Can the Poor Participate in Payments for Environmental Services?: Lessons from the Silvopastoral Project in Nicaragua

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ABSTRACT. This paper uses data from a Payments for Environmental Services (PES) project being implemented in Nicaragua to examine the extent to which poorer households that are eligible to participate are in fact able to do so, an issue over which there has been considerable concern. The study site provides a strong test of the ability of poorer households to participate as it requires participants to make substantial and complex land use changes. The results show that poorer households are in fact able to participate—indeed, by some measures they participated to a greater extent than better-off households. Moreover, their participation was not limited to the simpler, least expensive options. Extremely poor households had a somewhat greater difficulty in participating, but even in their case the difference is solely a relative one. Transaction costs may be greater obstacles to the participation of poorer households than household-specific constraints.

SUMMARY. As the use of Payments for Environmental Services (PES) approaches in developing countries has grown, concern has arisen over the ability of poorer households to participate. This paper examines this concern with data from the Matiguás-Río Blanco area, where the Regional Integrated Silvopastoral Ecosystem Management Project is using PES to encourage the adoption of silvopastoral practices in degraded pastures areas. The Silvopastoral Project offers a strong test of poor households' ability to participate in PES, as many of the measures it supports are both expensive and technically challenging to implement. At the same time, however, the project also offers several easier and cheaper options. Should either investment requirements or technical capacity prove to be formidable obstacles for poorer households, there would be a clear division in the types of PES-supported activities they implement. The study area is characterized by high levels of poverty, with most households falling below the poverty line, and many below the extreme poverty line.
The experience of the Silvopastoral Project in Matiguás-Río Blanco indicates that poorer households are able to participate in a PES program—indeed, by some measures they

participated to a greater extent than better-off households. Nor was their participation limited to the simpler, least expensive options: poorer households tended to implement more substantial changes in land use. Extremely poor households do appear to have had somewhat greater difficulty in participating, but even in their case the difference is solely a relative one. Extremely poor households not only were not shut out, but participated at high rates in the project. And again their participation was not limited solely to the simpler and cheaper practices. These results are particularly strong in that the Silvopastoral Project imposes much greater burdens on participants than most PES programs.

Our results help us identify several specific factors that tend to affect participation, suggesting ways to design PES programs so as to reduce obstacles to participation by the poor. The availability of credit or other financing sources may well be important when, as in the Silvopastoral Project, participation in PES requires initial investments. The need for technical assistance is less clear from our results, though this may be due to the practices promoted by the PES program being already relatively well known in the area. The availability of multiple participation options can also help, as it allows households to choose the options that work best for them, in light of their particular constraints.

In general, transaction costs are likely to be a bigger threat to the participation of poorer households in PES programs then their own ability to participate. Even if poorer households participate more intensively (in terms of share of their land converted), their contribution to the absolute increase in environmental service generation is often limited by the small size of their holdings. As transaction costs are largely per contract rather than per unit of environmental service provision, PES programs are likely to find it attractive to focus on large land holdings. Keeping transaction costs low—in addition to being desirable in itself—is thus imperative if poorer households are not be shut out of many PES programs.

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1. Introduction

Recent years have seen considerable interest in using Payments for Environmental Services (PES) to finance conservation in developing countries (Landell-Mills and Porras, 2002; Pagiola *et al*., 2002; Wunder, 2005; Pagiola and Platais, forthcoming). The PES approach is a market-based approach to conservation financing 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 should be compensated for providing them. The approach seeks to create mechanisms to arrange for transactions between service users and service providers that are in both parties' interests, thus internalizing what would otherwise be an externality. The PES approach is attractive in that it (i) generates new financing, which would not otherwise be available for conservation; (ii) is likely to be sustainable, as it depends on the mutual self-interest of service users and providers and not on the whims of government or donor funding; (iii) is likely to be efficient, in that it conserves services whose benefits exceed the cost of providing them, and does not conserve services when the opposite is true.

Latin America has been particularly receptive to the PES approach. PES programs are in operation in Colombia (Echevarría, 2002b), Costa Rica (Pagiola, 2005), Ecuador (Echevarría, 2002a; Alban and Wunder, 2005), El Salvador (Díaz *et al*., 2002), Mexico (Muñoz *et al*., 2006), and others are under preparation or study in several countries. The World Bank is supporting the implementation of PES mechanisms in several countries, including Colombia, Costa Rica, El Salvador, Mexico, Nicaragua, and South Africa, and helping prepare additional projects that use the approach in the Dominican Republic, Panama, Venezuela, and Kenya.

As use of PES approaches grows, there is a need to understand how they affect the poor. Many have assumed that PES will contribute to poverty reduction by making payments to poor land users, while others have warned of potential dangers (Kerr, 2002; Landell-Mills and Porras, 2002; Pagiola *et al*., 2002; Grieg-Gran *et al*., 2005; Pagiola *et al*., 2005). There has been little empirical verification to date, however. A recent review of the potential linkages between PES and poverty (Pagiola *et al*., 2005) raised three key questions: (1) Who are the actual and potential participants in PES programs, and how many of them are poor? (2) Are poorer households able to participate in PES programs? And (3) are poor households affected indirectly by PES programs?

This paper uses data from a PES project being implemented in Nicaragua to examine the second of these questions: whether poorer households that are eligible to participate in a PES program are in fact able to do so. PES programs pay participating households 'upon delivery' of the desired environmental services (or rather, of land use that are expected to generate the service). The difficulty and cost of the required actions may well prevent poorer households from undertaking them.

The Matiguás-Río Blanco area in Nicaragua provides an interesting setting to study the participation of poor households in a PES program. This area is one of the pilot sites for the Regional Integrated Silvopastoral Ecosystem Management Project, which is using PES to encourage the adoption of silvopastoral practices in degraded pastures areas. This PES program offers a wide range of participation options, ranging from simple and inexpensive land use changes to substantial and complex changes (with correspondingly higher payments). We are thus able to go beyond examining binary participation/non-participation decisions and look at intensity of participation. That some of the choices offered by the project are complex and onerous provides a particularly strong test of poorer households' ability to participate. Moreover, the study area is characterized by high levels of poverty, with most households falling below the poverty line, and many below the extreme poverty line.[1]

We begin by discussing the factors that might hinder poorer households' ability to participate in PES projects, drawing on the review by Pagiola *et al*. (2005) and on the rich literature on technology adoption by smallholders in developing countries, many of whose lessons are relevant to PES. We then describe the Silvopastoral Project and the Matiguás-Río Blanco area. We use data collected at the study site to analyze participation patterns, with particular attention to participation by poorer households. We first examine the extent to which different groups of households participate, and then undertake an econometric analysis to determine the factors that affect participation decisions. We then discuss the implications of our results for the design of PES programs.

2. Constraints to the participation of poor households in PES programs

PES programs pay land users to maintain or switch to land uses that provide environmental services that others value. Participation is voluntary, and participants receive payments for doing so. This creates a *prima facie* presumption that participants are at least no worse off by joining than they would be by not joining. Were this not the case, they could simply decline to participate. PES payments, in addition to covering opportunity costs, have the further advantage of being highly predictable. Unlike returns to crop production, which vary with weather and market conditions, payment amounts are fixed for the duration of the contract (as long as participants comply with its terms). PES programs have thus often proven highly attractive to land users. About three times more land is typically offered to Costa Rica's and Mexico's PES programs every year than available funding can cover (Pagiola, 2005; Muñoz *et al*., 2006).

The potential impacts of PES programs will only be realized by those who participate. The literature on technology adoption and program participation provides many insights into the factors likely to affect participation (Feder *et al*., 1985). The literature on adoption of agroforestry practices (Pattanayak *et al*., 2003; Mercer, 2004) is particularly pertinent here, as the practices promoted by the Silvopastoral Project are very similar. Pagiola *et al*. (2005) group the factors that might affect a household's decision to participate in a PES program into three categories: factors that affect eligibility to participate; factors that affect households' desire to participate; and factors that affect their ability to participate. The three categories form a logical sequence (ability to participate only become an issue for households that wish to do so, and that in turn is only relevant for households that are eligible to participate). In this paper, we focus on examining the factors that affect the participation of eligible households, and particularly on how they affect the participation of poorer households.

Eligibility to participate is affected by the program's targeting and by requirements it may impose. Thus Costa Rica's PES program requires applicants to be located in a priority

[1] We focus here on participation by service providers. In some cases, there may be concern over the impact of PES programs on poor households that are service users (Pagiola *et al*., 2005). This concern does not arise in the project discussed here, however, as the benefits sought are global in nature and payments to participants are made with funding from the global community, as represented by the Global Environment Facility (GEF).

conservation area (based primarily on biodiversity criteria) or in a watershed covered by an agreement with an individual water user, and to meet a variety of requirements (such as not being in arrears with the country's social security system). For a time, it required most participants to have land titles; this requirement has now been eliminated (Pagiola, 2005). Similarly, Mexico's PES program defines eligible areas in terms of their importance to water supplies and other criteria (Muñoz *et al*., 2006).

Some of these eligibility requirements may well affect the poor differentially. As most of Mexico's remaining forests are in land owned by poor *ejidos*, the fact that Mexico's PES program focuses on conserving existing forests means that many participants will be poor. More generally, geographic targeting has often been assumed to favor the poor, as most of the poor tend to be found in rural areas, and particularly in marginal areas such as the steep slopes of the upper watersheds (CGIAR, 1997; Heath and Binswanger, 1996). There have been few efforts to document this presumed spatial correlation between poverty and service provision, however, and these show mixed results. For example, Nelson and Chomitz (2002) find that watersheds in Guatemala and Honduras where substantial active deforestation is occurring on steep slopes tend to have the highest concentration of poverty. Conversely, Pagiola and Colom (2006) find very little correlation between poverty rates and the importance of an area for water service provision in Guatemala. Other eligibility requirements may also affect the poor differentially. Costa Rica's requirement that applicants have land titles tended to shut out poorer land users while it was in force (Pagiola, 2005).

The eligibility of poorer households will thus likely often be an important consideration. It is not an issue in our study, however, as we focus on an area that was selected for inclusion in the project. Moreover, as noted below, we only look at participants, who are by definition eligible.

Assuming that a given household is eligible to participate, the next question is whether it desires to participate. This is likely to depend primarily on whether it expects to be better off as a result. Previous analyses confirm the significance of factors that tend to affect the benefits or the costs of participation, such as prices faced, farm characteristics, and the opportunity cost of household labor, the fit in the farming system, or the risk involved (Pattanayak *et al*., 2003). Factors such as slope, for example, can affect the extent to which productivity is threatened under current practices, thus increasing incentives to adopt land uses that are less vulnerable to degradation. As developing-country PES programs typically offer fixed payments per hectare for adopting a given practice, the payment itself is unlikely to differentially affect the desirability of participation across households.[2]

A household may want to participate in a PES program and yet be unable to do so, for a variety of reasons. Participation in a PES program requires adoption of the land uses promoted by the program. This may be simple, if the program calls for retaining existing land uses (as in the Costa Rica program's forest protection contract), or it may be complex, if the program calls for switching to new practices (as in the Silvopastoral Program studied here). Tenure issues are often critical, particularly in cases where PES programs require long-term investments, such as

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[2] A possible exception to this statement might result if differences in risk aversion and in the risk profile of the household's other activities lead some household to value the certainty of PES payments more than others. Although there is a substantial literature on farm household behavior under risk, there has been no empirical studies to date of their perception of PES payments, to our knowledge.

reforestation or adoption of silvopastoral practices. Tenure variables were significant in 72% of agroforestry adoption studies that included them, with greater tenure security being consistently associated with greater adoption (Pattanayak *et al*., 2003). In Costa Rica, both Thacher *et al*. (1997) and Zbinden and Lee (2005) found tenure-related variables to be highly significant in explaining participation in the country's PES program and its predecessors. Programs that require adoption of new practices may also face technical or financial constraints. When the new practices to be adopted are complex, access to technical assistance may be an issue. Access to extension was found to significantly affect agroforestry adoption in 90% of studies that included it (Pattanayak *et al*., 2003). This was the case in two studies in Costa Rica, for example (Thacher *et al*., 1997; Zbinden and Lee, 2005). Adopting new land use practices may also prove difficult if households cannot finance the necessary investment. Savings, remittances, or off-farm income may help some households undertake the necessary investments. Assets and credit both tend to increase adoption of agroforestry practices, and their role is very often significant (Pattanayak *et al*., 2003).

Many of the factors that affect a household's ability to participate in PES may well be more salient for poor households. Poorer households are less likely to have secure tenure, tend to have fewer savings and less access to credit, and are less likely to receive technical assistance (de Janvry and Sadoulet, 2000; López and Valdés, 2000). Whether poor households will be able to participate in PES programs (assuming that they are eligible and interested in doing so) is thus a legitimate source of concern.

Worries that poorer households may not be able to participate in PES programs have been heightened by recent case studies in Costa Rica indicating that many participants in that country's PES program are relatively well-off (Ortiz Malavasi *et al*., 2002; Miranda *et al*., 2003; Zbinden and Lee, 2005). In Mexico, better-off *ejidos* were over-represented in terms of their participation in that country's PES program, while very highly marginalized *ejidos* were substantially under-represented (Muñoz *et al*., 2006).

3. The Silvopastoral Project

The Regional Integrated Silvopastoral Ecosystem Management Project is piloting the use of PES in three areas: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua (Pagiola *et al*., 2004). The project is financed by a US$4.5 million grant from the Global Environment Facility (GEF), though the World Bank. It is being implemented in the field by local non-governmental organizations (NGOs). In Nicaragua, this work is being conducted by Nitlapan, an NGO affiliated with the Central American University.

Silvopastoral practices, which combine trees with pasture, offer an alternative to prevalent cattle production systems. Cattle production has long been an important cause of the loss of natural habitat and biodiversity in Central America (Downing *et al.*, 1992; Kaimowitz, 1996). In addition to the environmental problems caused by the initial loss of forest, extensive grazing often suffers from loss of soil fertility and diminishing grass cover, resulting in soil erosion, contamination of water supplies, air pollution, and landscape degradation. Lower income for producers results in continuing poverty and can lead to pressure to clear additional areas.

Silvopastoral practices include (1) planting high densities of trees and shrubs in pastures, thus providing shade and diet supplements while protecting the soil from packing and erosion;

(2) cut and carry systems, in which livestock is fed with the foliage of specifically planted trees and shrubs ('fodder banks') in areas previously used for other agricultural practices; and (3) using fast-growing trees and shrubs for fencing and wind screens. These practices provide deeply rooting, perennial vegetation which is persistently growing and has a dense but uneven canopy.

The on-site benefits of silvopastoral practices to 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). These benefits can be important, but 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% (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.

Because of their increased complexity relative to traditional pastures, silvopastoral practices also have important biodiversity benefits (Dennis *et al*., 1996; Harvey and Haber, 1999). 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. 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 *et al*., 1994; Pfaff *et al*., 2000). Both biodiversity and carbon sequestration benefits are off-site, however, so land users will tend not to include them when they decide which practices to adopt. Silvopastoral practices can also affect water services, though the specific impact is likely to be site specific (Bruijnzeel, 2004). GEF funding for the Silvopastoral Project is based on the desire to secure these biodiversity and carbon sequestration benefits.

Most PES programs focus on very few land uses. Costa Rica's program, for example, pays for conserving existing forest and for establishing timber plantations (Pagiola, 2005).[3] But pastures with low tree density provide fewer biodiversity and carbon benefits than pastures with higher tree density. Likewise, biodiversity benefits will be greater when a variety of native species with different canopy heights is used. To encourage adoption of more beneficial practices, the Silvopastoral Project offers payments that are proportional to the level of services provided. To do so, it developed indices of the biodiversity conservation and carbon sequestration services that different land uses provide, then aggregated them into a single 'environmental services index' (ESI).[4] The project distinguishes 28 different land uses,[5] each with its own ESI score, and pays participants according to the change in total ESI score over their entire farm area.

PES will have the desired effect only if they influence land use decisions appropriately. Silvopastoral practices tend to be unattractive to land users, despite their long-term benefits, primarily because of their substantial initial investment and because of the time lag between investment and returns. This leads to the hypothesis that a relatively small payment provided

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[3] An agoforestry contract has recently been added, based in part on the example of the Silvopastoral Project.

[4] The ESI is described in detail in CIPAV (2003) and Pagiola *et al*. (2004).

[5] Not all of these land uses are relevant for the Nicaragua site.

early on could 'tip the balance' between current and silvopastoral practice, by increasing the net present value of investments and reducing the initial period in which these practice impose net costs on land users.[6] By the time payments end, the silvopastoral practices themselves will begin generating income for land users. The payments also alleviate the liquidity problems faced by many land users and help them finance the required investments. Based on this analysis, the project provides payments of US$75 per incremental ESI point, per year, over a four-year period. In addition, participants receive a one-time payment of US$10/point for the baseline points.

The Silvopastoral Project offers a strong test of ability to participate, as many of the measures it supports are both expensive and technically challenging to implement. Table 1 shows the estimated investment costs of some of the practices concerned at the study site. Many of these practices are also technically complex. Choice of species and appropriate management can have a significant impact on their benefits. At the same time, however, the project also offers several easier and cheaper options. Should either investment requirements or technical capacity prove to be formidable obstacles for poorer households, there would be a clear division in the types of PES-supported activities they implement.

4. Study site

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

Land use in the watershed is dominated by extensive grazing.[7] As shown in Table 2, pastures account for about 63% of the area. Of this, about half is degraded pasture, and a little over a quarter has either no or few trees. Annual crops make up a very small part of total area. It is noteworthy that some forest remains, accounting for about 20% of total area; most of this is riparian forest. It is also noteworthy that silvopastoral practices, though not common, were not unknown even before the project: there were some 550ha of pastures with high tree density, and 88ha of fodder banks, for example. Farms range in size from 10-30ha to a few of over 60ha. Most households are poor, with many falling below Nicaragua's extreme poverty line.

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6 It is important to note, however, that payments in PES programs should generally be on-going rather than finite. The use of short-term payments in the Silvopastoral Project means that the conditionality of payments is limited to the first few years, which may well affect the Project's long-term impact. Indeed, this limited conditionality has led some to question whether the Silvopastoral Project should be considered PES at all. Although there is at present no generally accepted definition of PES, all available formal definitions (Pagiola and Platais, forthcoming; Wunder, 2005) consider conditionality a key aspect of PES programs. We believe that the Silvopastoral Project can be considered a PES program in that it pays service providers based on their (expected) provision of environmental services, with funding provided by a representative of service users. Payments are not based on the cost of implementing land use changes (as in traditional subsidies to natural resource managements investments), but are proportional to expected service delivery and conditional on having undertaken activities expected to provide the desired services. Nevertheless, the Project's limited conditionality may well affect the long-term viability of the mechanism at this site, as we discuss in more detail in a separate paper (Pagiola *et al.*, in review). The use of short-term payments is not pertinent to the issue considered in this paper, which focuses on the extent of participation, and whether poverty affects it.

7 In the discussion that follows, all figures refer only to the area managed by project participants. This area accounts for about 60% and 40% of total area in the Bulbul and Paiwas microwatersheds, respectively.

5. Data collection

To examine participation decisions, we used three data sets. The first is the baseline survey conducted in October-November 2002, during project preparation. This survey included very detailed information on household characteristics. A second survey of participants was conducted in March-May 2004, after the first year of project implementation. This survey collected information on land use changes that occurred in the intervening period.[8] Our analysis only includes participants with information in both surveys, giving us a total of 103 observations. Information from these two surveys was then complemented with detailed land use data for each farm, derived from maps prepared annually by the project for each farm using remote sensing imagery.[9] These maps gave us more accurate and consistent measures of area than data from the surveys, and ensured that land uses were classified consistently into the project's categories.

Both the baseline and follow-up surveys included a control group, as does the mapping dataset. The main intended purpose of this group was to attempt to distinguish project-induced land use changes from changes induced by other factors, as recommended by Ferraro and Pattanayak (2006). Upon analysis, however, control group members were found to differ from participants in many important characteristics (such as income, farm size, or herd size). As project participants make up a large proportion of all households in the two microwatersheds in the project area (65% in Bulbul and 35% in Paiwas), non-participants had to be sought elsewhere. Unfortunately, they were poorly chosen. Because of these differences, we decided that using the control group would not be useful. Our analysis, therefore, focuses entirely on participants.

As our interest is on the ability of poorer households to participate, measuring household income is critical. We computed household income by adding all income sources reported by participants, including net income from agricultural, forest, and dairy production; livestock sales; off-farm work; net income from non-farm enterprises; and remittances. Dairy, agricultural, and forest products consumed by the household are included in the calculation of income using market prices, and the value of family labor is imputed using local wage rates for unskilled labor. Expenditure is generally preferred over income as an indicator of household welfare, as it tends to be less variable (Ravallion, 1992). However, the baseline survey only collected data allowing income to be computed. Moreover, these data are based largely on information self-reported by the farmers, and so are subject to both recall problems and possible biases. As our primary interest is in assessing differences in participation within our sample, these biases are unlikely to affect our results as long they are similar across income groups. We used our estimates of household income per capita to classify households into three groups using the poverty lines given in the World Bank's (2003) report on poverty in Nicaragua: those with incomes below the extreme poverty line ("extremely poor"), those with incomes between the extreme poverty line and the poverty line ("poor"), and those with incomes above the poverty line ("non-poor").[10]

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8 The questionnaires for both surveys are available from the authors on request.

9 Quickbird imagery with a 61cm resolution was used, providing very high levels of detail. Land use maps for each farm derived from these images were then extensively ground-truthed to match each plot to one of the 28 different land uses recognized by the project.

10 The report classified individuals with income per capita in 2001 below C$5,160 as poor and individuals with income per capita below C$2,690 as extremely poor. Adjusting for inflation between 2001 and 2003 using the consumer price index given in the World Bank's *World Development Indicators* database (2001 CPI= 1.00,

6. Participating households

All households in the area that met minimal farm and herd size criteria were eligible to participate. Participants were selected on a first-come basis until the maximum number allowed by available funding was reached. The characteristics of participating households are summarized in Table 2. The average participating household has about 31ha of land and about 30 head of livestock, of which a third are cows. The average household is composed of six members. The average per capita income of about C$4,700 is below the poverty line. Other indicators confirm the low living standards of the area's households: few have water or electricity, and education levels are very low. Agriculture is the main economic activity, with few households having off-farm income.

Figure 1 shows the distribution of participating households according to their estimated household income per capita. As can be seen, most participating households are either poor (20%) or extremely poor (46%). Even those above the poverty line cannot be characterized as wealthy (hence our term "non-poor").

Breaking down participants into income groups shows both similarities and differences. Extremely poor households have significantly less land and smaller herds than poor households, which in turn have significantly less land and smaller herds than non-poor households. Extremely poor and poor households also have larger households and more dependents per adult. They are less likely to have either electricity or water. Particularly important for what follows, they are less likely to have access to credit and extremely poor households also are less likely to have year-round access by road. On the other hand, differences in educational level and experience are minimal and not statistically significant, as are the extent of off-farm employment. The proportion of farm area that is hilly is somewhat higher for poorer households, but the difference is not significant. Likewise, access to technical assistance appears to be slightly lower the poorer the household, but differences are not statistically significant.

Although none of the participating households could be considered wealthy (even the best-off household has per capita income below US$10 a day), there are substantial differences within the group. Even US$10 a day would be riches to the 49% of households that have less than US$0.60 a person a day (the extreme poverty line). In particular, several variables that previous research has shown to have an important effect on participation, such as farm size, access to credit, and access to roads, differ significantly across income groups. Other important variable also vary across the group, though not necessarily in ways that are correlated with income.

7. Changes in land use

The Silvopastoral Project made its first payments, for baseline ESI points, in July 2003. It made its first payment for changes in land use in May 2004. Additional payments have since been made, in 2005 and 2006. Our analysis focuses on land change in the first year of the project.[11]

2003 CPI=1.09), we obtain a poverty line for 2003 of C$5,640 and an extreme poverty line of C$2,940. In 2003, US$1=C$14.25.

11 Because payments under the Silvopastoral Project are for only four years, participants have an incentive to undertake as much of their planned land use changes as possible early.

Table 3 compares land use by participants prior to the project and after the first year of the project. Overall, there was substantial land use change: 545ha (over 17% of the total area) experienced some form of land use change. A wide variety of changes were observed, ranging from minor changes such as sowing improved grasses in degraded pastures to very substantial changes such as planting high-density tree stands or establishing fodder banks.[12] The area of degraded pasture experienced the largest fall, being reduced by over half (467ha of the original 869ha), and the area of annual crops also fell by almost a third (70ha of the original 232ha). Pastures with low tree density experienced a net increase of 228ha, and pastures with high tree density of 201ha (in addition, substantial areas of natural pastures with either low or high tree density were sown with improved grasses). There was also a substantial increase in the area devoted to fodder banks (66ha, almost doubling the original area). These changes are also illustrated in Figure 2. Overall, these changes increased the total ESI score of participants by 25%.

Figure 2 breaks down observed land use changes by household income group. Poor households and extremely poor households accounted for a substantial share of land use changes. They accounted for 51% of the decline in degraded pasture and 70% of the decline in area under annual crops. Moreover, land use changes by poorer households were not limited to adopting technically simpler and less onerous practices. Extremely poor households established 40ha of fodder banks (61% of the total), for example, and poor households another 11ha (17%), compared to only 14ha (22%) by non-poor households.[13] Poor households were also responsible for the bulk of increase in pastures with high tree density (118ha, or 59%) with extremely poor households providing another 45ha (23%). Indeed, it was the non-poor who seemed to focus on the simpler practices: establishing natural pasture with low tree density was the most important single change these households made.

Table 4 examines various indices of household participation across income groups. Non-poor households converted just under 12ha each, on average, almost twice the average area converted by all poor households. Within the poor, however, there was a wide difference between poor and extremely poor households, with the former converting practically as large an area as the non-poor, and the latter considerably less. The differences shrink considerably in terms of proportion of farm area converted, arguably a better indicator of ability to participate than total area converted, as poorer households tend to have smaller farms. Although extremely poor households converted the smallest proportion of their farm of any of the groups, the difference was less marked. Poor households converted the greatest proportion of their farm. Poor and extremely poor households also increased their use of live fencing proportionally more than non-poor households. A similar pattern can be seen in the changes in ESI points: the increase is greatest in absolute terms for non-poor households, but higher in proportional terms for poor households, with extremely poor households trailing. Extremely poor households had

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[12] The lack of a proper control group prevents a comparison to land use changes elsewhere, but casual observation suggests that land use changes in nearby areas were substantially less extensive, in both area affected and degree of change. The figures quoted actually under-state the extent of change, as they show *net* changes. In addition, existing silvopastoral practices were often upgraded to more intensive practices (for example, increasing the density of trees in pastures).

[13] The popularity of fodder banks among poorer households may be due to the greater availability and lower opportunity cost of labor in such households. The cut-and-carry practices that such banks imply require substantial amounts of labor.

the highest initial ESI/ha, however, so they may have had less scope for substantial improvements.

Table 5 shows how different groups financed the investments they made, according to their responses on the first-year participant survey. Some investments were undertaken entirely with family labor and so did not require financing. The most frequently mentioned source of funds was the sale of animals (61% of all households), followed by the project's initial 'baseline' payment (53%). A fairly large proportion (41%) was able to finance investments from savings, and a surprisingly large fraction (32%) had access to credit from a local community bank. In general, there were almost no significant differences in the importance of different financing sources across income groups. Surprisingly, the poor had slightly better access to credit from private banks, but the overall importance of this financing source was minimal.

8. Household participation decisions

A simple examination of observed land use change indicates that poorer households are in fact able to participate quite extensively in this particular PES program, even though it requires some technically complex and onerous land use changes. To shed further light on participation decisions and the factors that may affect them, we undertook an econometric analysis of participation rates.

The literature on adoption decisions usually looks at the binary choice of whether or not to adopt a given practice, using cross-sectional data on adopters and non-adopters, and the effect of different factors on the probability of adoption (Pattanayak *et al*., 2003). This approach is not relevant in our case, for two reasons. First, the pilot nature of the Silvopastoral Project means that the participation decision is not entirely up to farm households. Project funding limited the number of participants; many non-participants wanted to participate. Second, a binary adoption/non-adoption choice would fail to capture the nature of participation in the Silvopastoral Project. Rather than participation per se, what is of interest here is the intensity of participation. The formal question we want to pose, then, is how household characteristics affect the intensity of participation, with a particular focus on whether poorer households are less able to participate than better-off households. Our approach is similar to that of Nkonya *et al*. (1997), who examined the intensity of adoption of improved seed in Tanzania using continuous variables (hectares planted with improved maize seed or amount of fertilizer applied per hectare of maize), and of Rajasekharan and Veeraputhran (2002), who examine the share of farms using intercropping in Kerala, India.

The dependent variable for our analysis can be formulated in many different ways. The simplest is the area converted: The greater the area converted, the higher the participation. Households with little land—including many poorer households—will clearly score poorly on this indicator, however. Using the proportion of farm area converted avoids this problem, but faces others. Converting 5ha of land to improved practices takes greater effort than converting 1ha, yet if the first household has 10ha and the second only 1ha, the first household (50% converted) will appear to be participating 'less' than the second (100% conversion). However expressed, area-based indicators also fail to measure whether changes are large or small. Planting trees at a low density in a plot of degraded pasture requires substantially less effort than converting it to fodder banks, 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. The ESI is not intended as a measure of effort, but higher-ESI land uses tend to involve more effort than lower-ESI uses. This measure is also appealing as it is the outcome of interest to the 'user' of the environmental services being sought. This measure could also be stated in different ways. The increase in total ESI is the simplest measure (and is readily available, as it is the basis for payments to participants), but like the 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.

We thus ran five separate regressions, one with each dependent variable. Similar to Rajasekharan and Veeraputhran (2002)[14], we employed a one-tailed Tobit to model farm area, as this variable is restricted to non-negative values. Likewise we employed a two-tailed Tobit model to model the percentage of the farm area converted, as this ranges between 0 and 100. Change in ESI, change in ESI per hectare, and percent change in ESI can take any value, and so are modeled using ordinary least squares (OLS).[15]

Our choice of explanatory variables draws on the factors identified by Pagiola *et al*. (2005) as likely to affect participation in PES, and by Pattanayak *et al*. (2003) and the studies they cite as likely to affect adoption of agroforestry practices, with modifications for the particularities of our case. Eligibility is not an issue here, as we focus on an area that was selected for inclusion in the project. The desire to participate *per se* is also not an issue, as we are only looking at households who have chosen to participate. However, as the Silvopastoral Project offers a wide range of participation options, variables that affect desire to participate remain relevant, as they may affect the desire to undertake more intensive practices. Our main concern, however, is on factors that may impede a household's ability to participate. Within these factors, tenure is not an issue in Matiguás-Río Blanco, as the site was selected partly for the absence of such problems.

The number of explanatory variables that could be included was limited by the relatively small sample size. In this case, increasing the sample was not an option: our data include every single project participant. Fortunately, the small size of the study site means that many potential explanatory variables vary little across households, and thus can be safely omitted.[16]

Many studies have shown that farm characteristics often have an important impact on adoption decisions. Most previous studies report a positive effect of farm size on adoption of various practices, which has been interpreted as indicating higher flexibility of the farming system or the existence of economies of scale (Rajasekharan and Veeraputhran, 2002; Thacher *et al*., 1997; Nowak, 1987). Labor availability would seem likely to be important, although it is not often significant (Pattanayak *et al.*, 2003). We include a measure of the hours per week worked on the farm. We also include measures of the experience (the number of years managing the farm) and gender of the household head, to capture characteristics of the farmers themselves which have often been found to be important.

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[14] Rajasekharan and Veeraputhran (2002) employed a one-tailed Tobit to study the adoption of intercropping in three regions in Kerala, India using the share of farm area under intercropping as the dependent variable.

[15] In principle, percent change in ESI could not be less than -100%. In practice, however, this limit is not binding, as no household even approached it. Indeed, only two households had a negative change in ESI.

[16] We found no evidence of either moderate or strong muticollinerarity in any of the regression models using the Belsley *et al*. (1980) diagnostics in OLS models and the Belsley (1991) diagnostic in the Tobit models.

As our study area is small, most farms face similar prices for inputs and outputs, and have similar yield potentials. The profitability of the various silvopastoral practices should thus be broadly similar throughout the area. Two factors which do differ across farms may affect the profitability of the practices. Farmers with lower accessibility will tend to face higher input costs and lower output prices at the farm gate. We include a binary variable indicating whether a household has year-round access by road, and expect a positive association with participation. Topography could also affect the profitability of different measures, although the direction of the impact is less clear. Land on steep slopes may benefit more from silvopastoral practices in that it is more vulnerable to degradation under traditional extensive grazing. On the other hand, the cost of implementing practices may be higher. We include a variable on the percentage of farm area with hilly topography, without making any prediction as to how it will affect results.

To examine whether initial investment costs affect ability to participate, we include variables on access to credit and off-farm income. Both have often been found to be significant. Access to credit is included as a binary indicator of whether a household had access to credit during the five years prior to project implementation.[17] It is expected to be positively related with participation. Off-farm income is measured as the income share of off-farm jobs held by all household members. It can be a financing source for investment in new practices, but can also result in a higher opportunity cost of labor.

Technical complexity of adoption of many practices may be overcome with training in their implementation. Indeed, the Silvopastoral Project provided such technical assistance to a (randomly-selected) subset of participants. We include a binary indicator for whether households received such support from the Project.

As poverty is multidimensional, we also include dummies for whether households are poor (with separate dummies for poor and extremely poor households), to capture other aspects of poverty that may not be captured by the previous variables.

Table 6 summarizes the results of the analysis.[18] The first two columns report the results of Tobit models for area changed and proportion of farm changed, and the last three columns the results for the OLS models for change in ESI, percentage change in ESI, and change in ESI per hectare. Measures of model fit are relatively low, but this is not surprising with cross-sectional data, particularly when sample sizes are small. They are comparable to those obtained by Rajasekharan and Veeraputhran (2002) and Ervin and Ervin (1982).

Although relatively few explanatory variables are significant, most estimated coefficients have the expected sign, and are largely consistent with the results of other studies. As expected, farm area is positively associated with intensity. This effect is strongest in the models using

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[17] The endogeneity of credit was tested using the Wu-Hausman and Hausman tests in the OLS models and the Smith-Blundell test in the Tobit models. Exogeneity of credit was not rejected in any model at the 90% confidence level.

[18] OLS models were tested for heteroscedasticity in the error distribution using the Breusch-Pagan test. Results for these tests rejected the null hypothesis of homoscedasticity of errors, which if ignored would result in the lost of optimality of the OLS estimator (Greene, 2000; Mittelhammer *et al*., 2000). In the absence of prior information about the structure of the heteroscedasticity, we used the OLS estimator with White's heteroscedasticity-consistent covariance matrix estimator (White, 1980). We found no evidence of either moderate or strong muticollinerarity in any of the regression models using the Belsley *et al*. (1980) diagnostics in OLS models and the Belsley (1991) diagnostic in the Tobit models.

absolute measures of area adopted or ESI increases, and only significant in those cases. This is not surprising: the larger the farm, the harder it will be to convert a large share of it, offsetting the flexibility and economies of scale that size might provide. Family labor is not significant. Experience shows either a very small or a negative effect on intensity of participation, and is significant in two cases. Other studies have often usually found a positive effect, though rarely a significant one and have generally attributed it to experience reducing the risk of adoption (Pattanayak *et al*., 2003); perhaps the negative effect we find is due to older farmers being less willing to make changes.[19] Male-headed households have greater intensity of participation under all measures, but this effect is only significant in one case.

Among the factors that can affect the profitability of adoption, and hence household's desire to do so, accessibility by road has the expected positive sign, and is significant in several of the models. The proportion of the farm on hilly terrain has a negative impact, but it is not significant. As noted above, there is no strong a priori reason to expect a particular sign on this variable. Among the factors that affect the ability of households to participate in the program, access to credit also has the expected positive sign. It is interesting that it is not significant in explaining area converted but is significant in explaining increases in ESI, which requires greater effort and cost. Access to technical assistance, on the other hand, has very inconclusive and non-significant results. As shown in Table 2, none of the silvopastoral practices promoted by the project were unknown in the region. Even the more complex practices, such as fodder banks, were already in use, albeit on a small scale. Almost half of farm households had already established fodder banks, for example. That technical assistance should not be significant is thus not very surprising; many households already knew how to implement them, and the others could probably learn from their neighbors if they did not have access to technical assistance.[20]

Finally, the poverty dummies show some interesting patterns. Poor (but not extremely poor) households have consistently higher intensity of participation than all other groups, and this effect is significant in several models. Conversely, extremely poor households have a lower intensity of participation (except in one model), though this effect is not significant in any model. These results are consistent with those shown in Table 4: the group of poor households generally has higher intensity of participation than either extremely poor or non-poor households, even after accounting for a variety of factors. Explaining this result will require further analysis; one hypothesis is that poor households have fewer constraints to participation than extremely poor households, but greater desire to participate than relatively better-off households, who may have better off-farm opportunities. Our results are line with those of Bandiera (2004), who found that farmer wealth was not a significant determinant of tree cultivation in Nicaragua.

9. Conclusions

Can poorer households participate in PES programs? The experience of the Silvopastoral Project in Matiguás-Río Blanco indicates that they can. Not only did poorer households participate quite extensively, but by some measures they participated to a greater extent than better-off households. Nor was their participation limited to the simpler, least expensive options:

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19 Age and education variables gave very similar results to experience.

20 Note that this result only speaks to the impact of technical assistance on the intensity of adoption. Access to technical assistance might have other impacts, however. For example, it might result in more effective implementation of adopted practices, thus increasing their profitability.

poorer households tended to implement more substantial changes in land use. Extremely poor households do appear to have had somewhat greater difficulty in participating, but even in their case the difference is solely a relative one. Extremely poor households not only were not shut out, but participated at high rates in the project. And again their participation was not limited solely to the simpler and cheaper practices. These results are particularly strong in that the Silvopastoral Project imposes much greater burdens on participants than most PES programs.

This conclusion obviously needs to be approached with some caution. It is possible that the high levels of participation by poorer households are due to self-selection bias: only those households able to participate may have joined. We believe this is unlikely, for two reasons. First, the project offered a very wide range of participation options, including many that are not very onerous, even for poorer households. Indeed, households could in principle have done absolutely nothing; they would then have received the baseline payment but would not have received any payment beyond that. In fact, no household chose that route. Second, as noted previously, a large proportion of all households in the two microwatersheds actually participated, and many of the others wanted to participate as well, but were prevented from doing so by the project's own limits on the number it could accept. But even if there were some self-selection at play, it is significant that in a poor area such as Matiguás-Río Blanco there are many poor households—including many extremely poor households—that are able to participate in a PES program, and even to undertake expensive and technically challenging land use practices.

Nevertheless, one should not jump to the sanguine conclusion that all poor farm households everywhere will always be able to participate in PES programs.[21] Both PES programs and local conditions differ from case to case, and there may well be cases where otherwise eligible poor households may find it difficult or impossible to participate. Indeed, results in Matiguás-Río Blanco show that extremely poor households do appear to have had greater difficulty in participating as intensively as other households.

Our detailed results help us identify several specific factors that tend to affect participation. This information can help design PES programs to reduce potential obstacles to the participation of poorer households. There is little that a PES program can do about poorer farms being less accessible, but it can do something about financing constraints and technical difficulty.

The significance of credit underlines an important potential constraint for poorer households. This constraint will not always be present in PES programs. When PES programs require maintaining existing practices—as in the majority of contracts in Costa Rica's program, for example—there are no investment requirements. Financing constraints may be important when land use changes are required for participation, however, as in Costa Rica's Reforestation or Agroforestry contracts. Our results suggest that this constraint is not absolute, as it is sometimes made out to be. Even poor households such as those in Matiguás-Río Blanco often have a variety of ways to finance profitable investments, as Table 5 demonstrates. Nevertheless, it is likely that poorer households will have fewer such alternatives: fewer savings, fewer assets that might be sold, worse access to credit. Providing some initial financing (such as the baseline

21 It is also important to recall that this case study does not speak to possible differences in eligibility to participate, due to spatial considerations or tenure problems. Pagiola and Colom (2006) find that the areas in Guatemala that are important for the provision of water services do not always have high poverty rates.

payment made by the Silvopastoral Project) may be desirable for PES programs that involve initial investments in areas with many poor households.[22]

The need for technical assistance is far less clear from our results. Again, this need is only likely to arise when PES programs require participants to undertake land use changes, and even then only if these are complex or little known. In the case of Matiguás-Río Blanco, the practices being promoted by the PES program were relatively complex, but were also relatively well known in the area.

The availability of multiple options in the Silvopastoral Project may well have contributed to high participation by the poor, as they were able to choose the options that work best for them, in light of their particular constraints. When there are multiple ways of providing a service (or different levels of a service), it makes sense to offer multiple ways in which households can participate, as long as transaction costs do not increase unduly. It is interesting to note, however, that at Matiguás-Río Blanco the poorer households did not choose the cheaper and easier land uses – in fact, it was the better off households that did so.

In general, transaction costs are likely to be a bigger threat to the participation of poorer households in PES programs then their own ability to participate (Pagiola *et al*., 2005). Our results illustrate this. Consider Table 4. All poor households converted almost 25% of their farms, on average, and increased their ESI score by about 25%. These participation rates compare favorably with those of non-poor households, who converted 26% of their farms and increased their ESI score by 24%. But from the perspective of the service buyer, what matters is the absolute increase in environmental service generation (whether proxied by area, as is commonly the case, or by more sophisticated measures such as the ESI), and the unit cost of achieving it. The cost, in turn, has two components: the cost of the payment, which is identical for a given increase in ESI for all households, and the transaction cost of contracting with each household. This second cost is likely to be largely fixed per household, irrespective of farm size. Thus non-poor households converted a total of 374ha and achieved a total increase in ESI of 222 points. At first glance, poorer households did better: they converted 450ha and increased ESI by 349 points. On a per contract basis, however, the comparison is less favorable: non-poor households converted 11.7ha and increased ESI by 6.9 points per contract, while all poor households converted 6.3ha and increased ESI by 4.9 points per contract. If poor households are distinguished from extremely poor households, the contrast is even starker: extremely poor households only converted 4.2ha and increased ESI by 3.2 points per contract. The larger the transaction costs, the more attractive it will be for PES programs to focus on large land holdings. As farm size tends to be highly correlated with income, in practice this will mean focusing on better-off households. This is not a purely hypothetical concern: In Ecuador, the PROFAFOR program has decided to adopt a 50ha minimum size for the forest plantations from which it buys carbon sequestration services (Alban and Wunder, 2005).

Keeping transaction costs low—in addition to being desirable in itself—is thus imperative if poorer households are not be shut out of many PES programs.[23] But the smaller

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[22] Costa Rica frontloads payments under its timber plantation contract for this reason. Frontloaded payments, however, introduce other problems, as they reduce the conditionality of the program.

[23] The Silvopastoral Project as presently conducted is a poor example of this, as it has relatively high monitoring costs dictated in part by its pilot nature and in part by the need to distinguish small differences in land use so as

farm size of many poor households means they will always have relatively higher transactions costs. It is thus important to attempt to devise mechanisms to overcome them. Costa Rica, for example, experimented with collective contracting, under which groups of small farmers joined the country's PES program collectively rather than individually, thus spreading transaction costs over a large group. This approach ran into problems, however, as non-compliance by a single group member resulted in payments being halted to all members. The approach has thus been revised to process the applications of such groups together, but then issue individual contracts; this avoids the partial compliance problem, but has much smaller savings in transaction costs (Pagiola, 2005). This is clearly an area in which more work—and some imaginative solutions—will be necessary. This is also an area in which development aid could be used to leverage PES programs by providing support to the participation of poorer households, and in particular by underwriting some of the transaction costs involved.

to compute ESI scores. Work is underway under the project to determine the nature of the tradeoff between monitoring costs and effectiveness.

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Table 1: Establishment costs for selected silvopastoral practices, Matiguás-Río Blanco, Nicaragua

(US$/ha unless otherwise indicated)

Improved pasture without trees	180
Improved pasture with low tree density (< 30 trees/ha)	340
Improved pasture with high tree density (>30 trees/ha)	390
Gramineous fodder bank	250-270
Fodder bank with woody species	170-270
Live fence (US$/km)	110-160
'Dead' fence (US$/km)	970

Notes: Costs shown are based on switching from degraded pasture; actual costs will vary if the initial land use is different.

Source: Silvopastoral project data.

Table 2: Characteristics of participating households, Matiguás-Río Blanco, Nicaragua

Variable	*Extremely poor*	*Poor*	*Non-poor*	*All*
Farm area (ha)	21.8*,†	35.0*	41.0†	30.7
Cattle (number of heads)	20†	26‡	49†,‡	30
Cows (number of heads)	8†	10‡	18†,‡	11
Year-round access by road (%)	82.00†	85.71	96.88†	87.38
Access by paved road (%)	8.00	14.29	21.88	13.59
Hilly topography (% of farm area)	15.24	13.57	24.47	17.77
Water (% with water service)	22.00†	19.05‡	40.63†,‡	27.18
Electricity (% with electric service)	2.00†	4.76	18.75†	7.77
Household size (number of members)	7*,†	6*,‡	5†,‡	6
Family labor (hrs/week/ha)	5.57*,†	2.93*	3.00†	4.23
Dependency ratio (number of non-adults/ number of adults)	0.90†	0.69	0.55†	0.75
Male headed household (%)	88.00	95.24	96.88	92.23
Education of household head (years)	2.30	3.67	3.47	2.94
Experience (years)	10.13	13.33	12.69	11.58
Principal occupation of household head is farming (%)	82.00	90.48	87.50	85.44
Off-farm work (% with off-farm employment)	20.00	23.81	9.38	17.48
Off-farm income (% of total income)	5.53	6.09	4.08	5.19
Non-farm enterprise (% with non-farm enterprise)	16.00	9.52	25.00	17.48
Technical assistance (% with technical assistance)	64.00	76.19	68.75	67.96
Credit (% with access to credit)	44.00†	42.86‡	68.75†,‡	51.46
Assets (‘000 C$)	6.49	15.23	2.95	7.17
Net income per capita (C$)	-2,446*,†	4,109*,‡	16,173†,‡	4,675
Number of observations	50	21	32	103

Notes: *,†,‡ indicate means are significantly different in paired t-test at 10% test level.
In 2003 $1US=14.25 C$. An adult is defined as an individual >12 years.

Table 3: Land use among Silvopastoral Project participants, Matiguás-Río Blanco, Nicaragua

(ha, unless otherwise noted)

Land use	*Environmental services index (points/ha)*	*Before project (ha)*	*Before project (%)*	*First year of project (ha)*	*First year of project (%)*
0. Infrastructure, housing, and roads	0.0	5.5	0.2	5.5	0.2
1. Annual crops	0.0	231.5	7.4	161.0	5.1
2. Degraded pasture	0.0	868.9	27.7	401.5	12.8
3. Natural pasture without trees	0.2	65.0	2.1	84.5	2.7
4. Improved pasture without trees	0.5	22.4	0.7	38.3	1.2
5. Semi-permanent crops	0.5	33.0	1.1	27.4	0.9
6. Natural pasture with low tree density	0.6	333.7	10.6	448.0	14.3
11/13/17/25. Fodder bank[a]	0.8	88.3	2.8	154.1	4.9
12. Improved pasture with low tree density	0.9	137.3	4.4	250.7	8.0
7/14. Natural pasture with high tree density[b]	1.0	381.8	12.2	471.3	15.0
10/15/19. Diversified fruit crops[a]	1.1	21.1	0.7	20.1	0.6
18/22. Monoculture timber plantation	1.2	1.1	0.0	2.1	0.1
9/20. Improved pasture with high tree density[b]	1.3	167.0	5.3	278.8	8.9
23. Scrub habitats (tacotales)	1.4	154.9	4.9	157.5	5.0
24/26/27/28. Secondary and riparian forest[a]	1.7	627.9	20.0	638.6	20.3
Total area		**3,139.4**	**100.0**	**3,139.4**	**100.0**
8/16. Live fence (km)	1.1	128.5		239.0	

Notes: Totals may not add up because of rounding

Land uses recognized by the project but not found at this site are omitted.

[a] Similar land uses with small areas have been aggregated; ESI shown is for use with largest area.

[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.

Sources: ESI score from Silvopastoral Project manual (CIPAV, 2003); land use from Silvopastoral Project, based on analysis of remote sensing imagery verified in the field

Table 4: Participation rates by income group, Matiguás-Río Blanco, Nicaragua

	Total land	*Change in land use*		*Live fencing*			*Environmental services index*				
				Initial	*Increase*		*(total points)*		*(points/ha)*		*Change*
Income group	*(ha)*	*(ha)*	*(%)*	*(km)*	*(km)*	*(%)*	*Initial*	*Increase*	*Initial*	*Increase*	*(%)*
Per household:											
All poor	25.7	6.3	24.7	1.1	1.0	91.3	19.7	4.9	0.77	0.19	24.9
Extremely poor	21.8	4.2	19.2	1.0	0.8	83.2	18.0	3.2	0.82	0.14	17.5
Poor	35.0	11.5	32.8	1.4	1.4	105.5	23.8	9.1	0.68	0.26	38.1
All non-poor	41.0	11.7	28.4	1.6	1.2	77.7	29.4	6.9	0.72	0.17	23.6
All	**30.5**	**8.0**	**26.2**	**1.2**	**1.1**	**85.9**	**22.7**	**5.5**	**0.75**	**0.18**	**24.4**
Total area:											
All poor	1,826.4	450.4	24.7	77.7	70.9	91.3	1,400.2	348.5	0.77	0.19	24.9
Extremely poor	1,092.0	209.5	19.2	49.3	41.0	83.2	900.1	157.9	0.82	0.14	17.5
Poor	734.4	240.8	32.8	28.4	29.9	105.5	500.1	190.6	0.68	0.26	38.1
All non-poor	1,313.5	373.6	28.4	50.9	39.5	77.7	941.7	222.1	0.72	0.17	23.6
All	**3,139.9**	**823.9**	**26.2**	**128.5**	**110.4**	**85.9**	**2,341.8**	**570.6**	**0.75**	**0.18**	**24.4**

Sources: Computed from Silvopastoral Project mapping data.

Table 5: Financing sources for investments in silvopastoral practices, by income group, Matiguás-Río Blanco, Nicaragua

(% of households citing source as among two most important sources)

	Extremely poor	*Poor*	***All poor***	*Non-poor*	***All***
No cash needed – used family labor	46.0	38.1	**43.7**	46.9	**44.7**
Savings	44.0	33.3	**40.8**	40.6	**40.8**
Borrowed money					
▪ Private bank	2.0	9.5	**4.2***	0.0*	**2.9**
▪ Rural bank/community bank	28.0	28.6	**28.2**	40.6	**32.0**
▪ Other sources	4.0	0.0	**2.8**	0.0	**1.9**
Others	8.0	4.8	**7.0**	3.1	**5.8**
NGO projects	0.0	4.8	**1.4**	3.1	**1.9**
Sold assets					
▪ Animals	60.0	61.9	**60.6**	62.5	**61.2**
▪ Land	0.0	9.5	**2.8**	0.0	**1.9**
▪ Equipment	2.0	0.0	**1.4**	0.0	**1.0**
▪ Other	2.0	4.8	**2.8**	0.0	**1.9**
Traded services for service	6.0	14.3	**8.5**	12.5	**9.7**
Payment from Silvopastoral project	50.0	52.4	**50.7**	59.4	**53.4**
Remittances from family members abroad	2.0	9.5	**4.2**	3.1	**3.9**
Income from off-farm activities	0.0	0.0	**0.0**	6.3	**1.9**

Notes: Percentages do not add to 100 because of multiple responses.
* indicates means are significantly different in paired t-test at 10% test level.

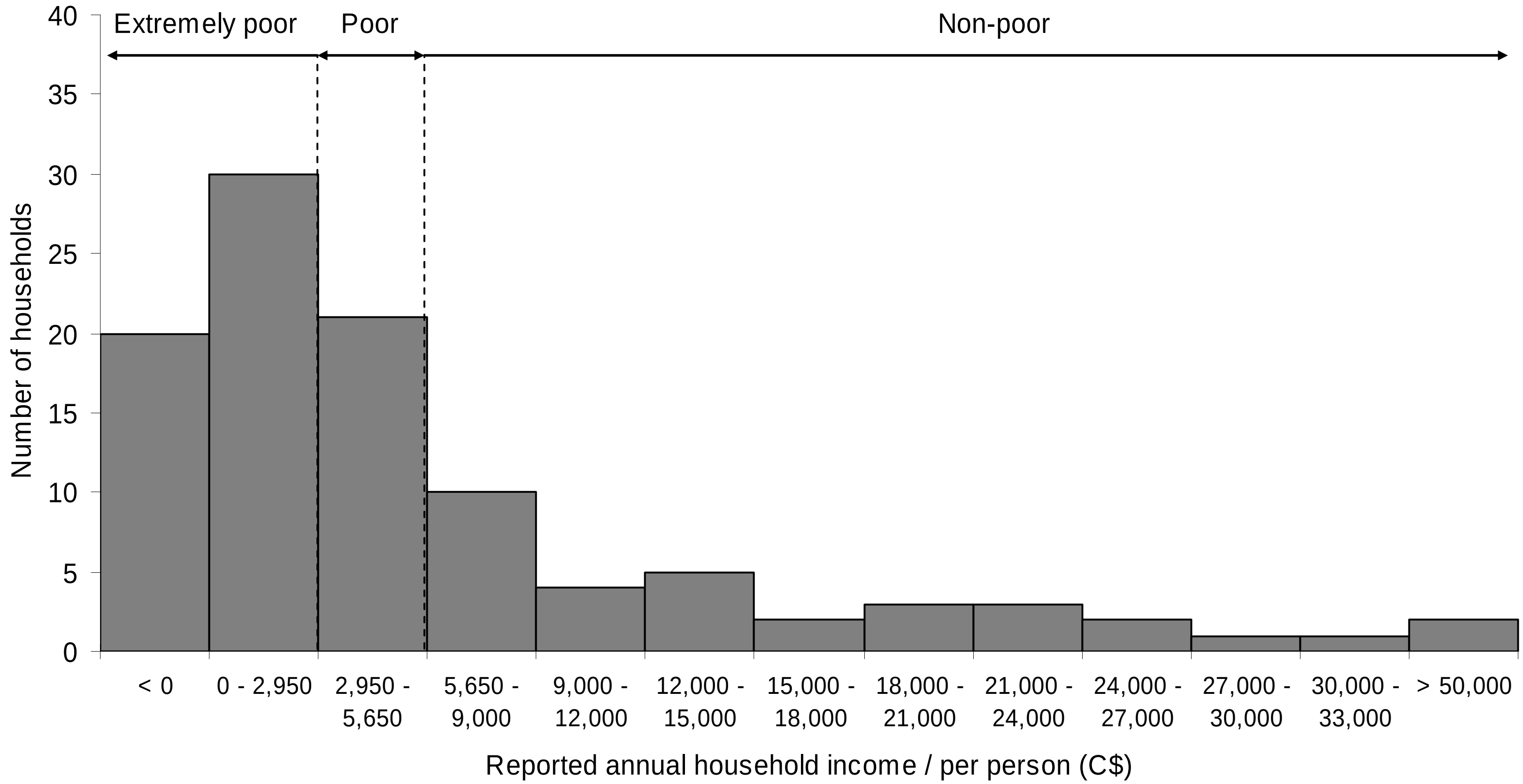
Sources: Computed from data in 1st year participant survey.

Table 6: Estimation results

Independent Variable	Dependent variable: / Model:	*Area changed (ha)*	*Proportion of farm changed (%)*	*Change in ESI (points)*	*% change in ESI*	*Change in ESI per ha*
	Model:	*Tobit*	*Tobit*	*OLS*	*OLS*	*OLS*
Constant		-4.321	4.859	-5.094*	-0.268	-0.023
		(3.726)	(10.182)	(2.761)	(18.756)	(0.068)
Farm area (ha)		0.264**	0.059	0.206**	0.026	0.001
		(0.030)	(0.081)	(0.041)	(0.156)	(0.001)
Family labor (hrs/week/ha)		0.068	0.249	0.078	-0.162	-0.001
		(0.180)	(0.492)	(0.108)	(0.893)	(0.004)
Experience (years)		0.040	-0.1328	-0.061	-1.170**	-0.003*
		(0.077)	(0.211)	(0.061)	(0.555)	(0.002)
Gender (1=male; 0=female)		2.674	7.116	1.656	10.998	0.075**
		(2.456)	(6.715)	(1.765)	(8.463)	(0.036)
Year-round access by road (1=yes; 0=no)		1.226	9.618*	1.741	25.503**	0.105**
		(2.073)	(5.658)	(1.397)	(10.750)	(0.0449)
Hilly topography (% of farm area)		-0.022	-0.052	-0.030	-0.124	-0.000
		(0.023)	(0.063)	(0.018)	(0.125)	(0.001)
Access to credit (1=yes; 0=no)		1.316	4.945	2.249*	13.945	0.054*
		(1.343)	(3.671)	(1.179)	(9.663)	(0.032)
Income share of off-farm jobs		3.574	12.663	5.709	21.77	0.122*
		(3.219)	(8.800)	(4.202)	(16.973)	(0.068)
Access to technical assistance (1=yes; 0=no)		0.191	0.852	-0.292	2.359	-0.013
		(1.367)	(3.737)	(0.859)	(7.430)	(0.026)
Poor (1=poor; 0=otherwise)		1.579	9.160*	3.807*	24.051	0.116**
		(1.856)	(5.075)	(2.210)	(17.878)	(0.052)
Extremely poor (1= extremely poor; 0=otherwise)		-2.256	-3.102	0.298	-0.281	0.028
		(1.626)	(4.445)	(1.167)	(13.485)	(0.035)
Adjusted R^2				0.46	0.02	0.10
Pseudo R^2		0.57	0.15			
Number of observations		103	103	103	103	103

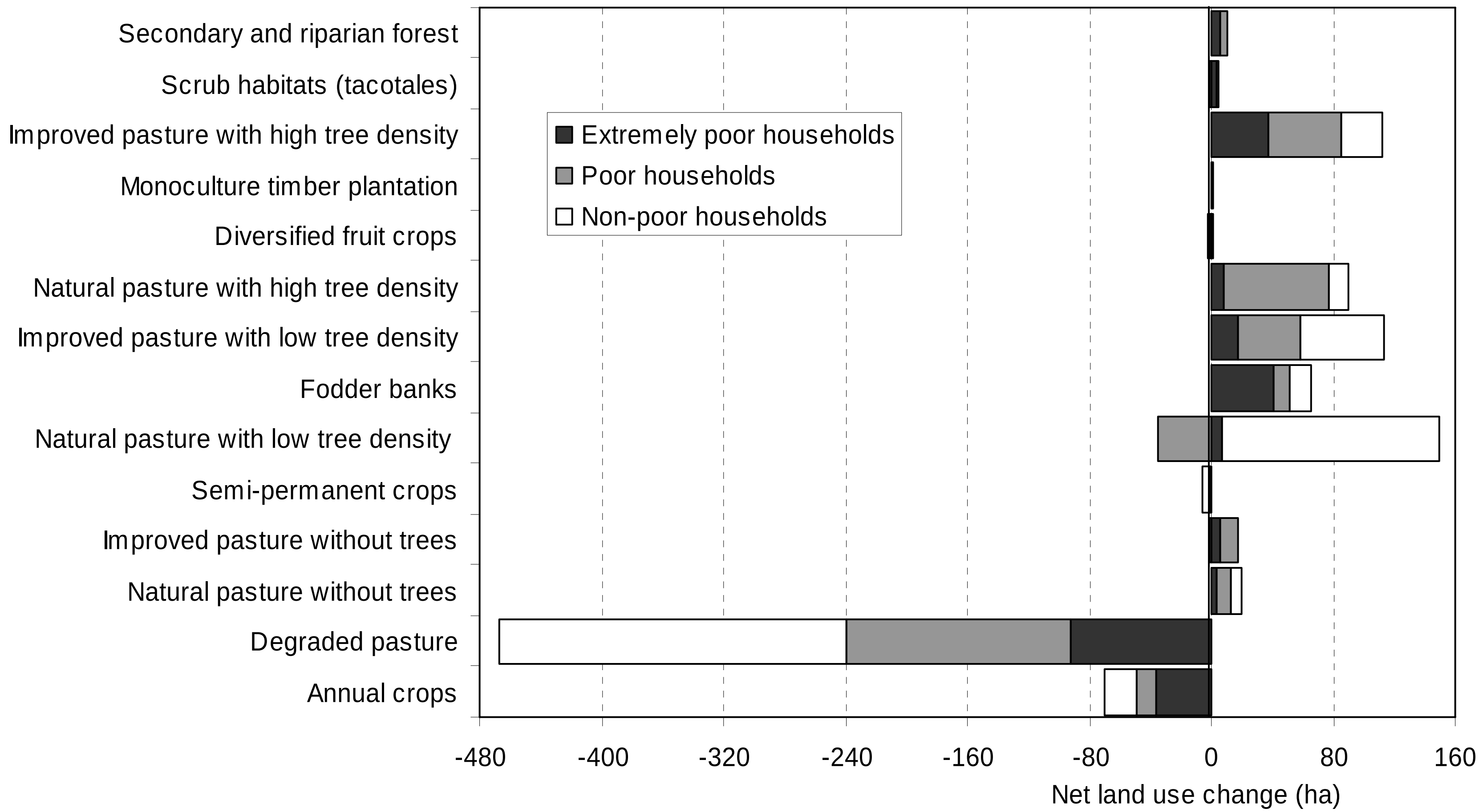
Notes: Standard errors in parentheses; robust standard errors for OLS coefficients.
*, ** indicates coefficient estimate is significantly different from zero at 90% or 95% confidence level.

Figure 1: Distribution of reported annual household per capita income among Silvopastoral Project participants, Matiguás-Río Blanco, Nicaragua



Source: Authors' computations from Silvopastoral Project baseline survey.

Figure 2: Land use change in first year of Silvopastoral Project, by income group, Matiguás-Río Blanco, Nicaragua



Source: Authors' computations from Silvopastoral Project mapping data.