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Evaluation of the Permanence of Land Use Change Induced by Payments for Environmental Services in Quindío, Colombia

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Abstract

The effectiveness of conservation interventions such as Payments for Environmental Services (PES) is often evaluated—if it is evaluated at all—only at the completion of the intervention. Since gains achieved by the intervention may be lost after it ends, even apparently successful interventions may not result in long-term conservation benefits, a problem known as that of permanence. This paper uses a unique dataset to examine the permanence of land use change induced by a short-term PES program implemented in Quindío, Colombia, between 2003 and 2008. This the first PES program to have a control group for comparison. Under this program, PES had been found to have a positive and highly significant impact on land use. To assess the long-term permanence of these changes, both PES recipients and control households were re-surveyed in 2011, 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 also help better understand the reasons 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 owners to adopt environmentally-beneficial management practices and that the benefits will persist after payments cease.

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Keywords

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

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Cover photo

Cows grazing in a pasture with high tree density, Quindío (Stefano Pagiola).

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1. Introduction

Payments for environmental services (PES) programs have attracted considerable attention as a strategy to protect natural resources and improve their long-term management (Ferraro and Kiss, 2002; Wunder, 2005; Engel and others, 2008; Wunder and others, 2008). As with many other conservation interventions, there are important questions concerning their effectiveness. One such question concerns the long-term sustainability of their results. However, there have been no empirical analyses to date of this long-term sustainability. The effectiveness of PES program has hitherto been evaluated (if it is evaluated at all), only at the completion of the intervention. Since gains achieved by the intervention may be lost after it ends, even apparently successful interventions may not result in long-term conservation benefits.

PES programs make payments that are conditional on managing natural resources in ways that generate benefits for others (Wunder, 2005; Engel and others, 2008; Pagiola and Platais, 2007; Wunder, forthcoming). The approach is based on the twin principles that those who benefit from environmental services (such as users of clean water) should pay for them, and that those who contribute to generating these services (such as upstream land users) should be compensated for providing them. It thus seeks to create mechanisms in which service users and service providers can undertake transactions that are in both parties' interests, internalizing what would otherwise be an externality.

Recent years have seen a substantial growth in the use of PES, particularly in Latin America. PES programs are being implemented in Brazil (Pagiola and others, 2013), Colombia (Blanco, 2006), Costa Rica (Pagiola, 2008), Ecuador (Wunder and Albán, 2008; De Koning and others, 2011), Mexico (Muñoz-Piña and others, 2008), and elsewhere, and others are under preparation or study in several countries. These programs cover a wide range of scales and contexts. National-scale programs are in place in Costa Rica, Ecuador, Mexico, and several Brazilian states. Smaller programs (usually watershed-scale) can be found throughout the continent, in almost every country. Many programs focus on preserving water services, but programs that sequester carbon (for regulated or voluntary markets) are also common, and may become even common if plans for Reduced Emissions from Deforestation and Degradation (REDD) come to fruition (Pagiola, 2011; Agrawal and others, 2011). Although few PES programs focus on biodiversity directly, biodiversity conservation is an important secondary objective of many programs.

As with other conservation interventions (Ferraro and Pattanayak, 2006; Miteva and others, 2012), there has been growing concern over the effectiveness of PES

(Pattanayak and others, 2010). Concerns have been raised that PES may not in fact induce the desired land use changes (that is, that they may lack *additionality*); that any induced land use changes may not in fact generate the desired services (for example, because the wrong land uses were induced, or total land use change was insufficient); that such changes may not be sustainable or *permanent* (because they are abandoned once the program ends); or that second-order impacts of the programs may diminish, or even negate, the benefits of the program (a problem known as *leakage* or *spillage*). There have also been concerns over distributional and social impacts. Despite these concerns, there have been few efforts to date to assess the impact of PES programs, and most of those have been hampered by lack of data, sometimes leading to very divergent results.

The few evaluations of PES programs that have been conducted have shown mixed results, in part because almost none had a control group to serve as a counterfactual, and few collected baseline data. Costa Rica's PES program has been the most studied, but the available studies have a wide range of results, ranging from a 10 percent increase in primary forest cover nationwide in 2005 over what it would have been without the PES Program (Tattenbach and others, 2006); to a minimal impact on deforestation in 1997-2000 (Pfaff and others, 2008), and only a slightly higher impacts in 2000-2005 (Robalino and others, 2008); and an increase in forest cover among PES recipients of about 11-17 percent of the area under contract (Arriagada and others, 2012). In Mexico, Alix-Garcia and others (2012), find that the national PES program reduced deforestation among participants by about 50 percent; Muñoz-Piña (2011) finds similar results. At a smaller scale, Honey-Rosés and others (2011) find that a PES program aimed at conserving the Monarch Butterfly Reserve succeeded in reducing deforestation and forest degradation compared to what it would have been, but not in eliminating it. In Colombia, Pagiola and Rios (2013) find that a short-term PES program achieved substantial and strongly statistically significant land use change among recipients. All these studies focused exclusively on the problem of additionality during implementation. Only Alix-Garcia and others (2012) examined the extent of leakage under Mexico's national PES program, finding that it partially offset the estimated impact on deforestation.

In this paper, we are specifically concerned with the long-term sustainability or permanence of the benefits generated by PES—the least studied aspect of the effectiveness of PES. We use a unique dataset to examine the long-term sustainability of environmentally-beneficial land use change induced by a short-term PES program implemented in Quindío, Colombia, between 2003 and 2008. Under this program, which was the first PES program to have a control group, PES had been found to have a positive and highly significant impact on land use, with the proportion of farm area devoted by PES recipients to environmentally beneficial land uses increasing substantially. Because of the short-term nature of the program, however, there was considerable concern that gains would be lost once the program ended. To assess the long-term sustainability of these changes, both PES recipients and control households were re-surveyed four years after the last payment was made to measure subsequent changes to land use.

We begin by discussing why evaluating the long-term sustainability of land use change induced by short-term PES programs is important and formulating several hypotheses about long-term outcomes. We then describe the project and its PES mechanism, and the Quindío site, and the land uses changes that were induced during implementation of the project. We then use detailed monitoring data collected at the study site to examine the land use changes that took place subsequent to the last payment being made. In particular, we search for any evidence that former PES recipients have abandoned the practices they adopted while receiving payments. We also examine the extent to which some of these land uses may have been further expanded even after payments ended, either by former PES recipients or by control households. 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. Some practices experienced continued expansion even after the payments ceased. The patterns of change in the period after the PES program was completed also help better understand the reasons for the program's success. We conclude by discussing the implications of our results for PES program design.

2. Long-term sustainability of PES impacts

In most cases, PES programs are designed to be long-term programs, making annual payments to landholders essentially indefinitely (although most PES contracts are typically for five years, they are usually renewable indefinitely). This is particularly true of PES programs that aim to conserve existing environmentally-beneficial land uses such as forests and prevent their conversion to less desirable land uses. The logic of these programs is that the returns to landholders of environmentally-beneficial land uses 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. Payments are made annually, upon verification that landholders have maintained the desired land uses. In such cases, there is no expectation of sustainability once payments end—on the contrary, the expectation is explicitly that the environmentally-beneficial land uses would be abandoned if payments ended. Concerns over sustainability thus focus primarily on the sustainability of the funding sources and the institutional arrangements that allow long-term payments to be made. In such long-term PES programs, the more important concern is that of *additionality*: many participants in such programs may be receiving payments for land uses they would have undertaken anyway, so that the programs generate few or no additional environmental services compared to the no-program counterfactual (Pattanayak and others, 2010).

In other cases, however, PES programs only make short-term payments. This is often the case of programs which seek to restore degraded ecosystems, replacing environmentally-harmful land uses with more beneficial ones. Wunder (2005) calls these programs “asset-building”, in contrast to the “use-restricting” conservation-focused programs. The logic in such cases is that returns to landholders from environmentally-beneficial land uses can exceed those of alternatives once obstacles to their adoption have been overcome. In such cases, a short-term PES program that

‘tips the balance’ between environmentally harmful and beneficial land uses may be sufficient. This was the hypothesis of the short-term PES program examined here.

The hypothesis that short-term payments are sufficient to induce lasting land use change may, however, be mistaken. If returns to environmentally-beneficial land uses are lower than those of alternatives, landholders may still participate in the PES program and temporarily adopt the desired land uses so as to receive the payments (so that PES appears to be successful during implementation), but would then abandon these land uses once payments cease. This would, of course, result in the loss of any environmental benefits after the program’s end. The resources used to induce the land use change would thus have been wasted. It is important, therefore, to verify, rather than assume, whether land use changes induced by short-term PES programs are indeed sustained after payments end.

Observing land use changes after completion of a PES program is also important for other reasons. In particular, while some fear that land uses will be abandoned once payments cease, others hope that—on the contrary—PES will lead to widespread adoption even after payments cease. This could occur, for example, if the main obstacles to adoption of environmentally-beneficial land uses were not due to their benefits to landholders. These land uses may not have been adopted prior to the PES program, for example, if landholders were not aware of their benefits, or did not know how to implement them. If the area under the desired land uses continues to expand even after the end of payments, it may indicate that the apparent benefits of PES may in fact have resulted not from the actual payments but from the technical assistance (TA) that was provided concurrently. In that case, a TA program alone may be sufficient. Alternatively landholders may have lacked the financing necessary to undertake the necessary investments, and the payments may have affected land use choice by relaxing this constraint rather than through their effect on profitability. In the latter case, a credit program may be an attractive alternative to PES.

The impacts of PES may differ across land uses, as the relative profitability and technical complexity of environmentally-friendly land uses vary. Thus, some land uses may prove to be sustainably adopted thanks to a short-term PES programs while others are not. Impacts may also vary across participants. Poorer households, for example, may have greater financing constraints than better-off households. These differences, if observed, would have important implications for PES program design. Any evaluation should thus seek to identify such differences in impacts rather than looking at average impacts.

To date, the only effort to assess the long-term sustainability of a PES program has been a study of China’s Sloping Land Conversion Programs (SLCP) (Grosjean and Kontoleon, 2009). This study, however, used stated preference techniques to try to predict whether the program would prove sustainable, rather than observations of actual behavior post-program.

3. Methods

This paper uses data from a PES program implemented in the Quindío area of Colombia from 2003 to 2007 to examine whether land use changes induced by PES are maintained once payments end. Quindío was one of three pilot sites for the *Regional Integrated Silvopastoral Ecosystem Management Project* (hereafter the ‘Silvopastoral Project’), which used PES to encourage the adoption of silvopastoral practices in degraded and treeless pastures, so as to generate increased biodiversity conservation and carbon sequestration (Pagiola and others, 2005). The Silvopastoral Project offers an excellent opportunity to assess the long-term impact of PES, as it undertook extensive monitoring of both PES recipients and of a control group of farmers. By comparing the land use changes undertaken by PES recipients and control households, we can distinguish the impact of payments from that of other factors that affect land use decisions. To examine the long-term sustainability of these land uses changes, we re-surveyed all of the participants in the Silvopastoral Project four years after the last payment was made.

The Silvopastoral Project

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). The project was financed by a US\$4.5 million grant from the Global Environment Facility (GEF), with the World Bank as the implementing agency. It 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 Colombia, this work was conducted by the Centre for Research on Sustainable Agricultural Production Systems (*Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria*, CIPAV).

Cattle production has long been an important cause of the loss of natural habitat and biodiversity in Latin America (Downing and others, 1992; Kaimowitz, 1996; Murgueitio, 2003). Moreover, traditional livestock production practices based on extensive grazing are often unsustainable. After an initial period of high yields, soil fertility is depleted and grass cover diminishes, resulting in soil erosion, contamination of water supplies, air pollution, further loss of biodiversity, and degradation of landscapes. Lower income for producers results in continuing poverty and can lead to pressure to clear additional areas.

Silvopastoral practices combine trees with pasture. They include (1) planting high densities of trees and shrubs in pastures; (2) cut and carry systems, in which livestock is fed with the foliage of specifically planted trees and shrubs (‘fodder banks’); and (3) using fast-growing trees and shrubs for fencing and wind screens. These practices provide deeply rooting, perennial vegetation which is persistently growing and has a dense but uneven canopy.

The on-site benefits of silvopastoral practices for land users 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 and Nair, 2003). Because of their increased complexity relative to traditional pastures, silvopastoral practices also have important biodiversity benefits: they have been shown to play a major role in the survival of wildlife species by providing scarce resources and refuge; to have a higher propagation rate of native forest plants; and to provide shelter for wild birds (Dennis and others, 1996; Harvey and Haber, 1999; Harvey and others 2008). They can also help connect protected areas. 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 impact is likely to be site specific (Murgueitio, 2003; Bruijnzeel, 2004).

Although silvopastoral practices offer numerous benefits, landholders will generally only take a portion of these benefits into account. Biodiversity conservation, carbon sequestration, and watershed protection benefits are all experienced off-site, so landholders will not normally take them into account when deciding which practices to adopt. The on-site benefits that landholders do take into account, however, are often insufficient 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 show 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 (2011), for example, found rates of return to adoption of improved pasture in Esparza, Costa Rica, of 9 to 12 percent. As a result, adoption of silvopastoral practices is often low.

The Silvopastoral Project sought to improve the adoption of silvopastoral practices by offering payments proportional to their expected biodiversity and carbon sequestration benefits (watershed benefits were not considered in this project). To do so, the project developed indices of the biodiversity conservation and carbon sequestration services associated with specific silvopastoral practices, then aggregated them into a single ‘environmental services index’ (ESI), described in detail by CIPAV (2003). The project distinguished 28 different practices, each with its own ESI score (see Appendix 1). Annual payments were based on the change in the total ESI score for the entire farm compared to its ESI score at the beginning of the project, with each incremental ESI point being worth US\$75 per year, over a four-year period. An initial, one-time payment of US\$10/point for baseline ESI points was also provided at the beginning of the project.

The Silvopastoral Project made its first payments, for the baseline ESI points, in July 2003. In May 2004, after monitoring land use changes, the project made its first payment for incremental ESI points. Additional payments were made in 2005, 2006, and 2007. Since 2007, the former program participants have received no systematic support, in terms of either payments or TA, from CIPAV. However, some have received occasional visits from CIPAV.

Study site

The Quindío area is located in Colombia's Central Cordillera, in the watershed of Río La Vieja, at about 900-1,300m above sea level. Farms range from 10-20ha to some of 50-80ha. Many of the larger farms are owned by urban professionals and managed by employees (*mayordomos*). There is a very wide range of income levels, from extremely poor to quite wealthy. As shown in Table 1, extensive grazing was the main land use in Quindío prior to project start, having replaced the previously dominant coffee production. Degraded and treeless pastures dominated the landscape, accounting for about 65 percent of the area. Livestock production was primarily for meat production, with a small proportion being used for milk production. Overall tree cover was low, although there were a significant amount of forest remnants, most of which was riparian forest. Silvopastoral practices such as pastures with trees, fodder banks, and live fences were practically non-existent. Only 7 in 110 farms surveyed had any fodder banks, for example, with an average of less than 1ha each. Some farms—particularly lower-income farms—had small areas dedicated to other productive activities, such as semi-permanent crops (mostly bananas), fruit crops, shade-grown coffee, and annual crops.

Treatment group

As a pilot project, the Silvopastoral Project had limited funding, so participation in Quindío was limited to 80 households. A series of public workshops were held in the area to explain the project, with support of the Quindío livestock association. Two field visits were also organized to the Reserva Natural El Hatico in the Cauca valley, where silvopastoral practices are already in use. Households who expressed an interest were then accepted on a first-come basis, provided they met some minimal criteria on size of herd.

The two primary treatments of interest were payments and technical assistance (TA). All households in the treatment group were offered PES, but 56 households were randomly selected among them to also receive on-farm TA. Although all participants received advice on which land uses might be most appropriate on their farms, the TA sub-group also received on-farm, in-person guidance on how to implement the selected land uses. In this way it would be possible to compare the effect of PES alone and the combination of PES and TA to the control group, which received neither. The treatment group was then further sub-divided, with half receiving payments for all four years of the project, while the other half only received payments for two years. The intent of was to allow an early assessment of whether land use change would prove sustainable once payments ended. Payment levels were slightly higher for the 2-year group, to compensate for the shorter duration of the payments, so that in principle the payment received to adopt a given land use should have been roughly similar in present value terms for members of both groups. Households were randomly assigned to either the 4-year or the 2-year group. There were thus effectively four treatments: PES for either 2 or 4 years, both either with intensive TA or without it. Among PES recipients, there were no significant differences in household characteristics among the sub-groups. Table 1 shows the characteristics of PES recipient households.

Control group

To allow project-induced land use changes to be distinguished from changes induced by other factors, the Silvopastoral Project also included a control group. In fact, it was the first PES project anywhere to include a control group. Ideally, applicants would have been randomly assigned to either the treatment or the control group (Ferraro and Pattanayak, 2006; Glennerster and Takavarasha, 2013). This was not feasible, however, as the treatment group had already been selected when the decision to include a control group was made. Fortunately, the number of applications received was sufficient that a control group could be selected from among rejected applicants. As applications had been accepted on a first come, first served basis, there was no reason to expect that rejected applicants differed systematically from accepted applicants. Despite some differences, the control households have broadly similar characteristics (in terms of size, type of activities, and agro-ecological conditions) to PES recipient households (Table 2). This is to be expected, given the relatively small sample size and the wide range of conditions in the area. Budget constraints, particularly on the cost of monitoring, meant that the control group had to be limited to 30 households.

Data collection

A baseline survey conducted in late 2002, during project preparation, collected detailed information on household characteristics of all PES recipients and control households at the site. All former PES recipients and control households were then re-surveyed in mid-2011, four year after the PES program ended. The questionnaire for the new survey was based on that of the 2002 baseline survey, but 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. The baseline survey included data on 110 households. Nine observations were discarded because households dropped out of the PES program, usually because they sold their land and moved away, or because the household head died, leaving 72 households receiving payments and 29 members of the control group, for a total of 101 observations.

From 2002 to 2007, detailed land use maps were prepared annually for each farm in the PES recipient and control groups, using 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 provide accurate and consistent measures of area and ensure that land uses are classified consistently into the project's categories. At the same time as the 2011 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, or by new personnel that had been trained by Silvopastoral Project personnel) to ensure consistency with the previous land use maps.

Outcome measurement

The Silvopastoral Project differed from most PES programs (and from many other development programs aimed at landholders) by offering a large menu of land

use options that participants could choose from, in light of their own preferences and constraints, rather than focusing on a small number of preferred land uses. As such, the outcome cannot be expressed by a binary participation/non-participation variable. The dependent variable for our analysis can be formulated in many different ways. The simplest formulation is to use the *area converted*: the greater the area converted, the higher the participation. Households with less land, such as those in the control group, may score poorly on this indicator, however, simply because they have less land. Investments such as establishment of live fences are also difficult to incorporate into an area-based indicator. Using the *proportion of farm area converted* avoids this problem, but faces others. Converting 5 ha of land to improved practices takes greater effort and has a greater environmental impact than converting 1 ha, yet if the first household has 10 ha and the second only has 1 ha, the first household (50 percent converted) will appear to be participating ‘less’ than the second (100 percent converted). However expressed, area-based indicators also fail to capture the quality of the changes. Sowing improved pasture grasses in a treeless pasture has substantially less environmental impact than converting it to pasture with high tree density, yet will have the same value in terms of either area converted or percent of farm area converted. Area-based indicators also omit investments in live fencing. One option to incorporate a measure of intensity is to weight the area converted by the ESI of the land use change, and then add the points for live fencing. This measure is also appealing as it is the outcome of interest to the buyer of the environmental services being sought. As adopting higher-ESI land uses tend to be more difficult than adopting lower-ESI uses, using the ESI also provides a rough measure of effort. This measure can also be stated in different ways. The *increase in total ESI* is the simplest measure, but like area converted is constrained by total farm size. Stating it in terms of *increase in ESI per hectare* or *percent increase in ESI* addresses this problem. As each of these alternatives has its advantages and disadvantages, we use them all in separate models.

4. Results

We begin by briefly reviewing the results of the Silvopastoral Project during its implementation period; these results are examined in more detail by Pagiola and Rios (2013). We then examine how these results changed in the three years after the project ended.

Participating households

The characteristics of participating households are summarized in Table 1 (which only includes households still active at the end of the project). The average household in the sample is composed of 4.5 members, and has about 36ha of land and a herd of about 57 livestock units. The average per capita income is about COP10 million. As can be seen, the average characteristics of the sub-group of PES recipient households differ slightly from those of the control group. This is to be expected, given the relatively small sample size and the range of conditions in the area.

Table 1: Characteristics of participating households, Quindío, Colombia

	<i>PES only</i>	<i>PES and TA</i>	<i>PES all</i>	<i>Control</i>	<i>All</i>
Income per capita (million COP)	5.1	9.8	8.2	14.3	10.0
Assets (million COP)	9.4	7.9	8.4	8.7	8.5
Farm area (ha)	25.8	47.4	40.2 ^a	25.4 ^a	36.0
Cattle (livestock units)	59.7	60.3	60.1	48.5	56.8
Flat (% farm area)	26.2	21.3	22.9 ^a	36.9 ^a	26.9
Distance to nearest village (km)	6.7	7.3	7.1 ^a	5.24 ^{ab}	6.6 ^b
Water (% with water service)	95.8	93.8	94.4	96.6	95.0
Farm resident (%)	33.3	29.2	30.6	17.2	26.7
Family labor (man-days/ha/yr)	7.2	8.9	8.3	nd	nd
Household size (members)	5.1	4.7	4.9 ^a	3.7 ^{ab}	4.5 ^b
Dependency ratio (children per adult)	0.40	0.40	0.40 ^a	0.22 ^{ab}	0.35 ^b
Age of household head (years)	45.2	41.8	42.9	43.9	43.2
Literacy of household head (%)	100	93.8	95.8	93.1	95.1
Education of household head (years)	5.2	5.1	5.2	4.3	4.9
Off-farm work (% with off-farm employment)	12.5	14.6	13.9	10.3	12.9
Technical assistance (% with current access)	45.8	31.3	36.1 ^a	10.3 ^{ab}	28.7 ^b
Credit (% with access to credit)	20.8	29.2	26.4	13.8	22.8
Number of observations	24	48	72	29	101

Notes: Data reflects conditions just prior to project start.

^{a, b} indicate means are significantly different in paired t-test at 10% test level.

nd = no data.

Children are household members under 12.

Livestock are converted into livestock units (*Unidad Gran Ganado*, UGG) using the following conversion factors: adult cows, 1.0 UGG; oxen or breeding bulls, 1.55 UGG; calves, 0.33 UGG; yearlings, 0.7 UGG.

Source: Silvopastoral Project baseline survey.

Changes in land use induced by PES

Table 2 and Figure 1 compare land use by PES recipients at the project's start (2003) and end (2007), and in 2011. Overall, the PES program induced substantial land use change during its implementation: between 2003 and 2007, almost 44 percent of total area experienced some form of land use change. A wide variety of changes were observed, ranging from very small changes such as sowing improved grasses in degraded pastures to very substantial changes such as planting high-density tree stands or establishing fodder banks. The area of degraded and treeless pasture fell by over 90 percent of its original area and that of natural pasture without trees by two thirds of its original area. (These figures understate total changes as they are for *net* changes in the area under each practice. For example, while some natural pastures with few or no trees were converted to natural pastures with high tree density, some

Table 2: Land use at the Silvopastoral Project site, Quindío, Colombia, 2003 to 2011

(% of farm, unless otherwise indicated)

<i>Land use</i>	<i>PES recipients</i>			<i>Control group</i>		
	<i>2003</i>	<i>2007</i>	<i>2011</i>	<i>2003</i>	<i>2007</i>	<i>2011</i>
Annual crops	1.3	1.3	3.0	7.7	11.3	8.1
Degraded pasture	2.8	0.3	0.7	1.9	1.0	1.4
Natural pasture without trees	24.8	8.1	9.9	6.8	3.8	2.2
Improved pasture without trees	37.3	30.4	23.4	51.2	42.7	30.7
Semi-permanent crops (plantain, sun coffee)	6.5	5.1	5.2	13.6	15.4	24.0
Natural pasture with low tree density (< 30/ha)	0.2	0.4	2.0	0.0	1.4	1.8
Diversified fruit crops	2.5	1.9	3.0	0.3	1.8	4.2
Fodder banks ^a	0.2	1.0	1.0	0.0	0.5	0.8
Improved pasture with low tree density (< 30/ha)	1.9	11.4	9.6	0.8	1.6	5.3
Natural pasture with high tree density (>30/ha) ^b	0.0	2.3	2.7	0.0	0.0	0.0
Shade-grown coffee	0.8	1.3	0.9	1.0	1.0	1.3
Improved pasture with high tree density (>30/ha) ^b	0.1	9.3	10.0	0.0	0.0	0.1
Bamboo (guadua) forest	1.5	1.8	1.8	0.2	0.2	0.2
Timber plantation ^a	0.0	0.2	0.3	0.3	0.3	0.3
Riparian forest	12.9	13.7	14.0	10.4	10.4	10.6
Intensive silvopastoral system (iSPS)	0.0	4.4	4.8	0.0	2.9	3.0
Primary and secondary forest ^a	7.3	7.1	7.7	5.9	5.8	6.1
Total area	100.0	100.0	100.0	100.0	100.0	100.0
Multistory live fence or wind break (km) ^b	2.1	356.9	386.4	3.0	13.6	16.6

Notes: Totals may not add up because of rounding.^a Similar land uses with small areas have been aggregated.^b The project distinguishes land uses with recently planted trees from the same land uses with mature trees for the purpose of computing the ESI score; here these land uses have been aggregated to their mature state and the corresponding ESI score is shown.*Source:* ESI from CIPAV (2004); area from Silvopastoral Project mapping data.

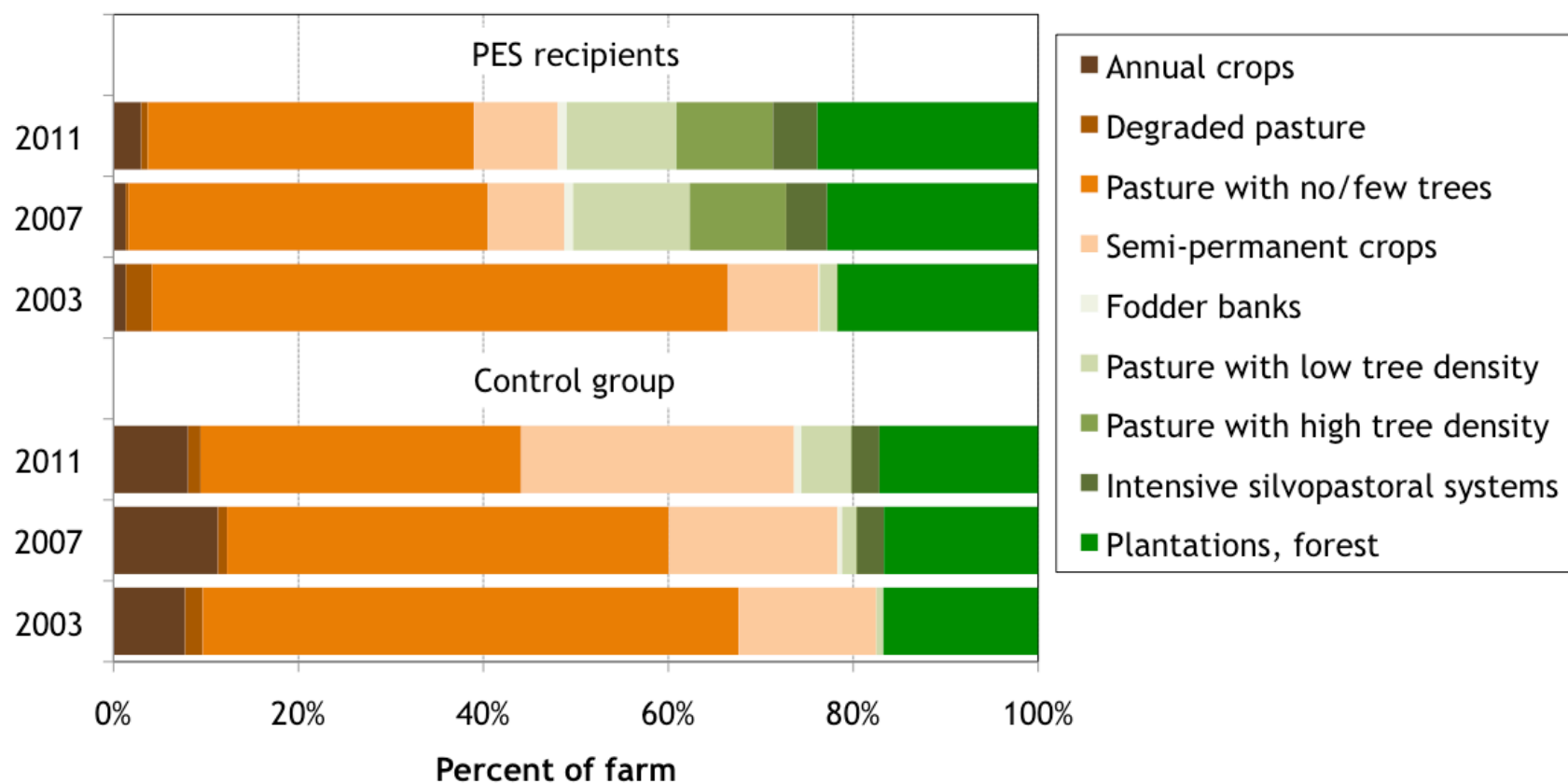
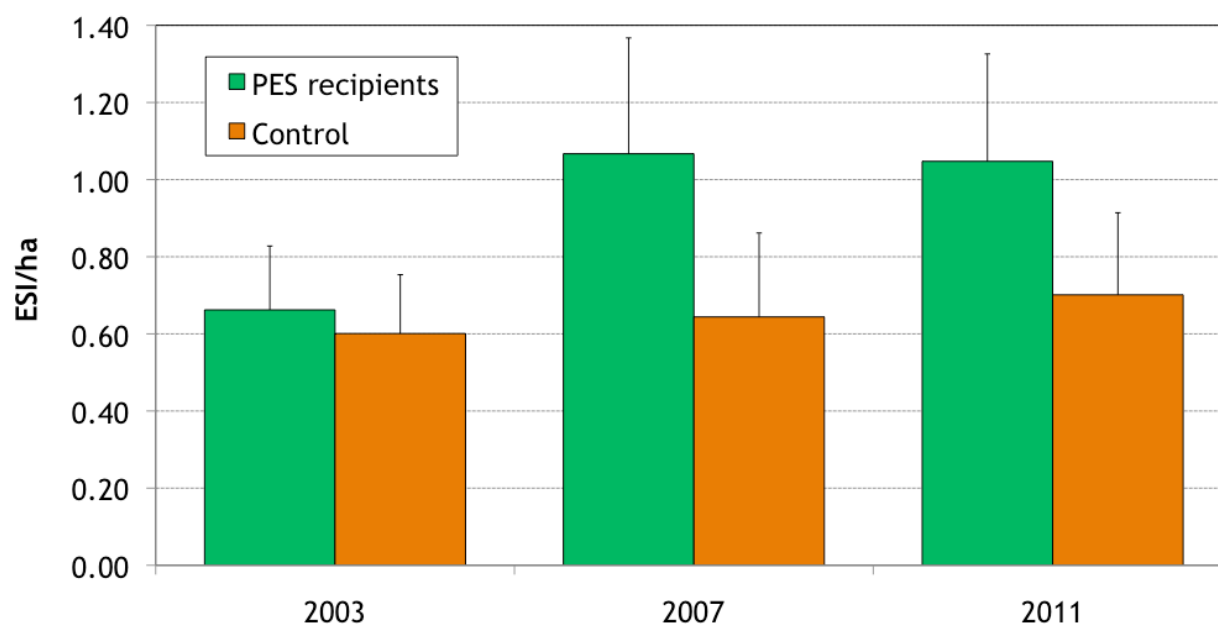


Figure 1: Land use changes during and after the Silvopastoral Project in Quindío, 2003 to 2011

natural pastures that already had high tree density were converted to improved pastures with high tree density, reducing the apparent net change in natural pastures with high tree density.) Most of the gains were experienced in pastures with high tree density, which increased by 334ha. The area of fodder banks also rose dramatically, from less than 5ha to over 28ha, while that of intensive silvopastoral systems (iSPS: *Leucaena* planted at 5,000 trees/ha) went from 0ha to 130ha. About 346km of live fencing were established. Semi permanent crops, fruit crops, and coffee found little favor, with their overall area declining by 39ha, while timber plantations and pure forest uses fared little better, their total area increasing by only 29ha. Overall, these changes increased ESI/ha of PES recipients by over 60 percent (significant at 1 percent), as shown in Figure 2.



Notes: Bars show standard deviations

Source: Computed from Silvopastoral Project data

Figure 2: Changes in environmental service generation under the Silvopastoral Project in Quindío, 2003 to 2011

In contrast, control households undertook substantially fewer land use changes in the same time period (Table 2 and Figure 1). Control households converted less than 13 percent of their land area, and adopted substantially less beneficial land uses, for an increase in ESI/ha of only 7 percent (a change which is not statistically significant). Econometric and difference-in-difference analyses confirm that these differences are statistically significant and did not result from differences in household characteristics (Pagiola and Rios, 2013). These results conclusively demonstrate that the land use changes induced by PES in Quindío were *additional*.

Among the possible land use changes, Pagiola and Rios (2013) found that there was very little adoption of more conservation-oriented land uses (such as secondary forests), even as production-oriented land uses (such as fodder banks) were adopted extensively—even though the payments offered by the project for conservation-

oriented land uses were higher. Pagiola and others (2010) also found that the extent and nature of changes made by relatively poorer households were not significantly different from those of relatively better off households. More surprisingly, Pagiola and Rios (2013) found that TA recipients did not undertake significantly more or better land use changes.

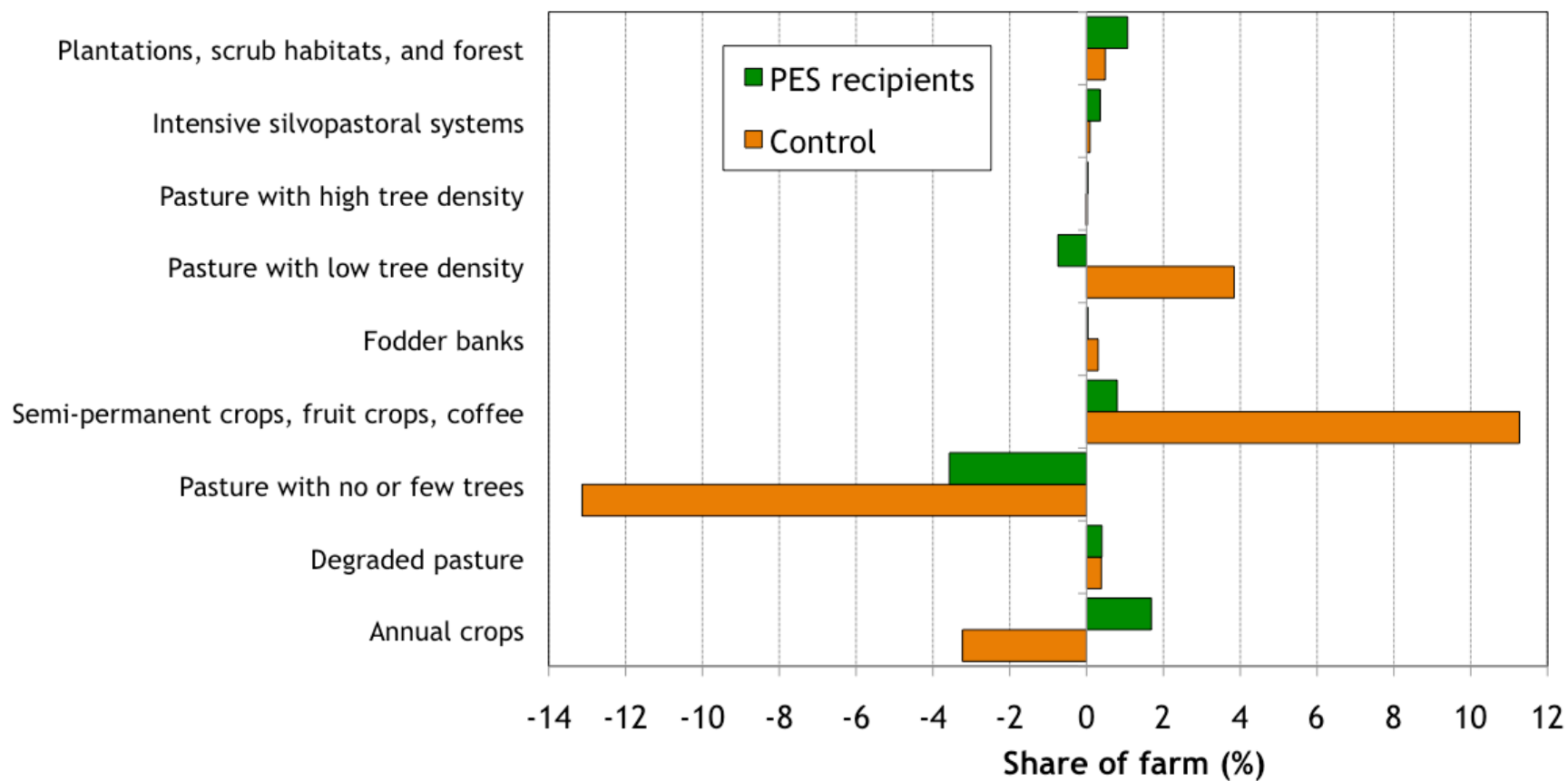
Post-PES land use changes

As noted, there was considerable concern that the environmental gains made during the operation of the PES program would be temporary, with previous land uses returning once payments ended. The inclusion of a sub-group that would receive payments only over two years was an initial effort to determine whether these concerns were well-founded. Pagiola and Rios (2013) found no significant differences between 2-year and 4-year PES recipients in land use change, at the time of the project's end. This result was promising, but did not entirely allay the concerns, 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.

Table 2 and Figure 1 show the observed land use changes in the four years since the PES programs ended. Among former PES recipients, these changes were minimal. The observed post-PES changes are shown in more detail in Figure 3. The main change was a continued decline in the area of treeless pasture, which fell by about 4 percent of the farm area of former PES recipients (compared to a fall of almost 24 percent of farm area during the project). Some of this area, however, was converted to annual crops and so did not bring any additional environmental benefits. Among environmentally-beneficial land uses, there was some very minor expansion (about 1 percent of farm area) of secondary and riparian forests and of semi-permanent crops—specifically, monoculture fruit tree plantations. Among silvopastoral practices there were very few changes, except for a small decline (less than 1 percent of farm area) of pasture with low tree density.

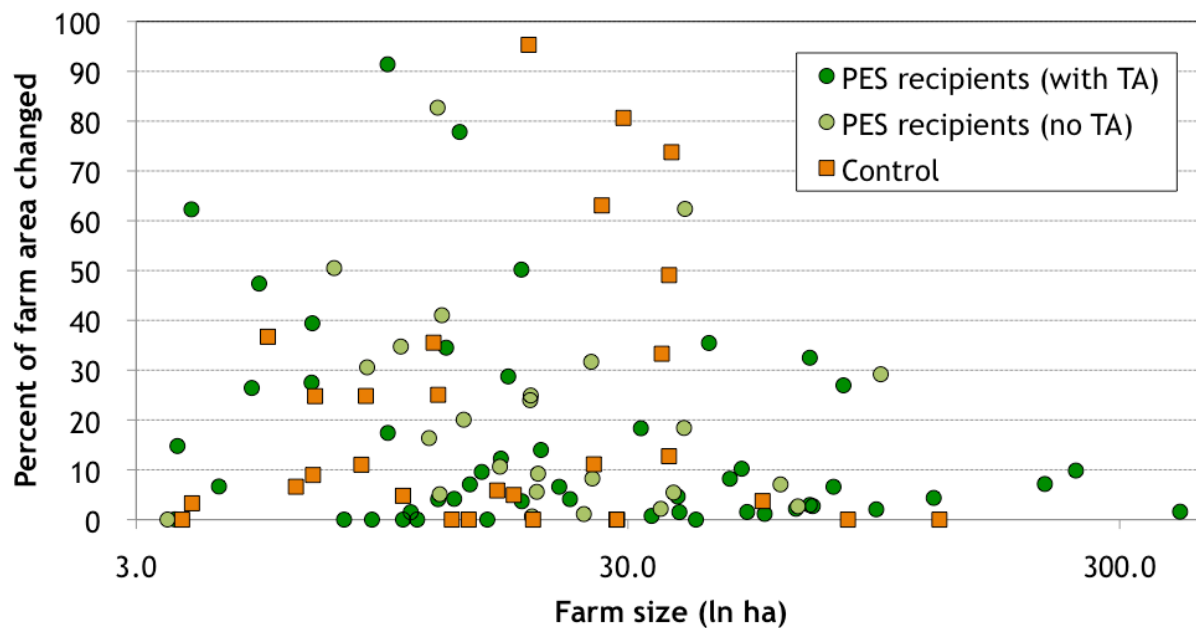
Land use changes in the post-project period among former control households were somewhat larger in terms of area, but very limited in terms of their extent, with a significant fall (over 13 percent of their farm area) in the area under degraded pasture, most of which was converted to semi-permanent crops—primarily un-shaded perennials (Figure 3). Indeed, observed changes among former control households are driven by a small number of farms converting areas of degraded pasture to semi-permanent crops—a land use change the Silvopastoral Project had not emphasized as it brings very limited environmental improvements. There was very limited adoption of any silvopastoral practice, with the sole exception of pastures with low tree density (adopted on less than 4 percent of their farm area).

As a result of these changes, the overall ESI/ha of former PES recipients declined slightly (by less than 2 percent), and that of control households increased (by almost 9 percent) but neither change was statistically significant (Figure 2).



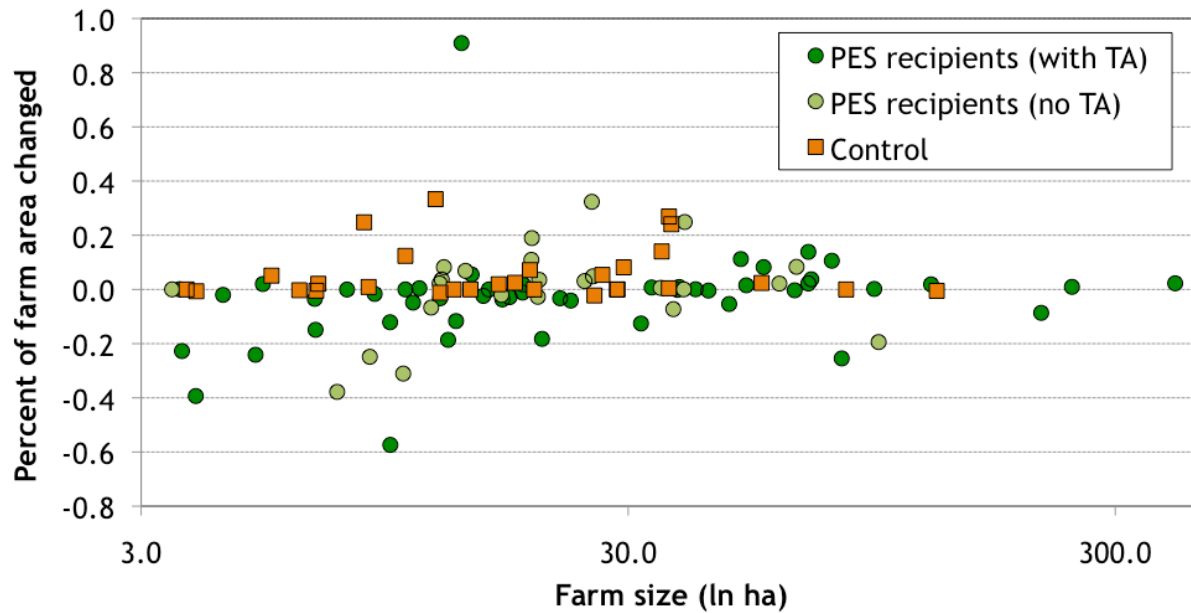
Source: Computed from Silvopastoral Project data

Figure 3: Land use changes after the Silvopastoral Project in Quindío, 2007 to 2001



Source: Computed from Silvopastoral Project data

Figure 4: Post-PES land use changes in Quindío, Colombia, by farm size



Source: Computed from Silvopastoral Project data

Figure 5: Post-PES changes in ESI/ha in Quindío, Colombia, by farm size

The observed changes are concentrated among a small group of farmers: 56 percent of PES recipients and 48 percent of control households changed less than 10 percent of their farm area, while 9 percent of PES recipients and 14 percent of control households changed more than half of their farm area. The households which did make substantial changes appear to have little in common, however. As can be seen in Figure 4, for example, there is no obvious relationship between farm size and the extent of post-PES land use changes (in terms of proportion of farm area converted), among either PES recipients or control households; being a TA recipient also does not appear to have made a difference. Likewise, as can be seen in Figure 5, there is no correlation between farm size and whether the changes made are environmentally beneficial (as measured by changes in the ESI). Both the positive and the negative outliers in terms of environmental impacts of post-PES changes, for example, are former PES recipients who had received TA. Econometric analysis confirms that having been a PES recipient had no statistically significant impact on post-project changes. Income levels are likewise non-significant.

The case of intensive silvopastoral systems

The evolution of intensive silvopastoral systems (iSPS) is of particular interest, as this practice is considered particularly promising in terms of environmental and economic benefits. While costly and technically complex to implement, it can raise carrying capacity from about half a head of cattle per hectare under extensive grazing to as much as five head per hectare. Prior to the project, the practice had been completely unknown in the area. During the course of the Silvopastoral Project, iSPS was adopted by 26 PES recipients (a third of the total) on 130ha, with areas ranging from 0.1ha to over 43ha, representing between nearly 0 and over 55 percent of their farm areas, as well as by one control household (on 21.5ha, or 75 percent of its farm) (Figure 6). iSPS adopters included some of the smallest farms and some of the largest. Non-adopters were also found throughout the size range. The largest areas of iSPS were found on larger farms, but smaller farms adopted iSPS on relatively larger shares of their farm areas. Both poor and well-off households were represented among iSPS adopters. Poorer households adopted iSPS on smaller areas, but differences in the portion of farm area dedicated to iSPS were not statistically significant. These results suggested that iSPS could be profitable even without PES. Based on these results, a follow-up project at first did not offer any payments for iSPS adoption, only credit and TA.

In the four years following the end of the project, the overall area under iSPS increased by over 7 percent, seemingly confirming this result. This average, however, masks considerable variation: Of previous adopters, 5 households did not change their area under iSPS, 9 households abandoned iSPS entirely, 9 households reduced the area under iSPS (with the biggest reduction being less than 3ha), and 4 households increased the area under iSPS (by an average of 7ha) (Figure 7). Moreover, 3 previous PES recipients and one control household that had not adopted iSPS under the project did so after the project's end, on an average of 1.5ha.

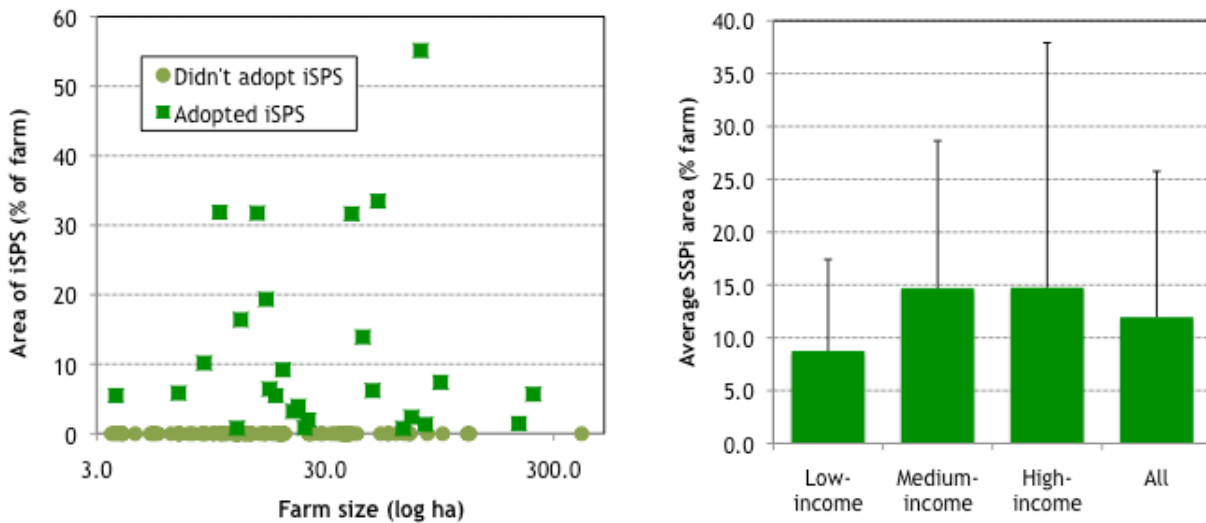
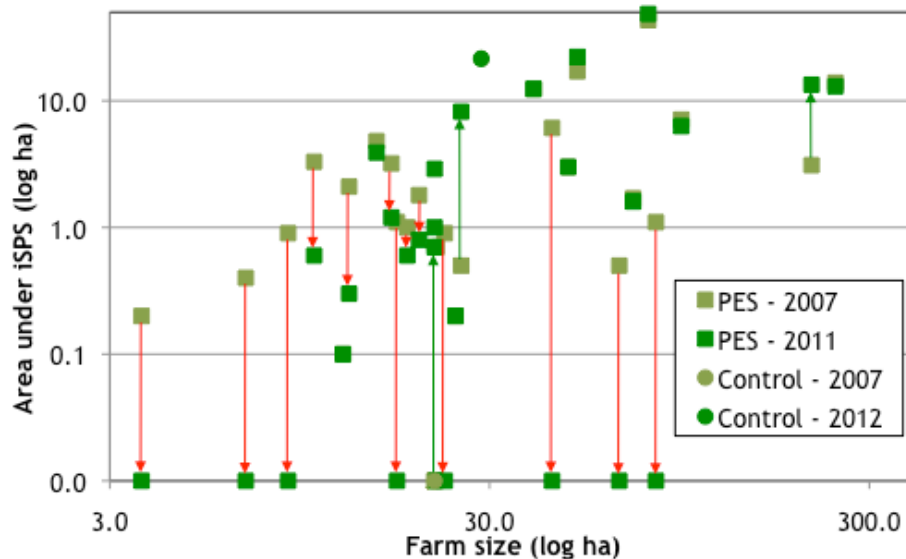


Figure 6: Adoption of iSPS during Silvopastoral Project, 2003-2007, by farm size and income level (PES recipients only)



Source: Computed from Silvopastoral Project data

Figure 7: Change in iSPS area, 2007-2011, by farm size (iSPS adopters only)

5. Discussion

PES recipients undertook substantial land use changes in the years in which they were receiving payments, far exceeding the changes undertaken by control households in terms of both quality and quantity. In an equivalent period following the end of the project, however, they undertook only minor land use changes. These results show that beneficial land uses adopted under the PES program were retained even after payments ceased. On the other hand, we do not see evidence that

adoption of these land uses continued spontaneously on any significant scale even in the absence of payments, as had been hoped.

That silvopastoral practices have not been abandoned after payments ceased strongly suggests that at the study site they are, in fact, more profitable than alternative land uses *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 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, the payments ‘tipped the balance’ towards adoption. Other possible explanations for the lack of adoption of silvopastoral practices are inconsistent with the observed results. 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 practically non-existent in the landscape. After four years in which the use of silvopastoral practices expanded dramatically in the Quindío area, these explanations are no longer plausible. If these 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.

The observed changes in land use among former control households also support these conclusions. Lack of knowledge about silvopastoral practices can no longer be blamed, as by 2011 control households had ample time to observe such practices; indeed, some of them had adopted silvopastoral practices themselves. Lack of experience is superficially more plausible as an explanation, as these households never received TA nor even basic guidance on selecting appropriate practices. But, again, such inexperience did not prove absolute obstacles as several control households have implemented silvopastoral practices—including, in two cases, the most complex practices on offer (iSPS).

6. Conclusions

The Silvopastoral Project was the first PES program to have a control group that was monitored from before the treatment began, which allowed strong conclusions to be reached concerning its effectiveness. It is also the only such program in which additional data was collected on results several years after the project ended, allowing the permanence of its results to be assessed.

The experience of the Silvopastoral Project in Quindío indicates that the PES program 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: land uses adopted under the PES program were not abandoned once payments ended.

In addition to the obvious dangers of generalizing from a single result, it is important to note the limitations of these conclusions. First, it should be emphasized 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 at pure conservation activities. These results should not create any expectation that “use-restricting” PES programs aimed at conserving existing environmentally-beneficial land uses could be sustainable without payments. In fact, if the land uses supported by such a use-restricting program were maintained after payments cease, it would likely indicate that the program was non-additional. Second, even among “asset-building” programs, the Silvopastoral Project was unusual in offering a very broad menu of options. Farmers were thus able to select the land uses that were best suited to their conditions, and were thus are less likely to find them a poor fit once payments end.

In addition to showing that PES-induced land use changes were sustainable, these results are also useful in that they help improve our understanding of the reasons why the original project was successful. That environmentally-beneficial land uses expanded rapidly when payments were offered for their adoption 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. Again, this is not to say that these alternative hypotheses may not be correct in other cases.

A follow-up project, the *Mainstreaming Sustainable Cattle Ranching Project*, is now being implemented in Colombia by the World Bank with the support of the GEF and of the United Kingdom’s Department of Energy and Climate Change (DECC). This project, which promotes similar land use changes and uses a similar payment mechanism, is being implemented at five sites across the country, under a range of agro-ecological and socio-economic conditions. It, too, will be the subject of an impact evaluation, thus further improve our understanding of the effectiveness of PES, including its long-term sustainability.

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Appendix: Environmental Services Index

Table A1: Environmental Services Index (ESI) used by the Silvopastoral Project

(points/ha except where stated)

<i>Land use</i>	<i>Carbon index</i>	<i>Biodiversity index</i>	<i>Environmental services index</i>
Annual crops	0.0	0.0	0.0
Degraded pasture	0.0	0.0	0.0
Natural pasture without trees	0.1	0.1	0.2
Improved pasture without trees	0.4	0.1	0.5
Semi-permanent crops (plantain, sun coffee)	0.2	0.3	0.5
Natural pasture with low tree density (<30/ha)	0.3	0.3	0.6
Natural pasture with recently planted trees (>200/ha)	0.3	0.3	0.6
Recently established or frequently pruned live fences	0.3 ^a	0.3 ^a	0.6 ^a
Improved pasture with recently planted trees (>200/ha)	0.4	0.3	0.7
Monoculture fruit tree plantation	0.4	0.3	0.7
Gramineous fodder bank	0.5	0.3	0.8
Improved pasture with low tree density (<30/ha)	0.6	0.3	0.9
Fodder bank with woody species	0.5	0.4	0.9
Natural pasture with high tree density (>30/ha)	0.5	0.5	1.0
Multi-story live fence or windbreak	0.5 ^a	0.6 ^a	1.1 ^a
Diversified fodder bank	0.6	0.6	1.2
Monoculture timber plantation	0.8	0.4	1.2
Shade-grown coffee	0.7	0.6	1.3
Improved pasture with high tree density (>30/ha)	0.7	0.6	1.3
Bamboo (<i>guadua</i>) forest	0.8	0.5	1.3
Diversified timber plantation	0.7	0.7	1.4
Early secondary growth (<i>tacotal</i>)	0.8	0.6	1.4
Riparian forest	0.7	0.8	1.5
Intensive silvopastoral system (iSPS)	1.0	0.6	1.6
Disturbed secondary forest	0.9	0.8	1.7
Secondary forest	1.0	0.9	1.9
Mature forest	1.0	1.0	2.0

Source: CIPAV (2003)