PES Learning Paper 2017-1

Assessing the Permanence of Land Use Change Induced by Payments for Environmental Services: Evidence from Nicaragua

Stefano Pagiola, Jordi Honey-Rosés, and Jaume Freire-González

May 2017

Environment and Natural Resources
World Bank
Washington DC, USA

Abstract

There have been few efforts to evaluate whether the positive land use changes induced by conservation interventions such as Payments for Environmental Services (PES) persist once the interventions end. Since gains achieved by conservation interventions may be lost upon termination of the program, even apparently successful interventions may not result in long-term conservation benefits, a problem known as that of permanence. This paper examines the permanence of land use changes induced by a short-term PES program implemented between 2003 and 2008 in Matiguás-Río Blanco, Nicaragua. This PES program had been found to have a positive and highly significant impact on land use, and particularly on the adoption of silvopastoral practices. To assess the long-term permanence of these changes, participants were re-surveyed in 2012, four years after the last payment was made. We find that the land use changes that had been induced by PES were broadly sustained in intervening years, with minor differences across specific practices and sub-groups of participants. The patterns of change in the period after the PES program was completed help us understand the reasons for the program's success, and rule out alternative explanations for the program's success. Our results suggest that, at least in the case of productive land uses such as silvopastoral practices, PES programs can be effective at encouraging land owners to adopt environmentally beneficial land use practices and that the benefits will persist after payments cease.

Authors

Stefano Pagiola is Senior Environmental Economist in the Environment and Natural Resources Global Practice, World Bank; Jordi Honey-Rosés is Assistant Professor at the School of Community and Regional Planning, University of British Columbia; and Jaume Freire-González is Researcher at Harvard University.

Keywords

Payments for Environmental Services (PES), impact evaluation, permanence, livestock, silvopastoral, Nicaragua

Acknowledgements

An earlier version of this paper was presented at the Special Session on Evidence-Based Ecosystem Management at the 4th Annual Summer Conference of the Association of Environmental and Resource Economists (AERE) in San Diego, June 3-5, 2015. The survey of long-term effects and the data analysis were partially funded by a grant from the Bank-Netherlands Partnership Program (BNPP).

Cover photo

A pasture planted with high tree density in Matiguás-Río Blanco, Nicaragua, adjacent to a traditional tree-less pasture (Stefano Pagiola).

PES Learning Papers

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1. Introduction

In the last two decades, payments for environmental services (PES) have become a mainstream environmental policy. A recent global review identified 55 PES programs across nearly every continent (Ezzine-de-Blas and others, 2016). Initially used primarily as a tool to conserve existing forest, PES has also started to be used to reforest or to restore degraded ecosystems. Unlike conservation-oriented PES programs, which usually offer long-term payments to participants, restoration-oriented PES programs usually only offer short-term payments. Whether the land use changes induced by such programs persist after payments end thus becomes a critical issue.

This paper contributes to the growing literature on the impact of PES by examining the permanence of land use changes induced by a short-term PES program. The PES program implemented by the *Regional Integrated Ecosystem Management Project* (hereafter the 'Silvopastoral Project') at several sites in Latin America between 2003 and 2008 had been found to have a positive and highly significant impact on land use, and particularly on the adoption of silvopastoral practices (Pagiola and Rios, 2013). To assess the long-term permanence of these changes, participants at two sites—Quindío, Colombia, and Matiguás-Río Blanco, Nicaragua—were re-surveyed in 2011-12, four years after the last payment was made. This is the first effort to examine the long-term permanence of land use changes induced by PES. In this paper, we examine the results from the Matiguás-Río Blanco site.[1]

We begin by reviewing the use of PES to induce land use change (section 2), and discussing alternative hypotheses of what might happen once payments end (section 3). We then present the PES program implemented by the Silvopastoral Project (section 4); the Matiguás-Río Blanco study site (section 5); the treatment groups (section 6); and data collection methods (section 7). We then review the land use changes that occurred during the period of implementation (section 8). We then examine land use changes in the four years following the end of the PES program (section 9), and discuss the implication of these changes for the various hypotheses of post-PES behavior (section 10).

We find that the land use changes that had been induced by PES were broadly sustained in intervening years, with minor differences across specific practices and sub-groups of participants. The patterns of change in the period after the PES

[1] The results for the Quindío site in Colombia are analyzed in Pagiola and others (2016).

program was completed also help better understand the reasons for the program's success, helping to rule out alternative explanations for the program's success. These results suggest that, at least in the case of productive land uses such as silvopastoral practices, PES programs can be effective at encouraging land use changes that persist after payments cease.

2. Using PES to induce land use change

PES programs make payments that are conditional on managing natural resources in ways that generate benefits for others (Wunder, 2005, 2015; Pagiola and Platais, 2007; Engel and others, 2008). The assumption in PES programs is that environmentally beneficial practices are under-adopted because some (perhaps most) of their benefits are externalities from the landholders' perspective. PES programs seek to remedy this problem by providing payments that increase the returns that landholders receive from environmentally beneficial land use practices.

PES has been used primarily to encourage forest conservation—that is, to avoid the conversion of forested lands to other, environmentally harmful practices (Alix-García and Wolff, 2014). Mexico's *Pagos por Servicios Ambientales del Bosque* (PSAB) program and Ecuador's *Socio Bosque* program focus exclusively on forest conservation, for example, while 90% of the area enrolled in Costa Rica's *Programa de Pagos por Servicios Ambientales* (PPSA) program is under conservation contracts (Muñoz and others, 2008; de Koning and others, 2011; Pagiola, 2008). In Brazil, São Paulo's *Mina d'Água* pilot PES program only offered conservation payments (Carrascosa von Glehn and others, 2013), as did Espírito Santo's *ProdutorES de Água* program (Silva and others, 2013) and Amazonas' *Bolsa Floresta* (Viana and others, 2013). Conservation is also an important element in many watershed PES programs.

Some PES programs, however, also attempt to induce positive land use changes. The largest such program is China's *Sloping Land Conversion Program* (SLCP, also known as 'Grain for Green') (Xu and others, 2004; Bennett, 2008). In Latin America, Costa Rica's PPSA program has supported reforestation from the beginning, albeit only on a small area (Pagiola, 2008). Espírito Santo's new *Reflorestar* program, which replaced the earlier *ProdutorES de Água* program, offers both restoration and conservation payments (Pagiola and others, 2017), while São Paulo's proposed *Crédito Ambiental Paulista—Mata Ciliares* (CAP-MC) program focuses exclusively on restoration. Many local PES programs also offer restoration payments, some exclusively so, such as the *Equitable Payments for Watershed* (EPWS) Program in Lake Naivasha, Kenya (Ndetei and Muigai, 2012). Most programs that sell carbon emission reduction credits from forestry activities also focus on reforestation—exclusively so, in the case of programs that sought to sell to the Clean Development Mechanism (CDM). Wunder (2005) calls PES programs that seek to induce positive land use changes 'asset-building', in contrast to the 'use-restricting' conservation-focused programs. Asset-building PES programs often focus on productive land use practices that also generate environmental benefits, rather than on pure conservation practices.

Relatively few rigorous impact evaluations of PES programs have been conducted to date (Ferraro and Pattanayak, 2006; Miteva and others, 2012), although preliminary impact evaluations show some success (Börner and others, 2016). The few impact evaluations conducted to date have mostly focused on assessing the impact of use-restricting PES programs such as Costa Rica's PPSA program (Sills and others, 2008; Arriagada and others, 2012; Robalino and Pfaff, 2013) and Mexico's PSAB program (Muñoz-Piña, 2011; Alix-Garcia and others, 2012, 2014). For example, an initial study of Costa Rica's PPSA program showed that deforestation rates in the country dropped in the same period as the program began making payments, however it was difficult to attribute reduced forest loss to the PES program since other national forest policies might also explain the reduced deforestation rates (Sánchez-Azofeifa and others, 2007). An updated assessment of the same program found similar modest results (Robalino and Pfaff, 2013). Similarly, a national evaluation of Mexico's PSAB program suggests that it led to decreased deforestation among enrolled particles by 1.2 percent (Alix-García and others, 2012). At a smaller scale, Honey-Rosés and (2011) evaluated a PES program aimed at conserving Mexico's Monarch Butterfly Reserve. In the first randomized-control trial of a PES program, Jayachandran and others (2016) find that a PES program in Uganda reduced deforestation from 7-10 percent in control villages to 2-5 percent in treatment villages.

The only impact evaluation of an asset-building PES program conducted to date focused on one of the Silvopastoral Project's sites, in Colombia's Quindío region (Pagiola and Rios, 2013); this was also the only impact evaluation to have a control group selected at program start until the work of Jayachandran and others (2016), a decade later.

3. Permanence of PES-induced land use changes

PES programs that focus on conservation generally provide long-term payments: although contracts are typically for five-year periods, they are usually renewable indefinitely. The working hypothesis in these programs is that the returns to landholders of conservation are lower than those of alternatives—if this were not case, there would be no pressure to change land use. Accordingly, perpetual payments are necessary to induce landholders to retain such land uses. The assumption is that conservation would cease once payments cease.[2]

In contrast, asset-building PES programs usually only make payments for a finite time. The working hypothesis of these programs is generally that returns to landholders from environmentally beneficial land uses can exceed those of current land uses once obstacles to their adoption have been overcome.[3] In such cases, a

[2] Indeed, if landholders were to continue to conserve forests even after they cease receiving payments, it would strongly suggest that their participation was not additional (Pagiola and others, 2016).

[3] Costa Rica's reforestation contract, for example, makes payments for 5 years (with half of the payment in the first year) for the establishment of timber plantations, with the objective of

short-term PES program can 'tip the balance' between environmentally harmful and beneficial land uses. This was the hypothesis of the PES program examined here. Based on this hypothesis, the expectation is that the land use changes induced by the program would be retained even after payments end—that these land use changes would be *permanent*.

There is reason for concern over this expectation. Many soil conservation and reforestation programs, as well as many agricultural technology adoption programs, were based on the same hypothesis that the new practices would be profitable for landholders once adopted and so would retained once the incentives offered by these programs ended (Lutz and others, 1994). This has often not been the case. Experience has shown that many such projects have achieved limited participation, or that participation has been followed by abandonment of the new practices once the project ended (Bunch, 2004). Possible lack of permanence has been a major concern for the sale of carbon credits (Dutschke and Angelsen, 2008; Kim and others, 2008).

PES programs differ from traditional approaches to induce land use change in several ways. Whereas traditional approaches have generally relied on up-front subsidies, PES relies on conditional payments, made after verification of compliance. In traditional approaches, the support offered to participants can take a wide variety of forms (the most common being cash, in-kind support, subsidized credit, or direct implementation of land use change by contractors) but is usually calculated as a share of the cost of adoption. PES programs—which almost always make payments in cash or cash equivalents—usually base their payments at least notionally on the value of the positive externalities.[4]

The conditionality of payments means that landholders would not be able to divert the resources provided by the project to other ends. The risk of non-compliance is thus much lower than in traditional projects. Whenever project support is finite in time, however, the risk of abandonment once payments end remains.

Consider Figure 1, which illustrates the possible configurations of net returns *to landholders* over time from environmentally beneficial practices A, B, and C, all of which are assumed to provide higher levels of environmental services than current practices.[5] The shape of the return profile assumes that there is some cost to switching to the new practices (for example, to plant trees), and that it takes some time for them to generate their full benefits (for example, because trees have to grow, or because soils take time to recover their fertility). What matters, ultimately, is the extent of the initial costs and the magnitude of the long-term net benefits,

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overcoming financing constraints; thereafter participants receive revenue from thinning and the from final harvest, typically after 15-20 years (Pagiola, 2008).

[4] This is not always the case. Many PES programs seek to determine the minimum payment necessary to induce land use change, and so their payments are also based to the cost of implementation.

[5] That is, the figure only shows the on-site, private benefits to landholders of each practice. It does not show the value of the environmental services being generated (nor the external costs of current practices), as these are externalities from the landholders' perspective.

relative to those of the current practice.[6] A short-term PES program modifies these return profiles by reducing the initial costs (as shown by the dotted lines), which shortens the time before their returns exceed those of the current practice and the time before they break even, and increases the net returns to their adoption.

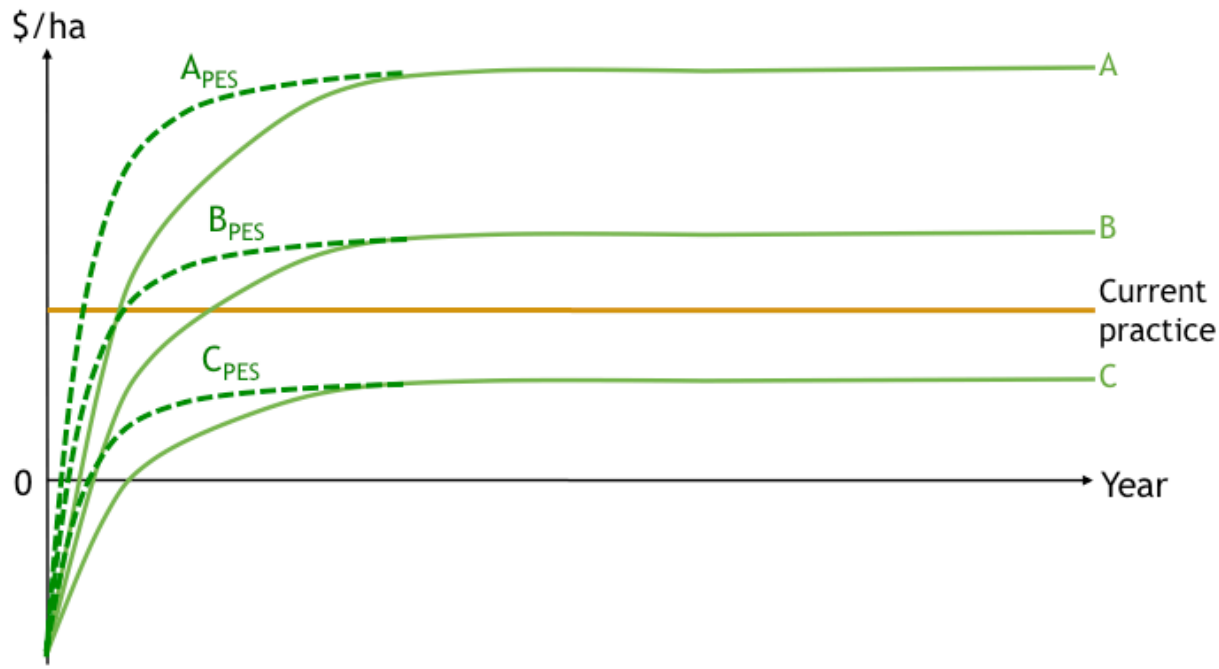

Figure 1: Typology of net return profiles to alternative land use practices

In general, practices whose long-term net benefits to landholders exceed those of current practices (such as practices A and B) are likely to be retained once established (that is, once the bulk of initial costs are sunk). Conversely, practices whose long-term benefits to landholders are lower than those of current practices (such as practice C), if they were ever adopted, are likely to be abandoned once payments end.

In an ideal world, designers of short-term PES programs would offer payments only for adoption of practice B. Practice A has such high returns that landholders are likely to adopt it without any external support, in spite of its initial costs. Support to adoption of practice A would thus reduce the program's additionality. Conversely, practice C has such low returns, even once it is established, that landholders who adopt it would likely abandon it as soon as payments end.[7]

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[6] To avoid having to repeat this qualification throughout the paper, when we speak of the profitability or attractiveness of a given practice, we shall henceforth always mean profitability or attractiveness relative to the current practice.

[7] This also shows one reason why command-and-control mechanisms often work so poorly: because they try to force landholders to adopt practices with return profiles such as C, which are less profitable to landholders than current practices even once established. Landholders have strong incentives to abandon these practices.

The problem facing PES program designers, however, is that except for limit cases, determining which profile the net returns of a given practice follow (A, B, or C) may be difficult. Natural forests in which nothing can be harvested, for example, may be very beneficial from an environmental perspective but would bring few net benefits to landholders—indeed, they may have negative net benefits for landholders.[8] Observing widespread spontaneous adoption might identify very profitable practices. But in many cases, the net returns will not be so clear. It is easy for projects to over-estimate the benefits to landholders of particular practices they seek to promote, or to under-estimate the benefits of current practices. Even if estimates are accurate for a given location, or for average conditions, they may not be accurate for many landholders in a heterogeneous landscape. Differences in local soils, climate conditions, productivity, access to markets, and other factors that affect returns, mean that the specific practices that fall within groups A, B, or C may differ from place to place. Moreover, landholders have strong incentives to mis-represent the likely returns to adopting new practices in the hope of securing higher payments.

If a PES program were to offer long-term support to all practices, it would almost certainly have permanent results. As long as the payments offered were sufficient, landholders would retain practice C. They would, of course, also retain practices A and B—they would have done so even without payments. Such an approach would obviously be inefficient. Conversely, if a PES program were to offer only short-term support to all practices, any landholders who had adopted practice C would abandon it once payments end.

Despite the risk of non-permanence, PES programs that offer only short-term support are attractive for many reasons. First, such programs can be funded by donors. Long-term payments for adoption of a given practice would require long-term financing, which cannot be sustainably provided by donors.[9] Second, short-term PES programs can rely on ad hoc organizational structures that employ highly qualified people for short periods. Long-term programs would require similarly long-lived organizational structures.

Many previous projects have tended to assume that environmentally beneficial practices were either uniformly of type A (and so would be readily adopted with little outside support except for credit and/or Technical Assistance, TA) or uniformly of type B (and so would be sustainably adopted with only short-term outside support).

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[8] The areas of permanent protection (*Areas de Proteção Permanente*, APP) that Brazilian law stipulates must be maintained under forest in riparian corridors are an example of such a practice. By law, forests in APPs cannot be harvested, nor used in any other way. Not only do such forests generate no income, but the cost of maintaining them (fencing etc) means that their net return to landholders is actually negative, even before considering opportunity costs.

[9] The one exception is when donor funds are placed in an endowment fund, and only the interest is used. Such arrangements have often been made to meet the long-term funding requirements of protected areas, for example, and there are also a few examples of trust funds being established to provide long-term financing to PES programs (Honey-Rosés and others, 2009). The limitations of this approach—particularly when interest rates are low—limit its applicability, however.

There was strong resistance to acknowledging that many environmentally beneficial practices may be of type C and thus would require sustained, long-term support, in part perhaps because until the advent of PES there were few tools to provide such support.

The extent to which the risk of non-permanence is likely to be realized will depend in part on the reasons environmentally beneficial land uses were not being adopted prior to the program. There are several possible hypotheses:

- **Environmentally beneficial practices are less profitable to landholders than current practices.** If this is the case, PES-induced practices are likely to be abandoned once payments end. Payments increased the relative attractiveness of environmentally beneficial practices, but this effect ceases when the payments cease.
- **High initial costs make environmentally beneficial practices unattractive, but once established, they are more profitable for landholders than current practices.** Asset-building PES programs are predicated on this hypothesis. If this hypothesis is correct, PES-induced practices will be retained even once payments end.
- **High initial costs make adoption of environmentally beneficial and privately profitable practices difficult because of financing constraints.** Cash-constrained landholders may not be able to finance the required investments or deal with the reduced (perhaps negative) income before the new practices begin generating benefits. In this case, short-term payments would work by providing the necessary financing. If this hypothesis is correct, PES-induced practices will be retained even once payments end.
- **Landholders are unaware of the private benefits of environmentally beneficial practices.** Under this hypothesis, landholders avoid adopting environmentally beneficial practices because they do not know whether they will receive sufficient benefits. In this case, the payments would reduce the risk of adopting new practices. If environmentally beneficial practices do in fact generate sufficient benefits to landholders, they would retain them even once payments end.
- **Landholders do not know how to implement environmentally beneficial practices.** Under this hypothesis, PES would work not through the effect on the profitability of environmentally beneficial practices, but through the TA provided to participants. If this hypothesis is correct, PES-induced land uses will be retained even once payments end.

Of course, these hypotheses are not mutually exclusive.[10]

[10] There are also other possible constraints to adoption of environmentally beneficial practices. Insecure tenure might be an obstacle in many cases, for example (by reducing the expected benefits of the investments due to the risk of being forced off the land). But PES is unlikely to prove sufficient to induce adoption in such cases. Permanence would not be an issue, therefore.

These various hypotheses have implications not only for whether environmentally beneficial practices are maintained once payments end, but also whether they are expanded. This effect is clearest in the case of knowledge constraints. Landholders who have adopted environmentally beneficial practices thanks to payments will clearly no longer be ignorant either of their benefits or of how to implement them. Thus even without payments, they would be expected to continue expanding their area. Conversely, if high initial costs were the primary constraint, expansion of environmentally beneficial practices would cease once payments end. If financing constraints had been the primary obstacles, the effects on continued expansion of environmentally beneficial practices is less clear: without payments, financing would be more limited, but higher returns from previously adopted practices could help fill the gap.

4. The Silvopastoral Project

The Regional Integrated Silvopastoral Ecosystem Management Project piloted the use of short-term PES to induce landholders to adopt silvopastoral practices to replace their traditional cattle production systems.[11] The project was implemented in three areas: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua (Pagiola and others, 2005). In this paper, we focus on the Silvopastoral Project's Matiguás-Río Blanco site. In a separate paper, we examine results at the Quindío site in Colombia (Pagiola and others, 2016).

Silvopastoral practices include (1) planting high densities of trees and shrubs in pastures, thus providing shade and diet supplements while protecting the soil from packing and erosion; (2) cut and carry systems, in which livestock is fed with the foliage of specifically planted trees and shrubs ('fodder banks') in areas previously used for other agricultural practices; and (3) using fast-growing trees and shrubs for fencing and wind screens. These practices provide deeply rooting, perennial vegetation that is persistently growing and has a dense but uneven canopy.

Silvopastoral practices generate high levels of environmental services, particularly in comparison to traditional pastures. They have important biodiversity benefits thanks to their increased complexity relative to traditional pastures, contributing to the survival of wildlife species by providing scarce resources and refuge; increasing the propagation of native forest plants; providing shelter for wild birds; and helping to connect protected areas (Dennis et and others, 1996; Harvey and Haber, 1999). Silvopastoral practices can also fix significant amounts of carbon in the soil and in the standing tree biomass (Fisher and others, 1994; Swallow and others, 2007). Silvopastoral practices can also affect water services, though the specific

[11] The Silvopastoral Project was financed by a USD4.5 million grant from the Global Environment Facility (GEF), with the World Bank as the implementing agency. The project was developed with support of the multi-donor Livestock, Environment and Development Initiative (LEAD), hosted by the Food and Agriculture Organisation (FAO). It was implemented in the field by local non-governmental organizations (NGOs). In Nicaragua, this work was conducted by Nitlapan, an NGO affiliated with the University of Central America.

impacts are likely to be site-specific (Bruijnzeel, 2004; Murgueitio, 2003). The biodiversity, carbon sequestration, and hydrological benefits of silvopastoral practices are off-site, however, so land users will not take them into account when they are deciding which practices to adopt. As a result, these practices will tend to be under-adopted.

The benefits of silvopastoral practices to landholders may include additional production from the tree component, such as fruit, fuelwood, fodder, or timber; maintaining or improving pasture productivity by increasing nutrient recycling; and diversifying production (Dagang and Nair, 2003). These benefits, while considerable, may not be sufficient by themselves to justify adopting silvopastoral practices—particularly practices with substantial tree components, which have high upfront planting costs and only bring benefits several years later. Estimates prepared for the project showed rates of return of between 4 and 14 percent, depending on the country and type of farm (Gobbi, 2002). Other studies found similar results; White and others (2001), for example, found rates of return to adoption of improved pasture in Esparza, Costa Rica, of 9 to 12 percent. These estimates, of course, only consider the on-site benefits of silvopastoral practices.

To encourage adoption of silvopastoral practices, the Silvopastoral Project offered payments proportional to the expected level of services provided. To do so, it developed indices of the biodiversity conservation and carbon sequestration services that different land uses provide, and aggregated them into a single 'environmental services index' (ESI). The project distinguished 28 different land uses, each with its own ESI score, and paid participants according to the change in total ESI score over their entire farm area.[12]

The Silvopastoral Project's central hypothesis is that silvopastoral practices are unattractive to landholders, despite their long-term benefits, primarily because they require substantial initial investments and because of the time lag between investment and returns. By offering a relatively small payment it hoped to 'tip the balance' between current and silvopastoral practices. The project provided a one-time payment of USD10/point for baseline ESI points followed by four annual payments of USD75 per incremental ESI point.

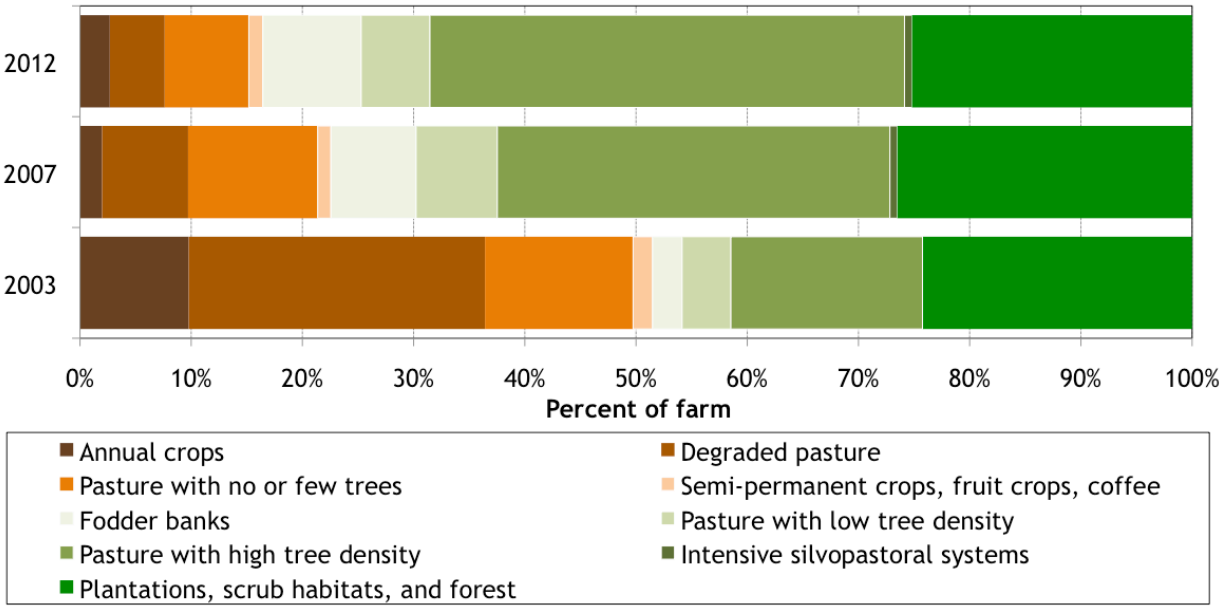
The Silvopastoral Project made its first payments, for baseline ESI points, in July 2003. It then made annual payments for incremental ESI points, after monitoring land use changes, from 2004 to 2007. Since 2007, the former participants have received no systematic support, in terms of either payments or TA.

[12] The ESI is described in detail in CIPAV (2003) and Pagiola and others (2005). Not all practices recognized in the ESI are relevant at Matiguás-Río Blanco.

5. Study site

The Silvopastoral Project piloted the use of PES in three areas: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua (Pagiola and others, 2005). In this paper, we focus on the Matiguás-Río Blanco site.

Matiguás-Río Blanco is located in the department of Matagalpa, about 140km northeast of Managua, on the southern slopes of the Cordillera de Darien. It has an undulating terrain, with an elevation of 300-500m above sea level. Average temperature is about 25C and average annual rainfall 1700-2500mm. Participants are clustered in the Bulbul and Paiwas microwatersheds.



Note: Only includes data from PES recipient households still present at the site in 2012.
Source: 2003 and 2007 based on Silvopastoral Project mapping data, 2012 from 2012 survey.

Figure 2: Land use changes by PES recipients during and after the Silvopastoral Project in Matiguás-Río Blanco, 2003 to 2012

In 2003, prior to the project's start, extensive pastures covered about 40% of the area (Figure 2). Of this, about to two thirds was degraded pasture. Another 10% of the area was devoted to annual crops. Unlike in Quindío, Silvopastoral practices were not unknown, though they were not widely used: pastures with high tree density covered about 17% of the area, and fodder banks 3%. Forest remnants, mostly in riparian areas, covered about 24% of the area.

Households in Matiguás-Río Blanco are composed of six members on average, and have about 31ha of land and about 30 head of livestock. Agriculture is their main economic activity, with few households having off-farm income. The average per capita income of about USD340 was below the poverty line. Few households have water or electricity, and education levels are very low. Although most households occupy public land, long-term occupancy gives them secure tenure.

6. Treatment groups

As a pilot project, the Silvopastoral Project had limited funding, so only 100 households could be accepted in the treatment group in Matiguás-Río Blanco. A series of public workshops were held in the area to explain the project. Households who expressed an interest were then accepted on an essentially first-come basis, provided they met minimal criteria on herd size.

Accepted participants received PES for 4 years, as well as TA on the selection and implementation of appropriate silvopastoral practices. However, some participants were randomly assigned to sub-groups that only received payments for two years and/or that did not receive TA, as shown in Table 1. The two-year PES program represented an initial effort to examine permanence: participants in this sub-group received a higher payment for land use changes, designed to be roughly equivalent to the payment that participants in the 4-year payment program would receive, in present value terms. The idea was to see whether 2-year payment recipients maintained the practices they had adopted once payments ceased, while the project was still in a position to monitor them.

Table 1: Participating households at the Matiguás-Río Blanco study site

	2-year PES	4-year PES	**Total PES**	**Total**
TA	13	39	**52**	**52**
No TA	5	15	**20**	**20**
Total	**18**	**54**	**72**	**72**

Note: Number of households shown is the number found at the time of the 2012 survey.

Because of out-migration from the area, the project lost a number of its initial participants over the years, reducing the number of PES recipients at the time of the re-survey to 72.

In an effort to distinguish project-induced land use changes from changes induced by other factors, the Silvopastoral Project also included control groups.[13] At the Quindío site, in Colombia, a control group was selected from the applicants that had not been accepted.[14] In Matiguás-Río Blanco, however, there were not enough such applicants, as promotional efforts had been focused on two microwatersheds and most farmers in those areas were participating. Control households had to be sought, therefore, in other areas, where applications had not been sought. This caused two problems: there was no way to control for potential fixed effects due to the different areas, as they were correlated with the treatment, and there was no way to control for selection bias. As a result, the Matiguás-Río Blanco control group is highly suspect, and a decision was made not to use it.

[13] To our knowledge, this was the first World Bank natural resource management project ever to include a control group.

[14] Rejected applicants are often used as a source of controls. Alix-Garcia and others (2012), for example, used rejected applicants from Mexico's PES program in their evaluation of that program.

7. Data

We use data from four data sets to examine land use changes in Matiguás-Río Blanco, including two household surveys and two sets of detailed land use maps.

A baseline survey conducted in late 2002, during project preparation, collected detailed information on household characteristics.[15] Second, a new survey of former participants was conducted in 2012. The questionnaire for the survey was based on that of the 2002 baseline survey. It also included questions on the motivations for maintaining, extending, or reducing the use of different land uses in the period since the end of the Project. For the analysis in this paper, we only used data from the 72 households remaining at the time of the 2012 survey.

From 2003 to 2007, detailed land use maps were prepared annually for each PES recipient. Remote sensing imagery (Quickbird imagery with a 61cm resolution) was used to prepare detailed land use maps for each farm, which were then extensively ground-truthed to match each plot to one of the ESI's 28 land uses. These mapping data give accurate and consistent measures of area and ensure that land uses are classified consistently into the project's categories. Finally, at the same time as the 2012 survey, the land use maps for each participant were updated, using the same methodology as was used during the Silvopastoral Project, by some of the same personnel, to ensure consistency with the previous land use maps.

8. Land use change during PES

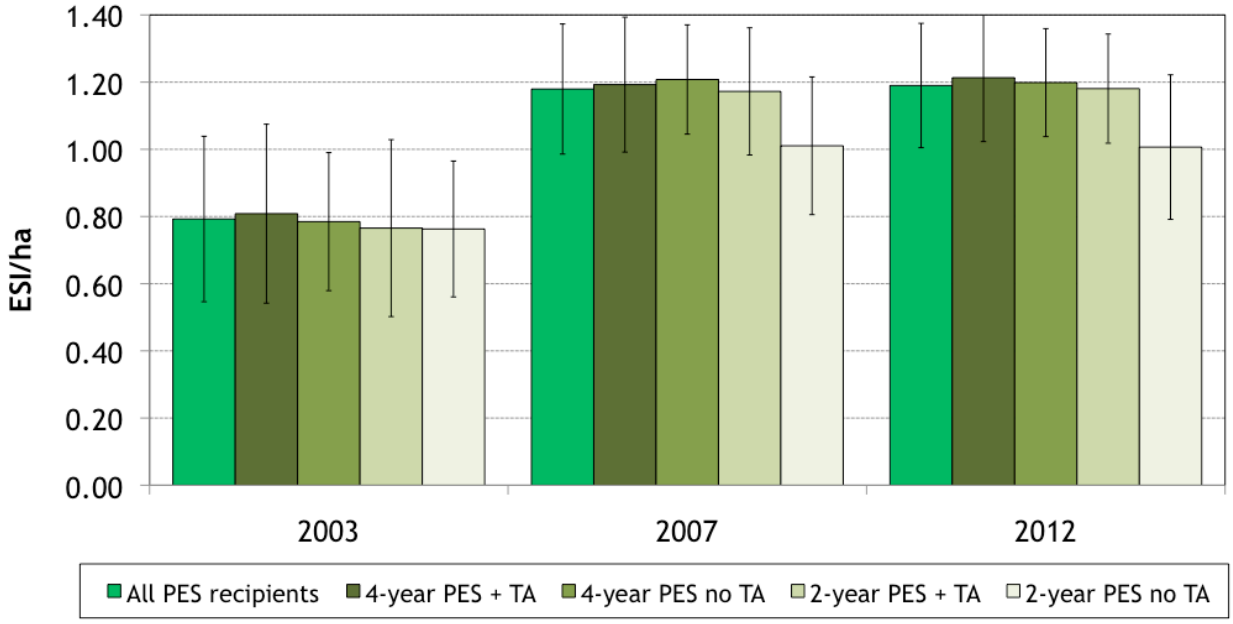
Figure 2 compares land use by PES recipient households in Matiguás-Río Blanco at the project's start (2003) and end (2007), and in 2012. Overall, the PES program induced substantial land use change during its implementation.

There was a precipitous drop in the area of degraded pasture, which fell by two-thirds, from almost 27% of farm area in 2003 to less than 8% in 2007. The area under annual crops also declined substantially (from almost 10% to only 2% of farm area). The area of pasture with no or few trees also contracted, though less markedly (from over 13% to under 12% of farm area). These areas were primarily converted to pasture with high tree density, whose share of farm area doubled from 17% in 2003 to over 35% in 2007. Fodder banks also increased substantially, from under 3% to almost 8% of farm area. There was also a small increase in the area of riparian and secondary forest, which went from 24% of farm area to 26.5%. The extent of live fencing more than tripled, from less than 90km to over 280km. Overall, these changes resulted in a increase of about 50% in environmental service generation, with ESI/ha increasing from 0.8 in 2003 (out of 2.0) to 1.2 in 2007 (Figure 3).

There were no significant differences in the extent of changes undertaken by the different subgroups of participants. As can be seen in Figure 3, all sub-groups had very similar initial land uses, in terms of their environmental service generation (as

[15] The questionnaires for this survey and for the 2012 survey discussed below are available from the authors on request.

measured by ESI/ha). By 2007, all had increased their environmental service generation by similar amounts. The sole exception was the group of 2-year PES recipients without TA. However, this group is so small (5 households) that caution is needed in coming to any conclusions; indeed, their average ESI/ha in 2007 is not significantly different from that of the other sub-groups.



Notes: Bars show standard deviations
Only includes data from PES recipient households still present at the site in 2012.
Source: 2003 and 2007 based on Silvopastoral Project mapping data, 2012 from 2012 survey.

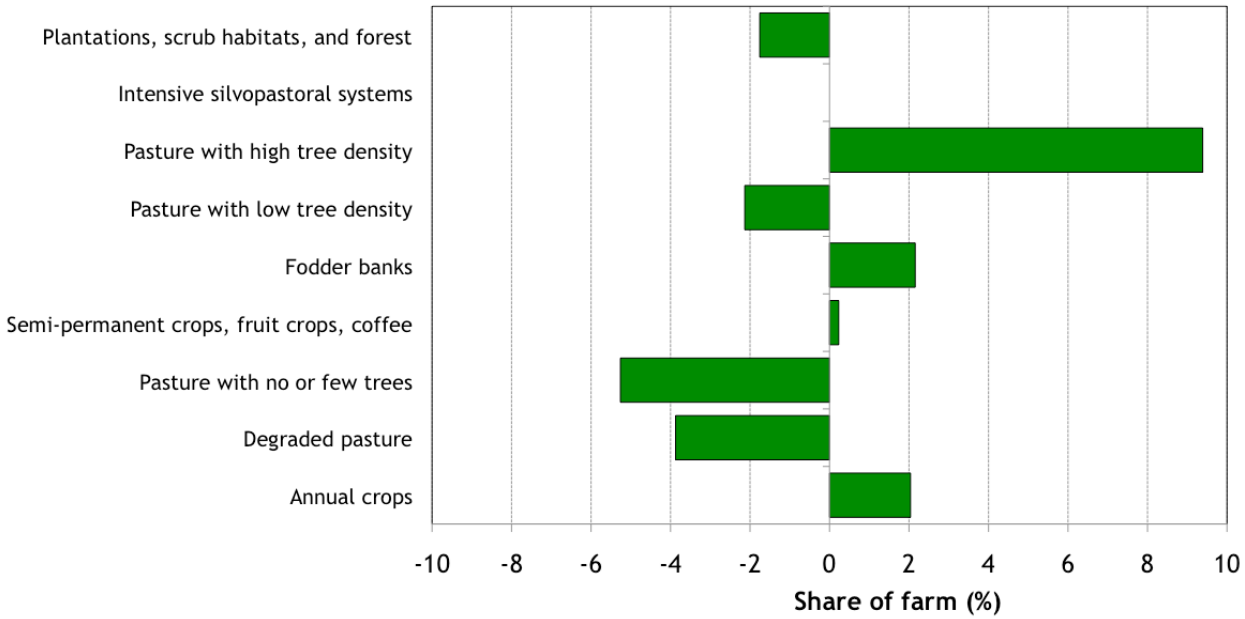
Figure 3: Changes in environmental service generation under the Silvopastoral Project in Matiguás-Río Blanco, 2003 to 2012

In the absence of a suitable control group, additionality cannot be confirmed at Matiguás-Río Blanco, but casual observation suggests that land use changes under the Project were substantially higher than in other areas, where very few land use changes were observed.

9. Permanence of land use changes after the end of PES

When the Silvopastoral Project closed in early 2008, it could look back with satisfaction on having induced some very substantial land use changes. Yet there was considerable concern over whether these changes would persist once payments ended. The sub-group of 2-year recipients was an initial effort to determine whether this concern was well-founded. As we have seen, there were no significant differences in land use changes between 2-year and 4-year PES recipients, at the time of the project's end. This result was promising, but did not entirely allay concerns over permanence, as the continued presence of monitoring teams during the remaining

two years could have inhibited 2-year PES recipients from abandoning the land uses they had adopted.



Note: Only includes data from PES recipient households still present at the site in 2012.
Source: Based on Silvopastoral Project mapping data for 2007 and 2012 survey.

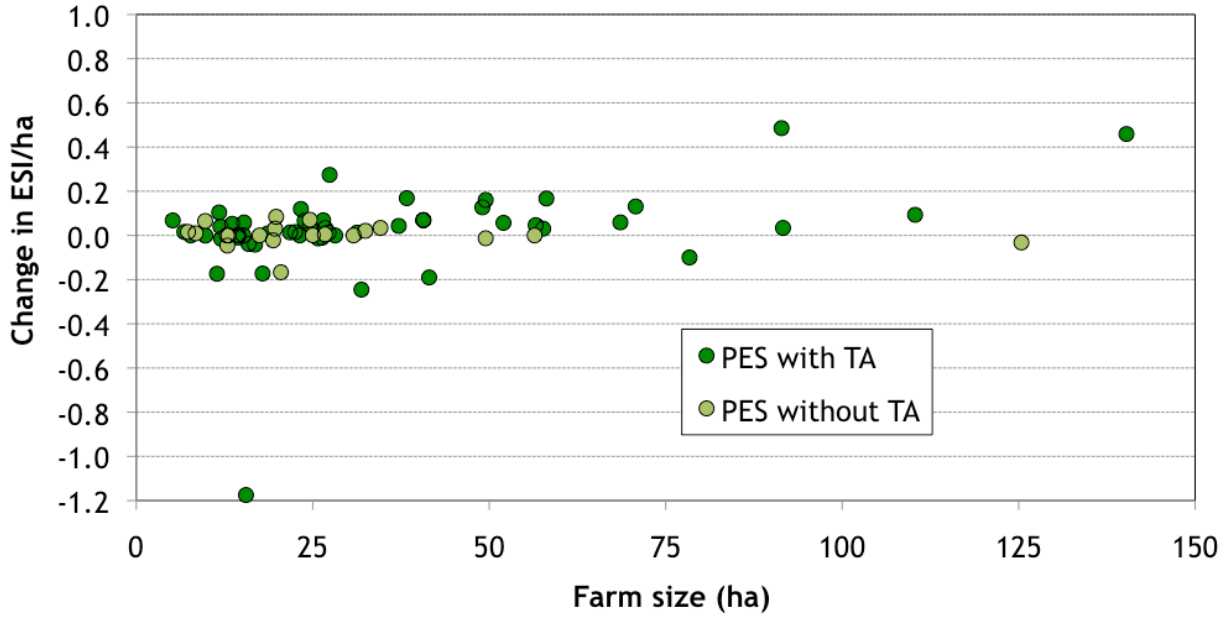
Figure 4: Land use changes after the end of the Silvopastoral Project in Matiguás-Río Blanco, 2007 to 2012

Figure 2 above shows the observed land use four years after the end of PES at Matiguás-Río Blanco. The observed changes are shown in more detail in Figure 4.

Changes after the end of the PES program were modest. The area of pasture with high tree density—the main land use adopted during PES implementation—continued to expand even after payments ended, growing from 35 percent of farm area in 2007 to almost 43 percent in 2012. Most of this increase was due to a continued reduction in the area of degraded pastures and pastures with few or no trees, as well as to densification of some pastures with low tree density. In some cases, however, pastures with high tree density were obtained by clearing *tacotales* (abandoned fields where forest is re-growing)—a higher-ESI land use. The area under fodder banks also increased. On the negative side, there was a small decline in the area under forest. The area of annual crops, which had plummeted during the project, recovered somewhat, but remains well below its pre-project level. No landholder increased the extent of live fences, while a few reduced it (two landholders removed live fences almost entirely). The net changes on ESI/ha resulting from these changes were very small and not statistically significant (Figure 3).

Changes were concentrated among relatively few households (Figure 5). Most landholders made changes that had little or no net impact on their environmental service generation. There were just three exceptions. Two landholders increased their environmental service generation significantly, by converting relatively large

areas (13 ha and 17 ha) of degraded pasture or pasture with few trees to pasture with high tree density. These landholders have large farms (91ha and 140ha) and had already adopted pasture with high tree density on large areas. Conversely, one landholder reduced her environmental service generation significantly, by converting a 5.4ha area of brush to annual crops on her relatively small farm (15.5ha). All three of these landholders had been part of the 4-year PES program, and had received TA.



Source: Based on Silvopastoral Project mapping data for 2007 and 2011/2012 surveys.

Figure 5: Post-PES changes in ESI/ha in Matiguás-Río Blanco, by farm size

9. Discussion

The results of the new survey show that the land use changes induced by PES at Matiguás-Río Blanco were broadly retained, putting to rest concerns that environmentally beneficial practices would be abandoned after payments ceased. However, it is also disappointing to observe that these practices did not significantly expand in the post-payment period. Although there was some land use changes post-PES, they did not result in any appreciable increase in environmental service generation.[16]

That silvopastoral practices have not been abandoned after payments ceased strongly suggests that they are, in fact, more profitable than alternative land uses at

[16] These results are broadly similar to those observed at the project's site in Quindío, Colombia, where land uses were observed to be mostly stable in the post-payment period (Pagiola and others, 2016). There was a 4 percent decline in the area of treeless pastures and small increase in the area of forests. The area of some environmentally beneficial practices fell slightly, but these reductions were very small (less than 1 percent), suggesting that the gains made in the payment period were largely permanent.

the study site *once they are established*. Had that not been the case, it would have been simple for landholders to remove them, and they would have suffered no penalties from doing so. At the same time, these results also supports the hypothesis that financial profitability of silvopastoral practices was the main obstacle to their adoption: that is, that payments 'tipped the balance' towards adoption by reducing the initial costs of adoption and providing some income in the period before silvopastoral practices begin to generate sufficient benefits to be profitable. If the practices had been highly profitable for all landholders even without payments, adoption would probably have continued even without payments.

These results also shed light on the other hypotheses on obstacles to land use change. Simple ignorance of their possible benefits, or of how to implement them, were plausible explanations for lack of adoption prior to the project start, when silvopastoral practices were little used. After four years in which the use of silvopastoral practices expanded dramatically, these explanations are no longer plausible. If ignorance or lack of expertise had been the main obstacles to the adoption of silvopastoral practices, the area under these practices would have continued to expand even in the absence of payments, and particularly so among landholders who received TA. Yet there was very limited expansion, and no significant differences in the extent of such expansion between those who received TA under the project and those that did not. Likewise, if the primary constraint had been the inability to finance the required investments, expansion should have continued even without payments—at least among better-off households, and perhaps even among poorer households, as the higher income generated by previously-adopted silvopastoral practices could have financed additional adoption. Although the few landholders who substantially expanded the area of pasture with high tree density had larger farms suggests that financing constraints might have been an issue, other large farms (which presumably also lacked such constraints) made minimal changes. The other possible explanations for the lack of adoption of silvopastoral practices are, thus, inconsistent with the observed results.

A characteristic of the project that is likely to have contributed to the permanence of its results is that it offered participants a wide menu of possible land use changes. Most reforestation/technology change projects tend to focus on one or a few practices. In a heterogeneous landscape, it is unlikely that any single practice would be the best option for all landholders. The large range of options offered by the Project allowed landholders to pick the combination of practices that best suited their own conditions. As a result, landholders were less likely to find the practices a poor fit once payments ended. Note, however, that not all PES programs offer such a wide range of options.[17] A PES program that offered only a narrow range of options may well prove less successful.

A major reason for the permanence of the land use changes adopted under the Silvopastoral Project is, quite simply, that land uses that required long-term support

[17] The 'agroforestry' contract offered by Costa Rica's PPSA program, for example, is quite restrictive, in that only timber species can be planted.

were simply not adopted by landholders. As shown in section 8, there was very little adoption of essentially conservation-oriented practices such as forests—even though the project offered its highest payments for these changes. This can be easily explained by differences in long-term profitability to landholders of such practices, compared to those that were adopted. Thus here, too, we see relative profitability to landholders as being a major factor.

The observed changes are also disappointing to those who hoped that use of environmentally beneficial practices would change the 'culture' of landholders, predisposing them to greater use of such practices. There were no significant changes in the extent to which environmental services were generated, with positive changes being balanced by negative ones, resulting in little net change. Though the behavior of some individual landholders could be interpreted as being consistent with more environmentally conscious attitudes, there are also counter-examples.

11. Conclusions

This paper describes one of the first efforts to assess the long-term permanence of land use changed induced by a PES program, years after the program ceased to operate. The experience of the Silvopastoral Project in Matiguás-Río Blanco indicates that PES has resulted in additional positive land use changes in terms of both the area affected and the nature of the changes. Our results show that concerns about non-permanence of land use changes were unfounded: practices adopted under the PES program were not abandoned once payments ended.[18]

It is important to note the limitations of our conclusions. First, we recognize that it may be dangerous to generalize from a single result, even though results at the project's site in Quindío, Colombia, were very similar. Second, we emphasize that the conclusion applies to an 'asset-building' PES program, in which payments are targeted primarily at productive activities (which also generate environmental benefits) rather than conservation activities. We do not expect that 'use-restricting' PES programs aimed at conserving existing environmentally beneficial practices could be sustainable without payments. In fact, if the practices supported by such a use-restricting program were maintained after payments cease, it would likely indicate that the program was non-additional. Lastly, even among 'asset-building' programs, the Silvopastoral Project was unusual in offering a very broad menu of options, and this may have played an important role in its success.

In addition to showing that PES-induced land use changes were sustainable, these results are also help us understand why the original project was successful. That environmentally beneficial land uses expanded rapidly when payments were offered but then remained essentially unchanged once payments ended is consistent with the hypothesis that limited profitability was the primary obstacle to their adoption, and

[18] As long-term permanence has seldom been documented, it is difficult to say whether the results of the Silvopastoral Project at our study sites are in fact better than those of other efforts to induce land use change.

inconsistent with several other plausible hypotheses, including that the primary obstacles were lack of knowledge of these practices or of how to implement them, or lack of financing for the required investments. While these rival hypothesis may be correct in other contexts, we did not find supporting evidence for them in our case.

Even with these caveats, the experience of the Silvopastoral Project offers important lessons, which are already guiding new PES programs. In Nicaragua, the *Adaptation of Water Supplies to Climate Change Project* is using a similar mechanism to induce adoption of practices that facilitate infiltration in the watersheds that provide water to rural communities. In Colombia, the *Mainstreaming Sustainable Cattle Ranching Project*, which promotes similar land use changes and uses a similar short-term payment mechanism at five sites across the country, is only offering payments for productive practices, to avoid the risk that landholders adopt practices that they are unlikely to maintain, while seeking to develop long-term payment mechanisms that would allow pure conservation practices to be supported as well (World Bank, 2010). In the Brazilian state of Espírito Santo, the *Reflorestar* PES programs offers two complementary payments: short-term payments (over three years, once only) for ecosystem restoration, and long-term payments (over five years, renewable indefinitely) for ecosystem conservation. Landholders who adopt conservation practices such as forests receive both payments, while those who adopt productive practices such as agroforestry or silvopastoral practices only receive short-term payments (Pagiola and others, 2017).

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