take the predicted median WTA for each community (estimated using the coefficients from column 5 of Table A8) and multiply this by the number of hectares of land enrolled in the program within each community. We then sum this amount across all beneficiary communities[15].

The first row of Table 5 shows that total yearly payments to sample beneficiaries were 238 million pesos (about 13 million USD), while the sum of the WTA over all of these beneficiaries is 104 million pesos (5.6 million USD) – 134 million pesos less than is actually being paid. At the community level, the average ratio of the payments given to each community versus the estimated community-level median WTA also suggests that payments were more than three times higher than the amounts recipients would need in compensation to participate. The payments above WTA exceed the total estimated WTA among non-beneficiaries in our sample, meaning that under the current budget, all properties in the sample could be enrolled if they were paid their WTA. Together, these calculations raise the possibility that more conservation could be achieved using the same budget.

Table 5: Social costs and government expenditures

Total PSA payments to sample beneficiaries (million pesos)	238.4
Total median WTA, sample non-beneficiaries (million pesos)	62.8
Total median WTA, sample beneficiaries (million pesos)	103.8
Payments above WTA (million pesos), median WTA	134.6
Community level ratio of total payment to median WTA	3.6

Total PSA payments are actual transfers made to beneficiaries. WTA estimates use coefficients from equation 5, Table A8. This equation is estimated from beneficiaries, with point estimates used for non-beneficiary calculations of WTA. Total median WTA is calculated by multiplying the median WTA estimate for each community by the area enrolled and summing across all communities. For non-beneficiaries, the area proposed to be enrolled is used for this computation. Payments above WTA are the difference between the actual payments made and the total estimated median and mean WTA. The community level ratio is the average ratio of payments to WTA across all communities.

This transfer may achieve other objectives desired by the government, such as providing funds for community investments or additional land management beyond simply maintaining existing cover, but it naturally raises two questions about potential levers for increasing cost-effectiveness. These levers are targeting – changing the criteria about who may enroll – and payment levels – adjusting compensation in such a way that might change enrollment and the distribution of surplus. The following sub-sections address each of these issues in turn.

[15] This does not take into account the costs of administering the program – which are up to 4% of payment amounts (Sims and Alix-Garcia, 2017).

6.1. Potential targeting schemes

We begin by varying targeting criterion and maintaining the current payment schedule. We investigate the distribution of the current scheme and compare it with three approaches to targeting:

1. Selecting those properties with the lowest willingness to accept values ("WTA targeting")
2. Selecting those properties with the highest deforestation risk ("risk targeting")
3. Selecting those properties with the highest ratio of deforestation risk to willingness to accept ("risk/WTA targeting")

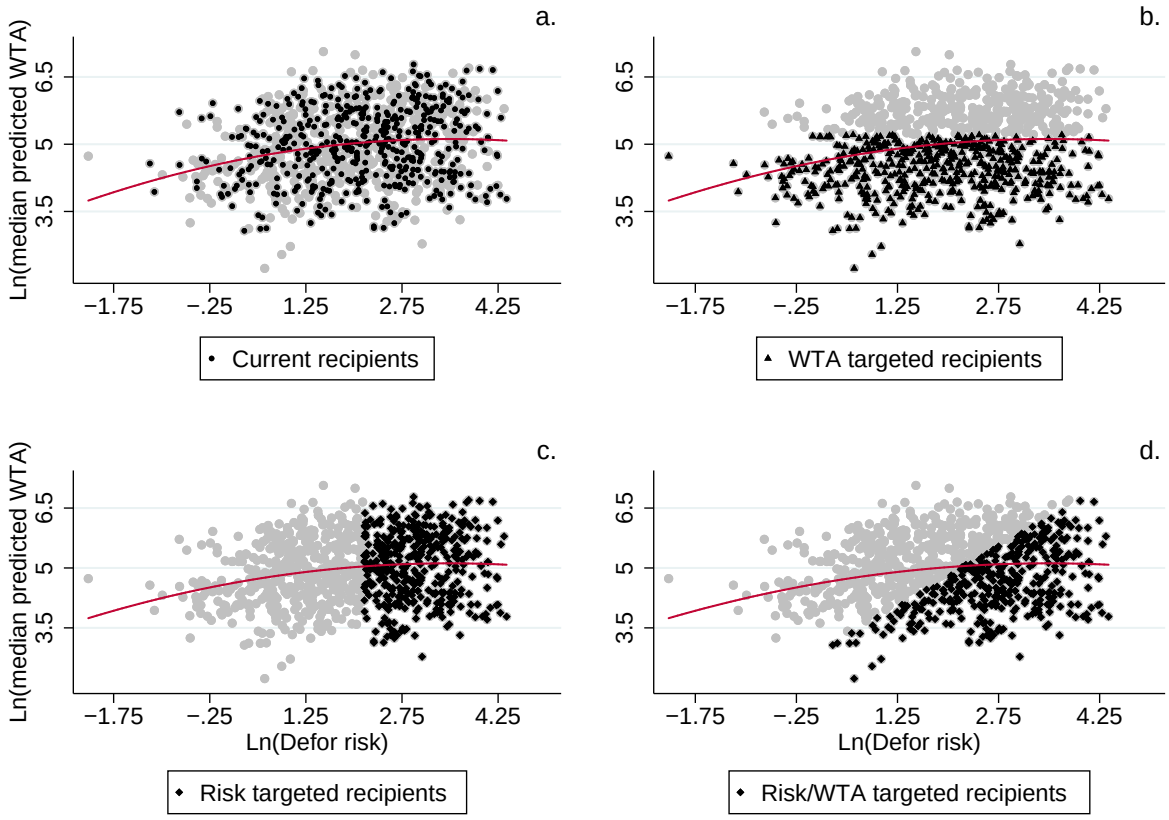
In order to simulate these schemes, we first rank the applicants according to the relevant criterion: estimated WTA, deforestation risk as estimated by our index, and the ratio of deforestation risk to WTA. For WTA targeting, we enroll properties beginning with the lowest-ranked one, and allocate payments according to what the property would be paid were it enrolled under the current payment system. We continue until reaching the budget constraint as defined by the total payments received by our sample of recipients under the current program. Because we only enroll complete properties, the final simulated budget is not exactly equal (but within 1%) to that of the current program. Similarly, for risk targeting, we begin by selecting the highest-risk properties and then proceed as with the WTA targeting. For risk/WTA targeting, we select from highest to lowest ratios until approximating the current budget, again applying the current scheme for payment levels. The practice of targeting by the ratio of risk to WTA is consistent with cost-effectiveness in the sense that it selects properties with the highest environmental benefit per social cost. However, since payments are allocated according to the current scheme, this approach will not necessarily result in the greatest actual cost-effectiveness.

6.2. Enrollment, surplus, additionality, and poverty

Figure 4 shows a scatterplot of all the properties in our sample, with log-transformed estimated WTA on the y-axis and deforestation risk on the x-axis. The red line maps out predicted values from a simple OLS regression of WTA on a quadratic of deforestation risk. The figure visualizes how the targeting schemes interact with deforestation risk and WTA. Dark points represent enrolled properties and light points applicants who were not enrolled. Panel a. shows which properties in our sample are enrolled in the current scheme, and the other panels illustrate enrollment in the various simulations. The figure shows that WTA targeting (panel b.) minimizes social cost by selecting properties under the red line, but favors properties for enrollment on which there is little potential environmental effect, since many have very low risk of deforestation. Risk-targeting (panel c.), by contrast, enrolls properties with the highest potential environmental effect, but at higher social costs. Finally, risk/WTA targeting maximizes the environmental impact per unit of social cost, favoring properties below the diagonal from the origin up to the right. The actual programmatic cost of these strategies depends upon the relationship between the payments, deforestation risk, and willingness to accept.

The figure also highlights the wide spread of WTA at varying levels of deforestation risk, which draws attention to the fact that although these measures are correlated they are not by any means perfectly related. At its strongest,

Figure 4: WTA versus geographic deforestation risk coded by targeting approach



Median predicted WTA comes from column 5, Table A8, and the estimation of deforestation risk is from Table A5, column 1. Light gray circles represent the full sample of applicants, while other symbols indicate which properties are selected from the program under different targeting schemes that hold the overall budget fixed. The red line shows the fitted values from a regression of ln(WTA) on a quadratic specification ln(defor risk).

the explanatory power of risk for WTA is 6.7% (the R^2 in column (3), Appendix Table A10). This is at least partly explained because in a country like Mexico, places with low absolute opportunity cost can have very high deforestation risk. This may be because poor households have few outside opportunities for production, so the possibility of earning a small amount of money from converting land to agriculture is preferable to no activity at all. Conversely, land with very high productive capacity may be owned by individuals with a variety of other income-generating options, so a high absolute WTA could be found in a place with relatively low deforestation risk. A regression of the ranked risk/WTA measure on specific exogenous covariates indicates that factors such as elevation, proximity to roads and being in particular states (Chihuahua, Puebla, San Luis Potosi, and Yucatan) are significant predictors of land with high risk and low WTA (Table A11). However, given the changing nature of risk over time, we suggest updating the risk of deforestation index periodically, rather than switching to a set of specific geographic criteria for targeting.

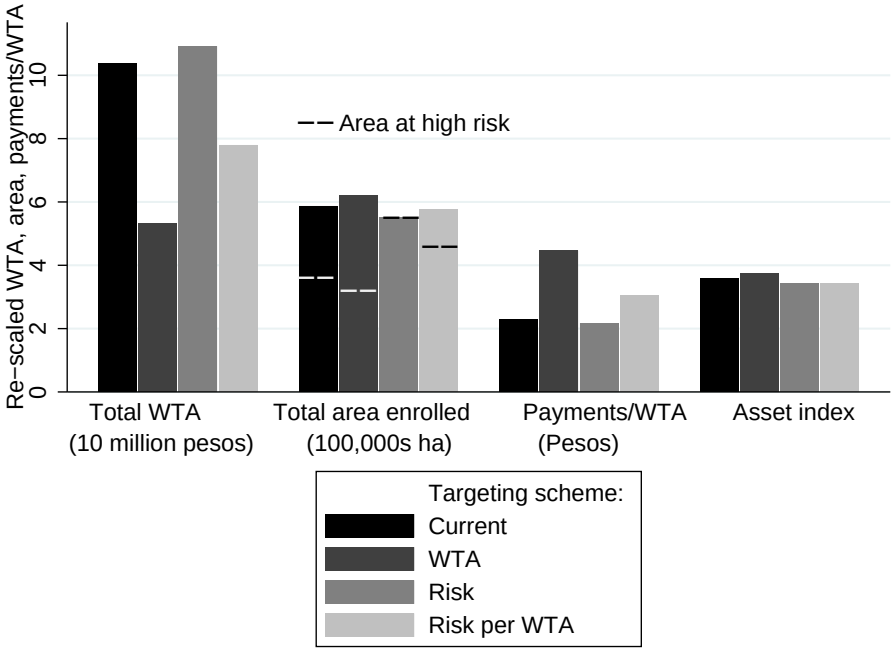
Figure 5 shows several possible indicators of program success: the total WTA (as measured by the sum of median community-level WTA multiplied by the number of hectares enrolled), hectares enrolled, the ratio of actual payments to WTA, and the average of the assets index under the different strategies. As anticipated from Figure 4, enrolling properties with the lowest WTA estimates results in the lowest social cost as approximated by WTA. It also creates the highest ratio between amount paid to beneficiaries and their estimated WTA: under WTA-targeting, payments as allocated under the current PSA schedule are more than 4 times higher than what we estimate villages would have accepted. Targeting only on deforestation risk results in the highest overall social cost (total WTA) and the lowest number of hectares enrolled. This arises from higher WTA being associated with higher payments under the established payment schedule, and with higher deforestation risk. It also yields a lower ratio of total payments to WTA. Prioritizing properties based on the ratio of risk to WTA and paying the current rates increases the number of hectares enrolled relative to targeting on risk alone. It also decreases the overall social cost (total WTA) compared to pure risk targeting, and increases the ratio of actual payments to WTA.

The figure also presents the total hectares above median risk of deforestation as a measure of potential program effectiveness[16]. The total effect of targeting on the enrollment of hectares at above median risk of deforestation is captured by the area under the dashed lines in Figure 5. These comparisons show that while WTA targeting enrolls the most hectares, it enrolls the least area at high risk of deforestation (about 58 percent of what is enrolled under pure risk targeting). The highest enrollment of hectares at high risk is under pure risk targeting, followed by targeting on risk per WTA (enrolling 84 percent of the amount enrolled under risk targeting).

Finally, the figure includes the mean simple assets index for enrolled properties under each scheme. Mean assets are slightly lower under both risk and risk per WTA targeting than under the other two schemes indicating more targeting to poorer communal properties. Appendix A.4 statistically examines shifts in the average values of deforestation risk and poverty for enrolled properties and demonstrates that the wealth levels of beneficiaries from a risk or risk/WTA targeting strategy are statistically significantly lower than those of the current program. In summary, the simulation

[16]Since deforestation tends to occur in small increments in Mexico it is difficult to predict precisely where it will be located. While another approach to assessing environmental effectiveness would be to use the exact predicted deforestation rate for each parcel (i.e., multiplying our risk index by the area enrolled from each community), we feel that this is likely to be inaccurate and somewhat misleading, since the areas at lowest risk are highly unlikely to contribute any avoided deforestation at all.

Figure 5: Impacts of targeting on social costs, area enrolled, excess payments and mean asset index given fixed budget



Total WTA $= \sum_c WTA_l x$ ha enrolled, where c are communities and l represents the estimate of WTA based upon the leader response. Area at high risk = total area enrolled x proportion above median deforestation risk, and is represented by the area beneath the dotted line for each scheme in the middle set of bars. Payments/WTA = total payments to targeted communities under existing payments per hectare/Total WTA. Numbers represented in graph are reported in Table A12. The mean poverty measure indicates the mean of the simple poverty index for properties enrolled, and is multiplied by 10.

results indicate that by combining referendum-based WTA with measures of deforestation risk, it is possible to re-target the program to achieve more avoided deforestation at less social cost and without adverse distributional consequences.

7. Using WTA estimates to set prices

The other lever for changing program cost-effectiveness is to adjust the payment scheme. This section presents two possible approaches to adjust the payments offered within the six zones described in Table 1. In both cases, the payment schedule offers a single price for forest in each zone, which in effect maintains the system currently used by the government but changes the amounts offered.

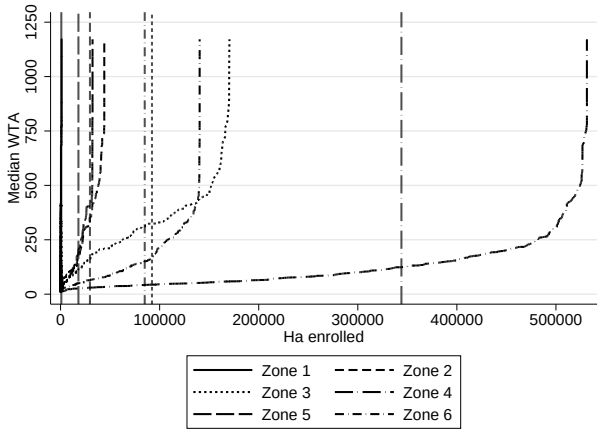
The first approach, which we call "adjusted payments", sets payment rates so that the supply of forest derived using our WTA estimates is equal to the area enrolled in each zone type under the present scheme. We then exploit our community-level median WTA estimates as best guesses of the payments that would induce participation of land submitted by the communities that we interviewed. Multiplying these estimates by the area submitted by each community yields approximate supply curves of land within each zone (Figure 6). The intersection of the area currently enrolled in each zone establishes a possible price by zone (panel a.).

However, offering these prices without any targeting will tend to enroll more forest at low risk of deforestation within each zone – the standard adverse selection outcome. For this reason, we compare this scheme with a second approach, labelled "targeted adjusted payments" that integrates both WTA and targeting on risk. For the second approach, we only permit enrollment of land at high risk of deforestation, and pay the price that would induce the current area at high risk in each of the zones to enroll (panel b.). This price is set where the supply curves (derived from the WTA estimates for high risk forest) intersect with the quantity of forest demanded, which is equivalent to the area at high risk of deforestation in each zone within the current program.

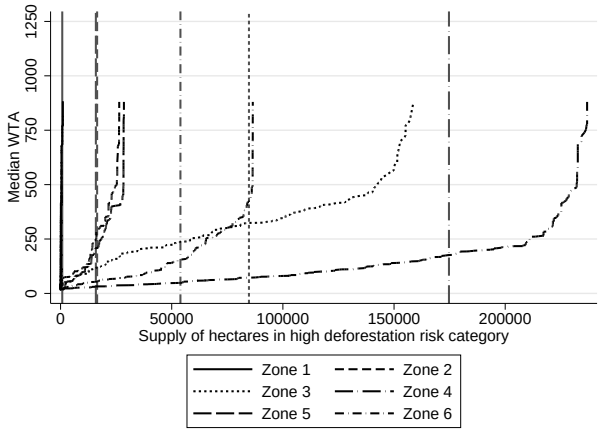
The prices established are shown in Figure 7, alongside the existing program prices by zone. In all zones, the adjusted prices are significantly lower than the current program prices offered. The prices generated for the adjusted and targeted adjusted scenarios are fairly similar, and the prices for high risk land are not always higher than those for any land.

Figure 8 shows the total WTA, hectares enrolled, hectares at risk enrolled, average price per ha at risk, and mean asset index for enrolled properties under the two adjusted payment approaches and the current payment scheme. By construction, the adjusted payments enroll the same amount of hectares as the current scheme, and the targeted adjusted payments the same number of hectares at risk. Total WTA decreases substantially under both adjusted payments schemes relative to the current scheme, since properties with very high WTA no longer enroll in these settings. In terms of environmental benefits, the adjusted payments yield fewer hectares at risk than the current scheme, but the risk-targeted adjusted payments are able to maintain high enrollment of hectares at risk. The differences in the price paid per ha at risk, which are an indicator of program cost-effectiveness, are substantial between both adjusted payment schemes and the current scheme. Payments under the current system exceed 600 pesos per hectare at risk. The adjusted payment scheme cuts this number in half, while risk-targeted adjusted payments are the lowest on a per hectare at risk basis.

Figure 6: Supply and demand of land by zone and median WTA



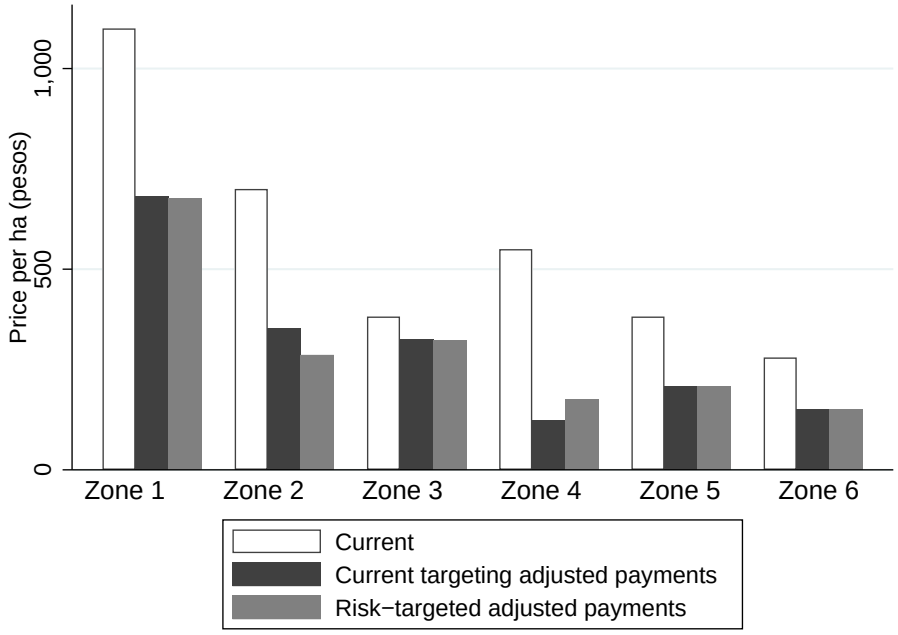
(a) Full sample by zone



(b) Sample at high risk of deforestation

Vertical lines represent total hectares enrolled in each zone (panel a.) and actual hectares enrolled at high risk (panel b.). Supply curves are calculated by multiplying the community estimate of WTA by the area offered by each community for enrollment, ranking these by WTA, and then plotting them against cumulative hectares. The X-axis in panel a. shows all hectares, and the X-axis in b. shows hectares at high risk of deforestation.

Figure 7: Offered prices under current program and proposed schemes

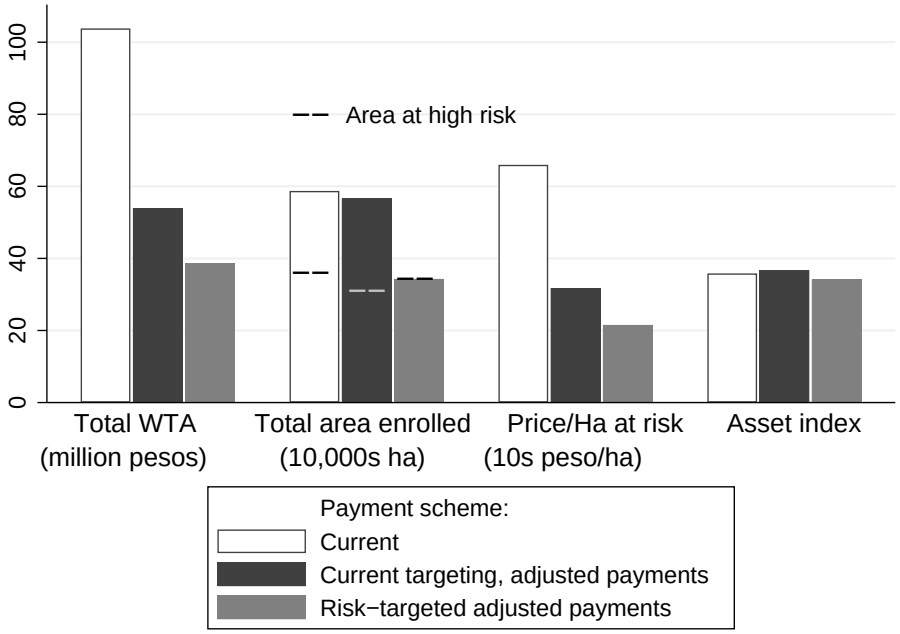


Zones represent the payment zones described in Table 1. Bars are the prices per hectare under the two proposed payment schemes compared with the current payment levels.

Finally, we show comparisons across the modifications in both targeting and in payment schemes (Table 6). As already indicated, both targeting by risk and adjusting payment schemes can increase program benefits (area at risk enrolled) and decrease social costs (total WTA). Table 6 underscores this conclusion, and shows that the biggest increase in cost-effectiveness comes from a combination of targeting and payment adjustments. For the targeting simulations, the budget outlays (total payments) are limited to the total payouts of the current program by construction. For the payment schedule simulations, the limiting factor is area of the current program – total forest area for the adjusted payments, and the area at risk for the high-risk targeting with adjusted payments.

The key cost-effectiveness measures are found in columns (5) and (6), which give the program cost per ha at risk and the WTA per hectare at risk, respectively. In the former case, budgetary outlays include the transfers as well as an additional 4 percent administrative cost allowed by law. The lowest budgetary and social cost per ha at risk is achieved by the risk-targeted adjusted payment scheme. Targeting explicitly by WTA also yields very low social costs per hectare at risk, but has the highest budgetary outlay per hectare at risk, mostly because this strategy enrolls a very low amount of hectares at risk. If policymakers only adjust targeting but not payment levels, the scheme with the lowest WTA per hectare at risk is WTA/risk-targeting. This approach, however, is more costly per hectare at risk in a budgetary sense, whereas outlays are lower under the scheme that targets by risk alone. Adjusting payments alone ("current targeting, adjusted payments") achieves far greater improvements in program cost per hectare at risk than any of the targeting schemes alone, and results in a WTA/hectare at risk nearly as low as in the WTA-targeted system.

Figure 8: Social costs, enrollment, and surplus from adjusted payment schemes



Total WTA $= \sum_c WTA_l x$ ha enrolled, where c are communities and l represents the estimate of WTA based upon the leader response. Area at high risk = total area enrolled x proportion above median deforestation risk, and is represented by the area beneath the dotted line for each scheme in the middle set of bars. Payments/WTA = total payments to targeted communities under existing payments per hectare/Total WTA. Numbers represented in graph are reported in Table A13. The asset index is the mean value for the enrolled properties under each scheme, and is multiplied by 100 in this figure.

Therefore, for agencies seeking to increase cost-effectiveness, the best strategy would be to both target on risk of deforestation and adjust payments according to WTA. Substantial cost savings could also come from adjusting payments alone. However, if changes in targeting are the only available option, simply directing payments towards areas with higher deforestation risk would be an important step towards improved cost-effectiveness.

Table 6: Cost effectiveness comparisons across all schemes

	Total area 100,000 ha (1)	Area at risk 100,000 ha (2)	Payments million pesos (3)	WTA million pesos (4)	Program cost/ Area at risk peso/ha (5)	WTA/ Area at risk peso/ha (6)
Current program	5.9	3.6	238.4	103.8	686.1	287.3
WTA-targeted, current payments	6.2	3.2	237.6	53.3	774.1	166.8
Risk-targeted, current payments	5.5	5.5	237.7	109.2	448.5	198.1
WTA/risk-targeted, current payments	5.7	4.6	237.5	78.0	536.5	169.4
Current targeting, adjusted payments	5.7	3.1	99.3	53.9	330.5	172.5
Risk targeting, adjusted payments	3.4	3.4	74.0	38.6	224.1	112.4

Area is the total forest area enrolled under each scheme. Area at risk is the area of forest with above median risk of deforestation. Payments represent the sum of the total payments given to beneficiaries under each scheme, and WTA is the median leader-calculated WTA per ha multiplied by the area enrolled per community and summed over beneficiaries in each scheme. Program cost/area at risk is column (3) plus 4%. The table reiterates some of the numbers already presented: columns (1)-(4) appear in Table (5), Figure (5), and Figure (9). Comparisons across rows within columns (1)-(4) are only appropriate for the first 4 rows as a group (targeting simulations) and the last two rows (payment schedule simulations).to reflect administrative costs divided by column (2), and WTA/Area at risk is column (4) divided by column (2).

8. Conclusion

In this paper, we address two key issues that bedevil the implementation of conditional cash transfer schemes: targeting to maximize additionality, and setting payments to minimize social cost. We analyze Mexico's national level payments for ecosystem services program, but the methods used are broadly applicable to many conditional cash transfer settings. We first show how simple predictions of deforestation risk can be linked to existing targeting efforts to identify land with likely higher benefits. We then combine this information with estimates of willingness to accept derived from a referendum question, using a well-established contingent valuation method to improve the cost-effectiveness of CCT targeting.

We present a simple strategy for adjusting the current payment scheme to more closely align with applicants' willingness to accept levels. We associate willingness to accept with current program payment rate-setting practices and show that the current program could be significantly expanded in ways that improve environmental and social impact. This expansion could also have a positive equity effect, since although payments to each beneficiary would be lower, they would be spread more widely across the population and would continue to go to those on the lower end of the income distribution. This application of the referendum approach is lower in cost and less complicated than implementing an auction to establish appropriate payment levels. Furthermore, it is significantly more likely to be practical and politically feasible where future CCTs will be scaled-up. It is also important to note that the plausible direction of bias resulting from using the referendum is upwards, so our results may overestimate the social costs of the program, and of the payments required to induce participation. Nonetheless, these estimates are close to estimated profits from agriculture on the sort of land likely to be enrolled in the program, and still significantly less than the actual payments given out by the program.

The referendum strategy could present a low-cost method for periodically adjusting payment levels. However, it is possible that such a strategy could induce strategic bias in a different way than we are concerned about in our one-time application of this method. For example, respondents might say "no" to low payments (that they would actually be willing to accept) in the hopes that it would convince the government to offer higher payments next time. Although this is possible, it seems fairly unlikely, as such strategic responses would require that respondents figure out and believe that their single shot, individual yes/no answer will influence federal policy. Further, if the government could guarantee that money saved from re-calibration of payments would be used to enroll more forest, communities might have further incentive to truthfully report. Implementing periodic surveys to recalibrate targeting and payment levels is not costless or without challenge, but we believe that the likelihood of strategic bias in surveys used for this purpose can be minimized through sampling subsets of program applicants on an occasional basis. This is feasible in the Mexican case because (1) governments do not recalibrate prices on a yearly basis, thus allowing significant time to pass between questioning and price calibration; (2) the program is large enough to allow representative sampling without repeats. In addition, if re-sampled, repeated surveying of applicants may actually provide an opportunity to extract useful information. A mixture of new and previously treated sample members would allow researchers to assemble information to improve the cost-effectiveness of CCTs (via the new sample members) while also measuring possible strategic bias (by comparing to the older sample members). Therefore, it may be both low cost and informative

to integrate this type of referendum question every few years for a random subset of program beneficiaries.

The analysis in this paper also identifies scope to expand the number of properties enrolled by changing program targeting and payment rates. However, in isolation, offering reduced payments will simply attract more applicants at low risk, resulting in less avoided deforestation. To address adverse selection, it is essential to combine payment adjustments with targeting to higher risk areas. This conclusion is broadly applicable to a variety of cash transfer situations – in the event that a behavior is costly, reducing the compensation for changing that behavior will reduce program effectiveness on aggregate, unless there is also a mechanism encouraging enrollment of those who are likely to engage in behavioral change.

Finally, this paper makes a methodological contribution to the stated preference literature by using information provided by households to test the use of community leader responses as measures of the median voter's willingness to accept. Although the specifics of Mexico's communal governance forests are rather unique, a recent global assessment found that at least 18 percent of the world's total land area is held communally or by indigenous groups (Rights and Resources Initiative, 2015). Thus in both land conservation and other realms, situations in which individuals are given voice by a leader are important, and we hope that our theory and analysis linking household stated preference to leader behavior on a referendum question can prove useful in other contexts.

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Appendix A. Supporting information
(for online publication only)

Appendix A.1. Description of method to extract median voter bid value

To recover the median voter prices for each community, note that given α_j and an estimate of θ, the predicted probability of observing a yes vote from a household i in community j is

$$Pr(y_{ij}=1)=\frac{exp(\alpha_j+\hat{\phi}lnB_{ij})}{1+exp(\alpha_j+\hat{\phi}lnB_{ij})}, \tag{A.1}$$

where $\hat{\phi}$ is the maximum likelihood estimate from the fixed effects binary logit model. We find that $\hat{\phi}=1.075$ with a standard error of 0.063, based on 6,146 households and 625 communities. Note that the number of communities is smaller than in our full sample, since the fixed effects logit model only uses groups with variation in the outcome variable. There is a subset of communities in our sample in which all respondents vote either yes (234 villages) or no (2 villages).

To recover an estimate of α_j we implicitly define $\hat{\alpha}_j$ based on

$$\frac{1}{N}\sum_{i=1}^{N_j}y_{ij}=w_j=\frac{1}{N}\sum_{i=1}^{N_j}\frac{exp(\hat{\alpha}_j+\hat{\phi}lnB_{ij})}{1+exp(\hat{\alpha}_j+\hat{\phi}lnB_{ij})}, \tag{A.2}$$

where N_j is the sample size in community j. Note that the equation defines $\hat{\alpha}_j$ as the value that makes the average predicted probability of a 'yes' vote in the community (the right hand side) equal to the observed frequency of 'yes' votes in the community (the left hand side). There is no closed form for $\hat{\alpha}_j$, but for the values of w_j that lie inside the $(0,1)$ interval, the continuity and monotonicity of the expression in $\hat{\alpha}_j$ guarantees there is a unique solution. We implement a numerical contraction mapping routine in Matlab, similar to what is described in Train (2009, p. 322), to find the values for $\hat{\alpha}_j$ that satisfy equation A.2 for the communities in our sample.

As noted above, there is a subset of communities in our sample in which all respondents vote either yes or no. For these $w_j=1$ or $w_j=0$, and so there is no unique solution for $\hat{\alpha}_j$ that satisfies equation A.2. To address this we implement a numerical patch similar to Timmins and Murdock (2007), whereby we set $w_j=0.99$ for villages with everyone voting yes and $w_j=0.01$ when everyone votes no, and solve for $\hat{\alpha}_j$. We examine if our findings regarding the relationship between leader voting and the median voter price are affected by using or leaving out these villages, and our show that our conclusions are unaffected.

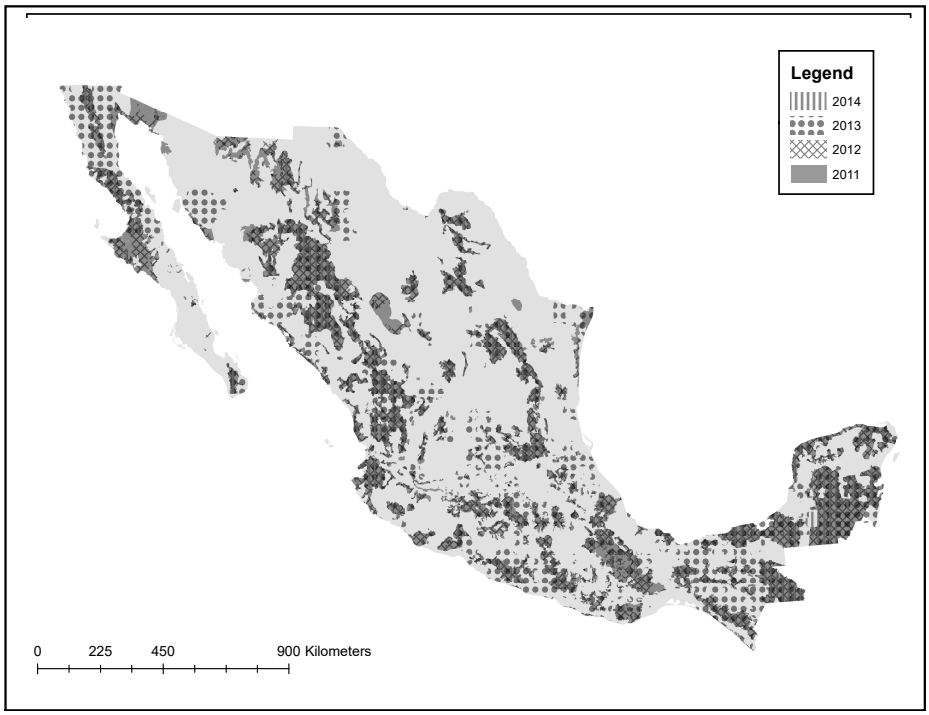
Once we have recovered $(\hat{\alpha}_1,...,\hat{\alpha}_J)$ a second numerical contraction mapping can be used to recover B_j^{50} in

$$0.50=\frac{exp(hat\,\alpha_j+\hat{\phi}lnB_{ij}^{50})}{1+exp(\hat{\alpha}_j+\hat{\phi}lnB_{ij}^{50})}, \tag{A.3}$$

for each village in the sample. Specifically, we search numerically for the value of B_j^{50} that satisfies equation A3, given $(\hat{\alpha}_1,...,\hat{\alpha}_J)$ and $\hat{\phi}$.

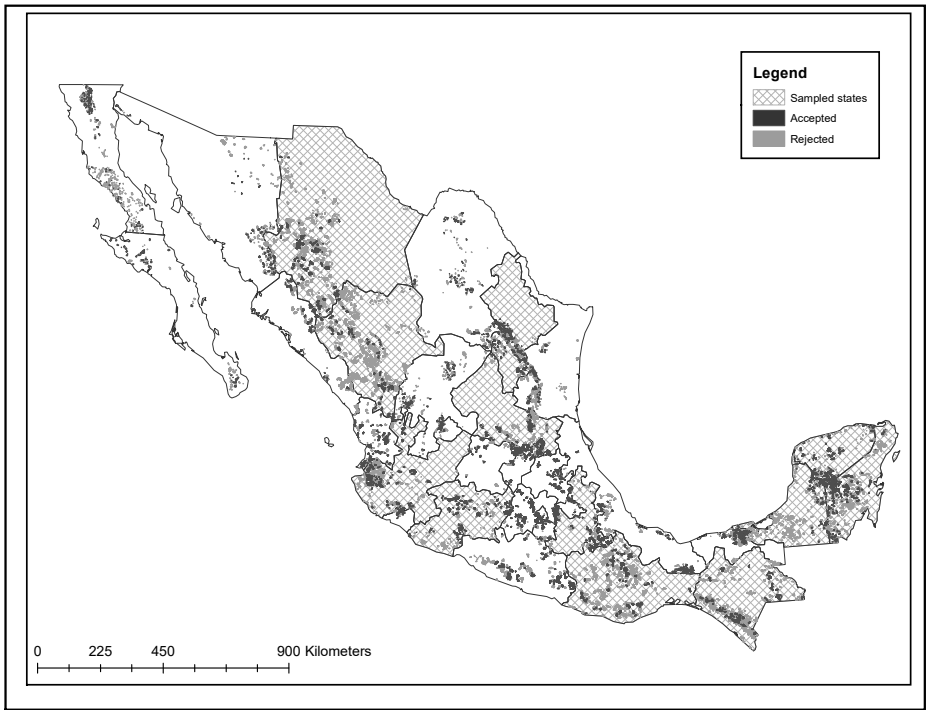
Appendix A.2. Additional figures

Figure A1: Eligible zones, 2011-2014



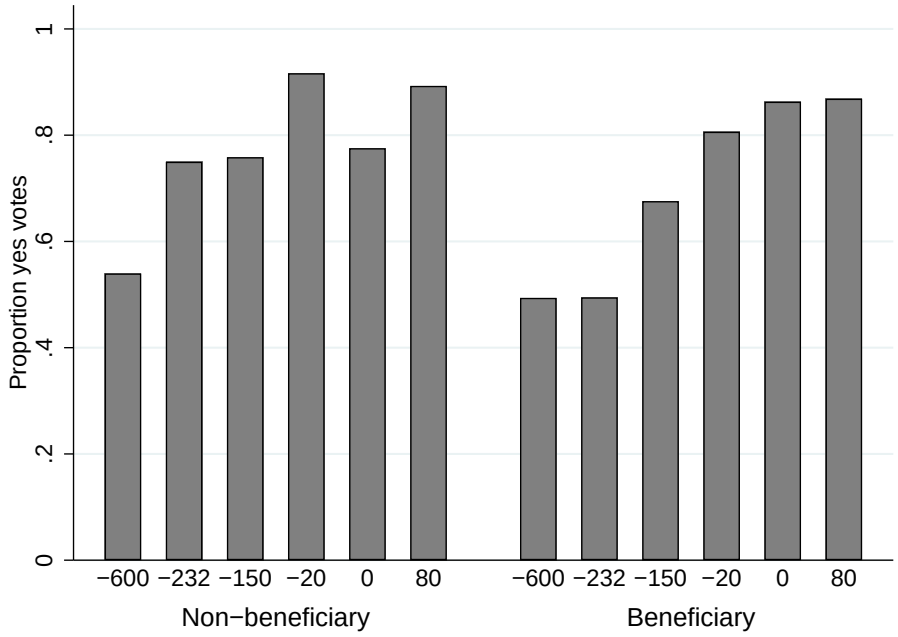
Shaded areas indicate eligible zones for each year from 2011 to 2014. These are areas within which applications to the PSA program will be considered.

Figure A2: Sample states



States included in sample appear with cross-hatch. The map shows all applicants to the PSA program between 2011 and 2014 coded by accepted (black) and rejected (gray).

Figure A3: Proportion yes votes by referendum deficit and recipient status



Note: The y-axis shows the proportion of yes votes from leaders. The left panel shows leaders from non-beneficiary communities and the right panel from beneficiary communities. The x-axis shows the difference between the payment per hectare value that the community would receive under the program and the referendum value that they were offered. Negative values therefore indicate referendum values lower than actual payment values, while positive values indicate referendum offers higher than actual payments. The number of observations in bins on either side of zero are of approximately equal size (15% of the population falls in each of the negative value bins, while 17.5% of the population is in each of the positive value bins). Bin numbers indicate the lowest value in the bin.

Appendix A.3. Additional tables

Table A1: Targeting criteria for PSA: 2011-2014

Geographic Selection Criteria	2011	2012	2013	2014
Within a Protected Natural Area	x	x	x	x
Within an area of high surface water scarcity	x	x	x	x
Located in an overexploited aquifer	x	x	x	x
Within area of high risk of deforestation as classified by INE	x	x	x	x
Area contains high biomass density determined by ECOSUR	x	x	x	x
Area has low rate of anthropogenic soil degradation	x	x	x	x
In a watershed where there are others with local payments for environmental services	x	x	x	x
In an area with an initiative for the development of a local PES mechanism	x	x	x	x
Land has an associated property management plan	x	x	x	x
In an area with a high risk of natural disasters	x	x	x	x
Within a Bird Conservation Area (AICA) or a Ramsar site	x	x	x	x
Within a hydrological priority region (RHP) or terrestrial priority region (RTP)	x	x	x	x
Priority site for biodiversity conservation as determined by CONABIO, CONANP, The Nature Conservancy, and Pronatura	x	x	x	x
Located within biological corridors	x	x	x	x
Within a strategic restoration zone as determined by CONAFOR	x	x	x	x
Proposed property has a shade grown agroforestry system registered with ASERCA	x	x		
Located within the habitat of endangered or threatened species (NOM-59-SEMARNAT-2001)	x			

Participant Selection Criteria	2011	2012	2013	2014
No active legal battle over enrolled land	x	x	x	x
Not enrolled in any other CONAFOR PSA programs	x	x	x	x
Applicant has never received support from CONAFOR	x	x	x	x
Priority to applicants with land of highest % forest cover	x	x	x	x
Applicant presents a forest management plan at time of application	x	x	x	x
Applicants in municipality with majority indigenous population	x	x		
Applicants from marginalized areas defined by CONAPO	x	x	x	
Applicant is a woman	x	x	x	x
Agrarian population center or indigenous population			x	x
Environmental Watch Network (red viga) created in ejido or community	x	x	x	x
Applicant has an assessment regarding the establishment of community conservation areas approved by CONAFOR			x	x
Applicant is P-PREDIAL approved				x
Applicant is a young adult (18-25 years of age)			x	x
Located within a municipality with National Crusade against Hunger program				x
Forestry certification			x	x
Audit or forest management certification in progress	x	x	x	x
Awards or recognition in environmental and forestry matters				x
Applicant is prepared to assume responsibility for additional land area		x	x	x
Applicant provides geo-referenced polygon	x	x		
Located in a municipality with a 100x100 strategy	x			
Located within an Indigenous Region of Mexico and indigenous municipalities			x	x
Applicant responds quickly to the program call	x	x	x	
Refrendos	x	x		

Land area criterion	2011	2012	2013	2014
Land Area				
Hydrologicals	100-200 ha per individual, 200-3000 ha (areas 1,2), 200-6000 ha (area 3) per community		100-200 ha per individual, 200-3000 ha per community	
Biodiversity	100-200 ha per individual, 200-3000 ha (area 4) and 200-2000 ha (areas 5,6) per community		100-200 ha per individual, 200-3000 ha (area 4), 200-3000 ha (areas 5,6) per community	100-200 ha per individual, 200-3000 (area 4), 200-2000 ha (areas 5,6) per community
Forest cover	50%		70% North-Central 50% South-Central	

Table A2: Investment of PSA funds among beneficiaries

	Mean	SD	Obs
Invested in materials for forest care (0/1)	0.818	0.386	446
Gave distributions to ejidatarios (0/1)	0.360	0.480	445
Paid wages for labor in the forest (0/1)	0.733	0.443	446
Gave distributions to non-ejidatarios (0/1)	0.045	0.207	445
Invested in village celebrations (0/1)	0.061	0.239	445
Gave emergency support to families in need (0/1)	0.144	0.351	445
Invested in village infrastructure (0/1)	0.324	0.468	445
% community investment	22.022	21.445	139
% emergency assistance	5.490	7.640	62
% village celebrations	10.158	13.874	27
% distributions to non-ejidatarios	26.015	23.308	21
% wages for forest labor	52.380	29.438	304
% distributions to ejidatarios	56.838	32.474	153
% materials needed for forest care	33.293	25.690	348

Table shows the proportion of villages investing payments in a particular investment category. The percent investments are only reported for those villages that reported positive amounts invested in a given category. Not all ejidos reported these amounts – 405 reported expenditures in at least one of the listed categories.

Table A3: Characteristics of household survey respondents

	Mean	SD	Max	Min
Primary activity marketed agriculture	0.21	0.41	1.00	0.00
Primary activity subsistence agriculture	0.19	0.40	1.00	0.00
Primary activity marketed livestock	0.13	0.34	1.00	0.00
Primary activity subsistence livestock	0.02	0.14	1.00	0.00
Household head has primary incomplete schooling	0.40	0.49	1.00	0.00
Household head has completed primary schooling	0.20	0.40	1.00	0.00
Household head has completed secondary education	0.11	0.31	1.00	0.00
Number of household members	3.87	2.01	15.00	1.00
Interviewee was a woman	0.13	0.34	1.00	0.00
Understood survey questions very well	0.72	0.45	1.00	0.00
Hh knows what PSA is	0.72	0.45	1.00	0.00
Obs	8413			

The table reports means, standard deviations, maxima and minimum of responses given by households interviewed in the household survey. The simple assets index is simply the sum of binary indicators for having a television, refrigerator, blender, microwave, computer, car, truck, moto, bicycle, gas stove, mobile phone, telephone, and electicity.

Table A4: Probability of assembly participation

	Dep. var = 1 if no attendance	
	(1)	(2)
Simple assets index	-0.008	-0.023
	(0.015)	(0.014)
Household head age	0.001***	0.001***
	(0.000)	(0.000)
Household head has completed secondary education	-0.021**	-0.021**
	(0.009)	(0.009)
Household has migrant abroad	-0.011	-0.012
	(0.008)	(0.008)
Ln(household size)	-0.005	-0.002
	(0.004)	(0.003)
Household's main income is agriculture or pastoral	-0.008**	-0.006
	(0.004)	(0.004)
State FE	no	yes
Observations	8249	8249
Pseudo R^2	0.028	0.075

* p< 0.10, ** p<0.05, *** p < 0.01. Estimates are probits, with standard errors clustered at the ejidal level. The dependent variable is equal to one when there the household has not attended an assembly in the past year. Column (2) contains fixed effects for each state. Marginal effects shown.

Table A5: Predicted deforestation risk

	Dep. var = 1 if defor > 2 ha	
	(1)	(2)
178 m elevation-	-0.401***	-0.407***
	(0.078)	(0.081)
964 m elevation-	-0.314***	-0.476***
	(0.099)	(0.106)
1670 m elevation-	-0.275***	-0.419***
	(0.105)	(0.114)
2302 m elevation-	-0.188*	-0.461***
	(0.108)	(0.122)
SD(elevation)	0.001***	0.002***
	(0.000)	(0.000)
IHS(slope in degrees)	0.055	0.016
	(0.039)	(0.042)
% forest, 2000	0.040***	0.109***
	(0.006)	(0.004)
Deforestation between 93 and 00	0.625***	0.604***
	(0.094)	(0.094)
Ln(km to major city)	0.192***	0.158***
	(0.035)	(0.040)
Ln(km to city > 5000)	-0.073**	-0.060*
	(0.032)	(0.034)
Ln(km to 60 kph hwy)	-0.187***	-0.165***
	(0.025)	(0.025)
State FE	no	yes
Observations	12674	12172
Pseudo R^2	0.248	0.229

* p< 0.10, ** p<0.05, *** p < 0.01. Estimates are probits, and also include the percentage of a polygon in a variety of key ecosystem types (results suppressed). The dependent variable is equal to one when there are more than 2 ha lost in a polygon between 2005 and 2010.

Table A6: Voting patterns on first and second price offers: leaders

	First response		
	Against	For	Total
Second response			
Against	125	119	244
For	169	449	618
Total	294	568	862

Tabulation of responses to first and second price offers on referendum question in leader survey.

Table A7: Voting patterns on first and second price offers: households

	First response		
	Against	For	Total
Second response			
Against	940	848	1788
For	1789	4836	6625
Total	2729	5684	8413

Tabulation of responses to first and second price offers on referendum question in household survey.

Table A8: Prediction equations for willingness to accept

	Dep. var = 1 if yes				
	Full	Full	Ben	Non-ben	Ben
	(1)	(2)	(3)	(4)	(5)
Ln(offer price)	0.153***	0.230***	0.283***	0.160***	0.259***
	(0.025)	(0.023)	(0.028)	(0.037)	(0.028)
Beneficiary in either cohort (0/1)	-0.070**	-0.085***			
	(0.030)	(0.027)			
Ln(area submitted)					0.041
					(0.026)
PSA land: Coniferous forest					0.140
					(0.086)
PSA land: Semi-perennial dry tropical forest					-0.062
					(0.058)
Ejidal mean of house_simple					0.733***
					(0.227)
Ejidal mean of assets index					-0.631***
					(0.212)
Ln(ejidatarios)					0.002
					(0.023)
Primary activity of households: marketed agriculture					0.023
					(0.043)
Primary activity of households: marketed livestock					-0.011
					(0.064)
Primary activity of households: forestry					0.131
					(0.117)
PSA land used for wood extraction in past 12 months					0.226**
					(0.103)
PSA land used for non-wood products in past 12 months					0.075
					(0.068)
Percent locality in protected area					-0.011
					(0.052)
Slope in degrees					-0.005
					(0.014)
Slope squared					0.000
					(0.000)
Ln(elevation in m)					-0.057*
					(0.030)
Ln(km to any road)					-0.006
					(0.022)
Ln(km to city $>$ 5000)					-0.021
					(0.032)
Percent forest in baseline					-0.013
					(0.069)
State FE	no	yes	yes	yes	yes
Observations	862	862	487	366	487
Pseudo R^2	0.037	0.206	0.219	0.199	0.279

* p$<$ 0.10, ** p$<$0.05, *** p $<$ 0.01. Estimates are probits that include dummy variables for each state. Marginal effects shown, with standard errors in parentheses. Columns (1) and (2) use the full sample, columns (3) and (5) just beneficiaries, and column (4) only non-beneficiaries.

Table A9: Estimated WTA using different subsamples and covariates: leaders

	Mean	sd	Max	min
(1) Full sample medians	173.75	149.49	568.39	31.53
(2) Beneficiaries medians	191.27	122.02	440.23	53.05
(3) Non-beneficiaries medians	151.16	179.85	556.37	14.23
(4) Beneficiaries medians, all covariates	198.51	163.96	1171.39	9.31

The table shows the average estimated WTA using different estimation equations to generate coefficients, as well as different subsamples. The median WTA for each community is calculated using equation with coefficients generated from the equations shown in Table A8. The mean WTA (row (5)) is calculated using equation . The first row shows results using the full sample of beneficiaries and non-beneficaries (column (2), Table A8), row (2) uses coefficients from column (3), row (3) from column (4), and rows (4) and (5) from column (5).

Table A10: WTA, actual payments, and deforestation risk

	Dep. var:							
	Ln(WTA)				Ln(payment)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(Defor risk)	0.141***	0.139***			0.051***	0.054***		
	(0.024)	(0.027)			(0.006)	(0.006)		
Ln(Defor risk, state FE)			0.190***	0.181***			0.095***	0.098***
			(0.024)	(0.030)			(0.006)	(0.007)
With area weights	no	yes	no	yes	no	yes	no	yes
Observations	861	861	860	860	862	862	861	861
Adjusted R^2	0.036	0.039	0.067	0.060	0.067	0.080	0.233	0.236

* p < 0.10, **p< 0.05, *** p < 0.01. Estimates are from simple OLS regressions with a constant. WTA is the estimated WTA from Table A8, column 5. Payments are the payment per hectare (for beneficiaries) or that would have been offered (for non-beneficiaries). Deforestation risk is calculated as described in section 3.2 above. Prediction equations for deforestation risk are shown in Table A4.

Table A11: Correlation of targeting criterion with geographic covariates

	Dep. var = field rank of		
	Risk/WTA	Defor risk	WTA
	(1)	(2)	(3)
Ln(area submitted)	-0.413***	-0.350***	0.125***
	(8.109)	(7.628)	(5.926)
PSA land: Coniferous forest	-0.090***	0.032	0.172***
	(26.218)	(22.811)	(16.595)
PSA land: Semi-perennial dry tropical forest	-0.003	-0.104***	-0.127***
	(18.527)	(18.595)	(11.425)
Slope in degrees	0.063	0.001	-0.054
	(4.719)	(4.503)	(2.797)
Slope squared	-0.183	-0.022	0.204***
	(0.159)	(0.155)	(0.094)
Ln(elevation in m)	0.535***	0.325***	-0.397***
	(10.383)	(11.809)	(6.560)
Ln(km to any road)	0.118***	0.082***	-0.070***
	(6.620)	(6.269)	(4.198)
Ln(km to city $>$ 5000)	0.022	-0.031	-0.082***
	(10.185)	(10.085)	(6.314)
Percent forest in baseline	-0.110***	-0.100***	0.032
	(24.568)	(23.734)	(16.806)
Percent locality in protected area	0.090***	0.037	-0.078***
	(19.573)	(19.561)	(11.281)
Chiapas	0.149***	0.038	-0.166***
	(44.039)	(40.702)	(27.550)
Chihuahua	-0.197***	0.205***	0.607***
	(48.081)	(45.989)	(29.588)
Durango	-0.042	0.289***	0.532***
	(48.574)	(45.464)	(32.031)
Jalisco	-0.001	0.119***	0.202***
	(46.671)	(46.006)	(32.132)
Michoacan	0.072	0.137***	0.083**
	(45.273)	(43.172)	(33.287)
Nuevo Leon	0.076	0.152***	0.122***
	(42.788)	(41.006)	(29.269)
Oaxaca	-0.000	0.062	0.120***
	(45.634)	(44.031)	(30.391)
Puebla	-0.192***	0.026	0.397***
	(55.625)	(52.711)	(33.619)
Quintana Roo	0.309***	0.086**	-0.316***
	(27.370)	(30.072)	(17.571)
San Luis Potosi	-0.084*	0.064	0.251***
	(47.933)	(46.714)	(32.640)
Yucatan	-0.109***	-0.024	0.241***
	(27.793)	(32.688)	(19.745)
Observations	861	862	861
R^2	0.509	0.548	0.789

* p$<$ 0.10, ** p$<$0.05, *** p $<$ 0.01. Estimates are OLS regressions with robust standard errors. Note that the ranks are field rankings, so lower ranks indicate higher values. Beta coefficients presented.

Table A12: Changes in surplus with different targeting strategies

Total PSA payments to sample beneficiaries (million pesos)	238.4
Total PSA payments to WTA-targeted beneficiaries (million pesos)	237.6
Total PSA payments to risk-targeted beneficiaries (million pesos)	237.7
Total PSA payments to risk per peso-targeted beneficiaries (million pesos)	237.5
Total median WTA, sample beneficiaries (million pesos)	103.8
Total WTA with WTA-targeted beneficiaries (million pesos)	53.3
Total WTA with risk-targeted beneficiaries (million pesos)	109.2
Total WTA with risk per peso-targeted beneficiaries (million pesos)	78.0
Area enrolled, current beneficiaries (100,000 ha)	5.9
Area enrolled, WTA-targeted beneficiaries (100,000 ha)	6.2
Area enrolled, risk-targeted beneficiaries (100,000 ha)	5.5
Area enrolled, risk per peso-targeted beneficiaries (100,000 ha)	5.7
High risk area enrolled, sample beneficiaries (100,000s ha)	3.6
High risk area enrolled, WTA-targeted beneficiaries (100,000 ha)	3.2
High risk area enrolled, risk-targeted beneficiaries (100,000 ha)	5.5
High risk area enrolled, risk per peso-targeted beneficiaries (100,000 ha)	4.6
Total payments/WTA, actual program	2.3
Total payments/WTA, WTA targeting	4.5
Total payments/WTA, risk targeting	2.2
Total payments/WTA, risk per peso targeting	3.0

Total payments are the sum of payments made using the current payment schedule but targeted under the different schemes. Total WTA is the sum over all enrolled communities of the median WTA from the leader estimation times total hectares enrolled. Area enrolled measures the total hectares enrolled across all communities under differing targeting schemes. Area at high risk is the total area enrolled in communities with above median deforestation risk.

Table A13: Changes in surplus with adjusted payment strategies

Total median WTA under adjusted payments (million pesos)	53.9
Total median WTA under targeted adjusted payments (million pesos)	38.6
Total median WTA, sample beneficiaries (million pesos)	103.8
Ha enrolled in adjusted payments (100,000s)	5.7
High risk ha enrolled in adjusted payments (100,000s)	3.1
High risk ha enrolled in targeted adjusted payments (100,000s)	3.4
Area enrolled, current beneficiaries (100,000 ha)	5.9
High risk ha enrolled in current program (100,000s)	3.6
Budget for adjusted payments (million pesos)	99.3
Budget for targeted adjusted payments (million pesos)	74.0
Total payments to sample beneficiaries (million pesos)	238.4

Appendix A.4. Regressions assessing distributional effects of targeting schemes

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We run a series of regressions intended to statistically assess changes in the mean levels of wealth and deforestation risk of properties enrolled under different types of targeting. The differences are indicated by a series of interaction terms. "Current beneficiary" measures the difference between communities enrolled in the current scheme and those rejected, while "WTA-targeted beneficiaries" indicates the additional effect of being selected under the WTA scheme, and "Current & WTA-targeted" is the interaction between these two, thus giving the additional difference in the wealth indices in properties selected by both schemes. The same sequence is true for risk and risk per peso targeting.

As outcomes we use two wealth indices – housing and assets – generated from community-level aggregations of responses to our household questionnaire. To assess changes in average deforestation risk we use as a dependent variable the log-transformed deforestation risk metric. Table A14 shows the results. The first three columns of the table show estimations for the housing index, the second three the index of assets, and the last three the deforestation risk index.

The interactions show that targeting by WTA yields significantly wealthier recipients. Risk targeting, and risk per peso-targeting, however, both seem to select communities with statistically significantly lower values for the housing and asset indices. In other words: selecting on deforestation risk can be pro-poor. When we compare the different targeting schemes across the deforestation indices, we see that targeting on risk alone raises the risk profile of recipient properties relative to those targeted under the current scheme, while targeting on WTA alone lowers the risk profile of recipient properties.

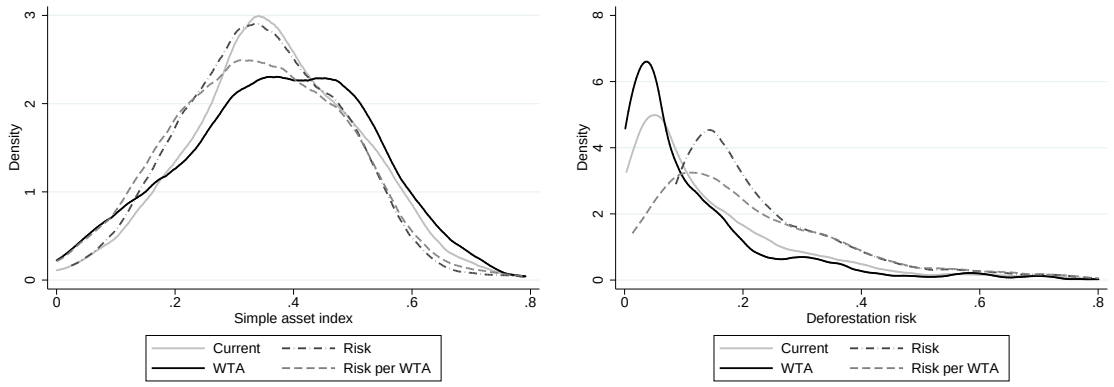
Figure A4 shows the complete distributions of wealth and deforestation risk using the beneficiaries selected by each of the targeting schemes. The solid gray line represents the status quo. The dotted lines show lower wealth and higher deforestation risk in the schemes that prioritize deforestation risk. Interestingly, beneficiaries selected on the WTA criterion draw from the extremes of the wealth distribution.

Table A14: Poverty, deforestation risk, and targeting

	Dep. var index:								
	Housing			Assets			Defor risk		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Current beneficiary	-0.000	-0.006	-0.005	0.027**	-0.008	0.008	0.023	0.007***	0.012**
	(0.011)	(0.011)	(0.010)	(0.014)	(0.015)	(0.013)	(0.015)	(0.002)	(0.006)
WTA-targeted beneficiary	0.067***			0.033**			-0.040***		
	(0.012)			(0.015)			(0.014)		
Current & WTA-targeted	-0.018			-0.040**			0.009		
	(0.015)			(0.020)			(0.019)		
Risk-targeted beneficiary		-0.038***			-0.056***			0.185***	
		(0.012)			(0.015)			(0.010)	
Current & risk-targeted		-0.006			0.030			0.015	
		(0.016)			(0.020)			(0.014)	
Risk per peso-targeted beneficiary			-0.000			-0.050***			0.145***
			(0.013)			(0.016)			(0.012)
Current & risk per peso targeted			-0.014			-0.002			0.015
			(0.016)			(0.020)			(0.017)
Observations	861	861	861	861	861	861	862	862	862
Adjusted R^2	0.060	0.031	0.001	0.002	0.018	0.028	0.023	0.487	0.309

* p< 0.10, ** p<0.05, *** p < 0.01. Estimates are from simple OLS regressions with robust ses. Robust ses in (). The housing index is the simple sum of indicators for valuable housing features, including having concrete walls, wooden, mosaic or marble floor, above median number of rooms, access to water and sewage connections, and above median days of water and electricity availability. The assets index is the sum of indicators for the presence of a television set, refrigerator, blender, microwave oven, laptop, car, truck, motorbike, bicycle, gas or electrical cooker, telephone landline, and mobile phone.

Figure A4: Distribution of wealth and deforestation risk across different strategies



(a) Wealth

(b) Defor risk

Both figures show kernel density estimations using the Epanchnikov kernel function. The simple asset index is the sum of indicators for the presence of a television set, refrigerator, blender, microwave oven, laptop, car, truck, motorbike, bicycle, gas or electrical cooker, telephone landline, and mobile phone. Deforestation risk uses the predicted probability of deforestation as estimated in column 1, Table A5.