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# Conserving Forests: Mandates, Management or Money?

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**Abstract**

Decision-makers are keen to learn which policy instruments are most effective at producing forest conservation outcomes. Using data from a patchwork of programs designed to preserve the overwintering habitat of the Monarch butterfly in central Mexico, we compare the effectiveness of three conservation instruments in limiting deforestation and forest degradation: protected areas, payment for ecosystem services (PES), and forest management. Using a matched sample of one hectare parcels and a spatial lag model of deforestation, we find that for preserving forest, PES is the most effective. Protected area status is ineffective for forest protection while forest management permits also help preserve forest. Forest degradation is not limited by PES or protected area status alone, but the combination of the two instruments significantly reduces forest degradation. Forest management, however, has the largest effect on limiting forest degradation.

Keywords: Payment for Environmental Services; Mexico; deforestation; logging regulation; protected area status; spatial econometrics.

JEL Codes: Q23, Q28, Q56, R14

## Introduction

As pressure builds to protect valuable carbon stocks and other forest related ecosystem services, forest conservation policies are attracting tremendous attention from policy makers (Pagiola et al. 2002; Harvey et al. 2010; Wunder 2007). Policy makers executing REDD projects will soon be confronted with the decision to how to invest conservation dollars, and which conservation instruments to use to obtain maximum impact. The United Nations Program on Reduced Emissions from Deforestation and Forest Degradation (REDD)+ offers national governments flexibility in choosing which forest protection measures to use (Harvey et al. 2010), and most agree that they will adopt a combination of instruments, including outright logging bans, improved forest management, integrated community development programs, and economic incentives through direct conservation payments. Views on which conservation measure is preferable has largely broken down along ideological lines (Berkes 2003), with little empirical work comparing the effectiveness of these measures in meeting their conservation goals (Ferraro and Pattanayak 2006).

In this paper we compare conservation outcomes of three forest policies: legal protection, through the declaration of protected areas, economic incentives, through a payment for environmental services program and forest management permits. We explore forest outcomes from a patchwork of these programs in place at the overwintering site for monarch butterflies (*Danaus Plexippus*) in central Mexico.

Establishing logging bans within protected areas is oldest conservation approach. Empirical research has shown that these protected area designations have been effective (Bruner et al. 2001) although somewhat less effective than what naïve comparisons might lead one to believe (Andam et al 2008, Joppa and Pfaff 2010). Since protected areas are not designated randomly, to determine their effect one needs to estimate what would have happened in absence of the program. Only recently have empirical studies begun to assess the effectiveness of protected areas using empirically counterfactuals (eg Andam et al 2008, Gaveau et al. 2012). Even if protected areas can claim to be effective at protecting forests, land use restrictions have been criticized for excluding local communities from decision-making and limiting development opportunities (Berkes 2003, Chhatre and Agrwal 2008). To avoid some of the problems associated with protected areas, policy makers have sought to explore forest protection measures that are less restrictive and more participatory.

Forest management is another favored approach for improving conservation outcomes. Forest management plans have the potential to help improve forest governance through community education and involvement. Because the plans themselves do allow resource extraction and are by their nature highly varied, establishing their contribution to forest conservation is challenging. A number of governments, such as Mexico, facilitate the development of community forest management plans in the hopes that these plans can both provide a long-run source of income along with conservation outcomes. To our knowledge, very little empirical research has studied the environmental outcomes from forest management plans.

Most recently, conservationists have begun to pay land owners to meet conservation objectives. This payment approach has been proposed as an alternative to protected areas, forest management or integrated community development programs (ICDPs) (Ferraro and Kiss 2006). In the last decade, Payment for Environmental Services (PES) programs have been rolled out throughout the developing world (Pagiola et al. 2002, Wunder 2007). By creating incentives for the community PES can improve monitoring and enforcement outcomes. To be successful, however, PES programs must be executed in sites with good governance and tenure security. Further, because most participation in PES programs is voluntary, concern has been raised that PES funders may be paying to protect forest that would have remained unlogged regardless (Sánchez-Azofeifa et al. 2007). As with protected areas, the evidence of PES program success has shown mixed results. Arriaga et al. (2012) showed that participation in PES contracts increased farm forest cover by about 11% to 17% over eight years.

Only a handful of authors have compared the effectiveness of various conservation instruments. Nelson and Chomitz (2011) compare the effectiveness of different types of protected areas: “strict” protection where not uses are allowed, and “multiple-use” that permits mixed-use within the park. In Latin America they were able to include the comparison of indigenous protected areas as well. Their analysis spanned developing countries in the tropics, and they used a binary measurement of deforestation, with forest fires as a proxy for deforestation. Across each region, multi-use protected areas were found to be more effective than strict protected areas, and in Latin America, indigenous protected areas were almost twice as effective as any other form of protection. In general, areas where some mixed-use is permitted is as effective or more effective as strict protection.

Porter-Bollund (2012) provide additional evidence that alternative conservation strategies may be more effective than strict legal protection. In a meta-analysis which included 40 protected areas and 33 community managed forest, the authors found that community managed showed lower deforestation rates than areas under legal protection. In an analysis that evaluated the outcomes of forest bans (regulatory), subsidies (economic incentives) and restoration plans

(management) in Austria, Weiss (2000) suggests that policy instruments cannot be analyzed separately because they are not applied independently from one another.

In this paper, we seek to compare the effectiveness of a protected area, a PES program and forest management. In earlier work, we demonstrate the combined protected area status and PES appears to preserve these forests (Honey-Rosés et al 2011). This earlier work does not disentangle the different effect of these instruments and does not consider the effect of forest management in the region. Here, we develop a simple model to compare these instruments and predict their ability to conserve forest given different community governance abilities. Next, we use detailed remote sensing imagery between 1986 and 2009 to evaluate these individual instruments and/or their combination has changed community behavior and produced conservation results. Since the decision to deforest one parcel is not independent of the decision to deforest its neighbors, we take parcel location into account. To analyze the effect of these instruments, we use a novel spatial matching technique developed in Honey-Rosés et al (2011) that matches over the characteristics of neighboring parcels along with time-invariant characteristics of the parcel itself. We use this method to create a dataset and then use a spatial lag model to estimate the effect of these programs on deforestation and forest degradation taking neighboring outcomes into account. We find that the expansion of the protected area had little effect on limiting illegal logging, but that payments help reduce deforestation and combined payments and protected area status reduce forest degradation. Forest management also conserves forest, particularly limiting forest degradation.

## **Data and Methods**

Our study area covers 342,774 hectares in central Mexico, and includes four Mexican states and 24 municipalities. Lower elevations have been converted to agricultural fields of corn or beans, while forests of oak (*Quercus* sp.), pine (*Pinus* sp.) or fir (*Abies* sp.) thrive in higher elevations.

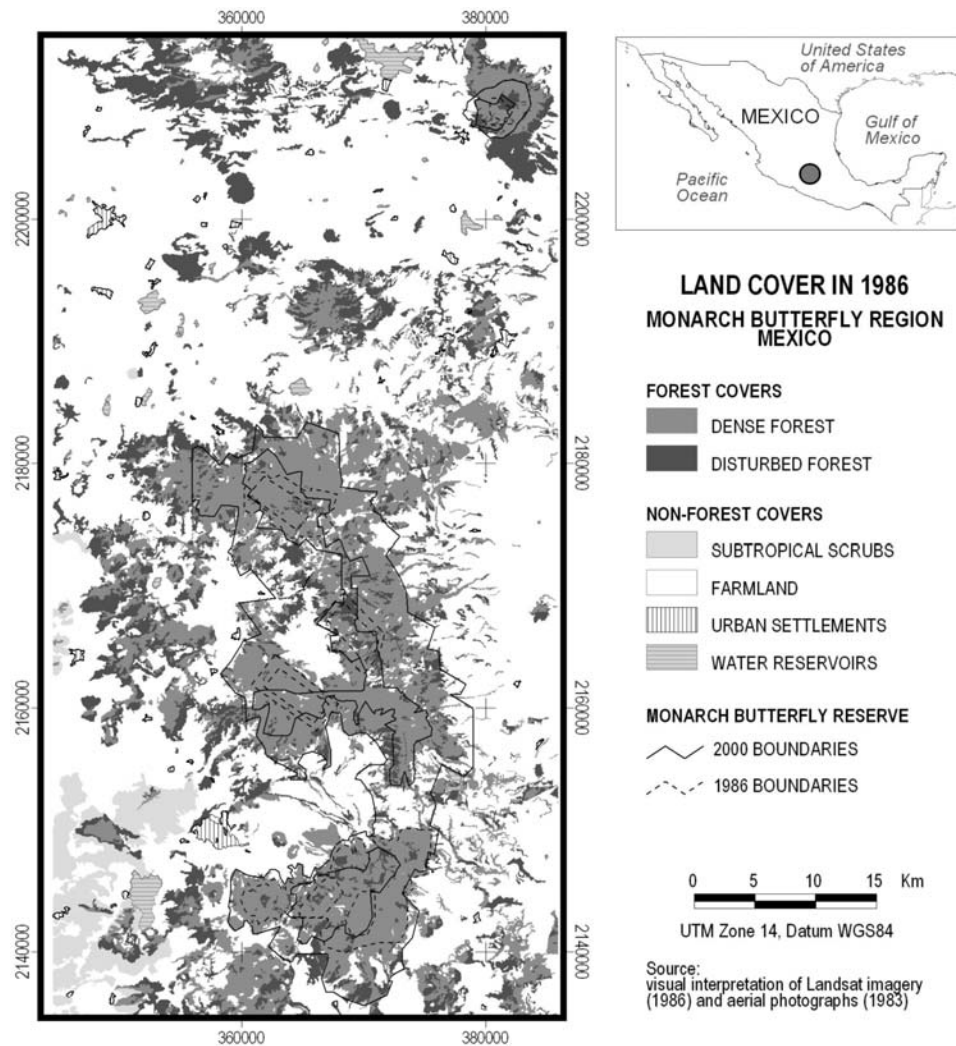


Figure 1. Study area surrounding the Monarch Butterfly Biosphere Reserve in Mexico (source: Honey-Roses et al 2011)

### *Protected Area: The Monarch Butterfly Biosphere Reserve*

The Monarch Butterfly Biosphere Reserve (MBBR) was originally created in 1986 covering 16,110 hectares. Legal restrictions on timber harvest were met with considerable local resistance, and viewed as an unwelcome imposition (Chapela and Barkin 1995). In 2000, the Mexican federal government enlarged the boundaries of the protected area to include 56,259 hectares, of which 13,551 were declared as no-cut zones. The boundary of the no-cut zone was established using transparent geographic criteria such as elevation, slope and aspect to capture the prime habitat for the monarch butterfly. Unlike most protected areas which often fall in remote and uninhabited areas, the MBBR is surrounded by inhabited areas, and the sites being protected are under considerable logging pressure.

### *PES: The Monarch Butterfly Conservation Fund*

The Monarch Butterfly Conservation Fund (MBCF) was established in 2000 as part of a negotiated agreement between the Mexican Government, local communities, conservation groups and foundations. The MBCF makes two types of payments to participating landowners. In June of each year, timber payments are made to communities who lost logging rights as a result of the new protected area boundaries. The second payment is made on a per hectare basis to all communities in the core zone of the protected area. Of the 40 properties in the core zone of the MBBR, the federal and state properties are ineligible for participation in the fund program. Of the 38 eligible property owners, 31 agreed to participate in the MBCF.

An interesting attribute of the fund was that it did not cover all regions that saw a change in regulation. Similarly, some areas in the earlier reserve only saw the introduction of a payment, but no change in regulations. Last, some areas had forest management plans prior to the legal restrictions while others did not. This mosaic of affected communities and community parcels, allows us to explore the differential effect of these various instruments.

### *Forest Management*

We collected data on management plans by community in the States of Mexico and Michoacan, including the number of permits, when those permits were initiated and how long the permits last. Anecdotally a number of communities rushed to establish logging permits when they heard that a PES program might be instituted to pay out based on existing logging rights. Therefore we test whether the forest management permits established in 1999 and 2000, right before the PES payment came into place, have a different effect than those management plans initiated at other years.

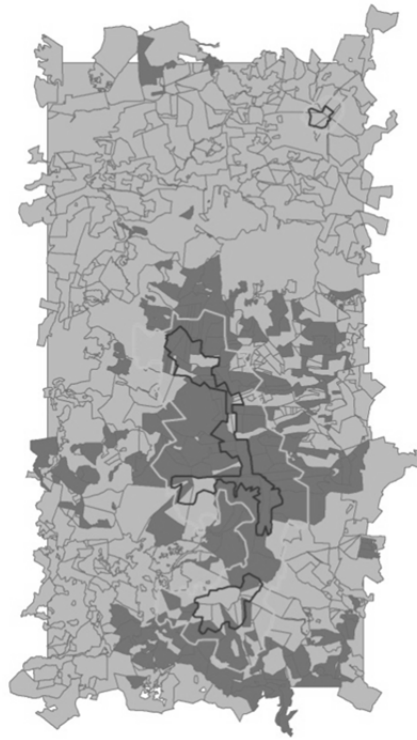


Figure 2. Forest communities with forest management plans are in darker grey. The boundaries of core zone the Monarch Butterfly Biosphere Reserve is in black.

The study area was divided into a uniform grid of cells 1 ha each (100 m x 100 m) for a total of 342,774 cells. We used ESRI ArcMap 9.3 for spatial transformations and analysis. We linked each cell with basic biophysical information: mean elevation, slope, distance to roads, and presence or absence of monarch colonies. Each cell also included political information such as State Government, Municipality and local community. Most rural communities in Mexico community owned and managed as either Ejidos or Indigenous Communities. In areas where the management structure was unknown, we assumed the area to be a private property for a total of 1143 property units. We combined various sources of ownership data in order to generate the most current version possible. This combined information from World Wildlife Fund and the Mexican Federal Government, including the formal boundaries established under the *procede* program. Using data from Landsat imagery in 1993, 2000, 2003, 2006 and 2009, we calculated the total hectares of conserved forest and total forest per cell (0.0-1) and the dominant tree species. We compare the forest cover in these cells by treatment group over time, in a difference-in-difference approach.

## 5.2 Data Analysis

We estimate the effect of protected area designation and payments for environmental services by comparing the outcomes in those 1 hectare parcels with and without the various ‘treatments’. One concern is that allocation for ‘treatments’ was not random, and therefore their assignment needs to be taken into consideration when developing an appropriate counterfactual (Ferraro 2009). In our case, the core region was determined based on observable geographic and biological features such as slope, aspect, elevation, distance to road, property tenure type, and state, so we can find units in the control region that share these same characteristics to ensure that difference in these characteristics do not bias our estimate of treatment.

We begin by considering only those 1 hectare parcels that are forest in 1986. We use a spatial matching technique, described in Honey-Roses et al 2011 to generate a set of control observations that share similar values of covariates with our different treatment observations. We use spatial matching to take the spatial nature of deforestation into account, where deforestation in one observation makes deforestation in the neighboring observation more likely (Pfaff 2009). Thus, the routine matches not only over an observation’s own characteristics, but the characteristics of its neighbour. We define a ‘neighbour’ using a contiguity-based weights matrix because we observe that deforestation spreads contiguously, presumably due to the construction of logging roads and the movement of machinery makes it easier to deforest contiguous plots. A second aspect of the spatial match is that we exclude those control observations on the boundary of a treatment group, as implementation of the treatment may directly affect the forest outcome in the neighbouring control observation, essentially contaminating that observation as a clean control. We specifically match over physical characteristics of the parcel, such as slope, elevation, distance to road, dominant tree species, size of the ecological patch and governance characteristics such as parcel ownership and state.

Once we generate our sets of comparable control observations, we use a spatial regression to estimate the percent of forest and the percent of dense forest in an observation. We determine whether deforestation follows a spatial lag and/or error process and explicitly control for this spatial effect using panel data methods.

We then use a difference-in-difference approach to identify the effect of treatment as shown in equation (1). We estimate deforestation and forest degradation ( $F_{it}$ ) as a function of a spatial lag ( $WF_{it}$ ), the variables used for matching ( $Z_{it}$ ), the year ( $Y_t$ ), an indicator of whether the parcel receives a specific treatment program ( $P_i$ ) and the interaction between the year the treatment is introduced and the dummy for those parcels receiving treatment ( $Y_t P_i$ ). In the case of payment, we estimate the regression both with a dummy variable for payment and the actual

amount received. The coefficient on last interaction term ( $\delta$ ) is the measure of treatment. In our case we will have three terms, one to capture the effect of being in the protected area, one to capture the effect of payment and one to capture whether the community has a forest management plan in place.

$$F_{it} = \rho W F_{it} + \alpha Z_{it} + \beta Y_t + \gamma P_i + \delta Y_t P_i + \varepsilon_{it} \quad (1)$$

We run this regression on a union of our matched samples.

Our treatment group for the protected area is defined as those parcels that moved into the protected area in 2000. Thus, as part of our control, we consider those parcels that were already part of the protected area in 1986. For PES, we consider all parcels that joined the PES program in 2000. We drop those communities who were eligible for the PES, but chose to not participate from our sample. In later work we hope to instrument for this decision. Last, we use data on community forest management plans to generate a variable that designates when the plan is in place. All parcels in a community when such a plan is in place are designated as being ‘treated’ by the management plan. Select summary statistics are given in table 1 for each of our treatment and control groups. We include the summary statistics for both the matched and unmatched controls for comparison.

Table 1: summary statistics for treatment and control groups

	<i>% dense forest in 1986</i>	<i>Fir in 1986</i>	<i>Pine in 1986</i>	<i>slope</i>	<i>elevation</i>	<i>distance to road</i>	<i>N</i>
Payment	0.85	0.68	0.32	39.07	2979.22	6384.94	8458
New Ban	0.83	0.65	0.35	37.68	2965.33	6122.75	5907
Payment Control	0.64	0.19	0.79	33.28	2610.95	5265.86	84798
New Ban Control	0.60	0.15	0.82	33.22	2561.81	5194.36	63935
Matched							
Payment Control	0.83	0.67	0.33	36.11	2967.64	6289.25	19660
Matched New							
Ban Control	0.86	0.75	0.25	38.30	3002.54	6159.64	15034

As can be observed, before matching, the average characteristics of our control observations are very different from our treatments. On average, our controls have lower dense forest cover in 1986, have lower elevation and are less sloped than our controls.

We use a panel fixed effects regression to control for unobservable site characteristics. Because our parcels are small and we use all treatment observations, we need to control for spatial spillover effects in our data. We do this using a spatial lag regression, where the spatial lag is the average outcome of the neighbouring units. Because the outcome of the observation

will also affect the outcomes of its neighbours, we instrument for the spatial lag using the second order spatial lag of the outcome, and the temporal lag of the spatially lagged outcome.

## Results

We regress both forest and conserved forest on our treatment categories and a spatial lag. Regression results are presented in table 2. We use the measure of forest management with and without permits that initiated in 1999 and 2000. We heard anecdotal evidence that shortly before the PES program was established a number of communities established management plans to increase their PES payments which were based on lost logging revenue. We therefore consider separately all forest management plans as well as those that were established in years other than 1999 and 2000.

We also see evidence that forest management helps preserve dense forest cover. While forest management plans overall appear to reduce deforestation, once we remove those anticipatory permits that started in the year before the PES program was established, we see that forest management permits decrease the forest cover. However, they still help preserve dense forest.

Table 2: Fixed Effect Spatial Lag panel regression on parcel forest and conserved forest

VARIABLES	forest	conserved forest	forest	conserved forest
W forest	1.107*** (0.00165)		1.107*** (0.00165)	
W conserved forest		1.099*** (0.00174)		1.099*** (0.00174)
PES	0.00268*** (0.00104)	-0.00323** (0.00128)	0.00220** (0.00104)	-0.00332*** (0.00128)
PA	-0.000451 (0.00315)	-0.00822** (0.00389)	-0.000848 (0.00315)	-0.00843** (0.00389)
PES + PA	0.00287 (0.00337)	0.0116*** (0.00416)	0.00367 (0.00337)	0.0118*** (0.00416)
Management	0.00240*** (0.000540)	0.00210*** (0.000667)		
Management w/o 1999 and 2000			-0.00169*** (0.000582)	0.00121* (0.000719)
parcel FE	yes	yes	yes	yes
year FE	yes	yes	yes	yes
Constant	-0.101*** (0.00158)	-0.0898*** (0.00148)	-0.101*** (0.00158)	-0.0897*** (0.00148)
Observations	143,610	143,610	143,610	143,610

Number of id2	28,722	28,722	28,722	28,722
Standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

In table 3 we report a random effects spatial lag regression that explores the effect of various time-invariant parcel characteristics on deforestation and forest degradation outcomes.

Table 3: Random Effects Spatial Lag Panel Regression on Forest and Conserved Forest

VARIABLES	Forest	Conserved Forest	Forest	Conserved Forest
D (W Forest)	1.149*** (0.00224)		1.104*** (0.00268)	
D (W Conserved Forest)		1.103*** (0.00267)		1.150*** (0.00225)
PES			0.00740*** (0.00182)	0.0172*** (0.00263)
PES00			0.000450 (0.00134)	0.00864*** (0.00194)
Ban			0.00801*** (0.00148)	0.00661*** (0.00214)
NewBan00			0.00421 (0.00275)	0.00658* (0.00397)
Both			0.00444*** (0.00126)	0.00784*** (0.00183)
Both00			-5.09e-05 (0.00315)	0.000491 (0.00454)
perfor			2.40e-05 (0.000516)	0.00132* (0.000743)
cf86	-0.0300*** (0.000960)	-0.0111*** (0.000660)	-0.0116*** (0.000667)	-0.0304*** (0.000969)
slope	7.26e-05*** (1.85e-05)	-5.62e-05*** (1.28e-05)	-5.28e-05*** (1.30e-05)	6.85e-05*** (1.87e-05)
distance	-1.63e-07 (1.51e-07)	-2.51e-07** (1.05e-07)	-2.94e-07*** (1.06e-07)	-2.44e-07 (1.53e-07)
elevation	-1.56e-05*** (1.67e-06)	2.73e-06** (1.16e-06)	3.23e-06*** (1.17e-06)	-1.57e-05*** (1.68e-06)
comind	0.00343*** (0.00101)	0.00371*** (0.000702)	0.00319*** (0.000750)	0.00257** (0.00108)

privat	0.00260 (0.00158)	-0.00276** (0.00110)	-0.00284** (0.00114)	0.00128 (0.00164)
pino	-0.122*** (0.0328)	-0.324*** (0.0227)	-0.323*** (0.0227)	-0.118*** (0.0328)
oyamel	-0.120*** (0.0328)	-0.328*** (0.0228)	-0.327*** (0.0228)	-0.114*** (0.0328)
area86	1.31e-07 (1.41e-07)	8.25e-08 (9.77e-08)	8.94e-08 (9.77e-08)	1.18e-07 (1.41e-07)
Michoacan	0.000476 (0.000738)	0.00156*** (0.000512)	0.00209*** (0.000531)	0.000922 (0.000765)
wag	-0.0301*** (0.00672)	-0.0271*** (0.00466)	-0.0253*** (0.00471)	-0.0274*** (0.00679)
wpino	0.0171** (0.00800)	-0.0136** (0.00556)	-0.0129** (0.00558)	0.0203** (0.00803)
woyamel	0.0214*** (0.00794)	-0.0107* (0.00552)	-0.0102* (0.00554)	0.0239*** (0.00796)
warea86	3.87e-07** (1.64e-07)	5.46e-08 (1.14e-07)	5.88e-08 (1.15e-07)	4.10e-07** (1.65e-07)
rprocede1	0.00276*** (0.000877)	0.00129** (0.000609)	0.00129** (0.000635)	0.00242*** (0.000915)
ejidatars	-7.44e-07 (1.93e-06)	-7.78e-06*** (1.33e-06)	-6.78e-06*** (1.53e-06)	9.79e-07 (2.21e-06)
hectares	1.51e-07 (2.92e-07)	-3.10e-07 (2.03e-07)	-1.45e-07 (2.15e-07)	3.30e-07 (3.11e-07)
Constant	0.161*** (0.0341)	0.348*** (0.0237)	0.346*** (0.0237)	0.153*** (0.0341)
Observations	86,166	86,166	86,166	86,166
Number of id2	28,722	28,722	28,722	28,722

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The estimated policy effects are similar to those from the fixed effect regression above. However, we can explore the effect of time-invariant community characteristics using the random effects regression, although these results should be treated with caution since they may be biased. As can be seen, several governance variables appear to affect forest outcomes. The number of decision makers in the communities, identified as ejidatarios determines the rate of deforestation. Second, those communities that tenured their property under the Procede program also had lower rates of deforestation and forest degradation. Note that the ability to register a property with the federal government under Procede is both related to

forest outcomes but is also related to general governance of the community, it is likely endogenous.

## **Discussion and Conclusions**

In this paper we provide empirical evidence that different policy instruments generate different conservation outcomes. We observe little evidence that protected area status generates benefits on its own in our study region. We find that the PES helped increase forest conservation, but not dense forest cover. Thus, we see indications that communities may have received payments for conserving forest and then engaged in some selective logging, reducing dense forest cover. Only those communities who received both the ban and the PES did not reduce their conserved forest. We also see evidence that management helped preserve conserved forests.

There are a number of limitations of this paper. First, we ignore the potential endogeneity associated with forest management planning and registering properties through *Procede*. Future work will use measures of community governance to instrument for forest management plans and for participation in the PES. Second, the PES program explored in our paper is never totally unbundled from a PA status, so we do not observe the variation in PES participation that would occur with a truly voluntary program such as Mexico's payment for hydrological services.

That said, we see several contributions of this paper. First, unlike most literature, we not only see the coincidental move from no regulation to regulation + payment, we observe the initial imposition of regulation, then the expansion of the regulated area + payment. We also observe some regions that had regulatory changes but were ineligible for payment, and other regions that had no regulatory changes but did have payments. Second, unlike most literature, we are able to observe forest disturbance such as might occur with selective logging, not only complete deforestation. These data are particularly important for policy since the illegal logging often occurs as selective logging and the move to full deforestation is often much harder to reverse than when communities have only thinned forest. Fourth, we have detailed data on which communities have enrolled in various health and education programs which indicate a measure of community governance. Last, we are fortunate to have data before and after the program, within the 'treated' region as well as clearly outside the region. These data better allow us to construct counterfactuals for our various treatments.

## References

- Alix-Garcia, J., E.N. Shapiro, K.R.E. Sims. 2010. *Impacts of payments for ecosystem services on deforestation in Mexico: Preliminary lessons for REDD*, Land Tenure Briefs.
- Andam, K., P. J. Ferraro, A. Pfaff, A. G. Sanchez-Azofeifa, and J. A. Robalino. 2008. Measuring the effectiveness of protected area networks in reducing deforestation. *Proceedings on the National Academy of Sciences* 105:16089-16084.
- Arriagada, R.A., P.J. Ferraro, E. Sills, S.K. Pattanayak, S. Cordero-Sancho. 2012. Do payment for environmental services reduce deforestation? A farm-level evaluation from Costa Rica. *Land Economics* 88(2): 382-399
- Berkes, F. 2003. Rethinking Community-Based Conservation. *Conservation Biology*. (18)3:621-630.
- Bruner, A.G., R.E. Gullison, R.E. Rice, G.A.B da Fonseca. 2001. Effectiveness of Parks in Protecting Tropical Biodiversity. *Science* 291:126-128.
- Chapela, G and D. Barkin 1995. Monarcas y campesinos: estrategia de desarrollo sustentable en el oriente de Michoacán. Centro de Ecología y Desarrollo. Mexico D.F., Mexico.
- Chhatre, A., and A. Agrawal 2008. Forest commons and local enforcement. *Proceedings of the National Academy of Sciences* 105 36:13286-91.
- Engel, Stefanie, Stefano Pagiola, and Sven Wunder. 2008. Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* 65(4): 663-74.
- Ferraro, P. J. 2009. Counterfactual thinking and impact evaluation in environmental policy. In M. Birnbaum & P. Mickwitz (Eds.), *Environmental program and policy evaluation: Addressing methodological challenges*. New Directions for Evaluation 122: 75–84.
- Ferraro, P.J., Kiss, A., 2002. Direct payments to conserve biodiversity. *Science* 298:1718-1719.
- Ferraro, P.J., Simpson, R.D., 2002. The cost-effectiveness of conservation payments. *Land Economics* 78:339-353.
- Ferraro, P.J. S. K. Pattanayak. 2006. Money for Nothing? A Call for Empirical Evaluation of Biodiversity Conservation Instruments. *PLoS Biology* 4:4. 482-488.
- Ferraro P.J., Lawlor, K., Mullan, K.L., Pattanayak, S.K., 2012. Forest Figures: Ecosystem Services Valuation and Policy Evaluation in Developing Countries. *Review of Environmental Economics and Policy*. 6(1): 1-26. [Double check year]
- Gaveau, D. L. A., L. M. Curran, G. D. Paoli, K. M. Carlson, P. Wells, A. Besse-Rimba, D. Ratnasari, & N. Leader-Williams 2012. Examining protected area effectiveness in Sumatra: importance of regulations governing unprotected lands. *Conservation Letters* 5: 142–148
- Harvey, C. A., B. Dickson, and C. Kormos. 2010. Opportunities for achieving biodiversity conservation through REDD. *Conservation Letters* 3:56-61.

- Honey-Rosés, J., K. Baylis and I. Ramirez. 2011. A spatially explicit estimate of avoided forest loss *Conservation Biology* 25(5):1032-1043.
- Joppa, L, Pfaff, A 2010. Reassessing the forest impacts of protection: The challenge of nonrandom location and a corrective method. *Annals of the New York Academy of Sciences* 1185: 135–149.
- Nelson, A., K. Chomitz 2011. Effectiveness of Strict vs. Multiple Use Protected Areas in Reducing Tropical Forest Fires: A Global Analysis Using Matching Methods. *PLoS ONE* 6(8):e22722 doi:10.1371/journal.pone.0022722
- Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: synthesis. Washington D.C.: Island Press.
- Muñoz-Piña, C., A. Guevara, J. M. Torres, and J. Braña. 2008. Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results. *Ecological Economics*, 65, (4) (5/1): 725-36.
- Pattanayak, S.K., S. Wunder, P.J. Ferraro 2010. Show me the money: Do payments supply ecosystem services in developing countries? *Review of Environmental Economics and Policy* 4(2): 254-274.
- Pagiola, S., J. Bishop, and N. Landell-Mills, editors. 2002. Selling forest environmental services market-based mechanisms for conservation and development. Earthscan Publications, London, UK.
- Pfaff, A. 1999. What drives deforestation in the Brazilian Amazon. *Journal of Environmental Economics and Management* 37, 26-43.
- Pfaff, A., Robalino, J.A., Sanchez-Azofeifa, G.A., 2006. Payments for Environmental Services: Empirical analysis for Costa Rica. Columbia University, New York.
- Pfaff, A., E.O. Sills, G.S. Amacher, M.J. Coren, K.Lawlor, C.Streck 2010. Policy Impacts on Deforestation: Lessons from Past Experiences to Inform New Initiatives. Nicholas Institute for Environmental Policy Solutions & Packard Foundation.
- Porter-Bolland, L. E.A. Ellis, M.R. Guariguata, I. Ruiz-Mallen, S. Negrete-Yankelevich, V. Reyes-Garcia. 2012. Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management* 268:6-17.
- Sánchez-Azofeifa, A. G., A. Pfaff, J. A. Robalino, and J. P. Boomhower. 2007. Costa Rica's payment for environmental services program: Intention, implementation, and impact. *Conservation Biology* 21:1165-1173.
- Sills, E., Arriagada, R., Pattanayak, S., Ferraro, P., Carrasco, L., Ortiz, E., Cordero, S., 2006. Impact of the PSA Program on land use. Paper presented at the Workshop on Costa Rica's Experience with Payments for Environmental Services. San José, 25–26 September 2006.
- Weiss, G. 2000. Evaluation of policy instruments for protective forest management in Austria. *Forest Policy and Economics* 1:243-255.

Wunder, S. 2007. The efficiency of payments for environmental services in tropical conservation. *Conservation Biology* 21:48-58.