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Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results

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ABSTRACT

Mexico faces both high deforestation and severe water scarcity. The Payment for Hydrological Environmental Services (PSAH) Program was designed to complement other policy responses to the crisis at the interface of these problems. Through the PSAH, the Mexican federal government pays participating forest owners for the benefits of watershed protection and aquifer recharge in areas where commercial forestry is not currently competitive. Funding comes from fees charged to water users, from which nearly US $18 million are earmarked for payments of environmental services. Applicants are selected according to several criteria that include indicators of the value of water scarcity in the region. This paper describes the process of policy design of the PSAH, the main actors involved in the program, its operating rules, and provides a preliminary evaluation. One of the main findings is that many of the program's payments have been in areas with low deforestation risk. Selection criteria need to be modified to better target the areas where benefits to water users are highest and behavior modification has the least cost, otherwise the program main gains will be distributive, but without bringing a Pareto improvement in overall welfare.

1. Introduction

Water scarcity and deforestation are two of Mexico's most important environmental challenges. According to Mexico's National Water Commission (CNA), two thirds of the country's 188 most important aquifers are overexploited (Comisión Nacional del Agua, 2003), while an additional 28% are fully used. According to Ávila et al. (2005), this crisis was created by environmentally perverse subsidies to electricity for water pumping (nearly US$700 million per year) and the failure to price water according to its scarcity. The federal government's strategy to deal with the problem has consisted mainly in expanding the physical infrastructure through engineering projects, with very few examples of demand management through prices, and an almost complete absence of environmental management instruments.

Even using the conservative estimate of 1.3% annual deforestation reported for the 1990s (Torres Rojo and Flores Xolocotzi, 2001), it is evident that Mexico has been losing its forests at an alarming rate. According to its National Forest Inventory, Mexico had nearly 63 million hectares (ha) of forest in 2000, of which about half was tropical forest. The main driver of forest loss has been conversion to agriculture and cattle ranching. Between 1993 and 2000, approximately

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3.1 million ha of forests were transformed into agricultural fields, and an additional 5.1 million ha were converted to pastures (Velásquez et al., 2002), an annual expansion of these land uses of 2.0% and 4.6%, respectively.

Before introducing the concept of payment for environmental services (PES), the Mexican government's strategy to reduce deforestation relied on three types of instruments: (1) direct regulations of activities that change land use or degrade natural areas, (2) subsidies to sustainable forestry activities, and (3) police action to stop timber theft. The most important regulations are the obligation to have sustainable forestry management plans before undertaking any resource extraction, and the need to obtain authorization to change land use in natural areas, which requires an Environmental Impact Assessment (EIA). There are subsidy programs to hire technical advice in commercial forestry operations, and to establish plantations. Other programs undertake capacity building among poor forest-owning communities, and provide matching grants for the acquisition of forestry equipment. The government also temporarily hires community members to reforest degraded areas.

Regulations have a narrow scope. In practice, EIAs are limited to large-scale tourist, infrastructure, industrial, agribusiness, and urban development projects, not small-scale agricultural or ranching transformations, so only a small part of the total land use changes observed in Mexico have actually been under the true regulatory sphere of influence of the government. The reason is that enforcing regulations on the numerous low-value small-scale land use changes has been beyond the government's capacity and willingness to act. Less than 10% of Mexican forests are under commercial operations, so subsidies targeted to them also have limited scope in reducing deforestation. In this context, the PES program was designed to complement existing policies.

The Program of Payment for Hydrological Environmental Services of Forests (*Pago de Servicios Ambientales Hidrológicos*: PSAH) was conceived as playing a key role in those areas of hydrological importance where other policies have proven ineffective. It provides economic incentives to avoid deforestation in areas where severe water problems are linked to deforestation, but where commercial forestry cannot compete against agriculture or ranching. PSAH consists of direct payments to landowners with primary forest cover (forests in good state of conservation). Part of the PSAH's innovative approach is that it is funded through an earmarked portion of federal fiscal revenues from water fees, creating a link between those who benefit from the environmental services and those who provide them.

The policy was also motivated by fairness. Without PES, Mexico would face a dilemma in the many areas where forest owners are poor: effectively applying regulations that prohibit land use change would reduce deforestation rates, but eliminate income generating opportunities. Mexico thus faced real trade-offs between poverty reduction and environmental protection, between local and global benefits, and between the welfare of present and future generations. The objective of paying for forests' environmental services is to avoid those trade-offs, and protect natural capital.

2. Main actors

Background analysis and design of the PSAH was undertaken by a team of researchers from the *Instituto Nacional de Ecología* (INE) which is the Government's environmental research agency and part of the Secretariat of Environment and Natural Resources (SEMARNAT), two Mexican universities – the *Universidad Iberoamericana* and the *Centro de Estudios y Docencia Económica* (CIDE) – and the University of California at Berkeley. Work started in mid 2001 and continued until the program's launch in 2003. The then Minister of the Environment gave his support to the basic idea presented by INE in late 2001. SEMARNAT requested support from the World Bank, who provided advice and feedback throughout preparation and channeled a donation from the government of Japan to finance data gathering and analysis.

The Director General of the National Forestry Commission (CONAFOR) gave his agency's full support to develop the PSAH initiative, and provided the political backing it needed to pass through Congress. Organizations of communal or individual forest owners played a key role in shaping the policy. Water users, industrial associations and municipalities played a less active role. They provided valuable information through consultations but did not participate in actual negotiations, highlighting the fact that the forest-water externalities are an area where they thought they had little influence, until the PES policy brought them together.

During the lobbying process in the Mexican Congress, several key members of the Environment, Natural Resources, and Tax Commissions became very supportive of the PSAH, to the point that they declared their intention of presenting the initiative as their own if the Finance Ministry (SHCP) did not integrate SEMARNAT's proposal into the fiscal package. The interest from different political parties stemmed from their diverse agendas-environment, poverty reduction, water supply, and forest conservation-helped to build the necessary consensus to pass the initiative through the Review Commissions and to ultimately be approved by a majority vote in the general session.

3. Design issues: Financing the PSAH

One of the first design questions concerned who should pay for environmental services. The research team recognized that the PSAH could not be based on a competitive market because the water-related ecosystem services provided by forests are mostly public goods on a regional scale. Governments, either at the federal, state, or municipal level, would have to act as intermediaries between the owners of the forests and the citizens and firms that benefit from clean, abundant water or from lowering the impact of floods or other water related natural disasters. Thus the PSAH would necessarily be a monopsonistic market at some scale, with the government involved as the only buyer, who could choose which forest plots would be eligible to be paid, which types of actions would be rewarded, and what would the rate paid be.

The follow-up question concerned which level of government would be able to most effectively collect and deliver

PSAH payments. The initiative taken by SEMARNAT necessarily made the PSAH a federal program. However, a couple of local initiatives developed simultaneously during those years, and showed that successful implementation could also be achieved at this smaller scale. Thus the federal policy strategy is to gradually increase local government involvement to complement federal funding, and target areas of local interest, perhaps at the level of municipalities or micro-watersheds. This local part of the strategy is being pursued now through a new project supported by the World Bank. Several more cases of local PES mechanisms are expected to be launched in 2007.

Because of the importance of having those who benefit actually pay for environmental services (Pagiola and Platais, 2007), the design team recommended the creation of a fiscal instrument to finance the program in the form of a fee on water use. The federal water fee, which is set annually by Congress, was an ideal candidate. Mexico's lakes, lagoons, aquifers, and rivers are considered national property, so the Federal Rights Law (*Ley Federal de Derechos*: LFD) includes fees for their use (Cortina, 2002). The team proposed that water fees be raised and a percentage earmarked to pay for environmental services. The proposed modification of article 223 of the LFD initially earmarked a specific share (2.5%) of annual water revenues for PSAH payments. Later negotiations with the Ministry of Finance (SHCP) resulted in a specific amount being earmarked: M$200 million (US$18.2 million) annually, representing roughly 2.5% of average annual water revenues. Unlike Costa Rica's PES program, which relies primarily on fuel taxes (Pagiola, this issue), Mexico's use of funds from the water fee creates a more direct link between users and providers. To further emphasize the link, INE had proposed allocating funds by watershed and aquifer in the same proportion as federal water fees were collected. CONAFOR rejected this idea because most fees are collected in the three largest metropolitan areas, and they wanted to spread the money more widely.

It was difficult to convince the CNA to accept that water revenues be earmarked for PSAH. CNA officials still perceive water scarcity mainly as a problem of investment in infrastructure, dismissing the role played by natural capital. SHCP also needed to be convinced that the instrument was well designed, that it could be approved by Congress, and that it was aligned with current fiscal policy. Mexican fiscal policy has always opposed earmarking taxes because it aims to separate budget priorities from funding sources. However, this argument is weaker with regards to fees, which are payments for goods or services provided by the government. During the administration of President Vicente Fox, the revenue section of SHCP succeeded in having several environmental fees earmarked, most notably fees from visitors to protected areas and those obtained from hunting wildlife in federal lands. Nevertheless, CNA and SHCP staff strongly opposed earmarking part of the water fees for PSAH. The political reason was that under a previous agreement, municipalities received 100% of the water fees they had paid to invest in water projects. As water supply infrastructure is extremely deficient throughout Mexico, the devolution of revenues agreement resulted in unseen fee collection levels, three to four times higher than those observed in the past (Presidencia de la República, 2003), so CNA and SHCP were loath to make changes to such a successful agreement. However, the water policy analysis by INE showed a growing gap between investment in physical capital and investment in natural capital, and SEMARNAT overruled its water agency's reluctance to earmark an environmental component of the water fee. Ultimately, a compromise was reached which symbolically excluded municipalities from contributing to the PSAH, but maintained the full allocation of US$18.2 million to the program in 2003. With continued support from congress, the earmarked allocation was increased to M$300 million (US $27.3 million) in 2004 and subsequent years.

Public knowledge and perceptions about the relationship between forests and water flows were critical for policy design. There is a strong belief among Mexicans that forests play an important role in water supply. Rural and urban dwellers, peasants, professionals, representatives of producer's organizations or environmentalist groups, and public officials, all seem to recognize that there is "some kind" of important link between conserving forests and the quantity and quality of water they enjoy. A similar strong belief surrounds the relationship between the extent of deforestation and the strength and frequency of floods. These perceptions by stakeholders helped to sell the PSAH to key supporters in Congress and the administration, to navigate through the discussions with producer organizations, and to obtain the approval of key Congress committees.

In an effort to move beyond beliefs and public perceptions, a series of consultations with hydrologists and ecologists were arranged. They provided a picture of the relationship between forests and environmental services that was not as uniform in it conclusions as conventional wisdom. The actual relationship they saw was context-specific. The change in aquifer recharge rates depend not only of deforestation rates, but on what land use replaced forests, and on what management practices were followed (Chomitz and Kumari, 1998). The deterioration in water quality and increase in downstream silting depend on topography and preventive infrastructure. There is evidence of a positive deforestation-frequency of floods link, but mainly in small, steep watersheds (Bruijnzeel and Bremmer, 1989). The effects of large scale deforestation, on the other hand, had little empirical analysis and have been difficult to model (Costa, 2005) but impossible to ignore (Douglas et al., 2007). In summary, there were several sources of uncertainty, and strong dependence on variables which could not be reasonably and objectively identified and measured at a national scale. The clearest forest-water link was in the case of tropical montane forests, where humidity in fog was captured by trees and made available as surface water, especially in the drier seasons (Bruijnzeel, 2005).

Research in Mexico itself was insufficient to fill the information gaps, but provided some evidence of valuable services being provided by certain types of forests in certain regions. García-Coll (2002) estimated the contributions of cloud mountain forests of Veracruz in maintaining the surface water flows during dry seasons. Burgos (1999) found evidence that dry tropical forests in western Jalisco reduced the risk of floods during storms in the steep and short watersheds typical of the region. Carrillo-Rivera (2002) identified the forests in the Sierra Gorda located in key recharge areas for the aquifers supplying the cities of Querétaro and San Juan del Rio.

Despite the uncertainty on the true forest-water relationship the policy decision was to go forward with the program, for two reasons. The first invoked the precautionary principle (OECD, 2001): given the uncertainty on forest-water connections, it was better to err on the side of caution. Moreover, some officials considered avoiding deforestation worthwhile purely for biodiversity conservation. The second reason was that many deforested areas fulfill the conditions for a damaging impact of deforestation on watersheds; for example, most pastures are overgrazed and their soil is compacted, while only a handful of dams have infrastructure to reduce siltation. The global assessment of Douglas et al. (2007) considers several watersheds on Mexico's Pacific coast to be among the world's "hydrological hotspots", due to their short length and steepness.

4. Design issues: Paying participants

Once the fiscal reform earmarking water fees had been passed by Congress, the second step entailed establishing the operating rules defining the incentives that the program would provide. Which forests would be included? What actions would be rewarded? How much would be paid? What enforcement mechanisms would be put in place? The following sections look at how these four policy questions were answered.

The main policy objective of the PSAH is to give taxpayers valuable environmental services in exchange for their contributions. This means targeting payments to the forests that are most important for water supply and that are at significant risk of deforestation. The target is well-preserved forests. Although other ecosystems and agricultural lands can also provide environmental services, the program focuses on forest ecosystems because of the agency involved. Even with this focus, the hydrologic relevance criteria still left a large area of the country to choose from, and several criteria were introduced to narrow the target area further.

4.1. *Eligibility and prioritization*

One of the first issues analyzed was whether different types of forests should be prioritized. A Blue Ribbon Committee of Mexican and international scientists was assembled to help classify forests according to their importance for aquifers and watersheds. As described earlier, it concluded that cloud forests were most important because of their role in capturing water from fog in the dry season (See Bonell and Bruijnzeel, 2005). Some argued that dry tropical forests were also important for their role in reducing flood damage, but there was insufficient consensus on this point. The available evidence thus only allowed cloud forests to be singled out as being particularly important, and it was decided that their privileged place should be reflected in a higher price paid per hectare. No consensus was found regarding the effect of different forestry practices, except for clearcutting. As timber plantations were excluded from the program, however, no additional effort was put into the issue.

The initial PSAH operating rules required eligible areas to be located in the recharge area of overexploited aquifers, in watersheds with high water scarcity, or in areas with high flood risk. An indicator of overexploited aquifers was readily available, as the CNA had just published the geographical coordinates of the main 188 aquifers and their degree of overexploitation (Comisión Nacional del Agua, 2003). This indicator was perceived as objective and fair and has been used to define eligible areas since 2004. Equally valuable indicators of vulnerability to natural disasters and general water scarcity have proven more problematic to find. The Mexican National Disaster Prevention Center (CENAPRED, 2004) did not make available a detailed national map of areas at risk from natural disasters until the end of 2004. Although it is now widely considered the best available indicator among the academic community, CONAFOR officials have thus far declined to use it because the scientific basis for its preparation was unclear; knowledge sharing between agencies should resolve this situation. On the other hand, general surface water scarcity indicators were not introduced in 2003 because CONAFOR had doubts about the likely extent of participation, and wanted to include all possible areas. Even when participation proved not to be limited, scarcity indicators were not included as the areas of highest scarcity were concentrated in just a few states and CONAFOR wanted to have a national scope. CONAFOR thus only accepted the use of scarcity indicator as a variable in the application grading system, rather than as a factor in the definition of eligible areas. As a result, neither water scarcity nor natural disaster areas had clear indicators in the first three years of operation. In retrospect, this was a bad decision.

In order to link the federal PSAH program with future local payments, the initial operating rules required that participating forests be located in the area of influence of a population center of more than 5000 inhabitants. This was based on the expectation that local water users would eventually develop their own payment programs to complement or take over from federal payments. Internal lobbying by officials working on protected areas and the National Priority Mountain Program resulted in two alternative eligibility criteria being added, namely location inside a protected area or in a "priority" mountain. Officials holding these agendas saw the PSAH as a way to ease the pain of enforcing their regulations on poor communities. Although these two additional criteria are not necessarily inconsistent with hydrological services, they certainly are not equivalent.

In 2004, CONAFOR defined specific "eligible areas" based on available data on the value of hydrological services and other policy criteria (protected areas and "priority" mountains). Only plots within these areas could apply to the program and all were initially considered equally valuable in terms of environmental service provision. After demand for participation exceeded supply of funds, INE suggested that specific indicators of the value of the hydrological service be incorporated in the operating rules for 2005, not as prerequisites but as components of a grading system used to evaluate applications. The 2006 rules of operation incorporate this feature with all the suggested variables except those corresponding to natural disasters, for the reasons explained above.

4.2. *Payment levels*

Payments for environmental services could be based either on their value to consumers or on the opportunity cost of providing them. Because there was so little information about the value of environmental services, the design team recommended that payments be based on the opportunity cost of not deforesting in areas considered to be of highest hydrological value.

The design team initially recommended using auctions as the best way to obtain true information about opportunity costs, and to allocate funds in a way that would maximize the area protected for a given budget. As Latacz-Lohmann and Van der Hamsvoort (1997) and Stoneham et al. (2003) point out, there can be significant gains from using an auction instead of a fixed-price approach due to the presence of asymmetric information in conservation agreements (see also Ferraro, this issue). Among the different types of auctions, Cason and Gangadharan (2004) show that a discriminatory pricing auction would yield more environmental benefits by capturing the producer surplus for the government. However a single price auction – where the same price is paid to all successful bidders – appeared as the best option given the heterogeneous knowledge of the environmental services actually provided in Mexico and the consultations which showed a strong perception among forest owners that different prices for the same forests would be unfair.

However, the idea of using auctions was rejected early in the discussions by CONAFOR, who argued that it would be too innovative, that most of the communities would only be confused about the mechanism, and that it would have high administrative costs, especially because it had not been done before. The last argument would indeed carry some weight if the welfare gains were less than these administrative costs, but no estimates of the relative importance of these two factors came into play. One of the additional concerns of the implementing agency was that they did not want to appear to be buying the land instead of the environmental service, and that an auction would look more like a commercial transaction than the traditional fixed subsidy programs. In Mexico, buying common property land is prohibited by law, and any government action that intends to obtain land is frequently politically charged because it is linked to expropriations to build infrastructure and urban developments.

The option chosen was then a fixed-price program with only two tiers decided beforehand. These tiers differentiate only by type of forest, with cloud forests in the upper tier. Under a fixed payment system, two circumstances deserve special attention. The first is when the opportunity costs of preserving forest are zero; this occurs when agriculture and grazing are not profitable, or when they are less profitable than forest activities. In this case, forests would be preserved even without the PSAH program. Owners of such land would clearly be interested in participating in the PSAH program, since they would receive payments without actually sacrificing anything. This outcome can be considered fair in a sense; it would establish property rights over environmental services in favor of forest owners. However, payments to such forests would not be optimal from the government and water users' point of view, as they would waste the opportunity to take full advantage of available funds. When the opportunity cost is zero, no conduct is being modified by the payments and no additional environmental services are being provided. To help avoid such cases, an econometric model of deforestation was used to develop an indicator of opportunity cost that was introduced into the program's rules beginning in 2006.

The second concern is when opportunity costs are higher than the payment offered by the program. The owners of forests that would yield a higher income as agriculture, livestock, industrial, or urban projects would choose not to participate in the program. If these benefits are higher than the environmental benefits that would be generated, then society is better off if such forests remain outside the program. This situation presents no problem. However, if the environmental benefits are higher than both the opportunity costs and the amount offered, then the single price has effectively prevented a welfare-improving transaction (Pagiola and Platais, 2007). Increasing the price to induce participation by these forests, however, would mean having to pay more to the rest of the plots with lower opportunity costs, and thus limit the program. More price differentiation would certainly bring in more environmental benefits.

A team from INE studied the profits obtained from agriculture and livestock operations near forested areas as an input to the design of the program (Jaramillo, 2002). The objective was to estimate the distribution of the opportunity costs of conserving forests. Data were obtained from the government's main commercial agricultural credit organization (*Fideicomisos Instituidos en Relación a la Agricultura:* FIRA). These data are expected to overestimate the profits achievable in candidate areas of the PSAH because FIRA's clients tend to be at the high end of agricultural production, but they were useful as an upper-limit reference for policy analysis. The results obtained show average annual profits of US$37/ha from growing corn, and of US$66/ha for livestock production. The estimated distribution showed that with a payment of M $200 per hectare (US$18.2) more than 40% of forest owners in the sample would have preferred conserving forests to converting them to cornfields. The same payment would have stopped 12% of pasture owners from deforesting their land.

Based on this analysis, INE and CONAFOR initially proposed a payment of M$200/ha (US$18.2), except for cloud forests, which would be paid M$300 /ha (US$27.3) due to their higher value in terms of hydrological services. This amount would ensure that at least a fifth of candidates in areas likely to switch to agriculture would be interested in joining the program. Payments would be made annually, after verifying that no land use change had occurred, and would be renewed for 5 years if conditions were fulfilled. It is important to note the combination of a basic opportunity cost criterion with a value of environmental service criterion applied for cloud forests is more the result of political signaling aims than logical consistency. There is no information available to test if the distribution of opportunity costs in cloud forests is different from that of other forests.

During the approval process of the operating rules, rural organizations pressed for higher payments. INE and CONAFOR found their negotiating position puzzling at the start, as a higher payment with a fixed budget would mean fewer people would receive payments. It later became clear that the organizations' leaders wanted payments focused exclusively on areas where they had their own constituencies. After lengthy negotiations, a compromise was reached to pay M

$300 /ha (US$27.3) for all forests except cloud forests, which receive M$400 /ha (US$36.4).

4.3. *Working with communities*

The common property nature of more than 70% Mexican forests provides an interesting setting for a payment of environmental services program. Previous research on cooperation in Mexican *ejidos* and *comunidades* (McCarthy et al., 2001; Muñoz-Piña et al., 2003) has shown that the decisions regarding how much to maintain as commons and how much to privatize depends on the size of the group, the quantity and quality of resources, and other costs and benefits of cooperation. On the one hand, these studies show that larger and less homogeneous groups chose more frequently to have a larger share of their land in the form of individual plots (usually with crops or pasture), instead of keeping their forests as common property. On the other hand, having a higher quality forest (one providing more profits per hectare), makes it worthwhile for more communities to invest in cooperation in managing it. It is expected that a PES scheme would work in a similar way, giving incentives to cooperate in the conservation of the forests, especially in those areas with non-commercial timber stands. As in other activities, the communities' formal and informal governance institutions would still have to solve the problem of compensating each member potential individual gains from deforestation to gain the benefits of PES (see Alix-García et al., 2004). For those that fail to do so and thus fail to conserve forests as agreed, the consequence is the cancellation of current and subsequent payments. Strong monitoring and enforcement by CONAFOR is needed to send the signal to all other communities that they need to be serious about their internal arrangements to ensure cooperation.

Case studies on the distributional arrangements after a PES contract (Braña et al., 2005) show that communities chose a range of options: some communities use all the PSAH income to invest in public goods; others divide equally the payment among members, while others have a mixed strategy. A problem identified in most of these case studies is that few *ejido* members aside from those with directive or representation functions knew the conditions on the contract, even in *ejidos* that distributed payments among members. As mentioned later, INE is currently comparing deforestation outcomes across communities to identify if there are significant differences in compliance with PES contracts depending on cooperation-related variables.

Two recommendations to the implementing agency were given: first, that there should be *ejido*-level and not only leadership-level communication about the terms of the contract; and second, that the agency should also provide support for community investments in social capital and cooperation practices. The new World Bank-supported project will provide such support to communities.

4.4. *Conditionality*

To provide well defined incentives to conserve and protect forests, the program must have clear negative consequences for noncompliance. In the case of purposeful land use change, demonstrated by actually observing pasture or agricultural fields in previously forested areas, participants will not receive any payment at the end of the year, no matter how small the change. If deforestation occurs for other reasons, for example because of accidental forest fires or timber theft, participants do not get paid for the lost area, but do get paid for the remaining forest area.

The problem of leakage, or slippage, (Wu et al., 2001), was also carefully considered in design discussions. As payments would only be made for those portions of forests enrolled in the program it would be possible for owners to reduce deforestation there, but increase it elsewhere. Requiring forest owners to enroll their entire area was considered impractical given the very large size of several *ejidos* and *comunidades* (> 20,000 ha). Ultimately, it was decided not to introduce a specific instrument to prevent slippage but to monitor closely for any signs of significant slippage. It was also expected that additional monitoring might work as a deterrent to change land use elsewhere.

Another potential slippage problem could occur outside participating properties, through prices increases for agricultural or animal products whose supply is constrained by diversion of land to the PSAH (Wu et al., 2001). Even in the worst case of failing to reduce overall deforestation, however, simply displacing it to less hydrologically important areas would still result in social welfare gains. INE is currently comparing areas with and without PSAH payments using satellite images to test for intra-property and regional market slippage.

Another key design question concerned how long the program should pay for services. A one year limit was deemed too short, as land use decisions could be postponed with little cost to the landowner, so a horizon of 5 years was chosen. This compromise aims to send medium term signals while still allowing a sizeable amount of forests to be enrolled annually. Although participants are not prohibited from re-applying to the program, the operating rules set a maximum limit of 5 years to receive the payments for each participant. Public statements by CONAFOR officials are that they expect local authorities to take over those participants in the federal program that finish their 5 year period, and some State governments have declared that they will do so, but with one more year left on the first contracts there is still no evidence of how strong or encompassing this response will be.

If neither the federal nor local governments continue making payments, some plots would likely be deforested after their participation in the program ends. Society would thus have gained just 5 additional years of environmental services-precisely what was paid for. However, this is not the only possible outcome, even for high opportunity cost plots. In some cases, buying time may also buy opportunity. As forestry training and community organization efforts continue, and as credit for community firms' development expands, some of the PSAH ex-participants will be better able to undertake sustainable forestry activities in 5 years. Bray et al. (2005) suggest that the development of forest community firms in Mexico will increase rapidly over the next decade.

The fixed costs of setting up the PSAH were absorbed by CONAFOR, while the annual costs of implementation, monitoring and enforcing the program, which by law are required to be no more than 4% of the total budget, are paid from the funds coming from the earmarked water fees.

5. Results for 2003–2005

Since its launch, the PSAH has attracted considerable attention from *ejidos*, *comunidades*, and private owners. More than 900 applications were received in 2003, offering close to 600,000 ha. Budget constraints allowed less than a third of these applications, covering 127,000 ha, to be accepted, for 5 years (see Table 1). In 2004, Congress increased the PSAH's budget by 50% (to about US$26 million), and the number of applicants went up to nearly a thousand, so an additional 180,000 ha were enrolled that year for the next 5 year cycle. With another US$26 million allocation, an additional 169,000 ha were incorporated into the program in 2005; slightly less than the previous year because promotion of the program was less intense and there was less guidance in correctly filing applications. Data for 2006 are preliminary. In Table 1 the breakdown by type of property shows that most contracts are with common property owners, *ejidos* and *comunidades*. In terms of surface paid this prevalence of communal forest is even more important because the average common forest is three times larger than the average private forest plot.

The actual selection of applicants was done in an *ad hoc* manner until 2006. In the first year, without an eligible area definition, applications were ranked according to the percentage of its proposed area covered by forests. In 2004, with more limited eligible areas but with applications again exceeding the budget, an informal and simple grading system was implemented. In 2005 there was unexpectedly low turnout, so no selection process was necessary.

Analysis of program participants reveals that these procedures created several departures from what would have been optimal targeting (See discussion in Alix-García et al., 2005). The rest of the section summarizes the findings in terms of the two main PSAH objectives: targeting areas with significant water problems and high risk of deforestation, and in terms of equity of access: the extent to which payments reached the poor. These results were presented during the internal discussion of the PSAH performance in 2005, where INE recommended the establishment of a formal grading system based on the PSAH Program's policy goals. CONAFOR accepted this recommendation and a grading system was incorporated into the program's operating rules starting in 2006.

Table 1 – Number and type of participating forest owners PSAH 2003–2006

	2003	2004	2005	2006 [a]
Total area contracted ('000 ha)	126.8	184.2	169.1	118.0
Number of contracts	270	352	257	n.d.
Contracts with collective owners (%)	52	71	66	n.d.

Source: Instituto Nacional de Ecología, using data from CONAFOR.
[a] Preliminary data.

5.1. *Avoiding deforestation*

One of the concerns that emerged during the design of the PSAH was the lack of filters for zero-opportunity-cost plots. CONAFOR had no tool to distinguish between such forests and those with positive opportunity costs. In response, INE began to develop a map of deforestation risk based on an econometric analysis of deforestation patterns in the period 1994–2000, the best available information at the time, which could be used to classify applications. The risk of deforestation is a proxy for opportunity cost; the lower the opportunity cost, the lower the risk.

The spatial analysis (see Muñoz-Piña et al., 2004) uses qualitative dependent variable data on deforestation, observing whether a particular forested pixel in 1994 appears in the satellite images of 2000 as preserved, degraded, or deforested. It is an ongoing work, but the diverse specifications used until now find fairly robust relationships between deforestation and the structural variables linked to economic incentives (see Table 2). For example, the probability of deforestation of a particular pixel increases with its proximity to a village or town, measured in minutes of travel, due to the reduction in access costs by workers and costs to transport goods to the local food markets. Deforestation also increases with the proximity to a city, where distance is acting as a cross-section proxy for changes in net prices for the various products that compete with forests for land use. In countries like Mexico, these transport costs create a significant difference between farm-gate prices and average market prices.

Other variables capture the potential rents of forested land as such and in alternative activities. As a proxy for potential agricultural yield in the area we used the average corn yield in the local "basic geo-statistical area" (*área geo-estadistica de base*, AGEB), the smallest unit for which the National Statistics Institute collects data, only a few square kilometers each. The type of forest originally present (5 major types) is included to examine the ecosystem's capacity to produce valuable timber and non-timber products or to provide good pasture or crop yields. It is not surprising that conifer forests, with a large market for pine timber, have a lower probability of deforestation than tropical rainforests which have few commercial species per hectare and high pasture yields (at least in the short run).

The econometric analysis finds evidence that, *ceteris paribus*, poverty and lack of public infrastructure in the population centers closest to a forest increases the probability of deforestation. A dummy variable for location inside a federal Natural Protected Area has a negative estimated coefficient, suggesting that the combined effect of the set of property rights, regulation, enforcement and incentives that this status brings is indeed succeeding in its conservation objective.

Using the predictions generated by the probit specification in Table 2, all forest areas were classified according to their risk of deforestation and sorted them into quintiles. These are presented in Table 3 and compared with the distribution of CONAFOR's PSAH-eligible areas and with the plots actually enrolled in the first three years of the program's operation. One can observe that the largest share of the forests enrolled has low or very low risk of

Table 2 – Econometric analysis of deforestation in Mexico 1993/1994–2000

Explanatory variables	Coefficient (marginal effects)	(P>z values)
Slope (%)	– 0.00111	(0.003)
Average maize yields in census tract (tons × ha)	0.03256	(0.009)
Distance to nearest population center (min)	– 0.00101	(0.000)
Square of distance to nearest population center	0.0000005	(0.011)
Distance to nearest urban center (min)	– 0.00027	(0.027)
Square of distance to nearest urban center	0.0000003	(0.006)
Inside a Natural Protected Area (ANP)[a]	– 0.11103	(0.007)
CONAPO Marginality index for nearest location 1995	0.01838	(0.018)
Coniferous forests	(base category)	
Pine–Oak forest and cloud forest[a]	0.33805	(0.000)
Oak forest and dry temperate forest[a]	0.41787	(0.000)
Tropical rainforest[a]	0.32325	(0.000)
Tropical dry forest[a]	0.25281	(0.000)

Notes:
Probit specification on primary (not degraded) forests, $n=16{,}357$ observations.
Dependent variables: 1 = forest pixel was deforested; 0 = forest pixel was not deforested.
All estimations correct for the clustering effect of more than one pixel falling in the same property, a problem only emerging in the largest *ejidos* or *comunidades*.
Source: Muñoz-Piña et al., 2004.
[a] For these variables, dy/dx is for a discrete change of dummy variable from 0 to 1.

deforestation. In 2003, only 11% of participating forests come from high or very high risk of deforestation areas. This share improved to 28% in 2004, but fell again to 20% in 2005. The deforestation risk distribution of rejected applications has not yet been calculated, but if it was similar to that of accepted properties a selection process that privileged those at highest risk would have yielded a better set of participants according to the conduct modification criterion.

The program has reported no deforestation in participating areas. The claim of 100% compliance is difficult to believe in the Mexican context, especially when the seriousness of the cancellation of payments has not yet been experienced by any forest owner. INE researchers believe that the current low-resolution monitoring method is responsible for the over-enthusiastic results. High resolution methods are currently being tested, and preliminary results point to a program that does not completely stop deforestation but does indeed reduce it. The strong consequences of intentional deforestation in plots under the PES contract, which imply stopping that year's payment and canceling future payments will test CONAFOR's resolve to make this instrument truly an incentive and not just a transfer. Finally, the program's real effect has to be measured with a counterfactual: What would the observed deforestation have been in enrolled areas if the program had not existed? These tests are currently being carried out by INE, comparing plots with and without the PSAH payments with the same predicted risk of deforestation.

In terms of policy implementation, the pilot use of the risk of deforestation index was not accepted by CONAFOR until the 2005 selection. Even then, it was not used because there were an unusually small number of complete applications, less than the total that could be paid. In 2006 the use of this index was formally introduced in the rules of operation as part of the point based system crafted to select the best plots, a system that also included the other hydrological and social importance criteria. However, the technical team doing the selection made an error that year and took the maximum value of the index for all pixels in the proposed polygon, instead of its average, so that nearly all applications got either the highest or second highest value, rendering the scores practically useless to identify which applications were most valuable in terms of avoided deforestation. The result is that, while marginality and aquifer depletion criteria were satisfied to a much greater degree in the 2006 selection, thanks to the point-based system, targeting according to risk of deforestation criteria saw no such improvement (see Table 3). This has been corrected for the 2007 selection and we will be observing if it does work to target payments where they are most useful in modifying owner behavior.

5.2. *Targeting areas of water scarcity*

The degree of overexploitation of the aquifers whose recharge area is being protected provides indicators of the effectiveness of targeting areas of water scarcity. Table 3 shows that between 10% and 25% of PSAH resources have gone to areas with overexploited aquifers, and less than 7% to the most overexploited among them. This targeting is likely to improve in the following years by the introduction of a weight for the degree of water scarcity into the application grading system. Nevertheless, many issues remain. The degree of aquifer overexploitation needs to be complemented with indicators for surface water scarcity, for example. Other questions concern the correct watershed scale to use. Should it be the micro-watersheds of a few thousand hectares, or the large scale interconnected watersheds that comprise several states? These questions still require analysis and decisions.

Thanks to the combined effect of a higher price per hectare and CONAFOR highlighting their importance, cloud forests had a larger than proportional representation among participants. While this ecosystem represents just 3.4% of all forests in Mexico and 6.6% of CONAFOR's eligible areas, they account for 10% to 15% of the total area accepted each year into the PSAH.

5.3. *Reaching the poor*

Although poverty alleviation is not a primary policy objective for the PSAH Program, in the three years of program's operation 78% of payments went to forests owned by people living in population centers with high or very high marginalization (Table 3). A survey carried out by INE in 2004 showed that 31% of PSAH recipients have incomes below the extreme poverty line, while COLPOS (2004) finds that 86% of households in participating communities earn less than US$7.75 a day. This is not an unexpected result, as 85% of population centers within *ejidos* and *comunidades* in forests are classified as highly or very highly marginalized. However, there appears to be a bias against the poorest of the poor: the *very* highly marginalized are under-represented relative to the highly marginalized. It is not clear whether this is due to a correlation with other targeting criteria, or to a barrier to participation linked to poverty — for example low education levels or fewer opportunities to interact with local CONAFOR officials. If such barriers do exist, then the PSAH should be complemented with an outreach and support campaign to ensure that the poorest communities can participate on equal terms. The recently-approved project to support the PSAH includes such measures.

6. Conclusions and next steps

Mexico launched its program to pay for forest environmental services by earmarking a portion of federal water fees. Approval of this policy by Congress is an example of the political commitment that can be generated when there is a widespread perception among the public and key stakeholders that the forest-water environmental relationship is important, even when scientific knowledge is generated with a lag or raises questions about the exact relationship. In Mexico, the PSAH occupies a special niche among a landscape of programs. It seeks to complement the more richly endowed reforestation, plantation, and forestry development programs by addressing well preserved forests that are at risk of deforestation but that lack the countering force of profitable timber or non-timber forestry activities. Not surprisingly, it is at odds with agricultural policies that give incentives to expand the area under cultivation and pastures, as would any other environmental policies.

Table 3 – Characteristics of PSAH eligible areas and participating plots 2003–2006 (% of area, unless otherwise stated)

	All forests in Mexico[a]	Eligible areas[b]	PSAH 2003[d]	PSAH 2004[d]	PSAH 2005[d]	PSAH 2006[c]
Total area ('000 ha)	60,788	3424	126.8	184.2	169.1	118.0
Risk of deforestation[e] *(% surface, by quintiles)*						
Very high	20	12	4	11	7	6
High	20	6	7	17	13	10
Medium	20	18	17	20	21	16
Low	20	25	30	30	27	25
Very low	20	39	42	22	33	43
Total	100	100	100	100	100	100
Degree of aquifer overexploitation[f]						
Extremely over-exploited (+ 50% to + 800%)	0.1	7	0	0	7	13
Over-exploited (+ 5% to + 50%)	19	18	13	10	18	35
Equilibrium or margin for expansion (<+ 5%)	68	73	79	85	73	51
No information	13	2	8	5	2	2
Total	100	100	100	100	100	100
Cloud forests	3	7	7	16	4	4
Marginality index in nearest location(s)[g]						
Very high	69	35	25	22	26	36
High	17	43	47	61	53	47
Medium	9	6	18	8	14	12
Low or very low	5	15	10	9	8	5
Total	100	100	100	100	100	100

Notes:
[a] National Forest Inventory 2000.
[b] CONAFOR.
[c] Preliminary.
[d] INE using data from CONAFOR.
[e] INE, based on Muñoz-Piña et al. (2004) and ongoing work.
[f] Comisión Nacional del Agua, 2003.
[g] CONAPO-PROGRESA, 1998. The 1995 marginality index is a composite of 8 variables reflecting household poverty, literacy, education, quality of dwelling and access to public services in a particular population center. Each hectare of forest was assigned the average value of all population centers inside the corresponding *Ejido* or *Comunidad* area and within a 2 km buffer around it. For private property forests the value allocated was that of the single nearest population center.

The design process of the PSAH program considered several options, and some lessons can be derived from the choices made. The public good nature of water services made the Mexican government opt for a system in which it would act as intermediary between service providers and users, instead of creating a framework for private transactions between them. The lesson so far is that indeed the PES schemes are launched more easily and faster this way, but the point of showing they have value to individual water companies and individual users cannot be made aside at the risk of losing support for the measure. Once enough information about the environmental relationship is out there then water companies should be tried for their true willingness to pay.

Having a nation-wide program, instead of a series of local ones, was preferred because financing was obtained by earmarking a federal water fee. It has the benefit of attending large scale watersheds or aquifers effects but at the cost of having a program not perfectly tailored to local needs and conditions, and not linking directly contributions by users and payments to the forest owners that provide most of their environmental services. This will be improved: a second stage of the PES policy, currently being implemented, seeks to provide information, expertise, and start-up funds to local governments so they can deliver benefits to their own water users through similar water fees. The local example of a PES program in Coatepec (state of Veracruz), shows that entrepreneurial mayors can sell these types of initiatives to their voters when water scarcity problems are severe enough to be on the public agenda.

The PSAH is not a market. The Mexican government is acting as a monopsonistic buyer on behalf of water users. It establishes a price and waits to be offered forests to set aside for conservation. An auction could have found the price at which no excess demand for participation remained, but was deemed too complex for the country. So a two-tiered pricing structure was created, based initially on opportunity cost studies that estimated the amount per hectare that would have maximized the area protected for a given budget. These prices were later raised through the political process, resulting in substantial excess demand for participation. With current payment per hectare being difficult to reduce because of political restrictions, an *ad-hoc* allocation mechanism that created several targeting failures. Evidence of these failures resulted in a reform that introduced an application grading mechanism that will operate from 2006 onwards, and is expected to deliver more value to water users for the same budget.

The self-selection mechanism used by PSAH reveals information about the forest owners' willingness to accept restrictions on their land use decisions. Analyzing these patterns of participation, which interact the allocation mechanisms used by CONAFOR over the three years of operation, we can conclude that: Programs that lack a way to identify and filter out plots with zero opportunity cost will spend a large share of their budget paying to protect forests that were not going to be deforested anyway, as Mexico did until 2005. This reallocates environmental service rents to forest owners, but does not maximize welfare gains to water users.

A program that pays for environmental services by only asking for conservation can reach a large share of poor forest owners (Guevara, 2002). However, there is some evidence that the poorest of the poor are not participating as much as the rest, and more research is needed to find out whether this is due to the inability of the poorest communities to cover some transaction costs (Landell-Mills and Porras, 2002) or because of exclusion from the political networks linked to the forestry agency.

To solve these targeting problems, the Mexican government introduced a series of weights for water scarcity, deforestation risk, and poverty in the application grading system. Broad, nation-wide indicators were available for most objectives; the only tool that needed to be specifically generated was an indicator of the risk of deforestation. For countries that lack similar data, rapid assessment and estimations based on existing literature could provide the necessary indicators.

An alternative to the two tiered pricing worth exploring is to use the predicted risk of deforestation to differentiate prices.[1] While CONAFOR considers the deforestation risk indicator good enough to grade applications, however, it does not feel it is robust enough, in political and technical terms, to use as a basis for price differentiation. Another avenue for price differentiation might come from the evolution of the program over time. As time passes the number of applications is likely to drop because only higher opportunity costs areas will remain. To maintain program levels, the amount paid will have to increase. The program may thus actually function as a reverse-auction applied through time.

One of the options considered during the PSAH's design stage was to use funding from the LFD as a matching fund for payments by local users. This option was discarded because there were no immediate prospects to generate local funding at the level needed. The idea was reintroduced in 2005, but not as a prerequisite, which had effectively blocked the idea before. Instead, the existence of a local payment for environmental services was made part of the applications grading system. It is hoped that this will provide incentives for the development of local payment mechanisms. A multitude of local systems would generate a *de facto* price differentiated system, even if each mechanism has fixed prices, thus increasing the economic efficiency of the overall PES policy.

Over the past few years we have been witnessing an exciting emergence of PES systems in different countries, all of them experimenting with different rules and sets of incentives. The Mexican PSAH is among the largest in scale and scope, and it is providing important lessons for the collective learning that is taking place, especially for cases where forest ownership and poverty are highly correlated. PES programs are not a panacea for deforestation or for water or biodiversity problems, but they certainly are a valuable addition to the set of policies available to solve them. They have the potential of correcting market failures in a straightforward way, defining some property rights over the environmental services in favor of the owners of the forests, characteristics that can improve equity while producing a more efficient allocation of resources.

[1] This was suggested by one of this paper's anonymous reviewers.

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