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The Impact of Payments for Reforestation in the Mexican State Michoacán

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Abstract

As a means to adapt to climate change, the Mexican government grants, since 2003, payments as an incentive for landholders to conserve, maintain and increase the provision of environmental services through the promotion of a forestry strategy. This paper contributes to the literature with an empirical analysis of the impact of payments for reforestation in one of the states with the highest rates of deforestation, Michoacán. The impact is estimated by means of panel data regressions and propensity score matching. Our results suggest that the payments are not contributing to the overall reforestation in Michoacán because of the existence of leakage in areas that are not participating in the program. Our analysis underlines the challenges faced when implementing financial incentive based programs and provides policy makers with evidence for improving the design of such programs.

Keywords

Additionality, Leakage, Payments for Environmental Services, Market based Mechanism, Impact Evaluation

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Introduction

Forests contribute to human welfare providing a large number of other environmental services. More than just the provisioning services, like the extraction of raw materials or the purification of water, we benefit also from regulating services such as hydrological regime regulation, air quality improvement, land erosion control, or biodiversity conservation. Ecosystems provide also cultural services that have aesthetic, spiritual, and recreational benefits (TEEB, 2010).

Nevertheless, forests have been increasingly cleared because of the direct competition of other land uses, like agricultural production. This is claimed to yield serious environmental impacts (Walker, 1993) that may profoundly affect aspects of human well-being, such as economic growth, health and livelihood security (Millennium Ecosystem Assessment, 2005). Throughout the mid-1990s Mexico had already lost around 90 percent of its rainforests and around 50 percent of its temperate forests. The main driver of land use change in Mexico is associated with the expectation of a high rent from alternative land uses, such as agriculture, resource extraction, and oil exploration and extraction (Masera, 1996).

In order to address the rapid depletion of forests, which is by no means socially desirable, the Mexican government approved the establishment of the Mexican Forestry Fund through the General Law for Sustainable Forest Development. This fund, managed and administered by the National Forestry Commission (CONAFOR) 2003, is meant to promote the conservation and restoration of forest ecosystems, based on the rationale of Payments for Environmental Services (PES). This scheme has become a popular mechanism to motivate landholders to provide environmental services by translating external, non-market values of the environment into financial incentives (Engel et al., 2008).

As part of the Mexican Forestry Fund, a program called ProArbol⁴ was created with the purpose of enhancing the provision of environmental services through the increase of production and productivity of forestry resources, their conservation, protection and restoration. ProArbol fosters activities divided in two categories. One category is called *Forest Development*, which promotes a sustainable forest management through the elaboration of studies and the strengthening of the infrastructure and equipment needed for the production of raw material. The other category is called *Conservation and Reforestation*, and includes payments for reforestation and conservation, as well as payments for watershed services (PSAH) and payments for carbon, biodiversity and agro-forestry services (PSA CABSAs)⁵.

PES give landholders financial incentives for the provision of environmental services, which would otherwise not be provided because of their public good nature. As long as the private return from an environmental friendly land use is lower than the return from alternative land uses, landholders will not be inclined to provide environmental services even if the social returns are high (Ferraro and Kiss, 2002). Therefore, whenever the social benefit of the provision of environmental services is higher than the private return from the alternative land use, the establishment of a PES scheme can be justified. PES schemes, including the Mexican one, are usually based on the opportunity costs incurred by participating landholders. This implies that the payments must be smaller than the benefits to users for them to have a positive willingness to pay, but they need to exceed the foregone return of landholders that give up the alternative land use for them to have an incentive to participate (Engel et al., 2008). Ideally, the users of the environmental services should be the ones paying the compensation of landholders for their provision (Pagiola et al., 2005). The Mexican program has however a public scheme where the state acts as the buyer of environmental services through the collection of taxes and grants, assuming thus that the provision of environmental services is socially desirable for the whole country.

⁴ Since 2013 a comparable program was established under the name Programa Nacional Forestal (PRONAFOR)

⁵ Operational rules of ProArbol, 2012, Art.7

Although this policy reflects the willingness of the Mexican government to address the severe environmental problems the country is facing, there is concern that no additional environmental benefits are being generated through these PES. The success of ProArbol was officially measured through the area contracted, the share of participating women and indigenous people, and the acceptance rate⁶, but not through an evaluation of its additionality. It is not only important to determine whether there were positive environmental benefits in the contracted area, but also whether these can be attributed to the program, and whether the program is inducing leakage in other areas. After analyzing the impact of PSAH, Alix-García et al. (2012) concluded that although these conservation payments have significantly reduced deforestation rates, there is evidence of deforestation spillovers through price and substitution mechanisms, which in turn decreases the additionality of the program.

In this study we analyze the impact of the payments for reforestation, which to our knowledge has not been studied before. For reforestation, contracted landholders are paid between 1155 and 2417 Mexican pesos (78 – 163 USD⁷) per hectare, depending on the type of vegetation. Owners of pasture land used for grazing receive an additional amount of 674 pesos (45.4 USD) per hectare to account for opportunity costs. Half of the amount is paid at the beginning of the contract, the other half being paid at the end of the contract in case of compliance⁸. After having reforested the land enrolled, landholders may be supported for conserving it. The applications of all Mexican individuals or other legal entities are considered, if they own or possess forest land within the eligible areas, stipulated according to their susceptibility to conversion and social criteria, because ProArbol intends also to generate additional income sources and employment for the vulnerable population in rural areas⁹. Indigenous communities and women are more likely to receive a contract, as well as owners of land not enrolled before, ejidos, communities and small landholders (Operational rules of ProArbol, 2012, Art.3 and 14).

⁶ Evaluación de Consistencia y Resultados 2011-2012 ProArbol –SEMARNAT

⁷ Oanda exchange rate 08.01.2015

⁸ Requires a tree survival rate not smaller than 70 percent

⁹ <http://calderon.presidencia.gob.mx/tag/proarbol/> 05.02.2015 14:41 hrs

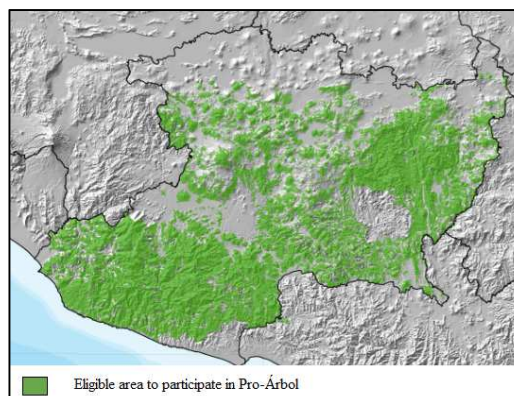
The study area is Michoacán, one of the Mexican States with the highest deforestation rates, and a great variety of ecosystems, located in the south-western part of Mexico (figure 1).

Figure 1: Geographic Location of Michoacán



Source: Cuéntame, Información por entidad, INEGI

Figure 2: Area in Michoacán eligible to participate in ProArbol



Source: Digital map, INEGI

According to the data provided by the office of CONAFOR in Michoacán, only 27 municipalities were involved in the Program until 2010, although the eligible area is located in a total of 65 municipalities (figure 2).

Figure 3: Satellite image of Michoacán



Source: CONAFOR

Michoacán consists of 113 Municipalities and has a territorial size of 58599 square kilometers, consisting of 10 percent grasslands, 16 percent forest cover, 10 percent rainforest, 1.7 percent urban areas and 28 percent agriculture, among other land uses (INEGI 2005) (figure 3). The heterogeneity of landscapes in Michoacán: mountain ranges, plateaux, plains, valleys and seacoast, produces a large variety of climate, vegetation and

soil. There are mountain humid forests, dry forests and grasslands (Información por entidad, Cuéntame, INEGI¹⁰). Its vegetation consists mainly of coniferous forests and oaks. Despite the high deforestation rates, there were reforestation efforts in Michoacán from 1994 until 2002. Because this tendency could have remained after 2003 even in the absence of the payments, reforestation after 2003 cannot necessarily be attributed to ProArbol.

In order to determine whether the ProArbol payments for reforestation in Michoacán have induced additional environmental benefits, we test three hypotheses. The first one is that ProArbol's payments for reforestation have a positive effect on reforestation in the participating area. Even if this hypothesis can be verified, this is insufficient to determine whether the program has an overall positive impact because of leakage, which can be tested by analyzing the effect that an additional unit of land enrolled in the program has on deforestation. The second hypothesis is that the program does not influence deforestation. Furthermore, the marginal effect of the program on reforestation in other areas is determined to account for possible negative spillovers in areas that are not enrolled. Even if the program has a positive effect on reforestation in contracted areas and no negative effect on deforestation, one cannot assume that reforestation is being additionally induced by the program, because the payments could have affected reforestation elsewhere. Hence, the third hypothesis is that ProArbol does not have an impact on reforestation in non-contracted areas.

There are several methodologies to undertake an impact analysis of payments for environmental services. The impact can be analyzed by means of regressions with data covering participating and non-participating entities (Sierra and Russmann, 2006), or through difference-in-differences estimators (Scullion et al., 2011). Matching the participants allows controlling for biases along dimensions that are observable, thus taking into account potential confounding differences between participants and control groups (Andam et al., 2008; Alix-García et al., 2012). If available, remote-sensing data can be used to assess changes in forest cover before and after program implementation (Scullion et al.,

¹⁰ <http://cuentame.inegi.org.mx/monografias/informacion/mich/default.aspx?tema=me&e=16> (03.08.2013, 11:41h)

2011). Our hypotheses are tested by means of panel data regressions and propensity score matching to account for the self-selection bias that the establishment of eligible areas can potentially induce.

Impact evaluation of reforestation payments: Methodology and Data

Program evaluation is a process of making inferences about a counterfactual event (Ferraro and Pattanayak, 2006). Therefore, to estimate the impact of ProArbol on reforestation, we have to answer the question of what would have happened in Michoacán in the absence of the payments. Analyzing the baseline scenario allows us to determine whether the payments granted through ProArbol induced additional environmental benefits. Before applying the methods to evaluate the counterfactual it is necessary to consider several case study specific aspects. First of all one has to think about the pre-intervention conditions. Wunder (2005) highlights the importance of determining whether the baseline is *static* (where the provision of the environmental service in question remained constant) *declining* or *improving*. The author explains that choosing the correct baseline is very important to avoid over or underestimating the impact. Assuming a static baseline, an increasing reforestation rate over time would imply that the additional reforestation was enhanced by the financial incentives. However, if in reality the baseline is improving, as it is the case of Michoacán, the additionality of the program could be overstated.

To evaluate the additionality of PES programs, confounding effects and covariates have to be considered. Confounding effects are contemporaneous with the intervention and could affect the outcome and bias the intervention's effect measurement. These include historical trends, unrelated programs or policies and unobserved environmental as well as social characteristics. Covariates are observable factors that have an influence on the outcome, and taking them into account can substantially improve the control for biases (Andam et al., 2008). This is why it is important to have control groups that do not experience the intervention but are otherwise similar on average (Ferraro and Pattanayak, 2006). These

could be individuals, communities, or areas. Ideally the control group has on average the same characteristics as the treated group; however this is often not the case in non-randomized settings like the Mexican one, where the government defines the eligibility of municipalities. This leads to biased results in the regressions. Participating and non-participating municipalities may have large differences on their observed covariates, and these differences can lead to biased estimates of participation effects. In such non-randomized observational studies, there is no control over the treatment assignment, and therefore direct comparisons of outcomes from the treatment groups may be misleading. A way to deal with this problem is by incorporating information on measured covariates into the study design, for example, through matched sampling (D'Agostino, 1998).

To evaluate the impact of the payments for reforestation we test our three hypotheses by means of panel data regressions correcting for the selection bias through a propensity score. Panel data allow estimating more realistic models by enabling the analysis of changes on an individual level, so that one cannot only explain why individuals behave differently but also why a given one behaves differently at different time periods. The panel data set includes the period from 2000 to 2010 for the 113 municipalities in Michoacán. The data were provided by the Municipal System of Data Base (SIMBAD) of the Institute of Geography and Statistics (INEGI) and by the National Forestry Commission (CONAFOR).

The propensity score is used to reduce the selection bias because it balances the covariates between participating and non-participating municipalities. The propensity score is the conditional probability of receiving payments for reforestation through ProArbol ($D=1$) given certain covariates (X), which are assumed to influence their likelihood to participate in ProArbol (equation 1) (Rosenbaum and Rubin, 1983). In our analysis we use the following covariates¹¹: *average road network*; *total area* of the municipality; *average population size*; *average education level*, measured as the number of schooling years (these variables were used following Andam et al., 2008); a *water index* measured as the average

¹¹ We used the average values of these variables because they are only available for the years 2000, 2005 and 2010, when the census is undertaken.

share of households with access to piped water; *gdp*; and the *average share of land used for forest, rainforest, agriculture, secondary vegetation, dessert, urban areas, and waterbodies*. A non-participating municipality can be regarded as a control unit for a participating one if they have the same propensity scores, because they have the same distributions on their covariates (D'Agostino, 1998). Therefore, integrating the propensity score of each municipality as an explaining variable in the panel data regressions, allows an analysis of the variance of the dependent variable, controlling for the selection bias.

$$(1) p(X) = \text{prob}\{D = 1|X\} = E\{D|X\}$$

The most suitable model to test our hypotheses is a random effects model that accounts for potential unobserved attributes correlated with the observed covariates¹². This model imposes an intercept β_0 and coefficients in β that are identical for all municipalities and time periods. The error term varies over municipalities and time and captures all unobservable factors that affect the dependent variable. In a random effects model, the error term is assumed to be homoscedastic and not correlated over time, with a time invariant component α_i that is homoscedastic across municipalities (equation 3). When the observable regressors are correlated with the unobservable characteristics, it is better to use fixed effects models that include individual-specific intercept terms, capturing all unobservable time-invariant differences across municipalities (Verbeek, 2008). The Hausman tests¹³ confirmed however that random effects models are appropriate to analyze our hypotheses, and, moreover, the propensity score is time-invariant for every municipality, so that it would not be captured by a fixed effects model.

¹² According to the Breusch-Pagan Lagrange Multiplier test, these models are better than pooled OLS models explaining the variance of the dependent variables because the differences across municipalities are significant.

¹³ The Hausman test compares an estimator that is consistent under both the null and alternative hypothesis and an estimator that is consistent (and typically efficient) under the null hypothesis only. A significant difference between the two estimators indicates that the null hypothesis is unlikely to hold. Therefore, this test reveals whether the fixed effects and random effects estimators are significantly different. One reason for this would be if the observable regressors X_{it} are correlated with the error term, which includes unobservable specific characteristics described by α_i (Verbeek, 2008).

$$(2) y_{it} = \beta_0 + x'_{it}\beta + \varepsilon_{it}$$

$$(3) \varepsilon_{it} = \alpha_i + u_{it}$$

Random effect models combine information from both, between and within dimensions. The between estimator is determined as the OLS estimator in a regression of individual averages of y on individual averages of x and a constant, so that it measures differences between municipalities (equation 4). The within dimension refers to the differences within municipalities, and is determined as the OLS estimator in a regression in deviations from means of municipalities. The random effects estimator can be determined as a weighted average of the between and within estimator (Verbeek, 2008).

$$(4) \bar{Y}_i = \beta_0 + \bar{x}'_i\beta + \alpha_i + \bar{u}_i$$

In order to test our hypotheses we use following dependent variables: *reforestation*, measured by both, the number of planted trees and reforested hectares; *reforestation in non-participating areas*, measured as the difference between the area reforested and the participating area under the assumption of full compliance; and *deforestation*, approximated by the hectares allocated to agriculture due to lacking information on deforestation and the limitation of this study to access satellite imagery. The latter can be justified by the fact that agricultural activities are the major cause of deforestation in Mexico. We are aware that this proxy does not take into account other activities inducing deforestation like illegal deforestation or urbanization; however, possible spillover effects would be a result of landholders compensating for agricultural land, so that this variable is suitable for the purpose of this study.

Participation in ProArbol's payments for reforestation is measured as the amount of hectares enrolled in the program, as well as the land tenure in the contracted area. To explain the variation of the dependent variables we use following covariates and counterfactual variables: *land tenure* in participating areas, which can be community,

ejido¹⁴ or private property; *land use productivity*, measured as the total value of crops produced in Mexican pesos; the number of submitted environmental claims as a proxy for *environmental consciousness* because environmental awareness could induce an intrinsic motivation to reforest; and the share of households receiving *subsidies for the rural sector* through the national program PROCAMPO.

Results and Discussion

We tested each of our hypotheses with random regression effects, controlling for land tenure land tenure in participating areas, land use productivity, environmental awareness, and agricultural subsidies. . The first hypothesis is that the program has a positive effect on reforestation in the participating area. This was tested by analyzing the impact of the area enrolled in the program on the amount of planted trees in the municipality. Considering the possibility of leakage, the second hypothesis supposes that the program does not influence deforestation, whereas the third hypothesis assumes that the program does not have an impact on reforestation in non-contracted areas.

The hypothesis that the program has a positive effect on reforestation in the municipalities of Michoacán could not be verified (table 1, first column). The regression results show a highly significant ($p < 0.01$) negative effect of the area enrolled in the program on the amount of trees planted. Specifically, an additional hectare enrolled in the program causes a decrease of 89 planted trees in that municipality.

¹⁴ Ejido is a form of land tenure established in the Mexican constitution 1917, Art. 27, where a group of persons held rights to land for agrarian purposes in perpetuity, that cannot be sold, rented or mortgaged (Gareth et al. 1998).

Table 1: Regression analysis: Impact of the reforestation payments on the amount of planted trees

Dependent Variables	Planted Trees	Deforestation	Reforestation in non-participating areas
Area enrolled in ProArbol	-89.34*** (11.86)	-0.008 (0.03)	-0.30*** (0.01)
Environmental awareness	5164.94*** (1829.03)	-5.82 (3.96)	12.10*** (1.82)
Land use productivity	-0.14*** (0.03)	0.0002*** (0.00)	0.00002 (0.000003)
PROCAMPO subsidies	-0.99 (16.31)	1.71*** (0.02)	-0.004 (0.013)
Propensity score	659107.9*** (71218.88)	-110.68 (106.82)	319.04*** (61.27)
Community	42601.86 (43715.44)	31.03 (148.00)	-329.00*** (47.46)
Ejido	21200.08 (40487.14)	80.85 (139.56)	-364.25*** (43.71)
Private Property	-30816.66 (56450.09)	-19.86 (193.66)	676.15*** (59.62)
CONSTANT	2649.39 (28173.04)	164.66*** (36.84)	-1.97 (23.23)
Number of obs.	1130	1243	1243
R-sq overall	0.30	0.06	0.45
R-sq between	0.41	0.48	0.34
R-sq within	0.10	0.06	0.50
Prob>chi	0.00	0.00	0.00

***, **, * statistically significant different from zero at a confidence level of 1%, 5%, and 10%, respectively.

The standard errors are shown in parentheses under the respective coefficient.

Data: INEGI and CONAFOR, Software used: STATA

The negative effect of the program on reforestation can be explained by the profitability of environmentally harmful activities that PES Schemes may unintentionally enhance by changing prices (Jack et al., 2008). Payments for reforestation may increase the purchasing power of landholders. This *income effect* might induce investments on activities like agricultural production, especially when landholders are credit-constrained (Jack et al., 2008). An income effect could imply deforestation in non-enrolled areas of the municipality, leading to a lower net effect on reforestation. Another effect likely to reduce the impact of the program is the *shadow price effect*. The allocation of land and labor to the program could imply a lower supply of alternative production outputs, like wood or

agriculture goods, which might make their provision more attractive for other landholders. For this purpose land might be deforested in non-participating areas (Pattanayak et al., 2010). The *leakage effect* is the third one that might explain the lack of impact of the program on reforestation. In order to compensate for the land allocated to tree planting, land could be allocated to alternative activities in areas outside the participating ones (Engel et al., 2008). However, the hypothesis that the program has no effect on deforestation in the municipalities of Michoacán could be verified (table 1, second column). The regression results show no significant effect of the area enrolled in the program on the area allocated to agriculture.

An alternative explanation for the lack of additionality induced by the payments could be that trees that would have been planted even in the absence of payments may now be planted in participating areas. Therefore, we tested the hypothesis that the program has no effect on reforestation outside the program, by analyzing the difference between the total reforested area and the participating area, assuming full compliance (table 1, third column). Our results suggest, that an additional hectare enrolled in the program decreases significantly ($p < 0.01$) the area reforested in non-contracted areas by 0.3 hectares.

The fact that participation in the PES program decreases reforestation in areas that are not enrolled in the program could be induced by two different channels. On the one hand, reforestation efforts that were done outside the participating areas before the program was implemented could now take place under the participating areas. This would mean that trees would have been planted also in the absence of the program. On the other hand reforestation payments in participating areas could give landholders of non-participating areas an incentive to stop reforesting their land and allocate their labor to alternative more profitable activities.

Conclusion

This study analyzed the effect of the Mexican program ProArbol of payments for environmental services in the state Michoacán. The objective was to determine whether the PES had a positive impact on reforestation between 2003 and 2010. To undertake the impact analysis, we tested three hypotheses that account not only for the impact in the contracted areas, but also in non-contracted ones. The analysis was undertaken by means of panel data regressions, thus controlling for the selection-bias induced by the eligibility of municipalities stipulated by the government.

Our results suggest that ProArbol's payments for environmental services are not inducing additional reforestation. The program of payments for reforestation did not only lack additionality, but it also contributed to a decrease in reforestation in the enrolled municipalities. The hypothesis that the program has a positive effect on reforestation in the participating area could not be verified because the area enrolled in the program has a significant negative marginal effect on the amount of trees reforested in those municipalities. Although the hypothesis that the program does not influence deforestation was verified because there was no evidence for negative effects in deforestation in participating municipalities, we found evidence of negative spillovers in non-contracted areas. The hypothesis that the program does not have an impact on reforestation in non-contracted areas could not be verified because the area enrolled in the program has a significant negative effect on reforestation in non-contracted land. The latter result can explain why reforestation in enrolled municipalities decreased in the presence of the program of payments for reforestation.

A weakness of PES schemes might be the fact that it cannot be controlled for leakage effects in non-enrolled land. The negative effect of the Mexican program on reforestation can be a result of income effects leading to investments in non-environmental friendly activities, or to shadow price effects making alternative land uses more attractive. Both effects can lead to deforestation in non-contracted land, or to the reallocation of land and labor to other activities rather than reforestation in non-contracted areas. Moreover trees

that would have been planted even in the absence of payments may now be planted in participating areas.

The lack of impact of the program could be partly attributed to the design of the PES scheme. The National Forestry Commission stipulated that areas with a higher risk of deforestation should be given priority; however, socio-economic criteria are also considered for eligibility. Although it is claimed that there can be synergies between the provision of environmental services and poverty reduction with an appropriate program design and under favorable local conditions (Pagiola et al. 2005), the main goal of PES schemes is to induce additional environmental benefits. The socio-economic criteria of ProArbol might shift eligibility to areas where environmental benefits are not additional, so that areas assessed by the payments in Michoacán may not be well targeted. A more profound analysis is needed to identify the areas where reforestation is not likely to take place without financial incentives.

Furthermore, leakage in the Mexican scheme can be caused by the fact that the program does not enroll the total owned area (Muñoz-Piña et al., 2007). Payments for reforestation are only made for a share of the land. This can lead to two different problems: landholders are likely to compensate for opportunity costs by using non-enrolled land; and if they were already reforesting land before the program was implemented, they might stop reforesting those areas to reforest the ones enrolled. This issue was addressed in the design of the Mexican PES program by monitoring the areas to control for slippage; however, according to our results this measure is failing. The idea of requiring landholders to enroll their entire area was rejected given the large size of several *ejidos* (Muñoz-Piña et al., 2007). Nevertheless, this might be a better way to deal with the problem of leakage and the resulting lack of additionality.

References

Alix-Garcia, J., Shapiro, E.N., and Sims, K.R.E. (2012): Forest Conservation and slippage: Evidence from Mexico's national payments for ecosystem services program, University of Wisconsin-Madison, Department of Agricultural & Applied Economics, Staff Paper No. 548.

Andam, K.S., Ferraro, P.J., Pfaff, A., Sanchez-Azofeifa, G.A., and Robalino, J.A. (2008): Measuring the effectiveness of protected area networks in reducing deforestation, PNAS, volume 105, no. 42, 16089-16094.

Assessment, M. E. (2003): Millennium ecosystem assessment, Ecosystems.

D'Agostino, R. B. (1998): Tutorial in biostatistics: propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group, Stat Med 17.19 (1998): 2265-2281.

Engel, S., Pagiola, S., and Wunder, S. (2008): Designing payments for environmental services in theory and practice: An overview of the issues, Ecological Economics, Vol. 65, 663-674.

Evaluación de Consistencia y Resultados 2011-2012 ProArbol, SEMARNAT, CONEVAL, Universidad Autónoma de Chapingo.

Ferraro, P.J. and Pattanayak, S.K. (2006): Money for Nothing? A call for Empirical Evaluation of Biodiversity Conservation Investments, PLoS Biology 4 (4): e105, 482-488.

Ferraro, P.J. and Kiss, A. (2002): Direct payments to conserve biodiversity, Science 298.5599 (2002): 1718-1719

Gareth A. and Ward, P. (1998): Privatizing the commons: reforming the ejido and urban development in Mexico. International Journal of Urban and Regional Research 22.1, 76-93.

Informe de Rendición de Cuentas de la Administración Pública Federal 2006 – 2012, Comisión Nacional Forestal, tercera etapa, Secretaría de Medio Ambiente y Recursos Naturales.

Jack, B. K., Kousky, C., and Sims, K.R.E. (2008): Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms. Proceedings of the National Academy of Sciences 105.28 9465-9470.

TEEB (2010): The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington.

Masera, O. (1996): Deforestación y degradación forestal en México, Documentos de trabajo 19 (1996).

Millennium Ecosystem Assessment (2005): *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

Muñoz-Piña, C., Guevara, A., Torres, J.M., and Braña, J. (2007): Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results, *Ecological Economics* 65, Issue 4, 725-736.

Pagiola, S., Arcenas A., and Platais G. (2005): Can payments for environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America, *World development* 33.2: 237-253.

Reglas de Operación del Programa ProArbol (2012), *Diario Oficial (Segunda Sección)*, 21 de diciembre de 2011, Poder Ejecutivo, Secretaría de Medio Ambiente y Recursos Naturales

Rosenbaum, P.R. and Rubin D.B. (1983): The central role of the propensity score in observational studies for causal effects, *Biometrika* 70.1 (1983): 41-55.

Scullion, J.T., Vogt C. W., Perez-Maqueo K. A., and Logsdon, M. G. (2011): Evaluating the environmental impact of payments for ecosystem services in Coatepec (Mexico) using remote sensing and on-site interviews, *Environmental Conservation*, 38(4), 426-434.

Sierra, R. and Russman E. (2006): On the efficiency of environmental service payments: a forest conservation assessment in the Osa Peninsula, Costa Rica., *Ecological Economics* 59.1 (2006): 131-141.

TEEB (2010): *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*. Edited by Pushpam Kumar. Earthscan, London and Washington

Verbeek, M. (2008): *A guide to modern econometrics*. Wiley.

Walker, R. (1993): Deforestation and economic development, *Canadian Journal of Regional Science* XVI: 3, 481-497.

Wunder, S. (2005): Payments for environmental services: some nuts and bolts, *CIFOR, Occasional Paper* No. 42.

ANNEX

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Area (sq. km)	1356	518.96	584.49	54.91	3460.73
Average GDP (thousand MXN)	113	542264.2	2642869	1228	2.49E+07
Average population	113	36291.38	72128.02	2916.33	677985.3
Average education (schooling years)	113	5.70	0.87	3.86	9.5
Water Index (% households)	113	0.87	0.13	0.47	0.99
Agriculture (% total area)	113	0.40	0.19	0.009	0.92
Grassland (% total area)	113	0.09	0.08	0	0.60
Forest (% total area)	113	0.16	0.16	0	0.60
Rainforest (% total area)	113	0.05	0.09	0	0.43
Dessert (% total area)	113	0.0005	0.004	0	0.04
Other vegetation (% total area)	113	0.003	0.01	0	0.14
Secondary vegetation (% total area)	113	0.23	0.1596522	0	0.77
Area without vegetation (% total area)	113	0.0008	0.004293	0	0.02
Waterbodies (% total area)	113	0.02	0.0794874	0	0.62
Urban area (% total area)	113	0.01	0.0127306	0	0.0736464
Road network (km)	113	75.23	55.84638	13	372
Planted trees	1130	138423.3	312295.3	0	2900000
Deforestation (ha)	1243	369.45	761.40	0	7409
Reforestation in non-contracted areas (ha)	1243	50.21	345.10	-4265.87	2320
Enrolled area (ha)	1243	172.23	736.11	0	10752.77
Private property (%)	1243	0.02	0.57	0	20
Community (%)	1243	0.03	0.58	0	20
Ejido (%)	1243	0.04	0.58	0	20
PROCAMPO subsidies (Households)	113	1222.36	1008.88	89	5544
Environmental awareness (number of claims)	1243	3.55	7.10	0	69
Land use productivity (thousand MXN)	1243	176535.6	317356.4	1931	3123590

Data source: INEGI and CONAFOR