

The Role of the Public and Private Sectors in Payments for Ecosystem Services

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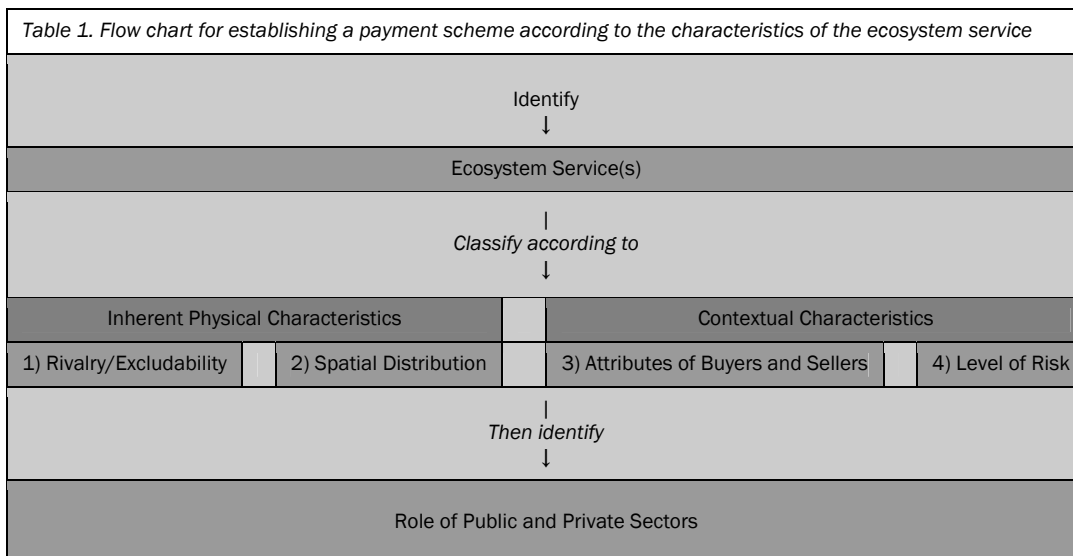
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Overview

Payments for ecosystem services (PES) have become an increasingly popular approach to dealing with environmental problems around the world. Hundreds of payment agreements have been arranged in both developing and developed countries. Several case studies have been written about their success, failures, limitations and the challenges of implementation (Landell-Mills and Porras 2002; Pagiola, Bishop et al. 2002). There has been little discussion, however, about how to design a payment program based on the inherent characteristics of each ecosystem service. The benefits of a payment program are maximized through varying levels of public and private sector participation dependent on the inherent characteristics of the service provided. In this paper we offer a framework for understanding the role of the private sector and government in establishing viable payment schemes.

We begin by introducing the concept of ecosystem services and why payments for ecosystem services have emerged as a solution to environmental degradation. Four payment programs that cover a variety of arrangements, locations, and services are presented. We then discuss the necessary condition for a payment program to improve social welfare: benefits must exceed costs. Each ecosystem service has innate characteristics and particular circumstances which shape the potential benefits and costs of establishing a payment program for that service. Twenty-three ecosystem services are classified according to two innate characteristics: first, the combination of rivalry and excludability; and second, the spatial distribution of the benefits. We also discuss additional circumstances that shape benefits and costs: the attributes of the buyers and sellers, and the level of risk or irreversibility of environmental damage. We provide recommendations for increasing the effectiveness of a sustainable payment scheme. Finally, we discuss the role of the private sector, including non-governmental and community organizations, and the government in establishing effective payment schemes according to the innate and contextual characteristics of the service(s) provided. *Table 1* shows a flow chart of this framework.



Introduction

Ecosystems provide services essential to human survival and well-being. For example, forests supply climate regulation, erosion control and aesthetic beauty; wetlands offer protection from storms and floods; and grasslands supply habitat and genetic resources (Costanza, d'Arge et al. 1997; Daily 1997). Yet, most ecosystem services are external to the market system. Not only are these services neglected, current economic incentives encourage rapid degradation of the natural capital, such as forests and wetlands, that provide the services. Natural capital plays dual roles. On the one hand it can be converted into raw material inputs essential to all economic production. On the other hand, it can be left intact to provide critical ecosystem services. As most economic output is in the form of market goods and most ecosystem services are non-market goods, the market system systematically favors conversion over conservation. In addition, natural capital provides ecosystem services at a given rate over time, over which humans have very little control. In contrast, we can decide how rapidly to convert natural capital to economic output. Short time horizons therefore favor conversion over conservation. The outcome is a downward trend analogous to selling off productive built capital, a car factory for example, as raw material. Most economists and policy makers recognize that it is the responsibility of the government to provide goods and services that are external to the market (Daly and Farley 2004).

Environmental degradation occurs through the emission of pollutants, through the harvest of natural capital for raw materials, or the conversion of natural capital to alternative land uses such as agriculture or development. These are different types of problems, requiring unique solutions. Typically, the government curbs emissions through taxation and regulation. When industry pollutes the atmosphere, for example, it is executing a privilege, not a property right – industry does not “own” the atmosphere. The government can revoke this privilege and reclaim clean air for the public, essentially establishing public property rights, by instituting a “polluter pays” principle or by regulating the amount of emissions allowed (Bromley 1993).

The harvest and conversion of natural capital, and in turn the loss of ecosystem services, must be handled differently. Unlike the atmosphere which cannot be owned by any one party, private landowners typically have explicit property rights to the physical, natural structures that supply ecosystem services. Forests provide climate regulation, an ecosystem service that benefits everyone, but a landowner is not obliged to relinquish ownership of his trees to provide climate regulation in the same way an industry polluter is obliged to reduce pollution to provide clean air. In fact, he has the right to fell the trees and sell the timber for profit.

There are two approaches to solving this dilemma. If strong, immediate action is warranted, the government can attempt to amend property rights. For example, in 2002 the U.S. Supreme Court upheld a moratorium on development, without compensation to landowners, by the Tahoe Regional Planning Agency that was instituted to protect the pristine beauty of the Lake Tahoe basin (Turnbull 2004). Alternatively, those who benefit

from an ecosystem service can compensate landowners for maintaining or restoring the natural capital on their property.

Payments for ecosystem services can take place between individuals, communities, businesses, and government entities. This paper aims to provide a framework for determining when payment schemes are appropriate and what type of payment arrangement works best for each ecosystem service.

Case Studies

The following examples of payment programs introduce different types of arrangements between *beneficiaries*, the individuals or entities who benefit from an ecosystem service, and *service providers*, the landowners who supply the service.

In France, Perrier Vittel, the world's largest bottler of natural mineral water, pays upstream landowners for undertaking less intensive agricultural practices and reforestation of riparian zones to provide improved water quality. The company determined that protection of the watershed was more cost effective than building filtration plants or moving continuously to new sources. Vittel also purchased 1,500 hectares of land around the springs. Landowners are not paid for measured water quality, rather they are compensated for their opportunity costs, risk of switching to new practices and the transition to new technology. The program has succeeded in reducing non-point source pollution in the basin (Perrot-Maitre and Davis 2001).

Costa Rica's Payment for Ecosystem Services Program (PSA) focuses on forest protection to provide four key ecosystem services: carbon sequestration, watershed protection, biodiversity conservation¹, and scenic beauty. It was established by the National Forestry Finance fund in 1991. Landowners receive financing for specific practices, including land conservation, reforestation, and sustainable logging (Pagiola et. al., 2004). Energy and agricultural projects are also funded (Rojas and Aylward 2003b). Program financing comes from several sources: a national fuel tax on crude oil derivatives, differentiated entrance fee schedules in national parks, voluntary contributions in the private sector such as payments by hydroelectric companies, Norwegian and Dutch governments through the UNFCCC Clean Development Mechanism, and a World Bank grant and credit line (Pagiola et. al 2004).

ICMS Ecológico provides an incentive for land protection and management on both public and private lands in several Brazilian states as a means of protecting biodiversity. Initiated in the state of Paraná in 1992, ICMS Ecológico redistributes part of a state level tax on circulation of goods and services (the ICMS) to local governments based on a weighted ecological index. It considers both the amount and ecological quality of

¹ Many payment programs identify biodiversity as an ecosystem service, however academic literature typically identifies biodiversity as a proxy for other services such as net primary product or habitat. See Costanza, R., B. Fisher, et al. (2006). "Biodiversity and ecosystem services: A multi-scale empirical study of the relationship between species richness and net primary production." Ecological Economics.

conserved land. In several states, this incentive has led to large increases in land protection (Grieg-Gran et. Al 2003).

In Chiapas, Mexico the “Habitat Enhancement in Productive Landscapes” (HEPL) project seeks to use certified shade grown coffee as a tool for biodiversity protection in Chiapas, Mexico. Implemented in 1999 by the Institute for Sustainable Development in Mesoamerica, along with several other nongovernmental organizations, the program has helped coffee cooperatives receive loans from the International Finance Corporation's Conservation Enterprise Fund (CEF). A collective certification process was implemented to reduce certification costs per farmer. HEPL has worked with Conservation International and CEF to reach a business deal with Starbucks, a large US coffee retailer, who sells the coffee at a premium to willing buyers (Pagiola 2004).

The Importance of Understanding Benefits and Costs

For a payment program to be possible, benefits must exceed costs. New York City's watershed program illustrates how benefits and costs can be assessed. The city relies on the filtering services of natural ecosystems to maintain high water quality in city reservoirs. However, poor agricultural practices were compromising the clean water (Daily and Ellison 2002). The city compared the costs and benefits of installing a filtration plant to the costs and benefits of implementing best management practices in the watershed, and determined that paying farmers to better manage their land would result in the same benefits at a lower cost.

The benefits of payment schemes are the ecosystem services themselves, in this case, purification of drinking water. In some situations a dollar value can be attached to specific ecosystem services in a particular area (Costanza, d'Arge et al. 1997). For example, if an ecosystem service can substitute for built capital, such as infrastructure for storm water runoff, or if it provides a good that can be bought and sold in a market, such as clean water, monetary valuation of the services provided is fairly straightforward. In our example, the city concluded that an effective watershed restoration program would be two to three times less expensive than a new filtration plant. However, valuation of ecosystem services that are not a substitute for built capital or do not provide a market good can be both difficult and controversial.

Costs associated with a payment scheme are easier to quantify than benefits. A service provider, (ie farmers in the NYC watershed), use opportunity costs and implementation costs to determine whether it is lucrative to enter into an agreement. The community of farmers will determine if the payment offered by the city will compensate them for lost revenues resulting from the transfer of farmland to forestland and for the cost of planting trees along the stream bank, among other measures. Transaction costs must also be considered. In NYC, this included the costs of inspection, assessments, and developing contracts and cost share agreements with farmers.

Let us now examine the benefits and costs of payments for ecosystem services in more detail.

Benefits

Ecosystem services are benefits gained both directly and indirectly by humans from functioning biologic communities (Costanza, d'Arge et al. 1997). The Millennium Ecosystem Assessment (WRI 2005) classified services into four categories: supportive functions and structures, regulating services, provisioning services, and cultural services.

Supportive Functions and Structures

Supportive functions and structures consist of “meta services” that make other ecosystem services possible. Examples include the conversion of sunlight to biomass, the storage and processing of nutrients, and the physical space where animals live.

Regulating Services

Regulating services are those that maintain conditions for human life and wellbeing. Examples include the regulation of chemicals (including carbon), regulation of water flows, waste breakdown, erosion control, and the suppression of environmental oscillations.

Provisioning Services

Provisioning services supply renewal of natural resources for human use. Examples include water filtration and storage, edible plants and animals, building and energy materials, and genetic, medicinal, and ornamental resources.

Cultural Services

Cultural services provide for human emotional, psychological, and cognitive needs. They include opportunities for recreation, appreciation of natural beauty, and scientific, educational, and spiritual pursuits.

Most PES programs focus on provision of biodiversity, carbon sequestration, scenic beauty, and water supply. In reality, these four categories draw on several services. Programs geared at biodiversity, for example, are aimed primarily at maintaining supportive functions and structures, particularly habitat, but inevitably include provisioning services as well. And programs focused on the provision of clean water also supply water, soil and nutrient regulation services. The interconnectedness of ecosystem services is important to keep in mind during our later discussion of methods for increasing benefits.

Costs

There are three types of costs associated with the development of a payment program. Each is shaped by particular factors and considered by different parties.

Opportunity Costs

Opportunity costs are the forgone, next-best alternative uses for a parcel of land. In most cases, the value of the opportunity cost depends on the agricultural or development potential of the property. If the land is marginal, opportunity costs will be low. If it is fertile, opportunity costs will be high. Access and slope also influence whether a

particular area is suitable for agriculture (Wunder 2005). A service provider will be inclined to participate in a program if the payment meets his reservation price, which is the opportunity cost of receiving a return on the employment of his land, labor and capital (Landell-Mills and Porras 2002). Payment schemes may not achieve the desired results and participation if they do not provide sufficient incentives to landowners who can achieve high revenues from alternative productive land uses (Mayrand and Paquin 2004). Most programs, including Costa Rica's PSA, compensate landowners for their opportunity costs, rather than the willingness to pay of the beneficiaries. If agricultural productivity increases causing a rise in returns to agriculture and, in turn, opportunity costs, a program may be put at risk (Ferraro 2001). Therefore, it is important for buyers to anticipate future rises in opportunity costs (Wunder 2005).

Implementation Costs

In addition to covering opportunity costs, a payment must also cover the costs incurred by the service provider of developing a management plan and establishing the ecosystem structure required to provide a service. For example, Costa Rica's PSA requires participating landowners to hire a professional to draw up a forest management plan and to monitor their practice for compliance certification (Chomitz, Brenes et al. 1999). Payments through the Clean Development Mechanism require reforestation or afforestation. Payments for water services usually require riparian reforestation or improved forest management. Other practices involved in meeting a requirement for participation and payment may include the creation of containment ponds and the removal of impervious surfaces. Meeting the requirements for management plans can be quite costly and prohibitive for small farmers and communities (Chomitz, Piet Buys et al. 2007).

Transaction Costs

Transaction costs for PES typically include: the technical work required to establish linkages between the ecosystem structure and the services it provides; the creation of organizations to manage, monitor and support a program; putting in place strong legal institutions to enforce property rights; and the on-going operating costs of monitoring and renegotiating contracts (Pagiola, Bishop et al. 2002). The costs of seeking out buyers and sellers, forming negotiations and agreements, and certifying deals also accrue at the inception of a payment program (Grieg-Gran and Bann 2003). Reducing transaction costs has been identified as one of the leverage points for motivating growth in payments for ecosystem services programs (Landell-Mills and Porras 2002). As we will show, solutions for reducing transaction costs can be developed according to the inherent physical characteristics of the ecosystem service provided.

Inherent Physical Characteristics of Ecosystem Services

Each ecosystem service can be characterized in two important ways (as shown in *Table 1*): by level of rivalry and excludability and by spatial distribution of the benefits. As we have just discussed, benefits and costs influence the viability of a payment program. Understanding the inherent physical characteristics of each ecosystem service is essential to determining the role of the private sector and government in increasing the benefits and reducing the costs of a payment program for a particular service.

Rivalry and Excludability

The levels of rivalry and excludability of an ecosystem service tell us something about the potential for creating a market for that service. Some ecosystem services are better suited for social rather than private provision.

Rivalry is an innate property that cannot be altered by policy or legal institutions. If a good or service is purely *non-rival*, the use of that good or service by an individual does not have a significant impact on the quality or quantity available to others (Samuelson 1954; Randall 1993; Daly and Farley 2004). One person benefiting from the protection of the ozone layer does not affect the quality or quantity of protection for another. However, the quality of some non-rival goods and services can be affected by the number of people using the good or service at one time. These are called *congestible* goods and services (Randall 1993; Daly and Farley 2004). For example, a hiker's experience in a state park, would probably not be altered if one other person was in the park. Yet, if there were several thousand people in the park, the quality of their experience would likely be diminished. A purely *rival* good or service, on the other hand, is one in which its use or consumption by an individual precludes use or consumption by another (Daly and Farley 2004). Commonly purchased goods or services, such as a t-shirt, an orange, or a haircut, fall under this category. Finally, an *anti-rival* good is enhanced with use by multiple people. Information often has this characteristic. For example, the more people who take a remedy for a contagious disease or use an effective pollution control device, the better off we all are. Yet excluding information through a patent rations its use to those who can afford to pay the monopoly price.

Excludability, unlike rivalry, is created through policy and institutions. No good or service is inherently *excludable*, although most rival goods can be made excludable through institutions. For example, a pair of jeans is certainly rival, but without property rights and enforceable laws, there would be nothing preventing an individual from walking into a department store and claiming a pair as his own. There is nothing intrinsically excludable about a pair of jeans. However, a good or service can be inherently *non-excludable*. It would be difficult, for example, to exclude someone from the benefits of climate regulation (Daly and Farley 2004). An ecosystem service that affects a specific spatial area may also be *indirectly excludable*. Where strong property rights to land exist, the land itself is both rival and excludable. An ecosystem service that is non-excludable but reaches a spatially bound area of land can be made excludable if an individual or entity owns the entire land area affected by the service. For example, Perrier Vittel in France is the sole beneficiary of improved water quality due to progressive agricultural practices upstream. However, if there were other landowners downstream, Perrier would not be able to exclude them from the benefits of the service. By owning all of the downstream property, Perrier is, in effect, excluding others from the benefits of the service.

An ecosystem service falls loosely into one of six categories depending on its combination of rivalry and excludability. Pure *public goods*, such as climate regulation, are decidedly non-rival and non-excludable. *Market goods*, such as raw materials and

most food products, are rival with strong, enforceable property rights. Other goods and services fall in between these two categories. *Congestible goods*, such as recreational services, are those that are non-rival but congestible and excludable. And *common pool resources* are goods and services that are rival but for which it is difficult to enforce property rights, such as ocean fisheries. When a service is anti-rival but excludable, it is an *inefficient market good*. An *indirect market good* is one that is rival and indirectly excludable.

In *Table 2*, we classify each ecosystem service in terms of rivalry, excludability and type of good. Ecosystem services, in general, are difficult to classify because they manifest differently according to their usage. In many cases a sub service can be categorized more precisely than its parent ecosystem service. For instance, water supply can be distinguished as either providing fresh water for drinking, a medium of transportation or water for irrigation. Each of these sub services has a distinct classification. Almost all of the supportive functions and structures have been classified as public goods. Because they are essential to the delivery of ecosystem services, their benefits are extensive and non-excludable.

Table 2. Ecosystem services classified by level of rivalry and excludability.				
Definitions				
Rivalry				
Rival – use by one individual precludes use by another. Congestible – quality of service is affected by the number of users. Non-rival – use by one individual does not preclude use by another. Anti-rival – use by more than one individual enhances the good or service.				
Excludability				
Highly Excludable – institutions and property rights exist and are enforced. Excludable – institutions and property rights exist but are not enforced. Potentially Excludable – institutions do not exist. Non-excludable – impossible to exclude use. Indirectly excludable – Non-excludable if multiple landowners, excludable through purchase of land by one entity or individual.				
Ecosystem Service*	Rivalry	Excludability	Type of Good	Description of Service*
Supportive functions and structures				
Ecological structures and functions that are essential to the delivery of ecosystem services.				
Nutrient cycling	Non-rival	Non-excludable	Public Good	Storage, processing, and acquisition of nutrients within the biosphere
Net primary production	Non-rival	Non-excludable	Public Good	Conversion of sunlight into biomass
Pollination				Movement of plant genes
<i>Pollination of same crop</i>	Rival	Indirectly excludable	Indirect Market Good	
<i>Pollination of different crop</i>	Anti-rival	Indirectly excludable	Inefficient Market Good	
<i>Seed dispersal</i>	Non-rival	Non-excludable	Public Good	
Habitat	Non-rival	Non-excludable	Public Good	The physical place where organisms reside

Hydrological cycle	Non-rival	Non-excludable	Public Good	Movement and storage of water through the biosphere
Regulating services Maintenance of essential ecological processes and life support systems for human well-being.				
Gas regulation	Non-rival	Non-excludable	Public Good	Regulation of the chemical composition of the atmosphere and oceans
Climate regulation	Non-rival	Non-excludable	Public Good	Regulation of local to global climate processes
Disturbance regulation	Non-rival	Indirectly excludable	Indirect Market Good	Dampening of environmental fluctuations and disturbance
Biological regulation	Non-rival	Indirectly excludable	Indirect Market Good	Control of pests and diseases; reduction of herbivory (crop damage)
Water regulation				Flow of water across the planet surface
<i>Modulation of drought-flood cycle</i>	Non-rival	Indirectly excludable	Indirect Market Good	
<i>Purification of water</i>	Rival	Excludable	Market Good	
Soil retention				Erosion control and sediment retention
<i>Avoiding buildup of silt in lakes and wetlands</i>	Non-rival	Non-excludable	Public Good	
<i>Prevention of soil loss by wind and runoff</i>	Rival	Excludable	Market Good	
Waste regulation	Rival	Excludable	Market Good	Removal or breakdown of nonnutrient compounds and materials
Nutrient regulation				Maintenance of major nutrients within acceptable bounds
<i>Prevention of premature eutrophication in lakes</i>	Non-rival	Non-excludable	Public Good	
<i>Maintenance of soil fertility</i>	Rival	Excludable	Market Good	
Provisioning services Provisioning and renewal of natural resources and raw materials.				
Water supply				Filtering, retention, and storage of fresh water
<i>Provision of fresh water for drinking</i>	Rival	Indirectly Excludable	Indirect Market Good	
<i>Medium of transportation</i>	Congestible	Indirectly Excludable	Congestible good	
<i>Irrigation</i>	Rival	Excludable	Market Good	
Food				Provisioning of edible plants and animals for human consumption
<i>Ocean fish</i>	Rival	Potentially excludable through permits	Common Pool Resource	
<i>Lake or stream fish</i>	Rival	Indirectly Excludable	Indirect market good	
<i>Hunting of game, gathering of fruits</i>	Rival	Indirectly Excludable	Indirect market good	

<i>Subsistence farming, aquaculture</i>	Rival	Excludable	Market Good	
Raw materials	Rival	Highly Excludable	Market Good	Building and manufacturing; Fuel and energy; soil and fertilizer
Genetic resources	Anti-rival	Excludable	Inefficient Market Good	Genes to improve crop resistance to pathogens and pests and other commercial applications
Medicinal resources	Rival	Excludable	Market Good	Biological and chemical substances for use in drugs and pharmaceuticals
Ornamental resources	Rival	Excludable	Market Good	Resources for fashion, handicraft, jewelry, pets, worship, decoration, and souvenirs
Cultural services Enhancing emotional, psychological, and cognitive well-being.				
Recreation	Congestible	Excludable	Congestible Good	Opportunities for rest, refreshment, and recreation
Aesthetic				Sensory enjoyment of functioning ecological systems
<i>Proximity of houses to scenery</i>	Rival	Excludable	Market Good	
<i>Access to natural landmarks</i>	Congestible	Excludable	Congestible Good	
<i>Open space</i>	Non-rival	Non-excludable	Public Good	
Science and education	Anti-rival	Excludable	Inefficient Market Good	Use of natural areas for scientific and educational enhancement
Spiritual and historic	Non-rival	Non-excludable	Public Good	Use of nature as national symbols; natural landscapes with significant religious values
*Adapted from Farber, Costanza et al. 2006				

Often, it is difficult to form a market for the services categorized as *public goods*. It is almost impossible to capture the full value of their benefits or to create property rights that can be bought and sold (Daly and Farley 2004). In a later section we will thoroughly discuss the role of the private sector and government in supplying these different types of goods and services.

Spatial distribution

Understanding the spatial distribution of ecosystem services is key to understanding transaction costs.

Spatial distribution can be characterized by the directional flow of the service, and scale, that is, the geographic extent to which benefits accrue (Costanza 2006). Climate regulation, for example, is an omni-directional service that accrues at the global scale. Water services, in contrast, are directional flow related and benefits accrue downstream at a regional, watershed scale. Biodiversity services, such as wildlife habitat occur in situ, but have global benefits.

In *Table 3*, each ecosystem service is categorized according to the flow of the service and the scale of the beneficiaries.

<i>Table 3. Ecosystem services classified by spatial distribution.*</i>			
Definitions			
<i>Flow of Service</i>			
Direction flow related – <i>service moves in one direction.</i> User movement flow related – <i>beneficiary must travel to service.</i> Omni-directional – <i>service moves in multiple directions.</i> In situ – <i>services supplied locally.</i>			
<i>Scale of Beneficiaries</i>			
Global – <i>potential to reach beneficiaries on a global scale.</i> Regional – <i>potential to reach beneficiaries at the watershed, regional or national scale.</i> Local – <i>potential to reach nearby beneficiaries.</i>			
Ecosystem Service*	Flow of Service**	Scale of Beneficiaries**	Description of Service*
Supportive functions and structures			
Ecological structures and functions that are essential to the delivery of ecosystem services			
Nutrient cycling	Direction flow related	Local	Storage, processing, and acquisition of nutrients within the biosphere
Net primary production	Omni-directional	Global	Conversion of sunlight into Biomass
Pollination and seed dispersal	Omni-directional	Local	Movement of plant genes
Habitat	In situ	Global	The physical place where organisms reside
Hydrological cycle	Direction flow related	Regional	Movement and storage of water through the biosphere
Regulating services			
Maintenance of essential ecological processes and life support systems for human well-being			
Gas regulation	Omni-directional	Global	Regulation of the chemical composition of the atmosphere and oceans
Climate regulation	Omni-directional	Global	Regulation of local to global climate processes
Disturbance regulation	Omni-directional	Regional	Dampening of environmental fluctuations and disturbance
Biological regulation	Omni-directional	Regional	Control of pests and diseases; reduction of herbivory (crop damage)
Water regulation	Direction flow related	Regional	Flow of water across the planet surface
Soil retention	In situ	Regional	Erosion control and sediment retention
Waste regulation	Omni-directional	Local	Removal or breakdown of nonnutrient compounds and materials
Nutrient regulation	Direction flow related	Local	Maintenance of major nutrients within acceptable bounds
Provisioning services			
Provisioning and renewal of natural resources and raw materials			
Water supply	Direction flow related	Regional	Filtering, retention, and storage of

			fresh water
Food	Direction flow related Or In situ	Local	Provisioning of edible plants and animals for human consumption
Raw materials	In situ	Regional	Building and manufacturing; fuel and energy; soil and fertilizer
Genetic resources	Omni-directional	Global	Genes to improve crop resistance to pathogens and pests and other commercial applications
Medicinal resources	In situ	Local or Global	Biological and chemical substances for use in drugs and pharmaceuticals
Ornamental resources	In situ	Local to Global	Resources for fashion, handicraft, jewelry, pets, worship, decoration, and souvenirs
Cultural services Enhancing emotional, psychological, and cognitive well-being			
Recreation	User movement flow related	Global	Opportunities for rest, refreshment, and recreation
Aesthetic	User movement flow related	Global	Sensory enjoyment of functioning ecological systems
Science and education	User movement flow related	Global	Use of natural areas for scientific and educational enhancement
Spiritual and historic	User movement flow related	Regional	Use of nature as national symbols; natural landscapes with significant religious values
*Adapted from Farber, Costanza et al. 2006 **Costanza et al. Ecosystem Services Conference, Burlington, VT, 2006			

In general, the more global the service, the higher the transaction costs. Because everyone benefits from global services, there is not a well-defined group of buyers, which causes negotiations and agreements to be costly (Salzman 2005). Homogenous services such as climate regulation that also have a high degree of spatial mobility tend to have higher transaction costs than more spatially bound services such as water regulation and supply (Wunder 2005).

Contextual Characteristics

In addition to inherent characteristics, there are characteristics particular to local conditions or the ecosystem providing the service that should be considered when creating a payment scheme. The attributes of the buyers and sellers of an ecosystem service, along with the level of irreversibility and threshold effects of an ecosystem, influence the role of the private sector and government in effectively providing ecosystem services.

Attributes of buyers and sellers

The attributes of the buyers and sellers of a service influence the benefits and costs of a payment program. Like spatial distribution, these attributes primarily affect transaction costs.

The more buyers and sellers there are for a particular service, the higher transaction costs will be due to difficulties in negotiating and implementing a payment scheme (Grieg-Gran and Bann 2003). For instance, in a watershed where a number of potential service providers live upstream and a number of beneficiaries live downstream, organizing a market for water regulation or supply would require significant organizational effort. Each group would have to come to an agreement on how much they are willing to accept as payment and how much they are willing to pay. Legal contracts would have to be drawn up and institutions would have to be put in place to ensure proper collection and distribution of payments. In contrast, when an individual or entity has monopsony power because they are the sole beneficiary and potential buyer of a service, their willingness to pay can be easily calculated based on the value of the service to their wellbeing or operation. Monopsony power in a payment program is preferred because transaction costs are lower. No coordination or agreement amongst buyers is required.

For instance, in Costa Rica, Energía Global, a private hydroelectric power provider, pays \$10/hectare/year for reforestation and forest management upstream to maintain smooth streamflow. It was determined that output and revenue are maximized through water regulation so the company would benefit from its investment in reforestation (Chomitz, Brenes et al. 1999). Energía Global's monopsony power reduced the transaction costs of establishing the payment system.

In contrast, monopoly power in the market has disadvantages. A service provider with monopoly power can potentially drive up the asking price, especially if the provider has little financial incentive to participate, the service provided is scarce, or because there is no pressure from partnering service providers to come to an agreement. Monopsony power does not skew a market for ecosystem services because although there is only one buyer available to purchase the ecosystem service, the seller is not forced to sell to that buyer because he has the option to use his property for the next best alternative such as agriculture or harvesting timber. In contrast, if there is only one service provider, such as a single landowner upstream, downstream buyers have no other option but to purchase the desired ecosystem service from the upstream landowner giving him extreme bargaining power. This problem becomes even more acute when demand for a service becomes inelastic, or almost infinite, due to the scarcity of the ecosystem service. For example, in Australia the owner of critical habitat for cassowaries, an endangered species, 'bargained' on the price to be paid for preserving his forest by bulldozing it until the price doubled.

The ecological literacy of buyers and sellers and the state of ecological degradation also affect costs and benefits. Many individuals have little knowledge of the services ecosystems provide. Landowners may be unaware of the benefits offered by the forests on their property, and beneficiaries may have little knowledge of how ecosystem services affect their livelihood and wellbeing. Education plays a role in forming sustainable payment programs. In well understood systems, benefits are clear and conservation strategies are well directed, reducing implementation costs. Because ecological processes rely on interrelated functions, it can be difficult for individuals to discern the value of ecosystem services to human well-being. The discrete contribution of a function is likely

unknowable until it fails and we are able observe its role within an ecosystem (Vatn and Bromley 1994). As degradation of ecosystem structure increases, both threats to ecosystem services and the value they hold, become more apparent.

Irreversibility and uncertainty

Complex systems in general are prone to non-linear behavior. One result of this is that increasing stress on a system in a dynamic equilibrium can lead to sudden, radical changes in system behavior, perhaps flipping it into an alternative, unpredictable equilibrium. As complex systems, ecosystems are prone to such behavior, where increasing human impacts lead them to irreversibly flip into an alternate state. For example, the Amazon forest recycles its own rainfall—the force of torrential rains is broken by canopy cover, the water is readily absorbed by soils aerated and held together by roots, where it is capture by roots. Evaporation from the canopy and evapotranspiration by the trees create clouds that fall again as rain on the forest, continuing the cycle. When forest cover is removed, the rains fall on raw compacted earth. Water, topsoil and nutrients are flushed into rivers where they flow to the sea and are lost to the system forever. Eventually, there is not enough water left to sustain the remaining trees, which succumb, leading to even faster water loss in a positive feedback loop which is only broken when a new ecosystem, perhaps savannah, is established.

Resilience is a measure of how much perturbation it takes for an ecosystem can manage before it irreversibly flips. For example, how much of the Amazon can be cut down before it no longer generates enough rainfall to sustain itself? Unfortunately, we can never be certain how resilient a unique ecosystem is: even if we carefully monitor degradation and are able to precisely determine the point beyond which the system can no longer recover, we only have a sample size of one, useless for statistical measures! In other words, we cannot assign meaningful probabilities to chance of irreversible change from a given level of degradation. When we know possible outcomes but not their probabilities, we confront uncertainty, as compared to risk, when both outcomes and probabilities are known. For most ecosystems, we cannot even predict the alternative state into which they might flip, or what services the new ecosystem might provide, a situation of pure ignorance.

Conventional markets operate on the principle of marginal values. The marginal value of a market good is its price, the most any single individual is willing to pay. The marginal value of a public good is the sum of benefits received by all individuals who enjoy it. However, where irreversible ecological thresholds exist, marginal changes in human activities lead to non-marginal outcomes, and we have left the realm of conventional economics. Marginal analysis no longer applies, and we have no meaningful or widely accepted way to determine values. When threatened with the loss of life supporting ecosystem services, we must assume that values of marginal impacts rise exponentially, approaching infinite as we near the unknown ecological threshold. But as such thresholds are unknown and largely unknowable, and many of the negative consequences of exceeding them are likely to fall on future generations, the rate at which values rise must account for ethical values as well, such as our obligations to future generations and attitudes towards risk. As we near such thresholds, market mechanisms may no longer be

appropriate—the private property rights of the few cannot be more sacred than the survival of the many (Farley to gather references).

Threshold Effects

Some ecosystem services are marked by threshold effects which exist when a minimum land area is needed for a service to be provided (Landell-Mills and Porras 2002). Threshold effects can occur with habitat, as species often have minimum habitat requirements. They also occur with water supply, as actions by a few landowners can jeopardize the ecosystem service. When threshold effects are present, each landowner who is a potential service provider, in effect, holds monopoly power in the market for the service.

Increasing Benefits and Reducing Costs

Now that we have discussed how the inherent physical characteristics of ecosystem services influence benefits and costs, we outline strategies for maximizing net benefits. Benefits can be increased by clearly delineating and managing for a spectrum of ecosystem services. Costs can be reduced through pooling supply and demand, and by utilizing existing intermediaries.

Delineating and Bundling Services

In many cases, buyers are interested in very specific services. For example, as opposed to generic “water services,” hydroelectric companies in Costa Rica desire a reliable dry season supply. Therefore, a good understanding of the linkages between particular land uses and services they provide is essential (WWF 2006, Pagiola et Al 2004). Yet ecosystem services are interconnected. Investing in one service may be detrimental to other services. For example, tree plantations designed for carbon sequestration are often low in biodiversity (Landell-Mills and Porras 2002). Bundling of services is a holistic approach that ultimately increases benefits. In a bundled approach, the focus is on providing multiple ecosystem services. The services are either sold together or subdivided and marketed to different buyers. Bundling services that have benefits across spatial scales is a way to expand the potential market and increase payments to a particular area. However, bundling services across scales and political boundaries does increase transaction costs.

For instance, Costa Rica's National Forestry Environmental Service's Program bundles the provisioning of carbon sequestration, watershed protection, biodiversity conservation, and scenic beauty services, and markets them to different buyers (Rojas and Alyward 2003). Bundling services can increase political support for a payment scheme by increasing the beneficiaries of the program. In Sukhomajri, India, a payment scheme, originally geared toward reducing siltation in Sukna Lake for recreational benefits, was able to gain needed support by provisioning irrigation benefits to upland villagers (Pagiola et Al 2004).

Provisioning locally valuable services

A lasting, positive change will take place if PES programs catalyze sustainable practices desired by those providing the services. For example, the suite of best management

practices initiated in the NYC Watershed will ultimately aid farm profitability by maintaining soil nutrients on site. In Sukhomarjri, the benefits provided to upland villagers are as important as those provided to residents of Chandigarh who utilize Sukna Lake. And in a reforestation scheme proposed for Awassa, a region in Ethiopia, reforested areas will eventually supply firewood, restore trees through sustainable practices, as well as improve grazing productivity by increasing the water holding capacity of the land (Reynolds, forthcoming).

Pooling supply and demand

Transaction and implementation costs can be minimized by developing a system for pooling funds from groups of buyers. The New York City Water Authority pools funds by modifying a fee already charged to city water users (Rosa et al 2004). Costs are further reduced when providers are organized cooperatively. In Brazil, local governments served as a collective entity receiving ICMS Ecológico tax revenue. And in Chiapas, coffee growers were able to reduce the costs of implementation through a cooperative certification program (Pagiola et Al 2004). In addition, Regional cooperation and the pooling of supply can help avoid threshold effects.

Utilizing existing intermediaries

Costs are also minimized when skilled intermediaries are already in place. In Costa Rica, the preexisting National Forestry Finance Fund served effectively as an intermediary. In New York, the NYC Department of Environmental Protection had sufficient expertise to direct user fees to conservation programs. Where government institutions are insufficient, preexisting nonprofit organizations can serve an intermediary role, as is the case in Chiapas, Mexico. Automaticity of payments is another way to reduce transaction costs (Stone 2002). This occurs, for example, when buyers of an ecosystem service are already organized as a group of consumers for a water utility and can make a payment through an additional fee on their bill (Pagiola, Bishop et al. 2002; WWF 2006).

Recommendations

We conclude by discussing the role of the public and private sectors in providing ecosystem services. This section is meant to provide guidance in determining the best approach to creating a payment for ecosystem services program. We make recommendations based on the inherent physical characteristics of ecosystem services in addition to opportunity costs, environmental thresholds and regulatory obligations.

Governments must play a key role in payments for ecosystem services. They can directly provide an ecosystem service by paying landowners or reclaiming public property rights. They also have the responsibility of establishing enforceable property rights so that markets can be established for excludable services, and they can act as an intermediary to coordinate buyers and sellers in order to reduce transaction costs. Under the appropriate circumstances, the private sector can establish markets or charge user fees. Non-governmental organizations can also act as an intermediary. Cooperatives can help reduce transaction costs by making implementation more efficient.

Rivalry and Excludability

Ecosystem services classified as *market goods* in Table 2, which are rival with enforceable property rights, can be efficiently allocated by a market (Daly and Farley 2004). If a service is rival, individuals know they will directly receive the full benefits if they pay for the service. However, most market goods cause negative environmental externalities resulting in inefficiency. Government can address this problem either through taxation, regulation or provision of ecosystem services.

Direct government provision is preferred for services that are inherently non-excludable, whether rival or non-rival. These services cannot be provided by a market or through user charges (Samuelson 1954; Randall 1993; Daly and Farley 2004). If a service is both non-rival and non-excludable, a *public good*, beneficiaries may be tempted to free-ride knowing they will benefit from the service whether they pay or not (Olson 1965). A service classified as a *common pool resource* that is rival with only potentially enforceable property rights, is at risk of over-utilization (Randall 1993). On the other hand, non-rival or *congestible* ecosystem services that are excludable with enforceable property rights could be provided by the private or public sector through user charges once the service has become congested. Before the point of congestion, a congestible service should be treated as a public good. (Randall 1993). For an *indirect market good*, the government can establish property rights which allows a market to emerge for what would normally be a public good. An *inefficient market good* should be directly provided by the government and managed as a public good. Incentives for use should be given to increase the benefits of the service.

To summarize, governments play a strong role in instituting and enforcing property rights for all potentially excludable services. A market solution is suitable for services that are rival and excludable. User fees make sense for services that are non-rival and excludable or congestible and excludable. For all non-excludable services, direct government provision through general funds is preferred.

Spatial distribution

As mentioned above, government or non-governmental organizations can play the role of intermediary when transaction costs are high due to the global distribution of the service. If benefits accrue locally, a market negotiation can more likely take place without exorbitant transaction costs. Institutions at the scale of the problem are required to establish property rights for excludable services. At the national and local scales, governments can reclaim property rights for the public by charging taxes or regulating activities or beneficiaries can pay service providers to induce provision of ecosystem services. However, no institutions exist at the international level so inducements and payments are the only available mechanism to provide global ecosystem services.

Buyers and Sellers

Government has a role to play in reducing transaction costs when there are many potential buyers and sellers. In Costa Rica, the government coordinates buyers and sellers by charging a fuel tax and distributing the payments. The government entity in this case

is, in effect, acting as a monopsonist (Chomitz, Brenes et al. 1999). Also, the government may act as a coercive force to reduce the free-rider problem in the supply of public goods to a large group of beneficiaries. The larger the group of beneficiaries of a public good, the more likely an individual will be tempted to free-ride because a single payment makes up a smaller proportion of the total payment than it does in a smaller group. If one individual does not pay in a smaller group, it is possible there will not be sufficient funds to provide the service and no one will benefit (Olson 1965). In addition, markets are not appropriate when there is monopoly power that drives up the price of an ecosystem service.

High Opportunity Costs and Risk of Irreversibility

A command and control approach may be appropriate in a high opportunity cost scenario (Wunder 2005). For example, a recent study published online in the Proceedings of the National Academy of Sciences found a high correlation between the amount of land deforested and the average annual soybean price in Mato Grosso, Brazil (NASA 2006). Also, in ecosystems where the risk of irreversibility is high, markets are an inappropriate approach due to the lack of flexibility in the situation. Direct provision is preferred (Daly and Farley 2004).

Regulation

The government also plays a role in establishing regulatory drivers, essentially reclaiming property rights for the public and allocating use, which creates markets for ecosystem services. By imposing quantity caps on emissions and allowing the trading of permits, government entities bring forth markets for waste absorption capacity (Pagiola, Bishop et al. 2002).

Payments for ecosystem services have emerged as powerful tools for protecting natural capital and the provision of ecosystem services. However, relying entirely on markets is not always the most effective approach. The characteristics of the ecosystem services, the potential buyers and sellers, and the level of risk to an ecosystem need to be carefully considered. The framework outlined in this paper can help clarify the role of both the private and public sectors in providing ecosystem services. The following tables summarize this framework.

First, weigh the level of irreversibility and threshold effects to determine if a market solution should even be considered as a method for providing ecosystem services (*Table 4.*) Next, consider the combination of inherent physical characteristics and the attributes of buyers and sellers to determine the appropriate role for the public and private sectors in providing the ecosystem service (*Tables 5 and 6.*)

Table 4. Role of public and private sectors in providing ecosystem services according to level of environmental risk

		Recommended Approach
Irreversibility and Threshold Effects	Irreversible Threshold	Direct government provision required: Markets may work for restoration
	Reversible Threshold	Intermediary such as an NGO or the government should pool supply and if service providers are using monopoly power to drive up price or if there is risk of failing to meet the threshold, government should provide the service directly
	Low Risk	Markets may be appropriate

Table 5. Framework for role of public and private sectors in providing ecosystem services according to inherent physical characteristics

		Spatial Distribution		
		Global	Regional	Local
Rivalry/ Excludability	Market Good	Private: Market feasible Public: Enforce property rights; can charge a tariff as a tax on negative externalities	Private: Market feasible Public: Enforce property rights; can charge tax or regulate to correct negative externalities	Private: Markets feasible Public: Enforce property rights, can charge tax or regulate to correct negative externalities
	Public Good	Private: Difficult to create market Public: No institutions exist	Private: Difficult to create market Public: Provide directly	Private: Difficult to create market Public: Provide directly
	Congestible Good	Private: Charge user/entrance fees when becomes congestible Public: Enforce property rights, treat as public good until congestible, then charge user fees	Private: Charge user/entrance fees Public: Enforce property rights, treat as public good until congestible, then charge user fees	Private: Charge user/entrance fees Public: Enforce property rights, treat as public good until congestible, then charge user fees
	Common Pool Resource	Private: Market may be appropriate Public: Establish property rights	Private: Market may be appropriate Public: Establish property rights	Private: Market may be appropriate Public: Establish property rights
	Indirect Market Good	Do Not Exist	Private: Market feasible Public: Enforce property rights	Private: Market feasible Public: Enforce property rights
	Inefficient Market Good	Private: Market feasible but inefficient Public: Provide directly, treat like public good and induce use	Private: Market feasible but inefficient Public: Provide directly, treat like public good and induce use	Private: Market feasible but inefficient Public: Provide directly, treat like public good and induce use

Table 6. Role of public and private sectors according to attributes of buyers and sellers

		Recommended Approach
Attribute of Buyers and Sellers	<i>Many Buyers and Sellers</i>	Government or non-governmental organization can act as intermediary to reduce transaction costs
	<i>Monopsony</i>	Market is feasible
	<i>Monopoly</i>	Direct government provision due to increase in price of ecosystem service

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