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

Stefano Pagiola[1], Jordi Honey-Rosés[2] and Jaume Freire-González[3]

Abstract
Gains achieved by conservation interventions such as payments for environmental services (PES) may be lost upon termination of the program, a problem known as permanence. However, there have been few efforts to evaluate the permanence of conservation results. This article examines the permanence of land-use changes induced by a short-term PES program implemented between 2003 and 2008 in Matiguás-Río Blanco, Nicaragua. Under this program, PES had induced substantial adoption of silvopastoral practices. To assess the long-term permanence of these changes, participants were resurveyed in 2012, 4 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 subgroups of participants. The patterns of change in the period after the PES program were completed to 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 practices and that the benefits will persist after payments cease.

Keywords
payments for environmental services (PES), impact evaluation, permanence, livestock, silvopastoral, Nicaragua

In the last two decades, payments for environmental services (PES) have become a mainstream environmental policy (Salzman et al., 2018). A recent global review identified 55 PES programs across nearly every continent (Ezzine-De-Blas et al., 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 (Reid et al., 2019). 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 (Pagiola et al., 2007; Wunder, 2007).

This article 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 & Rios, 2013). To assess the long-

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term permanence of these changes, participants were resurveyed in 2011 to 2012, 4 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 article, we examine the results from the Matiguás-Río Blanco site.[1]

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

The PES program had induced substantial land-use changes; we find that these changes were broadly sustained in the intervening years, with minor differences across specific practices and subgroups of participants. A careful look at the patterns of land-use change after the payments ended also sheds light on explanations for the program's success, ruling out several alternative hypotheses. 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-use changes that persist after payments cease.

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 (Engel et al., 2008; Pagiola & Platais, 2007; Wunder, 2005, 2015). The assumption in PES programs is that environmentally beneficial practices are underadopted 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. The expansion of PES programs has faced many critics who are concerned that financial instruments for conservation may lead to ineffective outcomes (Muradian et al., 2013), perpetuate global inequalities (Van Hecken & Bastiaensen, 2010), crowd out intrinsic motivations (Ezzine-de-Blas et al., 2019), prove insufficient to meet restoration goals (Ruggiero et al., 2019), or fail to structurally remove conservation threats and therefore be unable to provide lasting benefits (Pirard et al., 2010). An emerging literature has developed to explore when and under what conditions these PES programs have attained their intended goals (Börner et al., 2016, 2017).

PES has been used primarily to encourage forest conservation—that is, to avoid the conversion of forested lands to other uses (J. Alix-Garcia & Wolff, 2014). Mexico's *Pagos por Servicios Ambientales del Bosque* 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 (de Koning et al., 2011; Muñoz-Piña et al., 2008; Pagiola, 2008). In Brazil, São Paulo's *Mina d'Água* pilot PES program only offered conservation payments (Pagiola et al., 2013) as did Espírito Santo's *ProdutorES de Água* program (Silva et al., 2013) and Amazonas' *Bolsa Floresta* (Viana et al., 2013). Conservation is also an important element in many watershed PES programs.

Some PES programs, however, also attempt to induce positive land-use changes or promote restoration efforts. The largest such program is China's *Sloping Land Conversion Program* (also known as "Grain for Green"; Xu et al., 2004). 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 *ProdutorES de Água* program, offers both restoration and conservation payments (Pagiola et al., 2017), while São Paulo's proposed *Crédito Ambiental Paulista—Mata Ciliares* program focuses exclusively on restoration. Many local PES programs also offer restoration payments, some exclusively so, such as the *Equitable Payments for Watershed* Program in Lake Naivasha, Kenya (Ndetei & 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. 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 & Pattanayak, 2006; Miteva et al., 2012), although preliminary impact evaluations show some success (Börner et al., 2017). 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 (Arriagada et al., 2012; Pfaff et al., 2008; Robalino & Pfaff, 2013) and Mexico's *Pagos por Servicios Ambientales del Bosque* program (J. M. Alix-Garcia et al., 2010; Sims & Alix-Garcia, 2015). For example, an initial study of the national PES program in Costa Rica showed that deforestation rates in the country dropped in the same period as the program began making payments, although 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 et al., 2007). An updated assessment of the same program found similar modest results (Robalino & Pfaff, 2013). Similarly, evaluations of Mexico's PES program suggests that the program led to decreased deforestation among enrolled parcels, particularly in areas at high of deforestation (J. M. AlixGarcia et al., 2012, 2019). At a smaller scale, Honey-Rosés et al. (2011) evaluated a PES program aimed at conserving the Monarch Butterfly Reserve in Mexico and found that the combination of PES and a protected area seem to succeed at protecting forest cover but only when accounting for spatial dynamics in the model (Honey-Rosés et al., 2011). A more recent review of 56 PES programs in 69 countries found that these programs tend to become less effective overtime, raising questions about the long-term impacts (Ola et al., 2019).

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 & Rios, 2013).

Permanence of PES-Induced Land-Use Changes

PES programs that focus on conservation generally provide long-term payments: although contracts are typically for 5-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 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 of such programs is that the land-use changes they induce 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 and therefore be retained once the programs ended (Lutz et al., 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 upon termination (Bunch, 2004). The potential lack of permanence has also been a major concern for the sale of carbon credits (Dutschke & Angelsen, 2008; Kim et al., 2008).

PES programs differ from traditional approaches to inducing land-use change in several ways. Whereas traditional approaches have generally relied on upfront 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 percent of the cost of adoption. PES programs—which almost always make payments in cash or cash equivalents—usually base the amount paid 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 noncompliance 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 (e.g., to plant trees), and that it takes some time for them to generate their full benefits (e.g., 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, relative to those of the current practice.[6] A short-term PES program modifies these

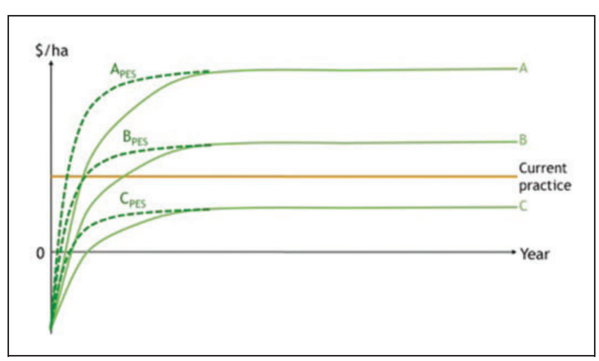

Figure 1. Typology of Net Return Profiles to Alternative Land-Use Practices. PES = payments for environmental services.

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.

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 (i.e., 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 these practices would thus reduce the program's additionality.[7] 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.[8] 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.[9]

The problem facing PES program designers, however, is that except for exceptional cases, determining which profile the net returns of a given practice follow (A, B, or C) may be difficult. 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 overestimate the benefits to landholders of particular land uses they seek to promote or to underestimate the benefits of current land uses. Even if estimates are accurate for a given location, or for average conditions, they may not be accurate for many or even most landholders in a heterogeneous landscape. Differences in local soils, climate conditions, and other factors that affect productivity, and in 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 misrepresent 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 nonpermanence, PES programs that offer only short-term support are attractive for many reasons. First, they 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.[10] 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 land uses 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). There was strong resistance to acknowledging that many environmentally desirable land uses 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 nonpermanence 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:

1. *Environmentally beneficial land uses are less profitable to landholders than current land uses.* If this is the case, PES-induced land uses are likely to be abandoned once payments end. Payments increase the relative attractiveness of environmentally beneficial land uses, but this effect ceases when the payments cease (Wunder, 2007).
2. *High initial costs make environmentally beneficial land uses unattractive, but once this hurdle is surpassed, the new land uses are more profitable for landholders than current land uses.* Asset-building PES programs are predicated on this hypothesis. If this hypothesis is correct, PES-induced land uses will be retained even once payments end (Wunder, 2005).
3. *High initial costs make adoption of environmentally beneficial and privately profitable land uses 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 land uses begin generating benefits. In this case, short-term payments would work by providing the necessary financing. If this hypothesis is correct, PES-induced land uses will be retained even once payments end (Pagiola et al., 2007).

4. *Landholders are unaware of the private benefits of environmentally beneficial land uses*. Under this hypothesis, landholders avoid adopting environmentally beneficial land uses because they do not know whether they will receive sufficient benefits. In this case, the payments would reduce the risk of adopting a new land use (Hejnowicz et al., 2014). If environmentally beneficial land uses do in fact generate sufficient benefits to landholders, they would retain them even once payments end.
5. *Landholders do not know how to implement environmentally beneficial land uses*. Under this hypothesis, PES would work not through the effect on the profitability of environmentally beneficial land uses, but through the TA provided to participants (Engel et al., 2008). If this hypothesis is correct, PES-induced land uses will be retained even once payments end.

Of course, these hypotheses are not mutually exclusive.[11]

These various hypotheses have implications not only for whether environmentally beneficial land uses 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 land uses 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 land uses could help fill the gap.

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. The project was implemented in three areas: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua (Pagiola et al., 2005). It was financed by a USD 4.5 million grant from the Global Environment Facility, with the World Bank as the implementing agency.[12] The project was developed with support of the multidonor Livestock, Environment and Development Initiative, hosted by the Food and Agriculture Organization. It was implemented in the field by local nongovernmental organizations. In Nicaragua, this work was conducted by Nitlapan, a nongovernmental organization affiliated with the University of Central America.

Silvopastoral practices include (a) planting high densities of trees and shrubs in pastures, thus providing shade and diet supplements while protecting the soil from packing and erosion; (b) 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 (c) using fast-growing trees and shrubs for fencing and wind screens (Table 1). These practices provide deeply rooting, perennial vegetation that is persistently growing and has a dense but uneven canopy (Dagang & Nair, 2003).

Silvopastoral practices generate high levels of environmental services, particularly in comparison to traditional pastures. Because of their increased complexity relative to traditional pastures, silvopastoral practices have important biodiversity benefits: they contribute to the survival of wildlife species by providing scarce resources and refuge, increase the propagation of native forest plants, provide shelter for wild birds, and can help connect protected areas (Dennis et al., 1996; Harvey & Haber, 1998). Silvopastoral practices can also fix significant amounts of carbon in the soil and in the standing tree biomass (Swallow et al., 2007). They can also affect water quality and/or water availability, though the specific impacts are likely to be site-specific (Bruijnzeel, 2004; Murgueitio, 2003). The biodiversity, carbon sequestration, and hydrological benefits of silvopastoral practices are largely off-site; however, so land users will not include them when they are deciding which practices to adopt. As a result, these practices will tend to be underadopted.

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 diversification of production (Dagang & 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 to landholders of between 4% and 14%, depending on the country and type of farm (Gobbi, 2002). Other studies found similar results; White et al. (2001), for example, found rates of return to adoption of improved pasture in Esparza, Costa Rica, of 9% to 12%. These estimates, of course, only consider the on-site benefits of silvopastoral practices (White et al., 2001).

To encourage adoption of silvopastoral practices, the Silvopastoral Project offered payments that were

Table 1. Silvopastoral Land Management Practices and the Environmental Services Index.

Land use	Environmental service index (points/ha)	Difficulty of adoption
Annual crops (annual, grains, and tubers)	0.0	
Degraded pasture	0.0	
Natural pasture without trees	0.2	
Improved pasture without trees	0.5	
Semipermanentcrops (plantain and sun coffee)	0.5	
Natural pasture with low tree density (<30/ha)	0.6	Low
Natural pasture with recently planted trees (>200/ha)	0.6	Low
Improved pasture with recently planted trees (>200/ha)	0.7	Medium
Monoculture fruit crops	0.7	Medium
Fodder bank	0.8	Medium
Improved pasture with low tree density (<30/ha)	0.9	Low
Fodder bank with woody species	0.9	Medium
Natural pasture with high tree density (>30/ha)	1.0	Medium
Diversified fruit crops	1.1	High
Diversified fodder bank	1.2	High
Monoculture timber plantation	1.2	Medium
Shade-grown coffee	1.3	Medium
Improved pasture with high tree density (>30/ha)	1.3	Medium
Bamboo (*guadua*) forest	1.3	Medium
Diversified timber plantation	1.4	High
Scrub habitats (*tacotales*)	1.4	Low
Riparian forest	1.5	Medium
Intensive silvopastoral system (>5,000 trees/ha)	1.6	High
Disturbed secondary forest (>10 m^2 basal area)	1.7	Low
Secondary forest (>10 m^2 basal area)	1.9	Medium
Primary forest	2.0	High
New live fence or established live fence with frequent pruning (per km)	0.6	Medium
Wind breaks (per km)	1.1	Medium

Note. The environmental service index is the sum of the biodiversity and carbon sequestration indices. Points per hectare unless otherwise specified.

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 provided, then 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 (Table 1).[13]

The Silvopastoral Project's central hypothesis was 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 annual payments of USD75 per incremental ESI point, over a 4-year period.

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 program participants have received no systematic support, in terms of either payments or TA.

Methods

Study Site

Matiguás-Río Blanco is located in the department of Matagalpa, about 140 km northeast of Managua, on the southern slopes of the Cordillera de Darien. It has an undulating terrain, with an elevation of 300 to 500 m above sea level. Average temperature is about 25 °C and average annual rainfall 1,700 to 2,500 mm. Participants are clustered in the Bulbul and Paiwas microwatersheds.

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. Silvopastoral practices were not unknown, but they were not widely used: pastures with high tree density covered about 17% of the

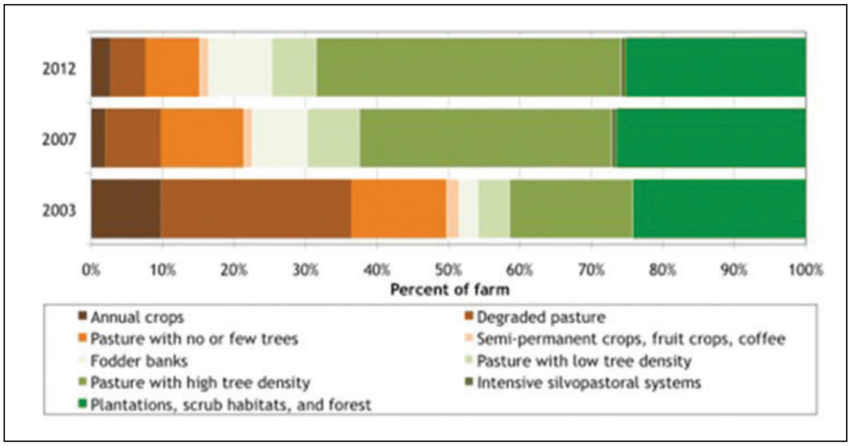

Figure 2. Land-Use Changes by PES Recipients During and After the Silvopastoral Project in Matiguás-Río Blanco, 2003 to 2012.

area, and fodder banks 3%. Forest remnants, mostly in riparian areas, covered about 24% of the area.

Participating households in Matiguás-Río Blanco are composed of six members on average and have about 31 ha of land and about 30 head of livestock. Regarding gender, 85% were headed by males and 15% by females. Average age was 43.4 years at the beginning of the project. 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. Only 30% of households have incomes above the poverty line (USD5,650/year), while 21% of households are poor (income below USD5,650/year) and 49% are extremely poor (income below USD2,950/year). Few households have water or electricity, and education levels are very low (primary education or less). Although most households occupy public land, long-term occupancy gives them secure tenure.

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 some minimal criteria on herd size.

Accepted participants received PES payments for 4 years, as well as TA on the selection and implementation of appropriate silvopastoral practices. However, some participants were randomly assigned to subgroups that only received payments for 2 years or that did not receive TA, as shown in Table 2. The 2-year PES program represented an initial effort to examine permanence: Participants in this subgroup 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 land uses they had adopted once payments ceased, while the project was still in a position to monitor them.

Table 2. 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. TA = Technical Assistance; PES = payments for environmental services.

Due to deaths and 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 resurvey to 72. We cannot rule out that attrition may have introduced some bias to our results; however, the number of households that we were unable to resurvey is reasonable given that nearly a decade passed between initial recruitment (2002) and the resurvey in 2012.

In an effort to distinguish project-induced land-use changes from changes induced by other factors, the Silvopastoral Project also included control groups.[14] In Matiguás-Río Blanco, however, there were not enough applicants in the two target microwatersheds, so we had to find control households in other areas. 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 we decided not to use it.

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 article, 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 61 cm 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.

Results

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 at both sites (Pagiola et al., 2007, 2008).

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 more than 13% to less than 12% of farm area). These areas were primarily converted to pasture with high tree density, which doubled, passing from 17% of farm area 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 almost tripled, from less than 90 km to over 280 km.

Overall, these changes resulted in an 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 subgroups had very similar initial land uses, in terms of their environmental service generation (as 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 (five households) that caution is needed in coming to any conclusions.

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.

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

Figure 2 shows the observed land use 4 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% of farm area in 2007 to almost 43% 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 regrowing)—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. However, the reason for this decline is that some high-ESI land uses were upgraded to even higher ESI land

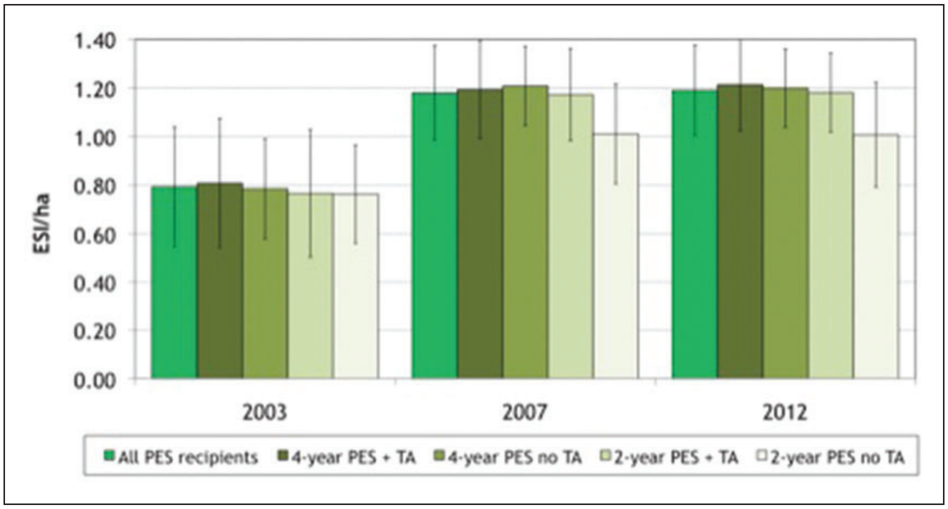

Figure 3. Changes in Environmental Service Generation Under the Silvopastoral Project in Matiguás-Río Blanco, 2003 to 2012. TA = Technical Assistance; PES = payments for environmental services; ESI = Environmental services index.

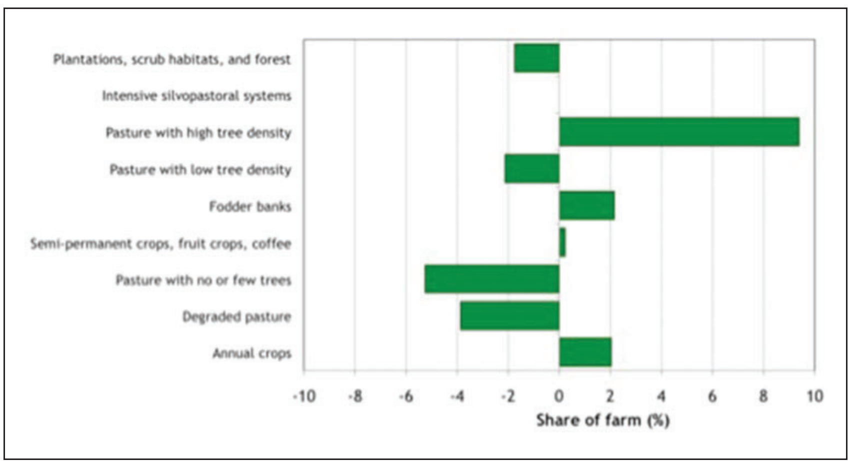

Figure 4. Land-Use Changes After the End of the Silvopastoral Project in Matiguás-Río Blanco, 2007 to 2012.

uses, for example, by additional planting that increased vegetation cover. The area of annual crops, which had plummeted during the project, recovered somewhat, but remains well below its preproject 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 small and not statistically significant (Figure 3).

The land-use changes after the PES program ended changes were concentrated among relatively small groups of 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. Both of these landholders have large farms (91 ha and 140 ha) and had already adopted pasture with high tree density on large areas. Conversely, one landholder reduced their environmental service generation significantly, by converting a 5.4 ha area of brush to annual crops on their relatively small farm (15.5 ha). All three of these landholders had been part of the 4-year PES program, and had received TA.

While our survey did not include in-depth interviews of households, we did collect answers to a question that inquired about why the households chose to continue to adopt silvopastoral practices. Households responded overwhelmingly that they were motivated by the financial benefits to their farm, while we see limited interest in these practices for environmental reasons (Figure 6).

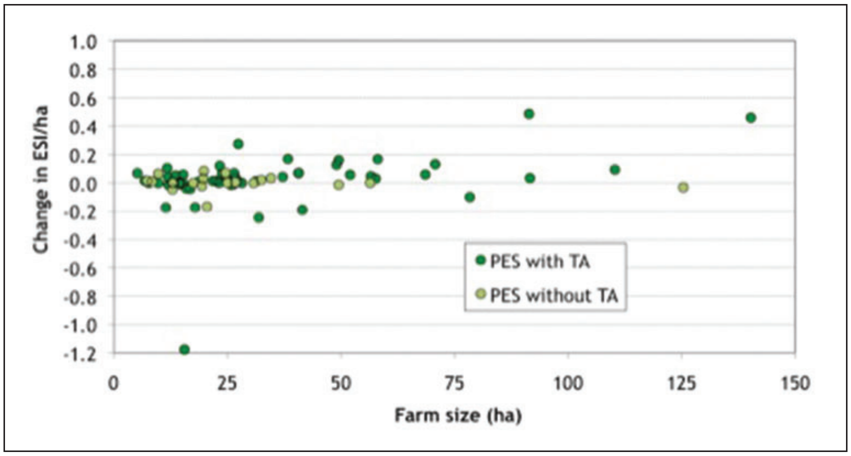

Figure 5. Post-PES Changes in ESI/ha in Matiguás-Río Blanco, by Farm Size. TA = Technical Assistance; PES = payments for environmental services; ESI = Environmental services index.

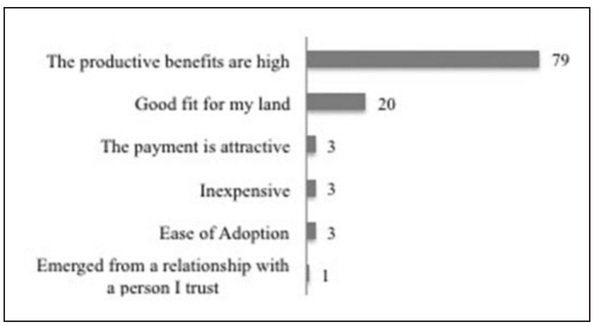

Figure 6. Motivations for Adopting the Silvopastoral Program Based On Qualitative Interviews, in Which the Respondents Overwhelming Pointed to the Expected Productivity Benefits Would Follow.

This focus on financial profitability is consistent with our theoretical framework which assumes that households make decisions based on financial returns.

Discussion

The results of the new surveys 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 postpayment period. Although there were 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 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" toward 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 even without payments, adoption would probably have continued even without payments.

These results also shed light on the other hypotheses on obstacles to adoption of silvopastoral practices. 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 such practices were little used. After 4 years in which the use of silvopastoral practices expanded dramatically, these explanations are no longer plausible. If these had been the main obstacles to the initial 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. That 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 at that site. 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 this outcome is that it offered participants at both sites a wide menu of possible land-use changes. Most reforestation/technology change projects tend to focus on one or a few land-use options. 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 Silvopastoral 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 offers 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 would have required long-term support were simply not adopted by landholders. As shown earlier, 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 with 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 the use of environmentally beneficial practices would change the "culture" of landholders, predisposing them to greater use of such practices. There were no significant changes after the project ended in the extent to which environmental services were generated, with positive changes being balanced by negative ones, resulting in little net change. Although the behavior of some individual landholders could be interpreted as being consistent with a more environmentally conscious attitudes, there are also counterexamples.

Implications for Conservation

This article describes one of the first efforts to assess the long-term permanence of land-use changes induced by a PES program, years after the program ceased to operate. The experience of the Silvopastoral Project in Matiguás-Río Blanco indicates that the PES program resulted in positive land-use changes in terms of both the area affected and the nature of the changes. Our results show that concerns about nonpermanence of land-use changes were unfounded: land uses 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 (Pagiola et al., 2016). 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 would be sustainable without long-term payments. In fact, if the practices supported by such a use-restricting program were maintained after payments cease, it may well indicate that the program was nonadditional. Third, our results are based on a relatively small sample of households and we encountered survey attrition in the decade that passed between our initial recruitment and our follow-up survey in 2012. Finally, 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 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 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 hypotheses may hold 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 program offers two complementary payments: short-term payments (over 3 years, once only) for ecosystem restoration, and long-term payments (over 5 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 et al., 2017). It will be important to undertake similar analyses of permanence of these new PES programs, to verify whether the lessons learned in Nicaragua applied there, too, or whether they need to be modified.

The permanence brought about by PES programs and the long-term maintenance of ecosystem services is particularly relevant in global policy arenas as countries aim to align national programs and policies to meet the Sustainable Development Goal Agenda 2030. We need to find policies that have strong synergies and reinforcing outcomes, and scholars have identified ecosystem services and livelihoods as one of the potential areas where these synergies may be strongest (Timko et al., 2018).

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Notes

1. The results for the Quindío site are analyzed in Pagiola et al. (2016).
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 et al., 2016).
3. Costa Rica's reforestation contract, for example, makes payments for 5 years (with half of the payment made in the first year) for the establishment of timber plantations, with the objective of overcoming financing constraints; thereafter participants receive revenue from thinning and the final harvest, typically after 15 to 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.
6. To avoid having to repeat this qualification throughout the article, when we speak of profitability or attractiveness of a given practice, we shall henceforth always mean profitability or attractiveness relative to the current practice.
7. A change is said to be additional if it would not have occurred without project support.
8. 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.
9. The areas of permanent protection (*Areas de Proteção Permanente*) that Brazilian law stipulates must be maintained under forest in riparian corridors are an example of such a practice. By law, forests in *Areas de Proteção Permanentes* 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.
10. 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 cases of trust funds being established to provide long-term financing to PES programs (Honey-Rosés et al., 2009). The limitations of this approach—particularly when interest rates are low—limit its applicability, however.
11. There are also other possible constraints to adoption of environmentally beneficial land uses. 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.
12. This is an example of a "government-financed" PES program (Engel et al., 2008), in that it is not financed by a direct user of the environmental services. The distinction is not critical to our analysis here, however, as we focus on service providers.
13. The ESI is described in detail in CIPAV (2003) and Pagiola et al. (2005). Not all practices recognized in the ESI are relevant at Matiguás-Río Blanco.
14. To our knowledge, this was the first World Bank natural resource management project ever to include a control group.
15. The questionnaires for this survey and for the 2012 survey discussed below are available from the authors on request.

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 et al., 2016). There was a 4% 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%), suggesting that the gains made in the payment period were largely permanent.
17. The "agroforestry" contract offered by Costa Rica's PPSA program, for example, is quite restrictive, in that only timber species can be planted.
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.

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