Ecosystem Services Economics

Making Payments for Ecosystem Services Work

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Abstract

This paper reviews the factors that make PES schemes work. Judging the effects of many PES schemes is challenging, partly because it is not evident what is being paid for compared with more traditional market transactions, and partly because it is not always possible to calculate the marginal net social benefit of the behaviors induced by the scheme. Given these difficulties, this paper analyzes the different schemes currently operating in order to identify the most efficient approaches in terms of both 'process' (how the scheme works) and 'outcome' (what the scheme produces). It poses and answers three questions: What are PES? What can they be expected to achieve? What lessons can be learned from experience to date on the efficient design of future PES schemes?

KEYWORDS: Payments for environmental services, Environmental externality, Public good, Economic efficiency

1. Posing the questions

For over fifty years economists have developed instruments to address the market failures behind the collapse of ecosystem services noted by the Millennium Ecosystem Assessment (MA, 2005). Such instruments include taxes, subsidies, user-charges, access fees, penalties for non-compliance and the like (Tietenberg, 2006). More recently, instruments of this kind have been linked explicitly to the provision of specific ecosystem services through the concept of payments for ecosystem services (PES) (Ferraro and Kiss, 2002; Hardner and Rice, 2002; Niesten and Rice, 2004; Scherr *et al*., 2004; Wunder, 2007). PES schemes differ from earlier approaches to the management of ecosystems such as Integrated Conservation and Development Projects or Community-Based Natural Resource Management in three respects: their focus on ecosystem services (the benefits provided by ecosystems), their use of positive financial incentives to achieve the production of additional services, and the conditionality of those incentives on some measure of performance (Sanchez-Azofeifa *et al*., 2007; Pagiola, 2008; Swallow *et al*., 2007; Wunder et al, 2008). Recent attention has focused on PES schemes that connect with climate change, such as the Reduced Emissions from Deforestation and forest Degradation in developing countries (REDD) scheme (Miles and Kapos, 2008; O'Connor, 2008). But PES schemes have also been developed that offer real financial incentives for local actors to provide a wide range of more localized external, non-market ecosystem services (Engel *et al*., 2008).

The problem which PES schemes are designed to solve is that approximately 60% of the ecosystem services evaluated in Millennium Ecosystem Assessment (MA) (70% of regulating and cultural services) are being degraded or used unsustainably. The rapid growth in provisioning services – the production of foods, fuels or fibers – in response to the incentives offered by existing markets has been at the cost of regulating services (such as disease and climate regulation) or of waste processing services (MA, 2005). Yet these services have value that is not reflected in current market prices. Many are ultimately critical to the sustainability of the provisioning services, affecting not just the mean level of output of those services, but also their variability in time and space (Figure 1). PES schemes – like other market-based environmental instruments – are designed to signal the importance of these services to the land managers whose decisions determine their supply.

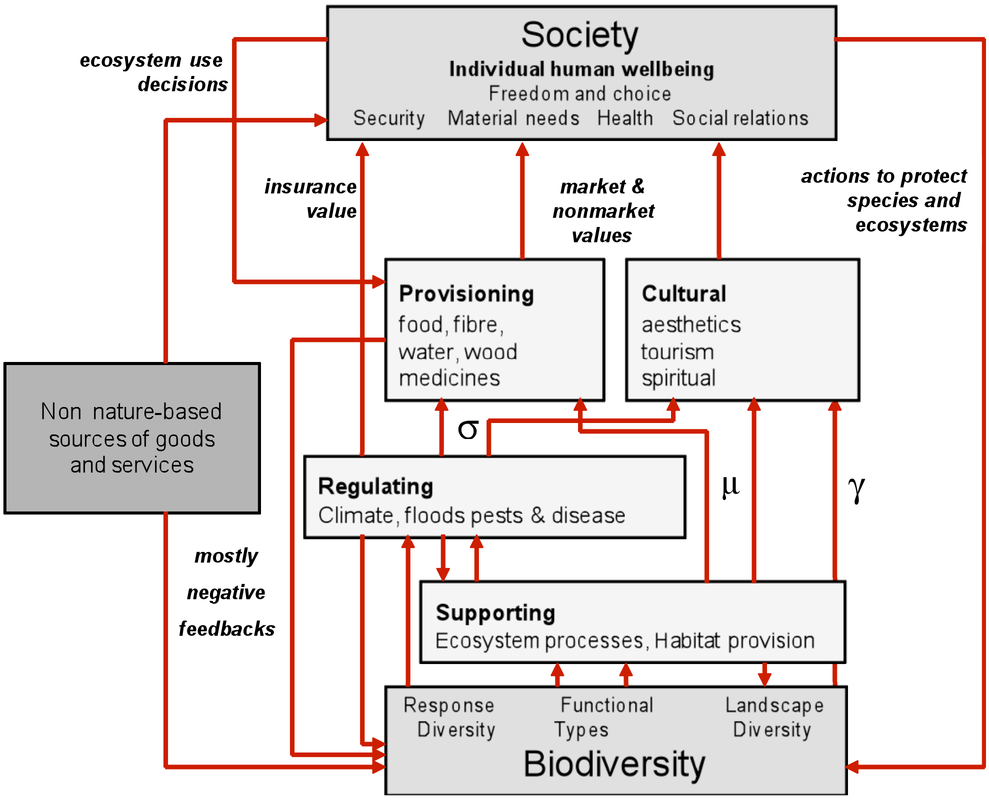

Figure 1. The pathways and processes by which biodiversity influences ecosystem services, and ecosystem services influence human wellbeing. The value of supporting services, most of the value of regulating services and most of the aspects of biodiversity is contained within the value of the directly-used provisioning and cultural services. These underlying elements can influence the direct services through altering the mean magnitude of the service (μ) or its variability in time (σ) or its variability in space (γ).

Source: Kinzig, Perrings and Scholes (2009)

This paper reviews the factors that make PES schemes work. PES schemes also offer benefits in terms of improvements in equity and the alleviation of poverty. These aspects are discussed elsewhere. [1] Judging the effects of many PES schemes is challenging,

[1] See Pascual *et al.* (2009), the first working paper in this series. PES systems have been closely associated with the target of poverty alleviation and equity. This is consistent with the Convention on Biological Diversity's (CBD) inclusion of the equitable sharing of the benefits of conservation as one goal of the agreement. It also recognizes the importance of incentives to preserve the traditional knowledge, innovation and practices needed to inform conservation efforts (United Nations 1993) and to address the

partly because it is not evident what is being paid for compared with more traditional market transactions, and partly because one needs an estimate of what would have hypothetically happened without the PES scheme. It is not always possible to calculate the marginal net social benefit of the behaviors induced by the scheme. Given these difficulties, the assessment of current schemes has tended to focus more on 'process' (how the scheme works) rather than 'outcome' (the ecosystem services produced). Since effective design is a necessary, though not sufficient, condition for the effectiveness of PES schemes, we follow this approach – while emphasizing that it is only part of the story. The paper poses and answers three questions: What are PES? What can they be expected to achieve? What lessons can be learned from experience to date on the efficient design of future PES schemes?

2. What are Payments for Ecosystem Services?

Like other environmental economic incentives, PES schemes aim to change the behaviors that have led to the degradation of many of the world's most valuable ecosystems. Tropical rainforests disappear due to illegal logging and extensive slash-and-burn practices, river basins are polluted by agrochemicals, and mountain watersheds are degraded by non-sustainable management practices (Ahlheim and Neef, 2006). Over the past fifty years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, biodiversity is being lost at unprecedented rates forcing many species to extinction, and many ecosystem services are rapidly deteriorating (MA, 2005; Duraiappah, 2007). Ecosystem services sustain human life. They are the source of food, water, timber, fiber, and genetic resources. They contribute to the regulation of climate, floods, disease, and water quality as well as waste treatment. They support recreation, aesthetic enjoyment, and spiritual fulfillment. They also enable soil formation, pollination, and nutrient cycling (MA, 2005). They supply food and drinking water, maintain a stock of continuously evolving genetic resources, preserve and regenerate soils, fix nitrogen and carbon, recycle nutrients, control floods, filter pollutants, pollinate crops and much more (FAO, 2007). Many ecosystem services are poorly understood or simply taken for granted by people who cannot see the relation between, for example, milk cartons or medicines and the services of nutrient cycling and biodiversity conservation that make their production possible (Salzman, 2005).

PES systems address the market failures involved where ecosystem services are 'public goods' or where changes in ecosystem services are 'externalities' of market production. If local land managers do not receive compensation for the production of valuable ecosystem services, they ignore them in their private decision-making – leading to socially sub-optimal land use decisions. Market failures of this sort may be due to incomplete information (i.e. ignorance and uncertainty regarding ecosystem functioning and conserving land use practice), as well as lags in time and space between environmental disturbance and recognition of environmental problems (Wertz-Kanounnikoff, 2006; Mayrand and Paquin, 2004). PES systems, like other market mechanisms, are intended to induce land-owners to incorporate the economic value of

problem of uneven wealth creation (Duraiappah, 2004). Although both the Millennium Development Goals (MDG) and the MA recognize the link between poverty, equity and conservation incentives, neither provided the kind of detailed road-map needed by governments to connect them in practical policies (Duraiappah and Roy, 2007).

ecosystem services into their financial decisions (Rojas and Aylward, 2003). The benefits of such mechanisms for poverty alleviation and equity lies in the fact that the emergence of market mechanisms for ecosystem services such as carbon sequestration or biodiversity conservation creates new income-generating opportunities for landholders at the same time as they generate efficiency gains (FAO, 2007). Their principal attraction is that they enhance efficiency. They increase the supply of socially desirable services and reduce the supply of socially undesirable services (disservices). In fact, in their review of World Bank-funded projects with biodiversity goals, Kareiva *et al.* (2008) found that the only predictor of overall biodiversity project success was the development of market mechanisms and new sources of finance for conservation.

In the light of this, the search for market-like mechanisms to enhance ecosystem services is gaining attention from policy-makers and private decision-makers (Daily and Matson, 2008; Tallis *et al.*, 2008). Historically, governments' attempts to correct environmental externality problems have primarily been through the use of command-and-control and other forms of direct interventions, which are easy to implement but can be quite inefficient (Bulte *et al.*, 2008). Yet industrialized nations have used conservation payments for decades to conserve agricultural soil, improve water quality, manage fisheries, and protect wilderness on private lands (Sills *et al*. forthcoming). The European Union Common Agricultural Policy (CAP) began operating in 1962, and agro-environment schemes have been supported since they were introduced in the CAP reforms of 1992. These schemes encourage farmers to provide ecosystem services that go beyond following good agricultural practice (EC, 2007).[2]

In less developed countries, projects that have implicitly embraced ecosystem services have historically been categorized as integrated conservation-development projects, community-based natural resource management, and, more recently, pro-poor conservation (Adams *et al.*, 2004). The first ecosystem services payment programs implemented in developing countries formed part of forest conservation initiatives in Latin America, following the limited success of the traditional regulatory approach that emphasized protected areas (Landell-Mills and Porras, 2002).

PES schemes have since emerged as a preferred policy solution for realigning the private and social benefits that result from decisions related to the environment. The approach is based on a straightforward proposition: pay individuals or communities to undertake actions that increase levels of desired ecosystem services (Ferraro, 2001; Bawa *et al.*, 2004; Berkes, 2004; Romeo and Andrade, 2004; Wunder, 2007; Jack *et al.*, 2008).

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[2] Conventional economic theory indicates that input price subsidies/taxes and output price subsidies/taxes will promote intensification/extensification of production processes. Subsidies will increase the use of variable production inputs, such as fertilizer, irrigation water, pesticides and herbicides; they will change the optimal combination or factor proportions with which inputs are used, and output price subsidies will lead farmers to substitute one crop for another or change between crop production and livestock production processes. Associated with this changing farmer/land user behavior will be different patterns of environmental impacts having both local and wider implications; that is, the environmental impacts will be felt at local, regional and global levels (Lingard, 2000). Literature on the negative environmental consequences of agricultural subsidies has been driven by a perception that the support to farmers neglected important ES (OECD, 1996; Pearce, 2003; Porter 2003; Summer and Champetier de Ribes, 2007).

Box 1. Payments for agro biodiversity conservation

Many PES schemes currently in operation have their origins on agricultural policies in Organization for economic Co-operation and Development (OECD) countries, dating from the 1980s (Fao, 2007). These policies were implemented in response to intensive farming practices. In fact, the best-known conservation payment initiatives are the agricultural land diversion programs of high-income nations (Ferraro and Simpson, 2002). Generally, agri-environmental payments in OECD countries are designed to compensate farmers for forgoing more intensive and more profitable farming practices.

Few programs in recent US history have had such a large and sweeping effect on farmland use as the Conservation Reserve Program (CRP) (Wu, 2000). The CRP was authorized by the Food Security Act of 1985 and re-authorized in subsequent Farm Bills. CRP offers annual payments for 10-15 year contracts to participants who establish grass, shrub and tree cover on environmentally sensitive lands. It aims at preventing soil erosion in cropland. CRP spends about $1.5 billion annually to contract for 12-15 million hectares. In Europe, fourteen nations spent an estimated $11 billion between 1993 and 1997 to divert over 20 million hectares into long-term set-aside and forestry contracts (OECD, 1997).

In the United Kingdom, through the Environmentally Sensitive Areas (ESA) Scheme created in 1987, farmers in eligible areas receive direct payments as compensation for adopting less intensive farming practices that conserve landscape and wildlife values. The total area designated as ESAs was estimated in 2003 to be 571,520 hectares. The scheme is voluntary, with farmers being encouraged to adapt their practices so as to enhance or maintain the natural features of the landscape and conserve wildlife habitat. In return, the Ministry of Agriculture pays the farmer a sum that reflects the financial losses incurred as a result of reconciling conservation with commercial farming. Schemes similar to ESA have been established in Denmark, France, Italy, and Spain (Wilson, 1996).

The Australian National Landcare Program was established in 1992 as one of the mechanisms to progress towards sustainable ecosystems, with a primary focus on sustainable agriculture and improved management of the natural resource base—soils, water and vegetation—at farm level.

No formalized definition of PES schemes exists in the literature, which causes some conceptual confusion (Wunder, 2007). Nevertheless, the basic principle of PES schemes is that those who provide ecosystem services should be compensated for the cost of doing so, whether these are direct costs of specific land use practices or more indirect opportunity costs of avoiding activities or types of land use (Grieg-Gran and Bann, 2003). Others believe that PES schemes should be a first-best direct-payment approach, and an incentive mechanism, used to purchase environmental services from local resource managers who otherwise would not provide the services (Ferraro and Simpson, 2002; Wunder, 2005; Wunder, 2007; Engel *et al.*, 2008).[3] In many cases, the term PES schemes seems to be used as a broad umbrella for any kind of market-based mechanism for conservation, including, for example, mechanisms such as eco-certification and charging entrance fees to tourists (Engel, 2008). Wunder (2005) defines PES schemes as

[3] Following Wunder (2007), the core idea of PES is that external beneficiaries of environmental services make direct contractual quid pro quo payments to local landowners and land users in return for adopting land and resource uses that secure ecosystem conservation and restoration.

(a) a *voluntary* transaction where (b) a *well-defined* ecosystem service or a land use likely to secure that service (c) is being 'bought' by a (minimum one) service *buyer* (d) from a (minimum one) service *provider* (e) if and only if the service provider secures service provision (*conditionality*).

One qualification to this is the requirement that 'ecosystem service purchasers' should be 'ecosystem service users' (Pagiola, 2006). Thus, rather than having the government or donor agencies financing the provision of ES, the ultimate ecosystem services beneficiaries should be the ones paying for the service provision. Payments are then shared by the providers of the ecosystem service under a 'provider gets' principle (Hodge, 2000). A second qualification refers to the requirement that PES schemes should primarily focus on internalizing indirect externalities, since this is often perceived as the main strength of PES schemes compared to other environmental policy instruments.

The logic of PES schemes illustrated in Figure 2 is that beneficiaries are asked or voluntarily decide to pay for the service provided to the landholders who are the source of the services, thus giving these people an incentive to follow land management practices that secure provision of the services. This is achieved through a variety of arrangements that transfer payments from those who benefit from an ecosystem services to those who conserve, restore, and manage the natural ecosystem which provides it. Payments may involve private sector or government financing, and can be made at local, national, and global levels (Pagiola and Platais, 2007).

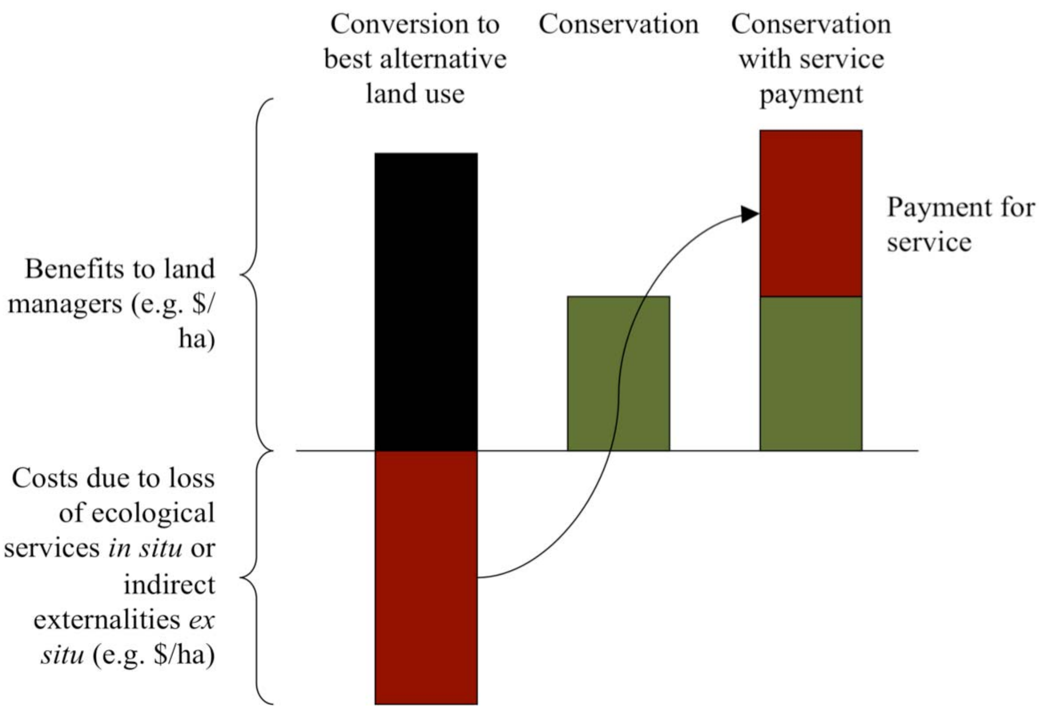

Figure 2. Logic of payments for environmental services
Source: Adapted from Pagiola (2002).

The forms of PES scheme are extremely varied (Grieg-Gran and Bishop, 2004). The differences reflect differences in the ecosystem services involved or in the social, economic, or political context in which they operate, or in the design of the instrument.

A critical issue concerns who the 'buyers' of the ecosystem services are. There is an important distinction between cases in which the buyers are the actual users of the ecosystem services (user-financed programs), and cases in which the buyers are others (typically the government, an NGO, or an international agency) acting on behalf of the users of the ecosystem services (government-financed programs) (Engel *et al.*, 2008). In the latter case, the funds used to compensate people who suffer lost economic opportunities to protect ecosystem services represent a public investment, and a governmental or other agency is typically responsible for collecting and redistributing the funds (Tallis et al, 2008). In general, the growing role of the PES schemes approaches today reflects underlying changes in environmental policy, and especially a greater emphasis on decentralization, flexible mechanisms, the private sector as a provider of public services, corporate self-regulation, consumer sovereignty, and civil regulation (FAO, 2007).

Hundreds of PES schemes are now being implemented around the world.[4] To date, the four main ecosystem services that have been addressed by PES schemes are watershed services, carbon sequestration, landscape amenity, and biodiversity conservation. Most current PES schemes are local level arrangements and involve spontaneous, private market-type arrangements. Such schemes tend to be modest in scale, and are very common in nature-based tourism and protection of small watersheds. Large PES schemes tend to be government driven, working at the state and provincial level (e.g. in Australia, Brazil, China and USA), or at national level (e.g. Colombia, Costa Rica, China and Mexico) (WWF, 2006).

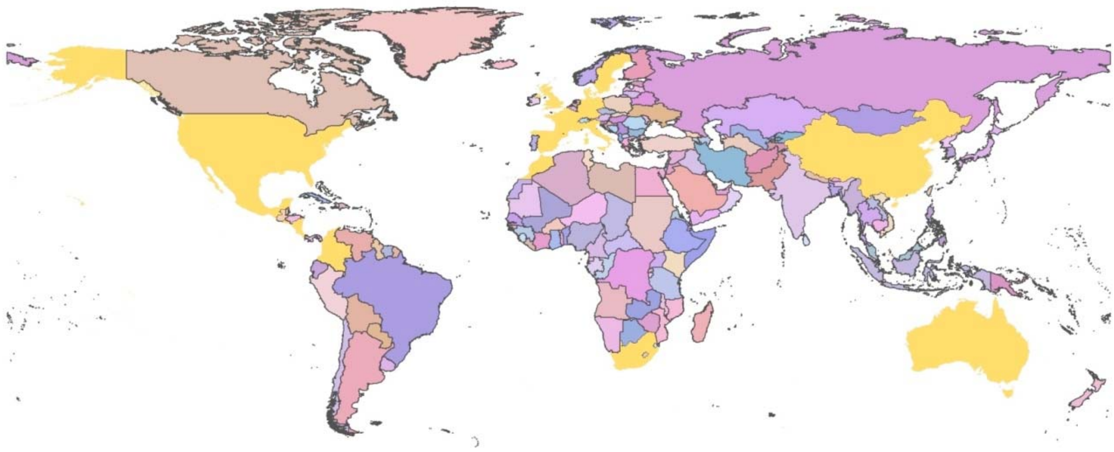

Figure 3. Countries implementing agrobiodiversity schemes (shaded yellow).
Source: Authors.

Figures 3 and 4 indicate the countries in which PES schemes for agro-biodiversity and water, respectively, are currently being implemented. While countries implementing PES schemes for agro-biodiversity are largely developed, countries currently implementing water protection schemes involve a much greater mix of developed and developing countries. This partly reflects the longer history of agri-environmental schemes in developing countries

[4] To date, relatively few PES programs have targeted farmers and agricultural lands in developing countries. There have also been relatively few examples of private payment mechanisms for the provision of environmental services in agriculture (FAO, 2007).

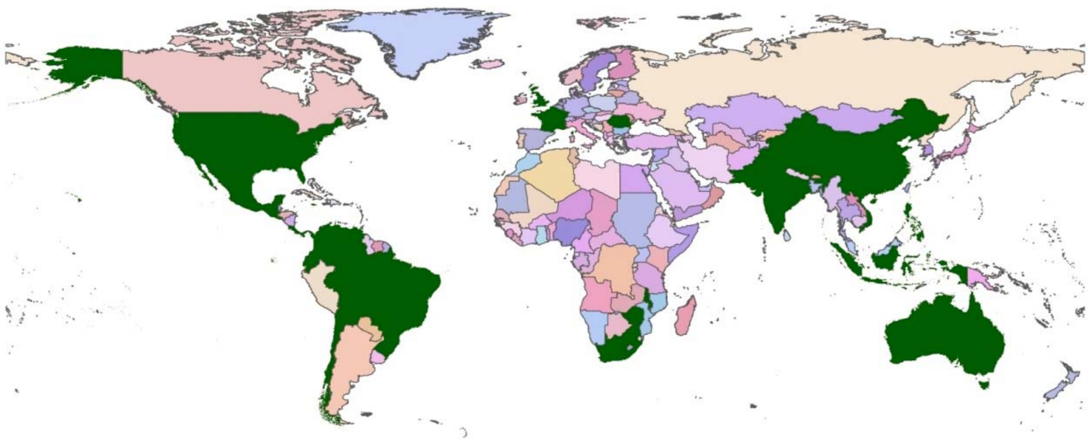

Figure 4. Countries implementing PES schemes (green shaded areas) for water protection
Source: Authors.

Large PES schemes also exist at the international level (e.g. EU) and can involve PES markets created by regulation of through an international agreement, such as carbon sequestration markets created by the Kyoto Protocol of the UN Framework Convention on Climate Change. Governments and companies in developed countries to finance tree plantations or forest conservation in developing countries to offset their greenhouse gas emissions. Investors have done so through voluntary carbon offsets (e.g. http://ww.planvivo.org), an less so through the Kyoto Protocol's Clean Development Mechanism (CDM), with only one CDM forestry project registered up to May 2008 and located in China (Bayon *et al.*, 2007).

The characteristics of existing PES schemes are shown in Table 1, which reports details of the ecosystem service involved, the buyer, seller, targeting criteria and payment system for a sample of PES schemes. The Chinese Grain to Green program is illustrative. After severe droughts in 1997 and massive floods in 1998 partially caused by farming on steep slopes and deforestation, China launched the Natural Forest Conservation Program (NFCP, also known as the Natural Forest Protection Program) and the Grain to Green Program (GTGP/ Sloping Land Conversion Program/Farm to Forest Program).

The NFCP and GTCP are the two biggest programs offering PES schemes in both China and worldwide in terms of scale, payment and duration, and their implementation is a milestone of China's forest management because it marks the end of an era dominated by timber production (Liu et al., 2008). To date, PES schemes in these and other programs have come primarily from China's central government. A total of 96.2 billion Yuan (at present $1 US=6.8 Yuan) has been designated for NFCP-related activities from 2000 to 2010 of which 81.5% of this amount is anticipated from the central government, and the remainder, from local governments.

Table 1: Characteristics of PES schemes

Case, Country	Environmental Services Paid for*	Environmental Services Non-Paid for	Buyer	Seller	Targeting Criteria	Payment Scheme
Government-Financed Programs						
Grain to Green Program, China (Bennett, 2008; Liu *et al.*, 2008)	Cropland retirement; conversion to forest and grasslands, re- and afforestation	Carbon sequestration	Chinese government	Chinese farmers	Slope steepness is the main criterion by which plots are chosen for inclusion in the program	Payment scheme adapts to priorities of participants including: technical assistance, technology transfer and direct payments
Environmental Quality Incentives Program, USA (Claassen *et al.*, 2008)	Watershed protection, biodiversity conservation (benign agriculture & agricultural land retirement)	Landscape beauty	US government	US farmers	Participants are selected based on environmental benefits and cost index	Annual cash payment. A reserved price is based on the rental value of land adjusted for its productive capability
Conservation Reserve Program, USA (Claassen *et al.*, 2008)	Watershed protection, soil conservation, wildlife protection and carbon sequestration (benign agricultural practices and agricultural land retirement)	Landscape beauty	US government	US farmers	Participants are selected based on environmental benefits and cost index	Annual cash payment. A reserved price is based on the rental value of land adjusted for its productive capability
Environmental Sensitive Area and Countryside Stwardship Scheme, UK (Dobbs and Pretty, 2008)	Biodiversity, recreation and watershed protection (benign agriculture & agricultural land retirement)	Carbon sequestration	UK government and European Union	Farmers in targeted areas	The ESA is open to all farmers in targeted areas and CSS selects participants	Cash payments
Australian Bush Tender Program (Department of Sustainability and Environment, 2008).	Biodiversity conservation (land management agreements for native vegetation	Watershed protection, carbon sequestration, landscape beauty	Australian government	Private landowners	Private landholders are contracted to improve native vegetation on their land. These contracts are awarded through competitive tendering on a best value for money basis	Landholders establish their own price for the management services they offer to better protect and improve their native vegetation. Successful bids are those that offer the best value for money
Swedish Payments for Wildlife Conservation (Zabel and Holm-Müller, 2008)	Number of carnivore reproductions certified on the villages' reindeer grazing grounds		Swedish state	Sami villages	About 20,000 Sami people live in Sweden grouped in 51 villages. All of them are eligible to participate in the program	Cash payments are determined according to the monetary damage that the offspring are expected to cause throughout their lifetime
Regional	Biodiversity	Wildlife	The World	Farmers	The project	Cash payments are

Integrated Silvopastoral Approaches to Ecosystem Management Project, Nicaragua (Pagiola *et al.*, 2008)	conservation and carbon sequestration	protection, water services	Bank (GEF grant). The NGO *Nitaplan*, is in charge of implementing the program	located in the Bulbul and Paiwas micro watersheds	developed an 'environmental service index' (ESI) and pays participants for net increases in ESI points	defined based on analyses of the relative profitability of different practices
Working for Water Program, South Africa (Turpie *et al.*, 2008)	Watershed and wetlands protection (clearing invasive alien plants)	Biodiversity conservation	Previously unemployed individuals that tender for contracts to restore public or private lands	Department of Water Affairs and Forestry, water management agencies	The program prioritize areas using ecological and social rationales	Cash payments to contractors staff that have been previously unemployed
Payments for Hydrological Environmental Services, Mexico (Muñoz-Piña *et al.*, 2008)	Watershed protection and aquifer recharge (conservation of preexisting forest area)	Biodiversity conservation, carbon sequestration, landscape beauty	CONAFOR (state forest agency funded through an earmarked portion of federal fiscal revenues from water fees)	Communal and individual landowners	Applicants selected where severe water problems are linked to deforestation, but where commercial forestry cannot compete against agriculture or ranching	Cash payments are defined according to land value in terms of hydrological services (cloud forest vs. other forested areas)
			User-Financed Programs			
The Vittel (Nestlé Waters) watershed protection program, France	Watershed protection (best practices in dairy farming)		Vittel	Dairy farmers (27 farmers enrolled)		Cash payments are base on new farm investment and the cost of adoption of new farming practices
Los Negros, Bolivia	Watershed and biodiversity protection (forest and páramo conservation)		Pampagrande municipality, US Fish and Wildlife Service	Santa Rosa farmers (46 landowners)		In kind plus technical assistance
Pimampiro, Ecuador	Watershed protection	Carbon sequestration, biodiversity conservation, landscape beauty	Metered urban users (20% fee)	Households in Nueva América Cooperative	Participant selection has focused on Nueva América because it is located near the water intake	Three differentiated cash payments according with forest type
PROFAFOR, Ecuador	Carbon sequestration (re- and afforestation)	Water services, biodiversity conservation	FACE (electricity consortium)	Communal and individual landholders	Process of site selection based on biophysical and economic criteria. Trade-offs between ES provision and opportunity costs rule selection.	Cash payments plus in-kind subsidies and technical assistance
Scolel Té Project, Mexico	Carbon sequestration	Biodiversity conservation, water services, landscape beauty	Individual farmers and communities	Trust fund Fondo Bioclimatico. Purchasers include Int. Automobile Fed, World Economic Forum, Pink Floyd and Future Forests	Through a management system, Plan Vivo, contacts between the Fondo team and local communities are arranged through farmers' and other organizations in the region	The Fund provides training and support during planning process.

By the end of 2005, >90 billion Yuan had been invested in the GTGP and the planned total investment will reach 220 billion Yuan by 2010. In 2004, 92% of the accumulated value of the Sloping Lands Program ($7.6 billion) was provided by the national government (Tallis et al., 2008). As a final goal, the NFCP aims to restore natural forests and meet domestic demand for timber in plantation forests. GTGP aims to reduce environmental degradation, to alleviate poverty and to promote local economic development. The area affected by these schemes is indicated in Figure 5.

Figure 5 Current distribution of the NFCP and GTGP in China
Source: Liu J. *et.al.* PNAS 2008;105:9477-9482.

3. What are Payments for Ecosystem Services Schemes able to do?

The attractiveness of PES schemes can in part be attributed to the interest of governments and civil organizations, especially conservation NGOs, to find new ways of promoting forest conservation while supporting the economic development of rural populations (Corbera *et al.*, 2008). Their effectiveness in meeting conservation goals is, nonetheless, not well understood (Kleijn *et al.*, 2001; OECD, 2003). An important feature of incentive systems generally is that since they are voluntary, their outcomes are products of the private decisions of landholders. First, the agency designs and offers a scheme to landholders. Then the landholders decide whether to participate, and, if so, in which areas to enroll. As in any economic (as opposed to any management) problem, the agency influences but does not completely control program outcomes (Siikamaki and Layton, 2006).

In principle, one would expect PES mechanisms to be more efficient than other non-market based policy measures. There is a long standing literature demonstrating the efficiency of market based instruments of environmental policy relative to traditional command and control measures, and the same arguments should apply to PES schemes (Pagiola, 2006; Wertz-Kanounnikoff, 2006). It is now widely accepted that the protection and long-term sustainability of diverse ecosystems will only be viable if the full range of services provided by these ecosystems are economically accounted for – which favors economic instruments (Liverman, 2004; Corbera *et al.*, 2008).

With perfect information, price-based mechanisms (of which PES schemes is an example) and quantity-based mechanisms (such as regulations prescribing particular behavior) could be equivalent. With incomplete information, the specific circumstances define which mechanism is more efficient. The relative efficiency of different mechanisms to address market failures has been the subject of considerable debate in the literature, beginning with the work of Weitzman (1974). Pagiola *et al.* (2005) find that one of the cases Weitzman examined is particularly relevant to PES, notably when there are multiple potential producers of a benefit (i.e. carbon sequestration) with different marginal costs which are not observable by the service buyer, price-based mechanisms are more efficient as they screen out the high cost producers, encouraging them to produce less and low cost units to produce more. Ferraro and Simpson (2002) demonstrated that paying for ecosystem protection directly can be far more cost-effective than encouraging activities, such as ecotourism, that indirectly generate ecosystem protection as a joint product. Siikamaki and Layton (2006) show that schemes which exploit landholders' knowledge about the opportunity costs of ecosystem service provision, are more efficient than top-down regulatory schemes.

While PES schemes are motivated by environmental concerns, there is an increasing interest in their potential to deliver development benefits. At the moment it remains unclear to what extent the two objectives of environmental conservation and development can be achieved simultaneously through such market-based mechanisms (Grieg-Gran *et al.*, 2005). Kareiva *et al.* (2008) do not find that environmental or biodiversity objectives are necessarily consistent with development objectives. Win-win outcomes are not easy to obtain. Yet attaining environmental goals without also addressing poverty is equally problematic (Sachs and Reid, 2006). Projects that use ecosystem services to simultaneously advance conservation and human agendas should nevertheless benefit from improved scientific understanding of four overriding issues: sustainable use of ecosystem services, tradeoffs among different services, the spatial flows of services, and economic feedbacks in ecosystem services markets (Tellis *et al.*, 2008).

Reactions to PES schemes in conservation and rural-development circles have been mixed. Advocates of PES schemes stress that innovation in conservation is needed because current approaches provide too little value for money, that PES schemes can provide new (especially private sector) conservation funding, and that poor communities can improve their livelihoods (Wunder, 2007). When buying an ES, it is not self-evident what is being paid for because ecosystem services are provided over time and space. While it is desirable to have an idea about what would hypothetically happen without the PES schemes scheme (i.e., construct some counterfactual service baseline), rigorous measurement of the counterfactual in the conservation literature is nonexistent, and PES programs are being implemented globally in much the same way that previous conservation interventions were implemented: with an unwavering faith in the connection between interventions and outcomes and without a plan to judge the effectiveness of such interventions (Ferraro and Pattanayak, 2006). Few well-designed empirical analyses assess even the most common biodiversity conservation measures (MA, 2005).

Box 2. Estimating the impacts of PES

The most obvious way to assess PES schemes programs is to quantify the area of ecosystem preserved by participants. However, this does not address an important issue: is the PES schemes program causing participants to preserve ecosystems that they otherwise would not have preserved? Answering this question requires estimating a counterfactual outcome: the area of ecosystems that landowners would have preserved if they had not received payments. However, if we want to estimate the PES schemes counterfactual outcome, we must worry about confounding effects—effects that are contemporaneous with the intervention and could plausibly affect the outcome and thereby mask the intervention's effect (Ferraro and Pattanayak 2006). Historical trends, unrelated programs or policies, and unobserved environmental and social characteristics are just some examples of these confounders. As in all scientific research, confounding effects are addressed through baselines, measure of covariates, and control groups. One potential confounder deserves mention because of its widespread but not well-understood, effects on our ability to make inferences about program effectiveness: endogenous selection. In any non-randomized PES program, characteristics that influence the outcome variable also influence the probability of being selected into the program. Failure to address the issue of endogenous selection can lead to biased estimates of a program's effectiveness. Because of the existence of confounding effects we cannot simply compare the outcome of a participating landowner to that of the average nonparticipating landowner.

Program evaluation provides the tools to focus on PES schemes outcomes instead of focusing on "inputs" (e.g. investment dollars) or "outputs" (e.g. number of PES schemes contracts). Program evaluation uses randomized experimental policy trials and, when interventions are not randomly assigned, as usual for the case of PES schemes programs around the world, appropriate statistical tools to evaluate the effects of an intervention. The use of program evaluation to measure conservation outcomes is almost absent in the conservation literature.

Matching is one method for addressing the selection bias and estimating the missing counterfactual without imposing strong distributional assumptions or extrapolating beyond a common support. Propensity score matching, originally proposed by Rosenbaum and Rubin (1983), is perhaps the most popular matching method used in a range of fields. However, there are still proponents of covariate matching, because in cases where there is a good understanding of the determinants of program participation and the outcomes of interest, them matching on these determinants will give unbiased estimates of program impact (Arriagada, 2008). Because matching relies on the assumption that all characteristics that affect program participation and program outcome are observable and are controlled during the matching, results are highly dependent on the quantity and quality of available data. This suggests an important policy recommendation for new PES schemes programs. The ideal database for a rigorous empirical evaluation of PES schemes would include observations on land use and characteristics of both participant and non-participant landowners and their properties both before and after the program. Collection of these data should be integrated into program operations when rigorous evaluation is a program goal but building experiments (random allocation of contracts) into the program is not politically feasible. The data should be sufficient to fully characterize program participants and feed this information into the matching process in order to select the most appropriate non-participants for estimating the missing counterfactual. Design of the database should be supported by qualitative studies of participants in PES schemes systems to identify key determinants of program participation and program outcomes. Equally important is collecting high-quality time series data on those program outcomes.

Finally, targeting payments to areas with high environmental risks (e.g. areas with high deforestation threats) is more appropriate than protecting forest that would be conserved with or without PES. Future evaluations of PES schemes should also concentrate on the impact of the program on provision of environmental services, given that payments on land with low opportunity costs may be justified if the environmental benefit is high (Arriagada, 2008).

There are many instances in which government-financed program may be the only option. As the number of ecosystem services buyers increases, transaction costs and incentives for free riding increase as well. Moreover, when the ecosystem services are public goods, it may be difficult to identify and delimit users, while non-excludability implies that users have strong incentives to free ride. Nevertheless, governments, NGOs, or international organizations can play an important role in reducing transaction costs (Engel *et al.*, 2008). User-financed PES schemes programs are often implemented in situations with local monopsonies or oligopsonies. According to Wunder *et al.* (2008) user-financed programs show greater adherence to a pure PES schemes definition, and are more targeted in their effects, compared to the larger, multiple-objective, government-financed programs that often have broader and less well-defined objectives. Indeed, the latter can sometimes be hard to distinguish from more traditional subsidy programs, the main differences coming in the conditionality of payments.

As most ecosystems provide not one but a large variety of ecosystem services, efforts are sometimes made to either ‘bundle’ various services together for sale, or to ‘layer’ payments from multiple buyers into payments to providers (Engel *et al.*, 2008; Wunder and Wertz-Kanounnikoff, in press). In the terms of conservation efficiency and effectiveness, the theoretical literature on PES, it has been suggested that the direct nature of the PES schemes transaction induces PES schemes to be both more effective and more cost-efficient than indirect tools such as ICDPs or eco-friendly premiums requiring investments in alternative lines of production (Ferraro and Kiss, 2002; Ferraro and Simpson, 2002, 2005 cited by Wunder, 2008).

However, several conditions must be met for implementation to be effective including mechanisms: for valuing (or at least measuring) a service where none currently exists, identifying how additional amounts of that service can be provided most cost-effectively, deciding which farmers to compensate for providing more of the service and determining how much to pay them (FAO, 2007). Whether a PES program succeeds in generating the desired ecosystem services depends on the successful completion of a series of steps. First, potential service providers must enroll in the program. Second, providers must comply with the terms of their contract. Third, compliance must result in a change in land use compared to what would have happened without the program (Wunder *et al.* 2008). The characteristics of a sample of existing PES schemes that correlate most closely with their performance are described in table 2.

Note that conditionality is critical to the implementation of PES. For payments to be conditional, it must be possible to verify the existence of the ecosystem services and to establish a baseline against which additional units ‘provided’ can be measured. This requires understanding causal pathways (‘processes’), recognizing spatial extent and distribution (‘patterns’), developing ‘proxies’ or ‘indicators’ for easy recognition and monitoring, and simplified, yet accurate and validated measures of environmental services provided (Tomich *et al.*, 2004). The potential ‘sellers’ of an ecosystem services are those actors who are in a position to secure the delivery of the ecosystem services. As long as participation is voluntary, ecosystem services sellers are unlikely to accept a payment lower than their cost of providing the ecosystem services, while conditionality ensures that they actually comply with their contracts.

Box 3 Efficiency of the Costa Rican Program of Payment for Environmental Services

The Costa Rican Program of Payments for Environmental Services (PSA) is currently the longest running program of payments for ecosystem services in the Tropics and it is mostly devoted to forest conservation (Costa Rican government assumes that by having forest protected, provision of ecosystem services will be secured). Along its story, PSA has applied different rules to select participants (in early years contracts were not assigned in a systematic fashion, but in recent years a more targeted selection of applicants has been used). Program administrators also did not design the program with the intention of empirically evaluating its effectiveness by testing and measuring against a clear baseline or "control" case. Moreover, forest cover has apparently been increasing in Costa Rica even before the establishment of PSA. To evaluate the effect of PSA on forest cover changes, the analyst must disentangle the effects of PSA from the effects of the elimination of government subsidies that promoted deforestation, incorporate the non-random assignment of contracts, and the economy-wide changes that have made deforestation less appealing. This makes difficult the evaluation of PSA impact.

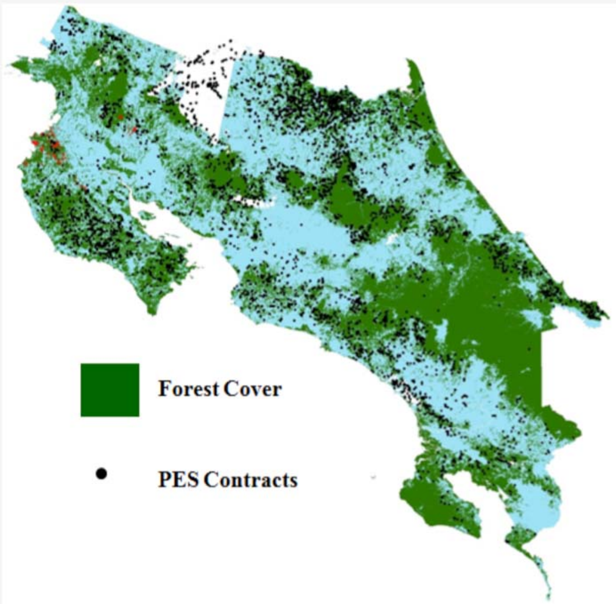

Figure 6 Distribution of PES schemes contracts in Costa Rica

Is the Costa Rican program causing participants to preserve ecosystems that they otherwise would not have preserved? Answering this question requires estimating a counterfactual outcome: the area of ecosystem that landowners would have preserved if they had not received payments. Sills *et al.* (2008) and Arriagada (2008) in a regional parcel-level analysis focusing on the initial years of the Costa Rican program found that regions with less productive land, fewer roads, and lower population density are more likely to have PSA contracts. In their study region, they found that absentee landowners with larger parcels that have more steep slopes and that are not used for commercial agriculture are more likely to have enrolled in PSA, as compared to other landowners who were also eligible but did not enroll. According to these authors, during the initial phase of PSA the program did have a statistically significant but small positive effect on gross and net deforestation. This result significantly extends previous suggestions of relatively low impact from PSA (e.g. Hartshorn *et al*. 2005, Sierra and Russman 2006, Sánchez-Azofeifa *et al*. 2007, Pfaff *et al*. 2008).

In a national evaluation of the program, Arriagada (2008) studied the impact of PSA on three different program outcomes: forest gain, forest loss and net deforestation. These outcomes are all important dimensions of forest cover in Costa Rica, although they have different implications for the bundle of ecosystem services produced and consequently are viewed differently by various stakeholder groups (e.g. stopping loss of existing mature natural forests is the priority of many environmental groups, while others interested in climate change and carbon sequestration are most likely to focus on net change in total forest cover). This author showed that PSA has different impacts on different dimensions of forest cover change. The most robust result is a positive and significant program impact on forest gain. PSA has no impact on forest loss which is not surprising given the deforestation trend in Costa Rica in the last two decades.

Table 2: Factors affecting program efficiency of PES schemes programs

Case	***Clear definition of participants***	***Clear definition of service***	***Additionality***	***No compliance penalties***	***Opp cost vs ecosystem services provision cost***
Working for Water Program, South Africa (Turpie *et al.*, 2008)	ecosystem services sellers are roving service providers in the form of small-scale contractors who perform restoration work on land under any type of ownership	The objective of the program is to control invasive alien plants to improve water delivery, biodiversity conservation and land productivity	The WfW program has been hailed as highly successful in terms of its objective of restoring water supply in alien infested catchments	The program works self-supervised by the Working for Water and does not include sanctions	Opportunity costs are low because no land use is displaced and treated land is likely to be more productive. Labor costs are low as the labor employed has few alternative formal sector employment opportunities
Grain to Green Program, China	Program focuses on farmers in Western China because of its ecological vulnerability, amount of soil erosion, cropland with slope > 25° and poverty	The stated environmental goals include reducing soil erosion and desertification, and increasing China's forest cover and area by retiring steeply sloping and marginal lands from agricultural production	High for land retirement; lower for reforestation. Five years after GTGP implementation, converted plots reduce surface runoff by 75-85% and soil erosion by 85-96% compared with croplands on steep slopes without the GTGP. However, no explicit baseline with which to evaluate these gains is presented	Program compliance is defined in terms of the quality, type and survival rates of the trees/grasses planted. Withholding of subsidies is based on survival rates, but survey results indicate that low survival rates have generally not resulted in significant withholding of subsidies	Farmers of Gansu Province lost 3,852-4,000 yuan/ha partially because of increased prices for agricultural products in 2003. It is possible that NPV of future income from trees and grasses planted under the program could more than offset farmers for foregone cropping income from enrolled plots
Regional Integrated Silvopastoral Approaches to Ecosystem Management Project, Nicaragua (Pagiola *et al.*, 2008)	Landowners in specific areas can participate. The Matiguás-Río Blanco site was selected based on its location in a biological corridor	The project developed indices of biodiversity conservation and carbon sequestration under different land uses, then aggregated them into a single ESI	Program pays only for additional ESI score in reference to a baseline. No control groups of non-participants exist to distinguish project-induced land use changes from changes induced by other factors	The project computes changes in ESI over the entire farm - any switch to land uses that reduce service provision would incur negative points, reducing total payment	Based on the relative profitability of different practices, a fixed payment per incremental ESI was established
Pimampiro, Ecuador (Wunder and Albán, 2008)	Trade-offs between ecosystem services provision and opportunity	The program was established for the Palaurco river upper watershed that delivers drinking	There is no scientific evidence to assess additionality in terms of water services. A	Range from payment suspension to permanent exclusion depending on	Recent work indicates that with a discount rate of around 15-20%, PES schemes yields a

	costs make selection to happen in high-altitude zones with a minimum contract size to avoid high transaction costs of working with smaller plots	water for the Municipality of Pimampiro	stronger case can be made for landuse additionality, although no formal baseline exists both of service provision and of landuse trends	amount of forest extraction	higher NPV than incremental deforestation
PROFAFOR, Ecuador (Wunder and Albán, 2008)	The process of plantation site selection was based on biophysical conditions and economic criteria	PROFAFOR is an Ecuadorian company acting in extension of the Forests Absorbing Carbon-dioxide Emissions consortium, financed by Dutch electricity companies to offset their carbon emissions	A carbon baseline was built based on vegetation and soil criteria on parcels adjacent to those under contract. In relation to land use, one can safely affirm additionality	For individual owners, contract compliance is pursued by establishing a lien on their lands. For communal lands, members have to reimburse the payments received if they do not fulfill the terms	Average forgone revenues from much more degraded pastureland with predominantly ovine livestock are much smaller than the one for Pimampiro
Scolel Té Project, Mexico (Tipper, 2002)	Farmers from six Tzeltal communities and four Tojolobal communities in the municipalities of Chilón and Comitán were selected to participate in the program	Its point of departure is the land use activities that communities and individual farmers were seeking to implement and then ask how the carbon benefits could be packaged and marketed	There is a carbon accounting system where payments are completed only when carbon is generated by the account holder.	Annual monitoring is conducted on all sites. The Fondo's own technical staff checks consistency and accuracy of measurements on 10-20% of sites. 5% of the value of timber products will be ceded to the Fondo in the event of non-continuation of the scheme	An independent economic assessment found that discounted benefits for most participants lie between -$110 and $1,700. These estimates take into account all labor inputs and carbon credit sales, but do not include other possible associated benefits such as soil conservation.
Payments for Hydrological Environmental Services, Mexico (Muñoz-Piña *et al.*, 2008)	2003 almost random, 2004 basic grading and regional balance of contract distribution (2005 grading in place)	The program focuses on forest ecosystems, the hydrological criteria still left a large area of the country to choose from, and other criteria were introduced to narrow the area	Many of the program's payments have been in areas with low deforestation risk	Annual payments are made after verifying that no land use change have occurred (the seriousness of the cancellation of payments has not yet been experienced by any forest owner)	Differentiated annual cash payments (higher payments for cloud forests)

Experience to date indicates that PES schemes are frequently inefficient. A number of reasons for this have been noted in the literature: s*ocial inefficiency* in the adoption of actions whose benefits are smaller than their costs (Pagiola, 2005); *lack of additionality* in paying for adoption of practices that would have been adopted anyway (Ferraro and Pattanayak, 2006); *leakage* in the inadvertent displacement of activities damaging environmental service provision to areas outside the geographical zone of PES schemes intervention (Robertson and Wunder, 2005); l*ack of permanence* in the construction of PES schemes that are dependent on the continued flow of financing from sources other than the beneficiaries of the services involved. Some authors have noted that this may be a particular problem in government-financed PES programs, where funding is subject to policy cycles, but that it less likely to be an issue in user-financed programs, as long as the program are delivering the ecosystem services for which users are paying (Engel *et al*., 2008).

4. What are the lessons for the efficient design of PES schemes?

The effectiveness of PES schemes programs depends on both their design and implementation, given the specific political, socio-economic and environmental context of the program. Where PES schemes are designed to meet a particular target level of ecosystem services, then the relevant criterion for program design is cost-effectiveness (FAO, 2007). Where they are established to clear the market for ecosystem services, the relevant criterion is efficiency. PES schemes satisfying either criterion typically share a number of the characteristics identified in Table 2. The first is a clear identification of the service of interest, and the way it contributes to human well-being. This implies an assessment based on: (a) an understanding of the underlying biophysical science, (b) the ecosystem service supply function (and the price elasticity of supply), and (c) the ecosystem service demand function (and the price elasticity of demand) (FAO, 2007). From a design perspective, defining the nature of the service for which communities are rewarded and establishing standard methodologies for the evaluation of ecosystem services provision is very important (Corbera *et al.,* 2008).

In addition to understanding the supply and demand functions for ecosystem services, it is important to estimate the transaction costs associated with making an exchange between buyers and sellers. Transaction costs, in this context, include the cost of attracting potential buyers or finding potential providers of ecosystem services, of working with project partners and of ensuring that parties fulfill their obligations. The considerable uncertainties and complexities involved in measuring, monitoring and exchanging services mean that transaction costs can be significant (FAO, 2007). To be effective, though, any payment to the land manager must make the net benefits derived from maintaining ecosystem services greater than those derived from alternative land uses (WWF, 2006).

A further design consideration is whether to pay for the service itself or for some proxy for the service. If ecosystem services can be measured easily, and if cause-and-effect linkages are straightforward, payments will be most effective if made directly for output of the services delivered. In other cases, payments may be linked to observable land-use changes that correlate with provision of the desired ecosystem service. In the vast majority of PES transactions to date, payments have been associated with land-use changes rather than with service provision directly, and the buyers have borne the risk of inadequate service provision. So long as the farmers manage their property in accordance with the terms of the contract, they are paid whether the service is provided or not.

In principle, it should be possible to estimate the marginal benefit of the introduction of a PES scheme. In practice, however, since most PES schemes concentrate on incentives to change land use rather than incentives to change ecosystem service output, there are few effective measures of output. In Costa Rica, for example, direct payments for conservation of existing mature forest has had a statistically significant and positive effect on the establishment of new forest (i.e. positive effect on forest gain and net deforestation) (Arriagada, 2008). More importantly, the program has had a positive indirect impact on areas not protected by the program (i.e. positive spillover effects), and is meeting some of its non-timber objectives from newly regenerated forests. While these forests may not be equal to the original forest in terms of biodiversity, they do sequester carbon and stabilize soil. Yet even Costa Rica has few direct measures of output.

In the absence of satisfactory measures of output, the only way to evaluate the potential efficiency of PES schemes is through design considerations of the type discussed above. Table 2, above, describes the factors affecting the efficiency of a subset of the PES schemes programs presented in Table 1. In order to evaluate the potential efficiency of these initiatives, we constructed an efficiency index that assigns a score to each of the criteria presented in Table 2. The score for an individual criterion extends from one (1) to five (5) where:

- one indicates that the design property is unlikely to enhance the efficiency of the instrument
- three indicates that the design property may be expected to make an intermediate contribution to the achievement of efficiency
- five indicates that the design property has a highly significant contribution to the achievement of efficiency.

Table 3 reports the resulting efficiency scores of the PES schemes described in Table 2.

As with environmental governance issues generally, PES schemes should match the scale of the ecosystem service flows at issue. For watershed services, for example, a large share of funding may be secured from local ecosystem service users (Corbera *et al.* 2008). By contrast, a service like carbon sequestration depends on global sources of funding. In both cases, though, there is likely to be role for national or local intermediaries. For example, the REDD scheme already referred to aims to reduce historic rates of deforestation through a system of transfers to national governments. REDD is part of the land use, land use change and forestry (LULUCF) provisions of the United Nations Framework Convention on Climate Change (UNFCCC). LULUCF imposes penalties on regions or countries that are clearing their forests, and rewards those which have been reducing rates of deforestation. But this still leaves open the question of how reductions in historic deforestation rates are implemented at the national level. Aside from the incentive effects of the scheme on national decisions – the potentially perverse incentive it offers either (i) to promote increased emissions and/or decreased removals at national or sub-national levels in the lead-up to implementation, or

(ii) to accelerate displacement of deforestation and forest degradation activities from countries that are early entrants into a voluntary REDD mechanism to those that are not (Angelsen *et al*., 2009) – the scheme depends on the development of a system of incentives at the national level that will translate national commitments into the decisions of individual landholders. This implies financial incentives, procedures for setting reference levels, methodologies for monitoring, reporting and verification, and processes to promote the participation of indigenous peoples and local communities. REDD programs will depend upon effective governance of remote forest regions and an equitable, efficient system of channeling these incentives to the people who control forests (Nepstad *et al*., 2007; Miles and Kapos, 2008).

Table 3: Efficiency index for PES schemes

Case	***Efficiency Score***					***Total Efficiency Score***
	Clear definition of participants	***Clear definition of service***	***Additionality***	***No compliance penalties***	***Opp cost vs ecosystem services provision cost***	
Scolel Té Project, Mexico (Tipper, 2002)	5	5	5	5	3	23
Regional Integrated Silvopastoral Approaches to Ecosystem Mgmt Project, Nicaragua (Pagiola *et al.*, 2008)	5	5	4	5	3	22
PROFAFOR, Ecuador (Wunder and Albán, 2008)	5	5	5	5	1	21
Pimampiro, Ecuador (Wunder and Albán, 2008)	5	5	3	2	5	20
Grain to Green Program, China	5	3	3	3	1	15
Working for Water Program, South Africa (Turpie *et al.*, 2008)	3	3	5	1	1	13
Payments for Hydrological Environmental Services, Mexico (Muñoz-Piña *et al.*, 2008)	5	3	1	2	2	13

It is worth highlighting the fact that user-financed schemes score higher than government-funded programs. The WfW program, which is a PES-like development program, scored between user and government-financed programs. Having buyers and sellers more directly connected assists the efficiency of market transaction through identification of the service at issue, the buyers and sellers, and the marginal benefits and costs of alternative levels of provision. Moreover, whether governments are able to identify the value environmental public goods depends heavily on the effectiveness of the political process at all levels. Since the provision of ecosystem services that are transboundary environmental public goods requires the involvement of both national governments and international representative bodies, it is extremely important that PES schemes designed to deliver such services properly reflect their value to the different constituencies involved.

PES schemes and their enabling institutions are part of an emerging system of international environmental governance that cuts across scales in novel ways (Tucker and Ostrom, 2005; Corbera *et al.*, 2008). This system of governance is rapidly evolving. Indeed, in an increasingly complex world, where diverse actors interact across scales, continuous institutional adaptation is important to the long-term effectiveness of governance mechanisms (Biermann, 2007). At present, relatively few PES schemes formally recognize off-site environmental benefits. Most are designed to realize conservation benefits/costs that accrue at local scales. Yet increasingly, PES schemes are going to be asked to assure provision of services that provide benefits at much larger scales, and that yield outcomes that are clearly verifiable.

Increasingly, also, PES schemes will have effects on land use decisions by those who are not directly involved in the scheme. Such spillovers (also called “leakage”) can be either negative or positive. Understanding these spillovers is important to understanding the additionality of the scheme. On the positive side, for example, there may be conservation benefits where neighbors of PES schemes are more likely to conserve forest because of the existence of the scheme. The mechanism for these spillovers may be the option value of a future PES scheme’s contract, shifts in preferences or increased knowledge about the value of standing forest, or increased enforcement activity (Sills *et al*. forthcoming). Depending on how the program is presented and perceived by landowners, there may also be negative effects: “a monetary reward to motivate socially desirable behavior may actually do the opposite because it may crowd out an individual’s sense of public-spiritedness” (Cardenas *et al*. 2000: 1720). Program benefits may also be reduced by leakages, with recipients of PES schemes payments investing the revenue in expansion of agriculture or pasture on other properties. According to Robalino and Pfaff (2006), policies that promote agricultural development or forest conservation in a specific area may also affect deforestation rates in non-targeted neighboring areas. More generally, the additionality of individual PES schemes depends on their impact on wider trends. For deforestation, for example, there is some evidence for the existence of a ‘forest transition’ analogous to the well-understood ‘demographic transition’ (Kates et al., 2002). Derived from historical studies of forests, the idea is that forest cover changes in predictable ways as societies undergo economic development, industrialization and urbanization (Mather, 1990; Walker, 1993; Mather and Needle, 1998). Specifically, a large decline in forest cover occurs; then the trend turns around, and a slow increase in forest cover takes place (Rudel, 1998). Since a scheme such as REDD is intended to alter the slope of the downward portion of the net-afforestation curve, it is important to understand what that curve looks like.

Finally, PES are the latest in a series of mechanisms designed to internalize environmental externalities and enhance the supply of environmental public goods. Their effectiveness ultimately depends on whether they are able to deliver outcomes – measured in terms of the flow of services – that are better than the outcomes in the absence of such schemes. The power of economic incentives to alter behavior in ways that enhance the efficiency or cost-effectiveness of ecosystem service provision has been demonstrated often enough that the principle of PES is well accepted. But as with many other incentive mechanisms, whether it works as intended depends both on mechanism design and the identification of appropriate measures of performance. Process-based measures are often easier to implement, but are not necessarily the most appropriate. It is important is that the incentive to landholders corresponds to the value of the services delivered to all those affected – that the mechanism captures the interest of all beneficiaries of the service or services produced by land management. It is also important that it reflects the substitutability or complementarity between services – whether there are 'trade-offs' between or 'win-win' associations between services. While few existing PES schemes do well if evaluated in these terms, some do better than others and are useful guides to the development of new schemes. This paper identifies those schemes that are better models for the future.

1.5. Concluding remarks

For over fifty years economists have developed instruments to address the market failures behind the collapse of ecosystem services noted by the Millennium Ecosystem Assessment. These instruments include taxes, subsidies, user-charges, access-fees, penalties for non-compliance and, more recently, payments for ecosystem services (PES). PES schemes have been developed that offer financial incentives for local actors to provide a wide range of ecosystem services that lie outside of normal market transactions.

Hundreds of PES schemes are now being implemented around the world covering four main ecosystem services: watershed services, carbon sequestration, landscape beauty, and biodiversity conservation. Most current PES schemes are local level arrangements and involve spontaneous, private market-type arrangements. Such schemes tend to be modest in scale, and are very common in nature-based tourism and protection of small watersheds. Large PES schemes tend to be government driven, working at the state and provincial level (e.g. in Australia, Brazil, China and USA), or at national level (e.g. Colombia, Costa Rica, China and Mexico).

Necessary conditions for the implementation of PES schemes to be effective include the creation of mechanisms for valuing (or at least measuring) services that are not currently valued in the market; identifying how additional amounts of that service can be provided most cost-effectively; deciding which farmers to compensate for providing more of the service; and determining how much to pay them. Whether a PES program succeeds in generating the desired outcomes (ecosystem services) depends on the successful completion of a series of several steps. Potential service providers must enroll in the program. Providers must comply with the terms of their contract, and compliance must result in a change in the provision of the ecosystem service compared to what would have happened without the program.

There are a number of implications for PES design and implementation that follow directly from these observations.

First, user-financed programs are generally more efficient than government-funded programs. Having buyers and sellers more directly connected assists the efficiency of market transaction through identification of the service at issue, the buyers and sellers involved, and the marginal benefits and costs of alternative levels of provision. Against this, user financed programs may ignore services that are public goods.

Second, the provision of ecosystem services at multiple spatial scales should reflect their value to the different constituencies involved. At present, relatively few PES schemes formally recognize off-site environmental benefits. Most are designed to realize conservation benefits/costs that accrue at local scales. Yet increasingly, PES schemes are going to be asked to assure provision of services that provide benefits at much larger scales. This requires effective involvement of those impacted by the service and an understanding of the substitutability or complementarity between services – whether there are 'trade-offs' between or 'win-win' associations between services.

Third, the provision of global ecosystem services through PES schemes (e.g. REDD) requires the involvement of both national governments and international representative bodies. PES schemes designed to deliver services that provide benefits to people in only a few countries may be negotiated by those countries alone, but schemes that provide global benefits such as carbon sequestration or biodiversity conservation require the involvement of international bodies and coordination with global agreements.

Fourth, PES schemes should avoid negative spillovers (leakage), or provide benefits sufficient to offset unavoidable spillovers. PES schemes frequently have effects on land use decisions by those who are not directly involved in the scheme. These spillovers should be taken into account in calculating the net benefits (additionality) of the scheme. We note that spillovers may be positive (e.g. where neighbors of PES schemes are more likely to conserve forest because of the existence of the scheme), and these too should be taken into account.

Fifth, the positive incentives offered by PES schemes should be sufficient to 'internalize' the externalities of pre-existing market conditions. The effectiveness of PES schemes depends on whether they are able to deliver outcomes – measured in terms of the flow of services – that are better than the outcomes in the absence of such schemes. As with many other incentive mechanisms, whether they work as intended depends both on mechanism design and an understanding of the responsiveness of service providers to incentives.

Finally, PES design should be complemented by the measurement of ecosystem services produced through the scheme. Effective PES design is a necessary but not sufficient condition for PES schemes to work. Ultimately, it is necessary to ensure that they deliver additional benefits relative to the status quo. Relatively few existing PES schemes do well if evaluated in these terms, but those that do are useful guides to the design of new schemes.

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