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Paying for Biodiversity Conservation Services in Agricultural Landscapes

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Abbreviations

ABC	American Bird Conservancy
CAPE	Cape Action Plan for the Environment
CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza* (Center for Teaching and Research on Tropical Agronomy)
CIPAV	*Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria* (Center for Research on Sustainable Agricultural Production Systems)
CRP	Conservation Reserve Program
EBI	Environmental Benefits Index
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
LEAD	Livestock, Environment and Development Initiative
NGO	Non-governmental organization
PES	Payments for environmental services
PSA	*Pago por Servicios Ambientales* (Payment for Environmental Services, Costa Rica)
PSAH	*Pago por Servicios Ambientales Hidrológicos* (Payment for Hydrological Environmental Services, Mexico)
RISEMP	Regional Integrated Silvopastoral Ecosystem Management Project
WBI	World Bank Institute

Executive Summary

Adoption of improved silvopastoral practices in degraded pasture areas is thought to provide valuable local and global environmental benefits, including biodiversity conservation, However, these practices are insufficiently attractive to individual land users for them to adopt them spontaneously, particularly due to their high initial costs. This paper describes the contract mechanism developed for the Regional Integrated Silvopastoral Ecosystem Management Project, which is being implemented with financing from the Global Environment Facility (GEF). The project is testing the use of the payment-for-service mechanism to encourage the adoption of silvopastoral practices in three countries of Central and South America: Colombia, Costa Rica, and Nicaragua. The project has created a mechanism that pays land users for the global environmental services they are generating, so that the additional income stream makes the proposed practices privately profitable.

Designing the mechanism required addressing issues such as (1) measuring the actual amount of environmental services being provided, so that appropriate payments can be made; (2) providing payments in a way that resulted in the desired change in land use; and (3) avoiding the creation of perverse incentives (for example, for land users to cut down existing trees so as to qualify for additional payments for tree planting). Two variants of the proposed payment mechanism are being tested, with participating land users assigned randomly to one or the other. The project also includes extensive monitoring of the effectiveness of each mechanism in stimulating adoption of the proposed measures and of the resulting impact on environmental services and on household welfare. These features, together with the three-country approach, will provide in the coming years a very rich dataset for testing the use of contract mechanisms for biodiversity conservation.

1 Introduction

As natural habitats have come to be increasingly restricted and degraded, increasing attention has been paid to conserving biodiversity in agricultural landscapes. This can be both an end in itself, driven by the realization that agricultural landscapes can have high levels of biodiversity, and a means of complementing conservation in protected areas (Pagiola and others, 1997; Daily and others, 2001). Classical approaches to conservation, attempting to preserve pristine habitats within protected areas, are necessary but insufficient in the face of growing pressure on land.

Efforts to enhance biodiversity in agricultural landscapes need to consider the incentives faced by individual land users, who decide what practices to use on their land, generally without considering what biodiversity benefits different land use practices may have. When biodiversity-friendly agricultural practices are the most profitable, there is a happy convergence of private and social interests. This is the case of jungle rubber in Indonesia, for example (Thiollay, 1995; Tomich and others, 1998). But biodiversity-friendly agricultural practices are not necessarily the most profitable from the perspective of individual land users. In some cases, the profitability of biodiversity-friendly practices can be boosted by inducing consumers to pay a premium for their outputs, as in the case of shade-grown coffee (Pagiola and Ruthenberg, 2002). But this approach requires complex certification schemes and is not always feasible.

A further approach, which has received increasing attention in recent years, is to provide direct payments for the provision of biodiversity services (Pagiola and Platais, forthcoming; Pagiola and others, 2002; Landell-Mills and Porras, 2002; Ferraro, 2001: Ferraro and Kiss, 2002). This approach internalizes what had been an externality, ensuring that it is taken into consideration in decisionmaking.

This is the approach taken by the Regional Integrated Silvopastoral Ecosystem Management Project (RISEMP), which is being implemented with financing from the Global Environment Facility (GEF). The project is piloting the use of payments for environmental services as a means of generating biodiversity conservation and carbon sequestration services in watersheds at three sites in Colombia, Costa Rica, and Nicaragua.

This paper examines the contract mechanisms developed for the RISEMP. It begins by describing the specific context in which the project is being implemented, that of degraded pastoral areas in Central and South America. It then describes the potential for silvopastoral practices to address this problem, which would provide both local and global benefits. But the on-site benefits of silvopastoral practices alone are insufficient to justify their adoption by farmers. Paying land users who adopt these practices for the biodiversity and carbon sequestration services they generate can tip the balance towards adoption. The RISEMP is piloting an effort to do so. The factors which led to the design of the contract used in the RISEMP are described next. These include the technical characteristics of the practices being promoted, the specific biodiversity and carbon sequestration being sought, and the economics of silvopastoral practices from the land users' perspective. As this is a novel approach, the RISEMP includes extensive monitoring efforts.

2 Silvopastoral Practices

Cattle production has long been associated with deforestation in Latin America (Barbier and others, 1994; Binswanger, 1991; Browder, 1985; Downing and others, 1992; Kaimowitz, 1996; Kaimowitz and others, 2004; Mahar, 1988; Mertens and others, 2002; Myers, 1981; Repetto and Gillis, 1988; Schneider, 1994), and as such has been an important cause of the loss of natural habitat and biodiversity in the region. In most countries, the prevailing policy framework encouraged deforestation for timber extraction and conversion of forest areas to pastures and crops, which were encouraged by subsidized credit, guaranteed prices, and other incentives. The extent of these policy distortions has been substantially reduced in recent years (Faminow, 1998) but pressure from poor landholders and-in some areas-large scale ranches continues to result in large-scale deforestation in many areas. In many countries, the legal framework encourages this process, by granting titles to land that is deemed to be 'improved' (that is, cleared and used for agriculture).

Table 1 summarizes changes in pasture and forest area in Colombia, Costa Rica, and Nicaragua. Forest cover has been in retreat throughout the region. The area under annual crops has fallen in many countries (Nicaragua is an exception, as the end of unrest in the early 1990s allowed a considerable expansion of agricultural land into areas that had been unsafe). There has been some expansion of permanent crops, although this trend has reversed in recent years, due to low coffee prices. Permanent pasture, on the other hand, has expanded steadily in all countries for which data are available, although at different rates. Appendix A provides more detailed data on land use changes in Central America and

Table 1. Changes in pasture land and forest area in Colombia, Costa Rica, and Nicaragua

	Colombia		*Costa Rica*		*Nicaragua*	
	Area, 2000 ('000 ha)	*Change 1990-2000 (%)*	*Area, 2000 ('000 ha)*	*Change 1990-2000 (%)*	*Area, 1995 ('000 ha)*	*Change 1990-1995 (%)*
Annual crops	2,818	–14.7	225	–13.5	2,457	25.2
Permanent crops	1,766	6.2	281	12.2	291	14.3
Permanent pasture	40,925	2.1	2,339	0.4	4,820 [a]	..
Natural forest area	49,650	–3.6	1,966	–7.5	3,278 [b]	–26.4 [c]

Notes: a. data from 1990; b. data from 2000; c. 1990–2000 change.
Source: World Bank World Development Indicators database.

Colombia in the last decade. These data show that these patterns were common throughout the region.

In addition to the environmental problems caused by the initial loss of forest, traditional approaches to pasture are often unsustainable. After an initial period of high yields, soil fertility is depleted and grass cover diminishes, resulting in soil erosion, contamination of water supplies, air pollution, further loss of biodiversity, and degradation of landscapes. Lower income for producers results in continuing poverty and in pressure to clear additional areas.

Silvopastoral systems, which combine trees with pasture, offer an alternative to prevalent cattle production systems in Latin America. They provide a deeply rooting, perennial vegetation which is persistently growing and has a dense but uneven canopy. These systems can be grouped in four major categories (Murgueitio, 1999):

- Systems in which high densities of trees and shrubs are planted in pastures, providing shade and diet supplements while protecting the soil from packing and erosion.

- Cut and carry systems, which replace grazing in open pasturelands with stables in which livestock is fed with the foliage of different trees and shrubs specifically planted in areas formerly used for other agricultural practices. Cut and carry systems have been particularly successful in Central America and in Colombia (Benavides, 1994).

- Use of fast-growing trees and shrubs for fencing and wind screens. This system, widely used in some countries of tropical America, provides an inexpensive alternative for fencing and supplements livestock diets.

- Livestock grazing in forest plantations. In this system, grazing is used to control the invasion by native and exotic grasses, thus reducing the management costs of the plantations.

Appendix B illustrates some of these systems in the RISEMP project sites, as well as the degraded pastures they are meant to replace.

On-site benefits

Silvopastoral systems can provide a range of on-site benefits (Dagang and Nair, 2003). The introduction of trees in pasture areas can improve pasture productivity. Silvopastoral systems tend to increase nutrient re-cycling across a deep portion of the soil profile occupied by the root systems of a wide variety of plants associated with silvopastoral systems. Depending on the species of trees being used and on local climate characteristics, trees extract water and nutrients from soil horizons inaccessible to grasses, and deposit the nutrients on the ground with the natural fall of foliage, twigs, and fruits. The biomass and amount of nutrients released by pruning the trees of the agroforestry systems varies depending on the kind of management in use. As much as 18 tons/ha of dry matter can be deposited on the ground annually, and the amount of nitrogen flowing through the system can reach values of up to 380 kg/ha/year (Alpizar and others, 1983). In addition, the trees can provide direct benefits in the form of products such as fruit, fuelwood, fodder, and timber. From the farmers' perspective, the benefits of silvopastoral systems derive from (a) additional production from the tree component; (b) maintaining and/ or improving pasture productivity; (c) diversification of production; and (d) contribution to the overall farming system (for example, by providing fodder or income at a time when other sources do not) (Current and others, 1995). The shade provided by trees may also enhance livestock productivity, especially milk production.

Biodiversity benefits

The increased complexity of silvopastoral systems relative to traditional pastures means they often bring important biodiversity benefits (Dagang and Nair, 2003). These take two main forms. First, they tend to support much higher species diversity than traditional pastures. Second, they help connect protected areas.

Silvopastoral systems 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 under these scattered trees; and to provide shade for grazing animals, and shelter for wild birds (Harvey and Haber, 1999). Food availability for wild birds is high in silvopastoral systems, and the complex structure of the vegetation provides a more adequate nesting substrate and better protection against predators than other agroecosystems. Silvopastures and other agroforestry systems also harbor a larger and more complex assemblage of invertebrates than monoculture pastures (Dennis and others, 1996). By providing alternative sources of fuelwood and other wood products, silvopastoral systems can also help reduce pressure on remaining natural habitats.

In agricultural landscapes characterized by the fragmentation of the natural habitats, silvopastoral systems can serve as biological corridors, helping to connect remaining habitats. At the regional level, silvopastoral systems may play an important role in the implementation of the Mesoamerican Biological Corridor, given the vast area of pasturelands in Central America and Colombia. It is expected that these corridors would provide adequate habitat for wildlife while facilitating seed dispersal and the regeneration of the native vegetation (Saunders and Hobbs, 1991).

Other benefits

Silvopastoral systems are capable of fixing significant amounts of carbon in the soil under the improved pastures and in the standing tree biomass (Fisher and others, 1994). Research in Colombia (Ramirez, 1997), Panama, and Costa Rica (CATIE, 1999; Pfaff and others, 20000) has shown that soils under silvopastoral systems have higher carbon content. Additional carbon is sequestered by the trees found in such systems. Moreover, grass-based pastures tend to sequester most of the carbon in the deeper part of the soil profile (between 40 and 100 cm depth), thus making it less prone to oxidation, and hence loss (Fisher and others, 1994; Beinroth and others, 1996).

Silvopastoral systems are also likely to affect water services, though the specific impact is likely to be site specific. Infiltration generally increases with the presence of trees, reducing superficial runoff with its attendant soil erosion. Improved livestock management can help reduce compaction, thus further reducing surface runoff. The presence of trees also leads to increased evapotranspiration, however, thus tending to decrease water yield (Bosch and Hewlett, 1982; Bruijnzeel, 1990).

In hilly areas, trees have an additional protective role in the ecosystem, that of preventing landslides (Bruijnzeel, 1990). Not only is the presence of trees essential for soil protection on slopes, but also the variety of species is important. Trees of different root depths are required for effective soil anchorage, in particular during torrential rain events accompanying tropical storms.

3 Barriers to Adoption

Despite their many benefits, silvopastoral systems have only been adopted to a limited extent (Dagang and Nair, 2003). National-level data typically do not distinguish land uses with a sufficient level of detail, but Table 2 shows average land use in the Quindío, Colombia, RISEMP project site. Pasture with no or low tree density dominates all other land uses (Mejía, 2004). Overall tree cover is low, although there is a significant amount of forest remnants, most of which is riparian forest. Permanent crops, mostly coffee, account for about 10 percent of the area. Coffee was once the dominant land use in this area, but it has been replaced by pasture in the last decade due to low coffee prices. Fodder banks are practically non-existent: only 7 in 110 farms surveyed had any, with an average of less than 1 ha each.

An important constraint to the adoption of silvopastoral practices is their limited profitability from the perspective of individual land users. Establishing silvopastures can entail high initial costs, as shown in Table 3. Increasing the livestock herd to take advantage of the increased fodder production entails additional costs. In addition, there are opportunity costs resulting from the time lags before the systems become productive (particularly important in systems with substantial tree components).

Figure 1 illustrates the typical time profile of returns to adoption of silvopastoral practices. The example shown is of a 20 ha farm in Nicaragua raising livestock for milk and meat. About 15 ha are used for unimproved pasture, with 2 ha devoted to cultivating basic grains for

Table 2. Average land use in farms in Quindío, Colombia

	Hectares	*Percentage*
Annual crops	0.9	2.6
Permanent and semi-permanent crops	3.7	10.8
Pasture with no trees	21.9	64.1
Pasture with low tree density	0.6	1.8
Pasture with high tree density	0.0	0.1
Fodder banks	0.0	0.1
Plantations, riparian forest, and forest remnants	7.0	20.5
Total	**34.2**	**100.0**

Source: Mejía, 2004.

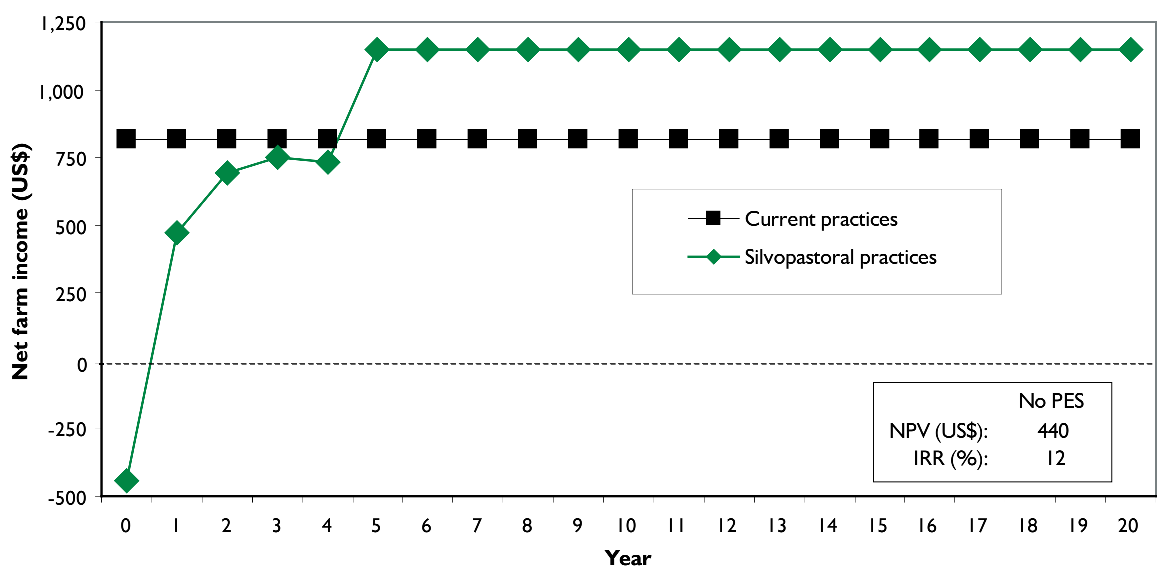
Table 3. Initial investment costs for selected silvopastoral practices

		Quindío, Colombia	*Esparza, Costa Rica*	*Matiguás-Río Blanco, Nicaragua*
Improved pasture	(US$/ha)	375	250	265
Planting 100 trees in improved pasture	(US$/ha)	55	50	
Planting 1,000 *leuceana* trees	(US$/ha)	1,000		
Protein bank	(US$/ha)	960	660	475
Live fencing	(US$/km)	700	610	390

Source: Gobbi, 2002.

the household's own consumption and 3 ha in brush. As shown in the figure, current land uses generate a net farm income of about US$800 a year. The proposed investment involves switching 3 ha of pasture to improved pasture with low tree density, and establishing a 0.75 ha fodder bank. This would allow an increase in the livestock herd from 14 to 15, but more importantly it would result in a substantial increase in the productivity of the herd due to the greater availability of higher quality fodder and the shade provided by the trees. Milk production would increase from just under 2,000 liters annually to over 4,000 liters. Once the silvopastoral systems have been established, net farm income would rise to about US$1,200 a year-a 50 percent increase. In the first years, however, farm income would be substantially lower because of the up-front investment costs and the time lag before the trees grow sufficiently to provide benefits. Only in the fifth year following the initial investment would farm returns rise above those of the current land use practices. As a result, these investments are

Figure 1. Typical time profile of benefits of silvopastoral systems



Note: 20ha farm in Matiguás, Nicaragua.

financially marginal: in this case, the rate of return to adoption of silvopastoral practices is less than 12 percent, and the net present value is only US$440 (over 50 years, at a 10 percent discount rate).

The low rates of return to the adoption of silvopastoral systems are typical. Estimates prepared for the RISEMP show rates of return of between 4 and 14 percent, depending on the country and type of farm (Gobbi, 2002). Other studies found similar results; White and others (2001), for example, found rates of return to adoption of improved pasture in Esparza, Costa Rica, of 9 to 12 percent. These estimates, of course, only consider the on-site benefits of silvopastoral practices. The biodiversity conservation and carbon sequestration benefits are not considered in the farmers' decisionmaking.

This problem is compounded by a lack of awareness by farmers of some of the on-site benefits offered by silvopastoral systems, such as reduced dependency on chemical fertilizers and pesticides, savings in water for irrigation, soil protection and enhanced fertility, and the potential for additional incomes from harvesting fruit, fuelwood, and timber. Limited knowledge of these on-site benefits further reduces the perceived benefits to land users.

Even if silvopastoral practices are financially viable, the high initial investment costs required pose problems for credit-constrained land users. In the Quindío project site, only 25 percent of households had access to credit in the past five years (Mejía, 2004). Access to credit is higher in the Matiguás-Río Blanco area in Nicaragua, thanks to presence of several NGOs that offer credit. About 50-75 percent of households in this area report having used credit in the past five years (Ramírez and others, 2004). However, credit is often only available for specific purposes and with collateral requirements that are difficult for farmers to meet.

The long-term nature of investments in most silvopastoral practices means that tenure security is an important factor in their adoption (Deininger and others, 2003, Meinzen-Dick and others, 2002). Tenure is not a constraint in the three study sites, however. In the Costa Rica and Colombia project sites, all farmers have formal ownership of the land (though they may not all have titles). In the Nicaragua project site, most ranchers occupy public land, but long-term occupancy gives them secure tenure.

4 Payments for Environmental Services

From the land users' perspective, the biodiversity conservation and carbon sequestration benefits are externalities. As such, they do not take them into consideration in making their land use decisions, thus reducing the likelihood that they will adopt practices that generate such benefits, including silvopastoral systems. Recognition of this problem and of the failure of past approaches to dealing with it has led to efforts to develop systems in which land users are paid for the environmental services they generate, thus aligning their incentives with those of society as a whole. The simple logic of Payments for Environmental Services (PES) is that compensating land users for the environmental services a given land use provides makes them more likely to choose that land use rather than another.

There has been considerable experimentation with PES and other market-based approaches in recent years (Pagiola and Platais, forthcoming; Pagiola and others, 2002; Landell-Mills and Porras, 2002). Latin America has been a particularly fertile ground for such experimentation (Pagiola and Platais, 2001). Costa Rica has developed an elaborate, nation-wide PES program, the Pago por Servicios Ambientales (PSA) (FONAFIFO, 2000; Pagiola, 2002). Under the 1997 Forestry Law, land users can receive payments for specified land uses, including new plantations and conservation of natural forests. The PSA program is now being supported by a World Bank loan and GEF grant under the Ecomarkets Project (World Bank, 2000) (Box 1). The town of Heredia has established an 'environmentally adjusted water tariff', the proceeds of which are used to pay landholders to maintain and reforest watershed areas (Castro, 2001; Cordero, 2003). In a separate initiative, hydropower producer La Manguera SA is paying the Monteverde Conservation League to maintain under forest cover the watershed from which its plant draws its water (Rojas and Aylward, 2002). In Colombia, irrigation water user groups and municipalities in the Cauca valley are paying to conserve the watersheds that supply them with water (Echevarría, 2002b). In 2003, Mexico created the Payment for Hydrological Environmental Services program (Pago por Servicios Ambientales Hidrológicos, PSAH), which pays for the conservation of forests in hydrologically critical watersheds using revenue from water charges (Bulas, 2004). In southern Mexico, the Scolel Té project is paying farmers to provide carbon sequestration services (Tipper, 2002). In Ecuador, the city of Quito has created a water fund with contributions from the water utility and the electric power company to pay for conservation in the protected areas from which it draws its water (Echevarría, 2002a).

The bulk of PES programs to date have focused on water services, reflecting both the urgency of addressing water issues in many developing countries and the relative ease with which the beneficiaries of water services can be identified (Pagiola and Platais, forthcoming). The approach has been used for biodiversity benefits in a few cases, mostly with GEF support as in the case of the Costa Rica Ecomarkets Project. Environmental NGO Conservation International has also used the approach (which it calls 'conservation concessions' or 'conservation incentive agreements') in several cases, including Guyana and Peru (Hardner and Rice, 2002; Rice, 2003). Many of these efforts have focused on relatively untouched areas, however, rather than on agricultural areas.

Box 1
World Bank Support for PES

The World Bank is working with several countries to develop PES programs, through loans, technical assistance, and capacity building. In addition to the RISEMP project, current operational activities involving PES include:

- **Costa Rica**. The Ecomarkets Project, which supports the country's PES program, includes a US$32.6 million loan from the World Bank to help the government ensure current levels of environmental service contracts and a US$8 million grant from the GEF to assist the program's conservation of biodiversity (World Bank, 2000).

- **Guatemala**. The Western Altiplano Natural Resources Management Project includes a component aimed at testing and piloting PES mechanisms at the local level and supporting the development of the required national policy framework and instruments (World Bank, 2003a).

- **Venezuela**. A GEF-financed project focusing on Canaima National Park is under preparation, including a mechanism to channel watershed conservation payments made by hydropower producer CVG-EDELCA.

- **Mexico**. The World Bank provided technical support to the government's efforts to establish the Payment for Hydrological Environmental Services program.

- **Dominican Republic, Ecuador, and El Salvador**. Pilot PES programs are under preparation in these countries. El Salvador is at the most advanced stage.

- **South Africa**. The Cape Action Plan for the Environment (CAPE), under preparation, aims to use a PES approach as one of the tools to encourage conservation in the Cape Floristic Region.

- **BioCarbon Fund**. The newly created BioCarbon Fund is examining the potential for buying carbon sequestration services generated by land use change. For example, one proposal would pay for carbon sequestered by improving shade-grown coffee systems in the Mexican uplands.

In addition, the World Bank's training arm, the World Bank Institute (WBI), has provided training on PES targeted to technical personnel in ministries, conservation agencies, and nongovernmental organizations (NGOs) involved in implementing PES programs.

It should be noted that the World Bank did not originate the PES concept. The World Bank has played an important role in launching such projects primarily because its borrowing countries have requested its assistance in doing so. By virtue of its role in assisting many countries, it has been able to cross-fertilize efforts in individual countries with the lessons learned in others (Pagiola and Platais 2003).

5 From Theory to Practice

Although the PES approach is intuitively appealing, putting it into practice is far from simple (Pagiola and Platais, 2003). The theoretical elegance of a blackboard concept needs to be translated into actual implementation arrangements on the ground. The remainder of this paper describes the approach adopted to do so by the RISEMP project.

The RISEMP, which began implementation in July 2002, is seeking to pilot the use of the payment for environmental services approach to encourage the adoption of silvopastoral practices in degraded pastures areas in Central and South America (World Bank, 2002). The project is being implemented in three microwatersheds: Quindío, in Colombia; Esparza, in Costa Rica; and Matiguás-Río Blanco, in Nicaragua. Participating land users enter into contracts under which they receive a payment for the environmental services that they generate. They receive annual payments over a two- or four-year period, based on the increment in environmental services provided relative to the baseline situation for that particular farm. Through this mechanism, the project aims to establish silvopastoral systems on 3,500 ha, thus enhancing the environmental benefits generated in watersheds covering about 12,000 ha.

The project was prepared with support of the multi-donor Livestock, Environment and Development Initiative (LEAD), hosted by the Food and Agriculture Organisation (FAO). It is financed by a US$4.5 million GEF grant, with the World Bank acting as implementing agency. In each country, field activities are being undertaken by local non-governmental organizations (NGOs): the Centre for Research on Sustainable Agricultural Production Systems (Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria, CIPAV) in Colombia, the Center for Teaching and Research on Tropical Agronomy (Centro Agronómico Tropical de Investigación y Enseñanza, CATIE) in Costa Rica, and Nitlapan in Nicaragua, with CATIE coordinating the work. The American Bird Conservancy (ABC) is providing technical assistance for the development of a common and consistent methodology for the monitoring of biodiversity at the three project sites.

What is being paid for?

Contracting for land users to provide biodiversity benefits is all very well in theory, but in practice it is clearly unrealistic to ask them to deliver biodiversity. A way is needed to communicate what is desired to potential participants in ways that they can understand. The typical solution has been to offer to pay not for biodiversity itself, but for land uses that are hospitable to biodiversity (Pagiola and others, 2002).

But land use alone can be a relatively blunt instrument. In Costa Rica's PSA program, for example, most contracts call for conservation of existing forest, and pay all participants the same amount (FONAFIFO, 2000; Pagiola, 2002). While this approach has the virtue of simplicity, it fails to recognize the very different levels of services that different land uses can provide. The biodiversity-friendliness of agricultural practices is not a binary, yes/no proposition. On the contrary, there is a spectrum of effects, ranging from relatively inhospitable systems such as monocultures with heavy agrochemical use to relatively hospitable systems such as organic coffee grown under a diverse shade canopy of native species. Location also matters: biodiversity-friendly practices in proximity to protected areas, for example, might be more valuable by helping to buffer and protect them. Failing to take these differences into account risks either under-paying for desirable land uses, or over-paying for relatively less desirable ones (Pagiola and Platais, forthcoming).

The solution adopted in the RISEMP was to prepare a list of land uses and associate each with a point system upon which payments are based. This approach is similar to that of the Environmental Benefits Index (EBI) used in US Conservation Reserve Program (CRP) (NCEE, 2001). Separate indices were developed for the biodiversity conservation and carbon sequestration benefits of each land use. These two indices were then aggregated to form an environmental service index to be employed as the basis for calculating payments to participants. A similar index for water benefits was not included, partly because of the lack of data needed to develop it, and partly because improved water flows would be national benefits, and thus are not eligible for GEF funding. The biodiversity conservation and carbon sequestration indices are presented in Table 4.

The biodiversity conservation index was scaled with the most biodiversity-poor land use (annual crops) set at 0.0 and the most biodiversity-rich land use (primary forest) set at 1.0. Within this spectrum, the points given to each specific land use were set by a panel of experts, taking into consideration factors such as the number of species (of plants, birds, small mammals, and insects), their spatial arrangement, stratification, plot size, and fruit production. Higher scores were given to land uses that have greater potential to maintain the original biodiversity of the region. Note that the index estimates the environmental benefits of all land uses, and not only silvopastoral practices.

This approach can take into consideration the different impact that different land uses are likely to have on biodiversity. There are, of course, limitations. The biodiversity impact depends not only on the characteristics of the land use, but also on its location, its extent, and its relationship to other land uses. At the pilot scale of the RISEMP, issues of location are not significant, as all three pilot areas were specifically chosen for their proximity to protected areas or to corridors between them. All three project areas were selected in part because of their location in ecologically-sensitive areas. The Quindío project site is in one of the most severely degraded regions of Colombia, with few, mostly unconnected remnants of natural habitats. Restoring a degree of habitat heterogeneity and connectivity would increase the chances of survival of species requiring large home ranges in an area considered as a priority for bird conservation. The Esparza area in Costa Rica is in the vicinity of conservation areas such as La Fortuna, the

Table 4. Environmental service indices used in the RISEMP
(Points per hectare, unless otherwise specified)

Land use		*Biodiversity index*	*Carbon sequestration index*	*Environmental service index*
Annual crops (annual, grains, and tubers)		0.0	0.0	0.0
Degraded pasture		0.0	0.0	0.0
Natural pasture without trees		0.1	0.1	0.2
Improved pasture without trees		0.4	0.1	0.5
Semi-permanent crops (plantain, sun coffee)		0.3	0.2	0.5
Natural pasture with low tree density (< 30/ha)		0.3	0.3	0.6
Natural pasture with recently-planted trees (> 200/ha)		0.3	0.3	0.6
Improved pasture with recently-planted trees (> 200/ha)		0.3	0.4	0.7
Monoculture fruit crops		0.3	0.4	0.7
Fodder bank		0.3	0.5	0.8
Improved pasture with low tree density (< 30/ha)		0.3	0.6	0.9
Fodder bank with woody species		0.4	0.5	0.9
Natural pasture with high tree density (> 30/ha)		0.5	0.5	1.0
Diversified fruit crops		0.6	0.5	1.1
Diversified fodder bank		0.6	0.6	1.2
Monoculture timber plantation		0.4	0.8	1.2
Shade-grown coffee		0.6	0.7	1.3
Improved pasture with high tree density (> 30/ha)		0.6	0.7	1.3
Bamboo (*guadua*) forest		0.5	0.8	1.3
Diversified timber plantation		0.7	0.7	1.4
Scrub habitats (*tacotales*)		0.6	0.8	1.4
Riparian forest		0.8	0.7	1.5
Intensive silvopastoral system (>5,000 trees/ha)		0.6	1.0	1.6
Disturbed secondary forest (> 10 m^2 basal area)		0.8	0.9	1.7
Secondary forest (> 10 m^2 basal area)		0.9	1.0	1.9
Primary forest		1.0	1.0	2.0
New live fence or established live fence with frequent pruning	(per km)	0.3	0.3	0.6
Multi-story live fence or wind break	(per km)	0.6	0.5	1.1

Note: The environmental service index is the sum of the biodiversity and carbon sequestration indices.

Monteverde Reserve complex, and the Alberto Brenes Biological Reserve. More biodiversity-friendly land use practices would help the chances of survival of several species occurring in these protected areas. The Matiguás-Río Blanco watershed in Nicaragua is part of the buffer zone of the Cerro Musún Natural Reserve, and is very close to one of the priority areas for bird conservation in the country. If this approach were to be scaled up and applied on a broader scale, location effects could be incorporated either by varying the points for activities in different locations or by varying the payment per incremental point. Issues of scale and contiguity are harder to address. Some biodiversity benefits may be obtained only after appropriate land uses cover a minimum area, or if the areas covered are contiguous rather than scattered. To an extent, these effects might be addressed by adding bonus points if the area covered by a given land use passes a threshold. Such an approach could quickly result in an excessively complex point system, however. Another approach would be to set a minimum participation threshold for the PES program to take effect; this approach was followed by New York City, for example (A. Appleton, pers. comm.)

A similar procedure was used to establish the carbon sequestration index, with different land uses given points according to their capacity to sequester stable carbon in the soil and in hard wood through the years. Recent studies indicate that secondary forest can fix an average of 10 tonnes of carbon per year in wood and in the soil. As secondary forest has a value of 1.0 in the index, 0.1 points correspond to an estimated sequestration of 1 tonne of carbon. Data from studies conducted by CATIE were used to calibrate the carbon sequestration index.

As data were insufficient to derive country-specific indices, the same index is being used in all three countries. Data from the monitoring efforts will be used to improve the indices, and it is expected that these will differ from country to country.

Should downstream water users be willing to pay for hydrological services, the approach could also be extended by adding an index denoting the contribution of each land use type to the desired water services, though developing such an index would certainly prove difficult.

Note that under RISEMP, biodiversity and carbon sequestration benefits are given equal weight in calculating payments. The two indices could easily be de-coupled, however, with separate payment levels for each kind of environmental service. Alternatively, different weighting schemes could be used to give proportionally more weight to one or the other, depending on the interest of those making the payments.

This index approach was tested with potential participants, and is proving quite intelligible to them in practice. Dissemination materials such as posters and handbooks have been prepared showing precisely what the payments would be for specific land uses.

How should payments be made?

The second challenge in developing an appropriate contract is the need to understand the economics of the farming system, so that the appropriate amount and form of payment can be determined. Payments for environmental services will have the desired effect only if they reach the land users in ways that influence their decisions on how to use the land.

Analysis of the time path of benefits generated by silvopastoral systems showed that they are unattractive to land users primarily because of their substantial initial investment, and because of the time lag between investment and returns, as shown in Figure 1 above. This leads to the hypothesis that a relatively small payment provided in the early period of adoption would be sufficient to ‘tip the balance’ between current and silvopastoral systems. This effect works by increasing the net present value of investments in silvopastoral practices, but also by reducing the initial period in which adoption of these systems imposes net costs on land users. By the time payments end, the silvopastoral practices themselves are ready to 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, it was decided to provide a relatively small, up-front payment to participating land users. This payment is of US$75 per incremental point, per year over a four-year period, up to a maximum of US$4,500 per farm (US$6,000 in Colombia, where input prices are higher). Both of these aspects deserve further discussion.

In principle, the amount should be no less than the land users' opportunity cost (or they will not participate), and no more than the value of the benefit provided (or it would not be worthwhile to provide the service). In practice, the actual value of the benefit provided is extremely difficult to estimate, and particularly so for benefits such as biodiversity conservation. In contrast, the farmers' opportunity cost can usually be estimated relatively easily. For this reason, as well as to limit the budgetary requirements of the payment, payment levels are usually set at slightly more than the opportunity cost of the main alternative land uses. All the existing systems of payments for environmental services implicitly or explicitly use this approach. Costa Rica's PSA program, for example, currently pays US$45/ha/year for forest conservation. This payment has proven to be quite attractive, with far more applications for this contract than the program has been able to finance. (In contrast, a payment of US$538/ha over 5 years for reforestation has proven to be less popular, as many landowners consider the payment offered insufficient to justify the investment.) In Mexico, a specific study was commissioned of the opportunity cost of land (Jaramillo, 2003) to provide a basis for payments levels under the PSAH; no study was made of the magnitude of benefits. Zelek and Shively (2003) propose a scheme to pay the opportunity costs of Philipino farmers who adopt practices that sequester carbon. Paying the opportunity cost of adopting the desired practice also accords well with GEF's policy of paying for the incremental costs of generating global environmental benefits.

In terms of payments for carbon emissions reductions, the US$75/point/year payment level is equivalent to paying US$7.5 per tonne of carbon sequestered, or US$2 per tonne of CO_2 equivalent. This compares favorably to current world prices for carbon emissions reduction of US$3–5 per tonne of CO_2 equivalent (World Bank, 2003b)—although these payments typically require a higher degree of assurance of the permanence of the emissions reduction and a more intensive monitoring regime than the RISEMP offers. No similar comparison is possible for payments for biodiversity conservation.

In general, emerging guidelines for payments for environmental services indicate that payments should be on-going rather than finite (Pagiola and Platais, forthcoming). In Costa Rica's PSA program, for example, payments for forest conservation contracts are for 5 years, but they are renewable indefinitely by mutual agreement. The logic for this is simple: if environmental services are to be generated over a long period of time (presumably, indefinitely), then payments for these services should also be made over a similarly long period. Ending payments sooner creates the risk that land users will revert to their previous land use practices.

This is a risk that has been observed time and time again in projects that attempted to change land use practices, such as soil conservation or reforestation projects (Lutz and others, 1994). This risk was thought to be relatively low in this instance, as the silvopastoral practices, once established, are privately more profitable (see Figure 1). Moreover, the payments represent only a small portion of the necessary investment costs, thus making it unlikely that land users would adopt practices they intend to abandon solely to receive the payments. In an effort to determine the long-term sustainability of the mechanism, a sub-group of participants is being given a slightly modified contract, in which the payments are frontloaded: rather than receiving them over a four-year period, farmers with this alternative contract will receive a similar amount over a two-year period. Farmers were assigned randomly to one or the other contract.

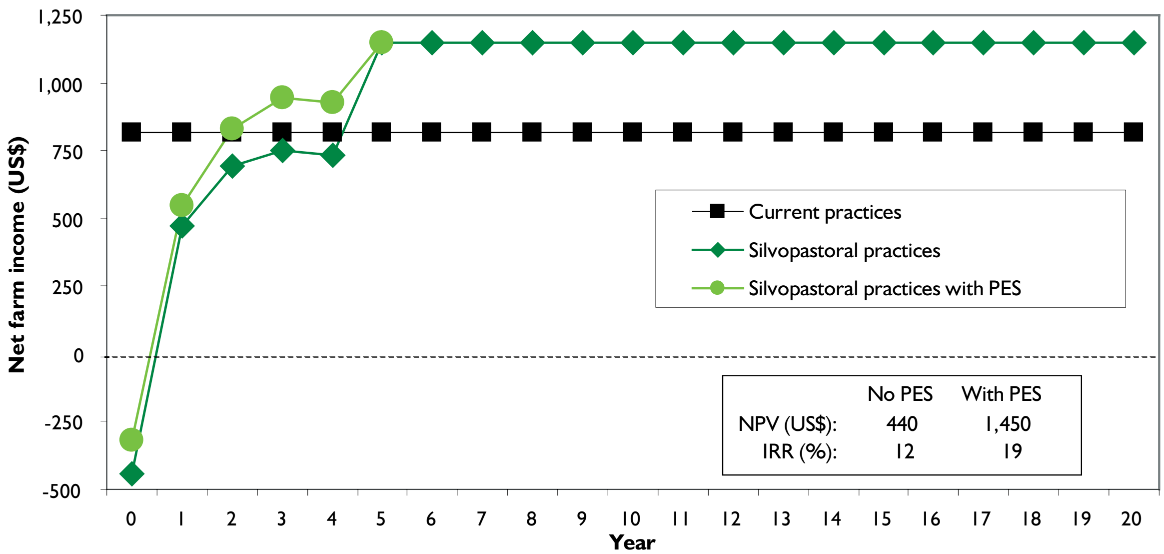
Table 5 illustrates the application of this contract for the 20 ha farm in Matiguás, Nicaragua, used in the previous example. In the baseline year, the farm has 2.5 ha under annual crops, 14.5 ha under natural pasture without trees, and 3 ha under brush (tacotal). Motivated by the project, it converts 3 ha of its pasture to higher tree densities: 1 ha a year for the first three years. It also plants an 0.5 ha fodder bank, and fences off the scrub areas so that secondary forest can regenerate. Finally, it plants trees along 1.5 km of its fence lines. Using the environmental service index in Table 4, the resulting scores can

Table 5. Example of payment computation

		Years from contract signing				
		0	*1*	*2*	*3*	*4*
Land use						
Crops (annual, grains, tubers)	(ha)	2.5	2.5	2.5	2.5	2.5
Natural pasture with low tree density	(ha)	14.5	13.0	12.0	11.0	11.0
Natural pasture with high tree density	(ha)	0.0	1.0	2.0	3.0	3.0
Fodder bank	(ha)	0.0	0.5	0.5	0.5	0.5
Scrub habitat	(ha)	3.0	0.0	0.0	0.0	0.0
Secondary forest	(ha)	0.0	3.0	3.0	3.0	3.0
Total area	(ha)	20.0	20.0	20.0	20.0	20.0
Wire fences with trees	(km)	0.0	0.5	1.0	1.5	1.5
Environmental service score (points)						
Crops (annual, grains, tubers)		0.0	0.0	0.0	0.0	0.0
Natural pasture with low tree density		8.7	7.8	7.2	6.6	6.6
Natural pasture with high tree density		0.0	0.9	1.8	2.7	2.7
Fodder bank (monocrop)		0.0	0.5	0.5	0.5	0.5
Scrub habitat		3.9	0.0	0.0	0.0	0.0
Secondary forest		0.0	5.7	5.7	5.7	5.7
Wire fences with trees		0.0	0.5	1.0	1.5	1.5
Total points for the farm		12.6	15.4	16.2	17.0	17.0
Baseline points		12.6				
Incremental points			2.8	3.6	4.4	4.4
Income from environmental services (US$)		**126**	**210**	**270**	**330**	**330**

Note: 20ha farm in Matiguás, Nicaragua.

Figure 2. Effects of PES on the profitability of silvopastoral systems



Note: 20ha farm in Matiguás, Nicaragua.

be calculated for the baseline and for each subsequent year. These scores are then used to compute the payments due to the farmer, including the initial baseline payment for existing services (see below) and the main payment for incremental services provided under the project. Figure 2 shows the impact of these payments on the time profile of benefits to adopting silvopastoral practices, and the resulting impact on the profitability of the investment. What had been a marginally viable investment now becomes more attractive.

Avoiding perverse incentives

The initial plan involved paying land users only for incremental improvements in land use practices. The extent to which land users had already adopted practices that conserved biodiversity or sequestered carbon prior to the project was to have been reflected in their baseline environmental service index, and only increments to this index were to be compensated. It soon became clear that this approach entailed a substantial risk of creating perverse incentives. "Bueno, corto todo," was a common reaction by land users when told they would not be compensated for pre-existing trees: "fine, I'll cut them all." It might have been possible to avoid this risk among project participants by imposing contractual restrictions on such actions, though this would certainly have required an increased monitoring effort, and thus increased costs. But there was also a broader risk that non-participants in surrounding areas would postpone adopting silvopastoral practices that they might have been tempted to adopt, so that they might wait for a project to come and compensate them for doing so. As a result, the initial plan was modified to allow for a payment to be made for pre-existing environmental services. A one-time payment of US$10/point will be made for the baseline points, up to a maximum of US$500 per farm. This payment has the further benefit of helping to alleviate financing constraints to implementing silvopastoral practices.

As part of the effort to avoid perverse incentives, the contract also specifies that burning in pastures is banned (except in areas devoted to food security, where burning is allowed in the first two years), and that the contract will be terminated if the participants cut down primary or secondary forest in their farms.

A related problem is that of minimizing 'leakage'-that is, avoiding environmentally-damaging activities being simply displaced, so that there is little net benefit. The RISEMP minimizes this problem by computing the points on which payments are made over the entire farm and basing payments on the net points over the entire farm. If land users cut down trees in one plot even as they plant them in another, the negative points earned from the adverse change will offset those gained from the positive change.

6 Monitoring Results

Monitoring is always important, as it allows the effectiveness of the project to be determined. It can also allow mid-course corrections to be made if they should prove necessary. The need for monitoring is particularly high in pilot projects, which are intended to serve as guides for future projects.

Changes in land use

For the purpose of monitoring compliance with the contract and computing payments owed, observation of participants would be sufficient. However, the RISEMP has the broader objective of piloting the application of PES systems to silvopastoral practices. This requires not only monitoring the behavior of participants, but determining that the project has been instrumental in affecting this behavior. Monitoring the degree to which the project is encouraging participants to undertake the desired changes in land use entails monitoring the changes in land use of the participants themselves, and of a control group (so that the impact of the project itself can be distinguished from other trends that might affect land use).

To address these issues, monitoring will be undertaken on three groups. In addition to the target group of participants (80 households in Colombia, 100 in Costa Rica, and 100 in Nicaragua), a control group of 30 households will be monitored in each country. This control group will be selected so as to have similar characteristics as the households in the target group, but will not receive any payments for environmental services. The target group itself will be partitioned into two groups, so that the impact of technical assistance provided by the project can also be tested. The main part of the group will receive both the payments and technical assistance, while a subgroup of 30 households will only receive the payments for environmental services (to the extent that they adopt the recommended practices), without the technical assistance. Each household in each of these groups will be monitored every other year. Their land use will be monitored, and a socio-economic survey will be conducted.

Impact of land use change on environmental services

To verify that the silvopastoral systems promoted under the project actually generate the expected environmental benefits, biodiversity and carbon sequestration will be monitored in all land use types in the three pilot areas. For biodiversity, counts of bird species will be the main indicator of biodiversity used, but they will be complemented by studies of butterflies, ants, and mollusks. Factors such as endemicity and rarity in the species observed will be taken into consideration. Water quality will be monitored only in the Colombian site, as funds did not permit a more general assessment of the contribution of these systems to improved water quality.

The changes will be compared to baseline measurements made at the start of the project. A study of the Matiguás-Río Blanco sites in Nicaragua, for example, found 131 bird species (Pérez and others, 2004). The key test for the project will be whether biodiversity increases significantly compared to the baseline.

The results of the monitoring will also be used to revise and refine the biodiversity and carbon sequestration indices. These revised indices could be used to determine payments under any future project. They will not, however, affect payments under the current project, which will be made based on an ex ante estimates of the global environmental benefits of each land use, as expressed in the environmental service index.

Impact of the project on participating households

In addition to the project's impact on the global environment, it is also important to understand its impact on household welfare: does welfare increase, and if so how much and in what way, and are there differences in how welfare increases across income groups? Payments for environmental services have been hypothesized as having the potential for improving the welfare of the poor in target areas (Pagiola and others, 2003), but there has been little empirical work on this topic to date. Data collected through the socioeconomic survey will help to address these questions. It will allow low-income households to be identified, and will provide a variety of measures of household welfare, including income-related measures (total income and income variability) and other indicators (such as health status).

7 Conclusions

The RISEMP project demonstrates that direct contracts for biodiversity conservation in agricultural landscapes are not just a theoretical curiosity. Such contracts are possible, if the link between land use and biodiversity is known. Specific details depend on the economics of the system being promoted.

It will be some time before the effectiveness of the mechanisms discussed in this paper can be determined. The intensive monitoring being undertaken will allow a very detailed analysis of this effectiveness, including consideration of numerous exogenous factors that might affect it. This project will thus allow both an overall conclusion on the effectiveness of the approach and provide data for its refinement. Already, however, a number of key questions can be identified, some specific to the particular approach used in the RISEMP, some that apply more broadly to PES approaches in general, and some that bear to the potential for replicating the approach on a wider scale.

Assessing the success of the project

Will the desired land use changes be induced? The extent to which the desired land use changes are induced depends in part on the payment level being sufficient to 'tip the balance' between current and improved practices. The appropriate level of the payment was a subject of intense debate. The higher the payment offered, the greater adoption is likely to be. However, higher payments also militate against the cost-effectiveness of the approach. Moreover, a higher payment per point also increases the risk that participants will adopt otherwise un-profitable practices only temporarily, so as to receive the payment, with the intention of abandoning them later. The payment level was initially set at US$50 per environmental service index point, but was raised to US$75 after field staff reported that participants considered US$50/point insufficiently attractive to justify widespread adoption of silvopastoral practices. Given the novelty of the approach, there is also a potential credibility problem of the project's promise to pay for environmental services. The baseline payments probably played an important role in this sense, over and above their benefits in avoiding perverse incentives.

Will changes in land use be sustainable? The RISEMP project is based on the hypothesis that silvopastoral practices, once adopted, are more profitable to land users than current practices. If this hypothesis is correct, then adoption should be sustainable with no further assistance. To test this hypothesis some participants are being paid over a two-year rather than a four-year period.

Will improvements in biodiversity conservation be significant? Baseline studies show that there is some pre-existing biodiversity in each of the project areas. The challenge for the project will be to demonstrate whether it has improved this biodiversity significantly. The project will monitor changes in biodiversity levels closely.

Will the poor benefit? If the farm models prepared for the project (illustrated in Figures 1 and 2) are correct, the project has the potential of increasing the net income of participating households quite substantially. Whether this will occur is being closely monitored. Constraints that might prevent poorer households from participating, and hence from obtaining these income increases, are also being examined closely.

Assessing the success of the approach

How cost-effective is the PES approach in terms of biodiversity conservation? Both the cost and the effectiveness of this approach remain to be determined. The two are to some extent inversely related. Payments will be high if land users adopt practices with high point values, and low if they adopt practices with low point values. The transaction costs of implementing the project must also be considered. Some have argued that an incremental conservation dollar would be most effectively spent on other approaches, such as protected areas. Certainly protected areas are likely to have much lower transaction costs than the approach discussed here. But their implementation costs may well be higher. Establishing a protected area would require buying the land from its current owners. That is, it would require compensating them for the loss of the entire flow of benefits it might generate in its most profitable use. The PES approach only requires compensating them for the difference between the net benefits they obtain under the conservation use and the most profitable use. Moreover, buying the land outright requires paying for the entire present value of the future flow of benefits up-front. In contrast, a PES approach makes payments over time. PES will also attract lower-opportunity cost lands, while a protected area approach usually privileges conservation benefits and thus may include higher-opportunity cost land. The PES approach is likely to be particularly advantageous if, as may be the case in the RISEMP, a short-term payment is sufficient to result in sustainable adoption of the desired land uses. Finally, buying land outright may simply not be politically feasible, or may entail undesirable social consequences because of the need to relocate the landowners. In the case of the Costa Rica Ecomarkets Project, the PES approach was found to be much more cost-effective than establishing a protected area of the same size (World Bank, 2000).

PES may be the cheaper way to conserve a given area, but the level of conservation is likely to be lower. If the land were bought outright and placed in a protected area, it could be managed optimally from the conservation perspective. Under a PES approach, land use is determined by the combination of conservation benefits (as reflected in the payment) and land user preferences; in many cases, this will lead to a compromise result. Moreover, some of the reasons that make PES cheaper may also lead to lower conservation benefits: lower opportunity cost land is not necessarily the most desirable from a conservation perspective, for example.

Replicating the approach

How can transaction costs be reduced? The transaction costs involved in implementing a PES approach are a key determinant of its cost-effectiveness, its sustainability, and its replicability. They also play a critical role in the extent to which poorer land users can participate (Pagiola and others, 2003). Because of its pilot nature, the RISEMP has relatively high costs for detailed monitoring and other activities that would not necessarily be needed in a scaled-up project. The environmental service index used in the RISEMP allows a very fine-tuned targeting of payments to expected benefits, but it also imposes relatively high monitoring costs. There is a need to find proxy indicators that are highly correlated with biodiversity conservation but are easy and cheap to monitor, ideally using remote sensing. If forest cover provides an adequate proxy, for example, it would be relatively cheap to observe. The current environmental services index cannot be monitored solely from remote sensing, as it includes elements of the type and quality of vegetative cover. A crucial question which needs to be explored is that of the tradeoff between the precision of the index and the transaction costs involved in implementing it.

How can the approach be made sustainable? Most of the discussion in this paper would be broadly applicable to PES approaches that address benefits other than biodiversity. Where biodiversity services differ, however, is in the long-term sustainability of payments. Emerging lessons indicate that payments under PES programs usually have to be made on a long-term basis if the desired services are to be generated sustainably (Pagiola and Platais, 2003, forthcoming). The specific practices promoted by the RISEMP project may not require a long-term payment, but this is likely to be the exception rather than the rule. In the more general case in which the systems with the highest external benefits are not the most profitable to land users, the short-term payment approach used in the RISEMP is unlikely to result in sustainable adoption of the desired land uses. Rather, longer-term, probably indefinite payments will be needed. In turn, this means that sustainable long-term financing sources will be required. Even if only short-term payments are sufficient, substantial additional funding flows will be required if the approach is to be extended beyond the pilot areas. For water services, potential sources for such financing can readily be identified-although capturing them can be difficult. Moreover, funding streams for water services can in principle be very sustainable, as they are tied to services that will continue to be used indefinitely (Pagiola and Platais, forthcoming). All available financing sources for biodiversity conservation, however, including the GEF, tend to focus on relatively short-term projects. Placing funds into a trust fund so as to generate a stream of future revenues is one option (GEF, 1999), but it requires substantial up-front financing. Because of the greater ease of generating long-term payment streams for water services, basing payments on water service provision may appear to be an attractive option. The municipality of Matiguás, for example, is interested in using this approach to protect its water supply. This approach should certainly be exploited as much as possible, but two constraints need to be borne in mind: first, water services are very site-specific, and so many areas would not be eligible for payments. The project areas near Matiguás, for example, are downstream of the water intakes for the municipal water supply system and so would not be included in a water service-based PES program. Second, the most desirable activities from the perspective of generating water services are not necessarily the same as those that generate the biodiversity and carbon sequestration services sought in the RISEMP project. Basing payments on water services, therefore, will require additional scientific research to improve the understanding of how land use affects water services. In general, therefore, water-based payments will not generate all the desired biodiversity and carbon sequestration benefits, and the need for separate financing for this purpose will remain.

Appendix A — Land Use Change in Central America and Colombia, 1990–2000

	Area ('000 ha)			*Change in area (%)*		
	1990	*1995*	*2000*	*1990-1995*	*1995-2000*	*1990-2000*
Annual crops						
Colombia	3,305.0	2,399.0	2,818.0	-27.4	17.5	-14.7
Costa Rica	260.0	225.0	225.0	-13.5	0.0	-13.5
El Salvador	550.0	582.0	560.0	5.8	-3.8	1.8
Guatemala	1,300.0	1,355.0	1,360.0	4.2	0.4	4.6
Honduras	1,462.0	1,600.0	1,068.0	9.4	-33.3	-26.9
Nicaragua	1,963.0	2,457.0	..	25.2	..	..
Panamá	499.0	500.0	500.0	0.2	0.0	0.2
Permanent crops						
Colombia	1,661.9	2,077.4	1,765.8	25.0	-15.0	6.2
Costa Rica	250.2	291.0	280.8	16.3	-3.5	12.2
El Salvador	259.0	273.5	250.7	5.6	-8.3	-3.2
Guatemala	487.9	553.0	542.2	13.3	-2.0	11.1
Honduras	358.0	346.9	358.0	-3.1	3.2	0.0
Nicaragua	254.9	291.4	..	14.3	..	..
Panamá	156.3	..	..	..	..	..
Permanent pasture						
Colombia	40,093.8	40,093.8	40,924.8	0.0	2.1	2.1
Costa Rica	2,328.3	2,338.5	2,338.5	0.4	0.0	0.4
El Salvador	640.2	750.1	793.6	17.2	5.8	23.9
Guatemala	2,504.7	2,602.3	2,602.3	3.9	0.0	3.9
Honduras	1,499.3	1,532.9	1,510.5	2.2	-1.5	0.7
Nicaragua	4,819.6	..	..	..	..	..
Panamá	1,473.7	..	..	..	..	..
Forest area						
Colombia	51,519.5		49,649.9			-3.6
Costa Rica	2,124.1		1,965.8			-7.5
El Salvador	192.7		120.2			-37.6
Guatemala	3,383.0		2,851.7			-15.7
Honduras	5,974.9		5,381.9			-9.9
Nicaragua	4,455.4		3,277.8			-26.4
Panamá	3,394.0		2,873.0			-15.4

Notes: Annual crops category includes temporary pasture.
.. indicates data not available.
Source: World Bank World Development Indicators database.

Appendix B — Degraded Pastures and Silvopastoral Practices

Photo 1 — Silvopastoral systems, in which pastures include significant tree cover, tend to be more productive and to provide a much better habitat for biodiversity. Here, cattle graze in pastures with high tree cover in Esparza, Costa Rica.

All images in Appendix B are by Stefano Pagiola

Photo 2 — Degraded pasture in Matiguás, Nicaragua

Photo 3 — Improved pastures with high tree cover in Matiguás, Nicaragua

Photo 4 — Degraded pastures in Quindío, Colombia

Photo 5 — Fodder banks in Quindío, Colombia

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