Farmer's perceptions of silvopastoral system promotion in Quindío, Colombia

Alicia Calle[1]
Florencia Montagnini[1]
Andrés Felipe Zuluaga[2]

[1] Yale School of Forestry
and Environmental Studies
370 Prospect Street
New Haven, CT 06511, USA

[2] Centro para la Investigación
en Sistemas Sostenibles
de Producción Agropecuaria (CIPAV),
Carrera 2 Oeste # 11-54
Cali, Colombia

Photograph 1.
Two centuries ago, Andean forests with high biodiversity and endemism still covered this watershed in Quindío, Colombia. Over the past century, fragmentation occurred as the landscape was transformed into an agricultural mosaic. Today, small isolated forest fragments like this remain only on very inaccessible slopes.
Photograph by A. Calle.

A. CALLE, F. MONTAGNINI, A. F. ZULUAGA

RÉSUMÉ

PERCEPTIONS PAYSANNES DE LA PROMOTION DE SYSTÈMES SYLVO-PASTORAUX À QUINDÍO, COLOMBIE

L'élevage classique est une des utilisations des sols les plus répandues en Amérique latine, et se solde souvent par leur dégradation rapide. L'adoption de systèmes sylvopastoraux (SSP), associant des arbres à usages multiples à des pâturages améliorés, est susceptible de rendre d'importants services environnementaux tout en réduisant les pressions qui entraînent de nouvelles déforestations. Cependant, des obstacles liés aux besoins d'investissement et d'information freinent souvent la généralisation de ces systèmes. Entre 2002 et 2007, le Fonds mondial pour l'environnement (Global Environment Facility - GEF) a financé un projet pilote pour la promotion des SSP dans certaines régions à pâturages fortement dégradés en Colombie, au Costa Rica et au Nicaragua. Sur cette période de cinq ans, l'état des terres s'est très sensiblement amélioré grâce à l'accroissement de la couverture végétale et de meilleures pratiques d'utilisation des sols. L'étude que nous présentons concerne la région de Quindío en Colombie, où le succès du projet a permis de s'en servir comme modèle pour généraliser l'initiative au niveau national. En organisant des entretiens semi-structurés et des visites de terrain, nous avons recueilli des informations sur les raisons de la réceptivité des paysans de cette région à l'égard des SSP. Les motivations, les informations en retour et les difficultés ayant influencé les décisions des paysans ont été évaluées. Les résultats de l'étude mettent en évidence le rôle d'une bonne assistance technique pour aider les paysans à comprendre les conséquences passées et futures de leurs décisions en matière d'utilisation des terres. Ils montrent également comment le principe de rémunération des services fournis par les écosystèmes permet d'emblée d'engendrer un climat de confiance et d'appréhender le lien entre l'adoption d'un SSP et les bénéfices environnementaux et économiques qui en découlent. Les leçons qui découlent de ce projet sont applicables à la conception de stratégies de promotion des SSP et d'autres pratiques de gestion durable à plus grande échelle, contribuant potentiellement à réduire la dégradation des sols et la déforestation en milieu tropical.

Mots-clés: rémunération des services fournis par les écosystèmes, systèmes silvo-pastoraux, utilisation durable des terres, adoption de technologies, assistance technique.

ABSTRACT

FARMER'S PERCEPTIONS OF SILVOPASTORAL SYSTEM PROMOTION IN QUINDÍO, COLOMBIA

Conventional livestock production is one of the most prevalent land uses in Latin America, and often results in rapid land degradation. The adoption of silvopastoral systems (SPS) which combine multipurpose trees and improved pastures, could provide important ecosystem services while reducing the pressure to clear more forests. Investment and information barriers, however, can discourage the widespread adoption of SPS. From 2002 to 2007, the Global Environmental Facility (GEF) funded a pilot project to promote SPS in degraded, pasture-dominated regions of Colombia, Costa Rica and Nicaragua. A substantial transformation of these lands was achieved over a five-year period, through increased vegetation cover and improved land use practices. This study focuses on the Quindío region in Colombia, where the successful project now serves as a model to take the initiative to nation-wide scale. Through semi-structured interviews and field visits, we gathered information on why farmers in this region were receptive to SPS. We assessed the motivations, feedback and difficulties that influenced the farmers' decision-making processes. The results highlight the role of adequate technical assistance (TA) in helping farmers understand the past and future implications of their land use decisions. They also demonstrate how Payment for Ecosystem Services (PES) can help to build initial trust, and to link the adoption of SPS to environmental and economic benefits. The lessons from this project can be applied in designing strategies to promote SPS and other sustainable practices at a larger scale which can potentially help to reduce land degradation and tropical deforestation.

Keywords: payment for ecosystem services, silvopastoral systems, sustainable land use, technology adoption, technical assistance.

RESUMEN

PERCEPCIONES DE LOS GANADEROS SOBRE UN PROYECTO DE PROMOCIÓN DE SISTEMAS SILVOPASTORILES EN QUINDÍO, COLOMBIA

Uno de los usos dominantes del suelo en América Latina es la ganadería convencional, que con frecuencia conduce a una rápida degradación de la tierra. La adopción de sistemas silvopastoriles (SSP), una combinación de árboles multipropósito con pasturas mejoradas, puede generar importantes servicios ambientales y reducir la presión sobre los bosques. Sin embargo, las barreras de inversión e información suelen dificultar la adopción de estos sistemas. Entre 2002 y 2007, el Fondo Mundial para el Medio Ambiente (GEF) financió un proyecto piloto para promover el uso de SSP en regiones dominadas por pasturas degradadas en Colombia, Costa Rica y Nicaragua. Se logró una transformación significativa en un período de cinco años, gracias al aumento de cobertura vegetal y mejores prácticas de manejo. Este estudio se enfoca en la región de Quindío, Colombia, donde el proyecto sirve como modelo para la expansión de la iniciativa a nivel nacional. Por medio de entrevistas semiestructuradas y visitas de campo, obtuvimos información sobre por qué los ganaderos de la región fueron receptivos a los SSP. Identificamos las motivaciones, beneficios y obstáculos que influyeron en su proceso de toma de decisiones. Los resultados resaltan el papel de la adecuada asistencia técnica para ayudar a los ganaderos a entender las implicaciones pasadas y futuras del uso que le dan a sus tierras. También demuestran cómo el Pago por Servicios Ambientales (PSA) puede contribuir a generar confianza inicial y a establecer la conexión entre la adopción de SSP y los beneficios ambientales y económicos. Las lecciones de este proyecto pueden ser aplicadas en el diseño de estrategias para promover SSP y otras prácticas sostenibles a gran escala, contribuyendo a reducir la degradación ambiental y la deforestación en los trópicos.

Palabras clave: pago por servicios ambientales, sistemas silvopastoriles, uso sostenible de la tierra, adopción de teechnología, asistencia técnica.

Introduction

Forests with high biodiversity and endemism once covered La Vieja River watershed in Quindío, in Colombia's central Andes. Over the past century, the landscape was transformed into an agricultural mosaic dominated by single-crop coffee plantations. With collapsing world coffee prices, many coffee plantations have been converted to pastures (Calle, Piedrahita, 2007), despite the unsuitability of these fragile soils and steep slopes for cattle ranching (Sadeghian *et al.*, 2001). Plant and animal diversity, forest cover, nutrient cycling, soil fertility, and water availability were all negatively affected by the large-scale shift from agriculture to pasture that took place during the 1990s (Chará, Murgueitio, 2005).

In this watershed, as in many other regions of Latin America, expanding livestock production is one of the main drivers of high deforestation rates (Fao, 2005). Widespread conventional ranching practices provide few ecosystem services and result in rapid land degradation, leading to further forest clearing (Pagiola *et al.*, 2004; Montagnini, 2008). According to Fao (2005), South America will lose an extra 18 million ha of forests by 2010, when 62% of the non-forested area will be occupied by pastures (Steinfeld *et al.*, 2006).

This destructive cycle, however, can be broken. The use of silvopastoral systems (SPS) can turn livestock production from an environmentally detrimental activity into a more sustainable one that increases rural incomes, enhances family nutrition and provides employment, while still helping to protect ecosystem functions (Murgueitio *et al.*, 2006). Thus, the large-scale adoption of SPS in Latin America could help transform vast cattle production areas into functional landscapes, providing key ecosystem services at the local and global scales.

Photograph 2.
At the beginning of the project, conventional ranching practices were the norm in the participating farms, and had resulted in severe land degradation. Large animals were grazing on the steep, deforested slopes, compacting the fragile soils and causing severe erosion problems. Vegetation cover was minimal and pastures had low productivity.
Photograph by A. Calle.

From 2002 to 2007, the Global Environment Facility (GEF) funded a project to promote the adoption of SPS using a combination of technical assistance (TA) and payment for ecosystem services (PES) in degraded regions of Colombia, Costa Rica and Nicaragua. The project resulted in substantial transformation of the rural landscape through increased vegetation cover and better land management practices in the three regions (Ibrahim *et al.*, forthcoming). In this study we focus on La Vieja River watershed in Quindío, Colombia, where the physical and socio-economic characteristics of the participating farms were the most heterogeneous. This enabled us to understand the wider range of factors that motivated farmers to adopt SPS, providing important guidelines in designing strategies to scale up such initiatives.

Silvopastoral Systems: a sustainable alternative for cattle production

Silvopastoral systems (SPS) combine trees and livestock production on the same land, generating economic and productive benefits to the farmer while protecting the ecological capital (Pattanayak *et al.*, 2003; Montagnini, 2008). Their use allows farmers to increase pasture productivity without depending on expensive commercial inputs. The combination of grass and tree fodder species adds nutritional value to the cattle's diet, while tree litter deposition stimulates nutrient cycling, protects the soil, and enhances its fertility (Ibrahim *et al.*, 2006; Pagiola *et al.*, 2007). Cattle grazing under the

Photograph 3.
The replacement of conventional fences with live fences is a simple system with multiple benefits, and was adopted on most of the farms. *Gliricidia sepium* was the preferred tree species for the fences because of its easy propagation and rapid growth. At *finca La Meseta*, more than 5 km of new *Gliricidia* fences were planted. These fences provide shade and can also be pollarded directly for fodder. Photograph by A. Calle.

shade of trees suffer less heat stress than in open pastures; they graze more and have lower respiratory rates, producing more milk and meat. SPS can also create new job opportunities for rural people and generate additional farm products such as fuelwood, timber or fruit (Murgueitio *et al.*, 2006).

Compared to open pasturelands, SPS also provide more ecosystem services. They favor biodiversity by creating complex habitats that support diverse plants and animals, harbor a richer soil biota, and increase connectivity between forest fragments (Ibrahim *et al.*, 2006). In humid regions, SPS can sequester more carbon than pastures or even native forests, and store it deeper and more permanently (Amézquita *et al.*, 2005). The combination of grasses and trees helps retain soil and water, protecting watersheds and soils from erosion (Ibrahim *et al.*, 2006). As trees mature, nutrient cycling speeds up and habitats become more wildlife-friendly (Murgueitio *et al.*, 2006). Ultimately, SPS can remain productive for longer periods than conventional pastures, and the pressure to clear more forests is reduced (Steinfeld *et al.*, 2006).

Adoptability of Silvopastoral Systems

Despite their potential to create better socio-economic conditions and generate local and global ecosystem services (Fao, 2005), adoption rates for SPS have remained relatively low for two main reasons. First, establishment costs can be high while capital availability in rural areas is usually low, and returns on the investment can be delayed for several years. Second, SPS can be complex so their adoption is risky when information and TA are insufficient (Ibrahim *et al.*, 2006; Murgueitio *et al.*, 2006). Programs intended to promote the adoption of SPS need to address both of these obstacles.

Predictive models were used to examine the correlation between measurable external factors over which the farmer has little control, and adoption rates in their region (Mercer, 2004; Thangata, Alavalapati, 2003). These factors were grouped into five categories: household preferences, resource endowment, market incentives, biophysical characteristics, and perceived risk and uncertainty (Pattanayak *et al.*, 2003). The predictive model developed by Pagiola *et al.* (2007) for Quindío found that PES was the variable that most affected the extent of adoption, while others like income level or farm area were less important.

Beyond the external factors, adoption decisions are also largely based on more subjective factors such as individual motivations and perceptions of the new systems. Thus, understanding the outcome of a SPS promotion effort requires consideration of these personal factors that operate at an individual level. Our study takes this approach, exploring individual farmer's perceptions and attitudes and how they influenced the adoption of SPS in Quindío.

The SPS Project in Quindío

The Integrated Silvopastoral Approaches to Ecosystem Management Project was funded by the Global Environment Facility (GEF), supported by FAO's Livestock, Environment and Development Initiative (LEAD) and implemented by the World Bank between 2002 and 2007. The project used PES to promote the adoption of SPS in three regions dominated by degraded pastures in Colombia, Costa Rica and Nicaragua (Pagiola *et al.*, 2007). The sites were selected for their potential to provide global ecosystem services —biodiversity conservation and carbon sequestration— through adoption of more sustainable land use practices. The local implementing agencies were the Center for Research on Sustainable Agriculture Production Systems (CIPAV) in Colombia, the Tropical Agriculture Research and Higher Education Center (CATIE) in Costa Rica, and the Institute for Research and Development (NITLAPAN) in Nicaragua. The American Bird Conservancy (ABC) provided the technical support for biodiversity monitoring (Pagiola *et al.*, 2004).

To encourage SPS adoption, participating farmers were paid for increasing the ecosystem services rendered by their farms. The different land uses identified in the region — from treeless pastures to forest fragments— were ranked based on their potential to provide such services (Pagiola *et al.*, 2007). Farmers observed a range of productive land use options and SPS during their visits to demonstration farms, and were then expected to adopt those that would help them intensify production in suitable portions of their farms, leaving unsuitable lands for uses such as riparian forest corridors or natural forest regeneration. TA was provided to ensure that the benefits of SPS were understood and to facilitate implementation. Detailed monitoring of the land use changes and their effects on biodiversity and carbon sequestration was used to calculate the annual PES delivered to each farmer during the five years of the project (Pagiola *et al.*, 2004; Steinfeld *et al.*, 2006).

Study site: La Vieja River watershed, Quindío, Colombia

The project site in La Vieja River watershed was located in the departments of Quindío and Valle del Cauca, in Colombia's central cordillera (figure 1). It covered a 500 km² area with elevations ranging from 900 to 1300 m asl. The annual average rainfall was 2000 mm, distributed bimodally. On average, the 80 participating farms had an area of 36 ha and a herd size

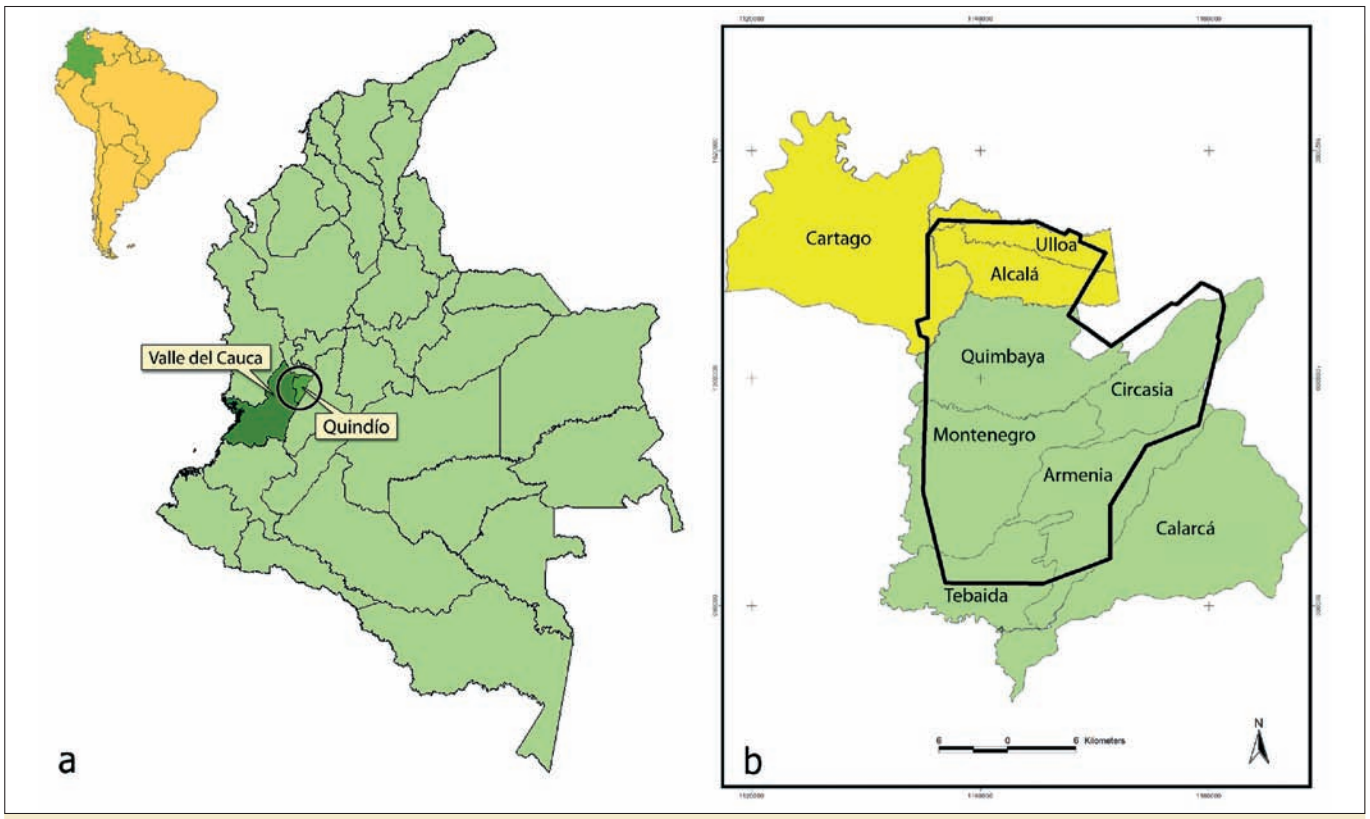

Figure 1.
Map (a) shows the location of the La Vieja River watershed in Colombia's Andean region. The project area shown in map (b) covers 9 municipalities in the departments of Quindío (darker) and Valle del Cauca (lighter). The 80 farms that participated in the SPS project were scattered across the 500 km² area delineated in map (b).
Source: CIPAV.

Photograph 4.
Some farmers chose to establish fodder banks, like this one in *finca La Cabaña* that combines the nitrogen-fixing tree *Gliricidia sepium* with *Trichantera gigantea*. These species are used to supplement the animals' diet with protein-rich fodder, partly replacing expensive commercial products.
Photograph by A. Calle.

of 57 animals, raised for both dairy and beef production. Participants were diverse in terms of sex, age, education and income level, and included both rural and urban landowners (Pagiola *et al.*, 2007; Ibrahim *et al.*, forthcoming).

At the beginning of the project in 2002, treeless pastures dominated 65% of the landscape and most of the nearly 3000 ha of pastures were under intensive grazing. The few forest fragments were small and unconnected (photograph 1). Simple SPS such as live fences were uncommon, and more complex ones were unknown (Pagiola *et al.*, 2007). Watersheds were unprotected and erosion problems were evident (Chará, Murgueitio, 2005) (photograph 2).

During the five years of the project, more than 800 ha of degraded pastures were replaced by SPS with varying degrees of tree cover. Over 350 km of new live fences and windbreaks were established, using mostly *Gliricidia sepium* (Jacq.) Kunth ex Walp (photograph 3). Fodder banks of *Tithonia diversifolia* (Hemsl.) A. Gray and other species (photograph 4), and more than 100 ha of intensive SPS with *Leucaena leucocephala* (Lam.) deWit, were planted. Cattle were removed from the steepest slopes on many farms, and multipurpose trees like *Albizia saman* (Jacq.) Merr., *Cassia grandis* Lf and *Inga* spp. were planted instead (photograph 5), or natural regeneration was encouraged to prevent soil erosion (photograph 6). Locally endangered species like *Syagrus sancona* (H.B.K.) Karst. Ex Dahlgren (Colombian foxtail palm) were also used. Watersheds were protected from cattle and reforested with native species like *Guadua angustifolia* Kunth (Colombian thorny bamboo), resulting in improved water supply and better landscape connectivity (Chará, Murgueitio, 2005).

These changes positively affected the rendering of ecosystem services, especially carbon sequestration and biodiversity protection. Bird abundance and species richness in the new SPS were found to be higher than in the original pastures and similar to those of the remnant forests. Of the 170 bird species recorded in these SPS, 54% are considered forest dependent (Ibrahim *et al.*, forthcoming), and one endangered species, *Ammodramus sabanarum*, was found. Milk production increased, while herbicide and fertilizer use declined substantially. These results led the National Cattle Ranchers Federation (FEDEGAN) to join CIPAV and GEF in the replication of the project nation-wide, and the government created an economic incentive for intensive SPS (Murgueitio, forthcoming). For a more complete description of the land use changes and ecosystems services generated by this project, see Pagiola *et al.* (2007) and Ibrahim *et al.* (forthcoming).

Methods

Data for this study were collected during June-August 2007, through semi-structured interviews and informal conversations with 28 farmers from the project in Quindío. The selected farms represent the watershed's geographic variability, different SPS adopted and varying degrees of success. During a guided tour of the farm, farmers described their land's initial condition, explained the innovations implemented, and discussed the benefits and difficulties encountered. Their motivations for participating, their attitudes about environmental issues of concern, and their assessment of conventional and sustainable ranching practices were discussed. This information was then coded to identify common themes and their relative importance, according to the emphasis they received in the interviews. Other key informants such as CIPAV researchers and local environmental authorities provided additional information on the technical challenges and the factors affecting the process.

Results and Discussion

Farmer's motivations for adopting SPS

Farmers cited four major types of motivations for participating in this project (table I):

Economic motivations

High prices of external inputs can stimulate the adoption of less input-intensive practices (Lee, 2005; Thangata, Alavalapati, 2003). In Quindío, the rising price of animal feeds and fertilizers was the top worry for 64% of the respondents, and 39% doubted the economic viability of ranching. Many farm inputs in Colombia are imported, so prices fluctuate with the volatile exchange rate. Since local markets are not as elastic, prices of farm products can only shift so much and thus profits are constantly shrinking. Hence, keeping production costs under control was a strong motivation to adopt SPS.

On the other hand, farmers in this study did not consider PES a strong motivation for adopting SPS, probably because the amount paid did not cover the full costs of implementation. Nevertheless, the PES incentive did play a role in building initial trust in the project, and perhaps most importantly, in helping farmers visualize the link between sustainable practices, provision of environmental services and economic benefits. For a detailed discussion of the economic impact of PES on this project, see Ibrahim *et al.* (forthcoming).

Productivity motivations

When population density is high and land scarce, intensification is the best way to increase productivity (Mercer, 2004). In Quindío land prices and opportunity costs are high, but road infrastructure and basic services are good and markets are readily available, so most farmers are reluctant to relocate. Thus, 46% of the farmers decided to use SPS hoping to regain previous levels of productivity and reclaim some of the lost profits.

Photograph 5.
Inga trees deposit abundant, nutrient-rich litter, increase biodiversity, and most importantly for SPS, have the ability to fix nitrogen. On *finca Pinzacuá*, these *Inga* trees were planted at high density on degraded soils. The pastures have now recovered their productivity and no longer require expensive urea fertilizers. Photograph by A. Calle.

Environmental degradation motivations

Because of its direct link to productivity, land degradation often motivates adoption of more sustainable methods (Mercer, 2004). In Quindío, years of intensive cultivation, excessive use of chemicals, and irresponsible land management practices had resulted in the rapid degradation mentioned by 39% of the farmers. According to one farm manager, "soil fertility was lost over a single generation." Farmers expressed concern over decreased fertility and the increasing need for fertilizers (36%), hillside erosion (32%), nutrient depletion (25%), and loss of the fragile topsoil (18%) and water quality and quantity (29%), especially during summer (table I).

Older owners remembered the diversity of birds, monkeys, snakes, small mammals and fish present in this region before sun-grown coffee and chemical inputs were introduced. About 46% of the interviewees mentioned biodiversity loss as a motivation for seeking other production systems. We think this answer may partly be the result of the impressive increase in wildlife presence that many farmers noticed after implementing SPS.

Table I.
Farmers' motivations for participating in the project.

		Answers (%)
Economic motivations		
Low profitability of traditional systems	Excessive dependence on expensive inputs (feeds and chemicals)	64
	Long-term farm sustainability is at risk	39
	High farm maintenance costs (conventional fences, labour)	29
	Rising overall production costs	18
	Cost/benefit analysis showed SPS as feasible option	14
PES incentive	Not enough, but worth getting	25
	Not necessary, changes are based on personal conviction	25
	Helps to pay for adoption of necessary changes	21
Productivity motivations		
Farm productivity	Need to improve pasture quality/quantity	46
	Need to improve soil quality	29
	Need to recover overall farm productivity	29
	Need to provide shade for cattle	4
Environmental degradation as motivation		
Biodiversity loss	Dramatically affected by land use change and high use of chemicals	46
Soil degradation	Soils have lost productivity and now depend on fertilization	36
	Severe erosion problems due to previous land use	32
	Nutrient-depleted soils	25
	Specific soil nutrient deficiencies on farm	21
	Fertile but very fragile soils	18
	Severely compacted soils	14
Water degradation	Water quantity has been decreasing over time	29
	Water is scarce or absent during summer months	29
	Water is polluted with chemicals or sewage	14
Forest degradation	Forest remnants are being cut for timber and posts	11
Land degradation	Land degradation has proceeded rapidly over the past decade(s)	39
Personal or social motivations		
Project credibility	Group visits to demonstration farms were positive	43
	Positive experience with previous environmental programs	32
	Technical assistance is an incentive	32
	Introduced to project by a trusted person/group	25
	Had heard about CIPAV's previous work	14
Personal or Family	Strong emotional ties to land, farm has been in family for many years	39
	Strong personal motivation to improve farm	25
	Desire to pass on land in good condition to next generation	18
	Self-starter and interested in research on farm	14
	Willing to try new things, innovator	11

Social and personal motivations

Helps reduce the perception of risk that accompanies any new technology by facilitating an understanding of how the innovation contributes to meet one's needs (Mercer 2004; Reed, 2007). In this study, 43% of the respondents considered visits to demonstration farms as a key factor that established the project's credibility and feasibility, offering participants the opportunity to see SPS and to ask other farmers about their practical and economic aspects. Such contact with other technology users has been found to stimulate adoption (Lee, 2005). According to one farmer, field visits are "the best learning experience because they challenge you. If another farmer with a similar farm and a similar worker can do it, you know you can too." At a personal level, a strong emotional tie to the land and the desire to leave it in good condition for the next generation were also important motivations (table I).

Perceived benefits of adopting SPS

After trying a new technology, evaluation of the costs and benefits determines the permanence of adoption (Current *et al.*, 1995). Since economic returns lag behind implementation, it is important that farmers perceive other types of immediate benefits in the meantime (Lee, 2005). Farmers perceived four types of benefits (table II):

Economic benefits

Even if participants were well aware that the bulk of the economic benefits from SPS would come in the long run, 39% reported reductions in input and maintenance costs within just a few months. Quick savings came from establishing relatively inexpensive live fences, which provided shade and fodder and eliminated the need to replace fence posts. One farmer said he previously did not use live fences "because I was a fool, we all were! I can't wait to have my entire farm in live fences." The largest economic benefits came from planting the nitrogen-fixing leguminous tree *Leucaena* in intensive SPS, but few farmers could afford the high investment required. Nonetheless, 43% of them considered this a secure investment that they would be willing to make if they had the means (photograph 7) (table II).

Productivity benefits

A substantial increase in the available amount and quality of fodder was mentioned by 64% of the farmers, which was reflected in the livestock's improved body condition reported by 43%. Many agreed that SPS facilitate farm maintenance and management (table II).

Environmental benefits

The benefits related to increased vegetation cover were most visible after four years of tree-planting efforts, according to 50% of the farmers. They also noticed improvements in water quality and yield following stream protection (photograph 8), and soil benefits such as lower compaction and higher presence of biota (table II).

The most frequently cited environmental benefit was an increase in biodiversity, particularly birds and small mammals, with awareness appearing to be higher in farms

Photograph 6.
These steep slopes in *finca El Guayabo* were once used for grazing. By increasing productivity in more suitable areas of the farm, the farmer was able to leave this area to regenerate. She fenced off the area, planted native trees, allowed natural tree regeneration, and now the forest is recovering quickly.
Photograph by A. Calle.

Table II.
Farmer's perceptions of the benefits of the SPS adopted

		Answers (%)
	Economic benefits	
Less need for external inputs and maintenance	Replacement of chemical fertilizers with N-fixing plants	43
	Dramatic reduction in use of chemical inputs	39
	Replaced conventional fences with live fences, which require less maintenance	39
	On-farm propagation of recommended trees	
	25 eliminated need to buy wood posts	18
	Producing own wood for energy	7
Future benefits to be expected	From by-products of the system (wood, charcoal, seeds)	18
	Approved of government incentive for SPS	11
	Productivity benefits	
Benefits to cattle	Increased quality and quantity of available fodder	64
	Improvement in cattle's overall condition	43
	Shade from trees protects cattle from heat stress and dehydration	39
	Cattle can feed directly on live fence prunings	21
	Increased weight gain by cattle	18
	Secured pasture availability even during the summer	14
Benefits to pastures	Increased fertilization by N-fixing trees	43
	Overall improvement (in growth, amount, colour, quality)	25
	Stopped overgrazing	21
	Reduced stress (heat, water and nutrient)	18
	Protected from desiccation by newly planted windbreaks	4
Farm management	Easier maintenance of live fences	36
	Easier livestock management with live fences	11
	Easier livestock management with longer pasture rotations	7
Land use	More efficient and appropriate land use	25
Increased farm capacity	Higher cattle carrying capacity per ha	18
	Increased milk production	7
	Environmental benefits	
Biodiversity	Dramatic increase in bird abundance and diversity	71
	Increase in plant and animal diversity	54
	More sightings of small wild mammals in pastures	36
	More sightings of animals in forests and riparian corridors	32
	Improved pest control resulting from higher biodiversity	21
	Increased sightings of endangered or rare species	11
Vegetation cover	Higher tree species diversity	54
	Increased tree regeneration in pastures and riparian strips	50
	Increased use of native species for reforestation	50
	Increased regeneration of rare or hard-to-propagate species	25
	More variety of plant species available for animal nutrition	21
	Reduced pressure on forest fragments	14

Table II. (Continued)

		Answers (%)
	Environmental benefits	
Water	Increased water quality and/or quantity	36
	Increased water availability during the dry season	29
	New springs appeared on farm	25
	Increased water quality indicator species (macro-invertebrates)	7
	Decreased chemical output from own farm	7
Soils	Improved erosion control using vegetation	25
	Enhanced soil quality through tree-planting	21
	Enhanced soil biota habitat through tree planting	18
	Personal and social benefits	
Personal and family values reinforced by project	Satisfaction from the learning and research experience	46
	Spiritual satisfaction from contact with nature	32
	Developed new methods by experimenting on farm	29
	Increased aesthetic value from more vegetation on farm	29
	Interest among children in some aspects of SPS	21
	Relaxation in farm forests	11
Social values and networks	Frequent visits by people interested in systems adopted	36
	Satisfaction from sharing results of own trials with others	25
	New social network for information exchange and feedback	18
	Have been stimulated by other participants' experiences	18
	Opportunity to share experience locally and internationally	11
Work values	Increased environmental awareness among workers	29
	Employee(s) demonstrated initiative and curiosity	21
	Employer provided opportunity to experiment with new systems	14
	Provided new knowledge of SPS for future job improvement	11
	Provided opportunity for training and education	11
	Opportunity to generate rural employment	11
	Reduced social conflicts (illegal logging, intrusion)	7
	Institutional benefits	
Demonstration farms	Helped ease uncertainty and risk associated to SPS	43
	Provided valuable ideas that were applied on own farm	43
	Were very helpful and motivating	43
	Provided valuable lessons on how to solve own problems	21
Working with CIPAV	Promoted an excellent research relationship	43
	Payments and assistance were delivered promptly	36
	Increased awareness of the consequences of own practices	32
	Reinforced existing efforts	32
	Provided good technical assistance on specific issues	29
	Provided general guidelines for own experimentation	11

Photograph 7.
Highly productive, intensive SPS like this one on *finca La Ramada* are established by planting high densities of the nitrogen-fixing tree *Leucaena leucocephala*. Cattle feed on the vigorous pastures and the *Leucaena* foliage, and the system is hardy enough to allow direct browsing on a regular rotation. Photograph by A. Calle.

where scientific monitoring (i.e. bird counts, water sampling, regeneration plots) had been undertaken. "We are now seeing agoutis, armadillos, foxes... fortunately they are returning since we started planting trees and mostly since we became aware that we need to leave the riparian strips alone." These improvements were interpreted as a hopeful sign of recovery in these degraded lands.

Personal and social benefits

At a personal level, 46% of the farmers valued the learning and research experience most, as well as the reinforcement of spiritual values through contact with nature. Socially, the unanticipated flow of national and international visitors made many realize the importance of their more sustainable choices, while the social network fostered by the project was valued as a SPS information-exchanging forum. Increased environmental awareness and the acquired skills were seen as positive because they can provide better job opportunities and contribute to the dissemination of SPS throughout the region (Current *et al.*, 1995; Franzel *et al.*, 2001) (photograph 9).

Institutional benefits

Institutional backup is instrumental in facilitating long-term adoption (Lee 2005; Current *et al.*, 1995). In Quindío, farmers were satisfied with the many roles played by CIPAV; the participatory methodology in which farmers were treated as co-researchers, encouraged to carry out trials, devise their own solutions, and share this information, was evaluated as effective. Farmers felt this method prepared them to solve future challenges on their own. Most expressed willingness to continue their work with CIPAV (table II).

Perceived barriers to adoption of SPS

Despite the project's good overall results, participating farmers also perceived four types of obstacles (table III):

Economic barriers

Lack of investment capacity, absence of economic incentives and the time lag before returns on the investment were common reasons for not trying out SPS. Government incentives, which often facilitate adoption (Lee, 2005; Murgueitio, 2009), were not available when the project began. Some farmers were reluctant to seek loans due to previous negative experiences with banks, and others had problems paying for the extra labor costs required (Lee, 2005). The temporary productivity drops expected during implementation discouraged 14% of the farmers (table III), but most devised alternatives to maintain some production while establishing their chosen SPS (Ibrahim *et al.*, 2006). Most farmers, however, were aware of the long-term nature of investing in SPS, which explains why costs were not cited more often as a barrier. In fact, Pagiola *et al.* (2007) found that once they were convinced of the benefits of SPS, even the poorest households in Quindío came up with ways to finance implementation. In this context, PES contributed to overcome the economic barrier among participating farmers (Ibrahim *et al.*, forthcoming).

Risk and uncertainty barriers

In Quindío, 21% of landowners had difficulty finding skilled workers to establish and manage SPS. Those trying systems new to the region also faced technical uncertainty, but the participatory research helped them adapt SPS to the area's specific needs, as found by Franzel *et al.* (2001). A few landowners were unable to use the recommended trees because their lands were outside the species' altitudinal range. As admitted by 14% of the farmers, barriers were mostly mental and cultural, and TA was a key to overcoming some preconceived ideas about SPS (table III).

Table III.
Farmer's perception of the barriers to adoption of SPS.

		Answers (%)
Economic barriers		
Investment	SPS require investments that exceed own capacity	21
	PES incentive is too small or too short-lived	18
	Excessive costs of inputs (plants, transportation, labour)	18
	Time lag between investment and returns	14
	Uncertainty about future land tenure	7
Productivity	Temporary drop during implementation	14
Markets	Market imperfections (distance, scale, prices)	11
Risk and uncertainty barriers		
Information and knowledge	SPS require particular skills not common among workers	21
	Some technical advice was not practical or applicable	14
	SPS contradict farmer's previous knowledge	14
	Owner lacks tree planting expertise/mentality	1
	Would have liked more technical assistance	7
Social barriers		
	Neighbour's practices (fire, herbicides) undermine efforts	14
	Aesthetic considerations	11
	Disagreement among multiple farm managers/owners	7
	Stigmatization of SPS techniques by traditional farmers	4
Institutional barriers		
	Mistrust of institutions due to past negative experiences	18
	Excessive bureaucracy to access government incentives	7
Implementation barriers		
	Made costly mistakes during implementation	46
	Cattle damage new trees	46
	Leaf-cutter ants damage new trees	32
	Aggressive grasses compete with new trees	29

Social barriers

SPS often counter mainstream practices, which can trigger problems. For example, 14% of the farmers reported that their new SPS were affected by herbicide or fire used by neighbors, and 4% were mocked or questioned by colleagues. Value conflicts emerged in farms with shared management, as described by this farmer: "Personally I love *Leucaena*, and if it were my farm I would plant it even in the patio. I convinced my siblings to plant *Leucaena* on the slopes but they do not want it on the flatlands, they say it looks ugly... they still have the aesthetic concepts of conventional agriculture." Contrary to many studies (Lee, 2005; Pattanayak *et al.*, 2003), adoption rates in Quindío seemed unaffected by the level of education; empirical knowledge of the land seems to have compensated for lack of formal education. Farmers' initial reluctance to trust CIPAV (18%) was explained by previous negative experiences with other institutional programs (table III).

Implementation barriers

All farmers found tree establishment to be a challenge due to damage by cattle, leaf-cutting ants, wind or competition by grasses (photograph 10). Additional difficulties included the unavailability of quality planting material, high seedling mortality and excessive tree maintenance costs. However, as found in other studies (Lee, 2005; Mercer, 2004), their previous tree-planting experience as former coffee-growers facilitated adoption.

Photograph 8.
On most participating farms, gallery forest was protected by fencing off a wide strip along both sides of the stream to exclude cattle, and by planting trees and encouraging natural tree regeneration. Because cattle no longer have access to this protected stream on *finca La Alborada,* water quality and quantity have improved substantially.
Photograph by A. Calle.

Conclusions and Recommendations

The project in Quindío showed that SPS are favored when the following conditions are met:
1) Farmers already have some motivation to try out SPS. Since productivity is commonly the top motivation, attempts to promote the use of SPS must address this aspect first. But because the underlying cause of productivity loss is generally related to environmental degradation, farmers need to be made aware of the direct and indirect links between both issues. Thus, environmental degradation becomes a strong incentive for adoption.
2) Farmers perceive benefits immediately after implementing SPS. Although economic and productive benefits are high priorities for the farmers, they are rarely evident immediately. Therefore, it is crucial for farmers to be made aware of the many additional benefits generated in the meantime, of their importance and their relation to productivity. This broader vision of the productive system will allow farmers to persevere in the adoption of SPS even when they know that the economic profits will only come in the long run.
3) Farmers are provided with incentives to overcome the investment barriers. PES can be used effectively to this end, helping farmers realize that society values the ecosystem services that result from implementing more sustainable practices such as SPS. Other types of incentives like credit or tax breaks might also prove effective.
4) Farmers are given the tools to overcome information barriers. TA can be used effectively to help farmers realize the detrimental consequences of conventional practices, reduce the risk of implementation failure by facilitating their understanding of SPS, and create a positive attitude toward the new systems. Effective TA prepares farmers to solve future challenges on their own, through creative problem solving and information sharing within their social networks.

Permanent adoption of SPS ultimately depends on farmers' perception of their costs and benefits compared to those of traditional systems. TA and PES can help farmers to better understand both types of productive systems so they can make more informed decisions. TA makes farmers aware of the less evident advantages of SPS, and reduces the risk of failure during implementation. PES eases the difficulty of financing implementation costs, and helps farmers realize the value of the environmental services provided by their farms. Thus, TA and PES facilitate attitude change, which is one of the major hurdles in promoting the adoption of more sustainable land uses. Used together, TA and PES can be effective tools to stimulate restoration and rural development in Latin America.

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Photograph 9.
Efrén Aguirre, the worker in *finca La Ramada*, played an instrumental role in the land use changes that took place on this land. He is proud of what has been achieved, and thinks his new skills can help him find better job opportunities in the future. Efrén frequently guides groups of visitors who want to see the farm, and explains why these sustainable SPS make more sense than conventional ranching practices.
Photograph by A. Calle.

Photograph 10.
The most common difficulties faced by farmers when trying to establish trees in pastures were damage by cattle, encroachment by grasses and herbivory by leaf-cutting ants. Solutions to these problems were more expensive and time-consuming than expected. These tree-protecting structures on *finca El Guayabo*, for example, are expensive to build and maintain, and not always effective in preventing cattle from browsing the new trees.
Photograph by A. Calle

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