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Abstract

Paying for the provision of environmental services is a recent policy innovation that is attracting much attention in both developed and developing countries. The innovation involves a move away from command and control environmental policies, harnessing market forces to obtain more efficient environmental outcomes. Linking payments for environmental services (PES) to economic development and poverty reduction is an issue of importance since they may represent a new source of finance to developing countries, and developing countries are potentially important suppliers of global environmental services. The objective of this paper is to apply economic concepts, particularly those from natural resource and environmental economics, to a wide range of issues associated with the introduction of ES programs in the context of economic development. We introduce a typology of ES based upon economic reasoning, showing that payments for ES provide a solution to externalities and public good problems within the bounds of political economic constraints. Secondly, we focus on the problem of who should pay for ES: to what extent are payments likely to be covered within a global framework rather within a national or regional framework? Third, we will turn to issues of program design. We present some answers to the questions of how to target payments to achieve their objectives efficiently, and what the implications of alternative design schemes are. In particular, we focus upon the equity implications of ES programs and how can they affect poverty alleviation. The final section addresses issues of monitoring and enforcement of ES contracts, and we summarize the key findings in the conclusion.

Key Words: Environmental Services, Agricultural Development, Poverty Reduction, Natural Resource Management.

JEL: Q01, Q24, O1, O13

Table of Contents

I. Introduction

Paying for the provision of environmental services is a recent policy innovation that is attracting much attention in both developed and developing countries. The innovation involves a move away from command and control environmental policies, harnessing market forces to obtain more efficient environmental outcomes. It also involves the notion of rewarding the providers of environmental services which until now have supplied services for free.

Linking payments for environmental services (PES) to economic development and poverty reduction is an issue of importance in developing countries for several reasons. PES may represent a new source of finance to support both the environmental and economic development policy objectives of the country through the mobilization of funds from the global community to suppliers of ES in developing countries. Developing countries are potentially important suppliers of global environmental services, as they may be low cost producers of the service or a unique source of the service where services which are location specific. Biodiversity conservation is an example of the latter, where developing countries are uniquely and richly endowed with species and ecosystems not found in the developing world Carbon sequestration is an example of the former type of service: its production is not location specific, but developing countries may be competitive suppliers due to low opportunity costs of labor and land. PES programs for the provision of global environmental goods can contribute to economic development by increasing employment and income generation possibilities, as well as diversification of livelihoods among the suppliers.

The development of payment schemes for the provision of local level environmental services could also be an important contributor to economic development. The impacts of the payments on employment and incomes are likely to be important here too, but in addition there could be significant economic development benefits associated with the ES itself. In many cases environmental problems create major barriers to economic development. For example, degraded soils result in reduced agricultural productivity, and poor water quality causes disease and health problems in many parts of the developing world. PES could be an effective means of dealing with these problems.

However PES programs may also pose problems for developing countries, most of whom are highly dependent on using, and often depleting, their natural resource base in the process of economic development. Diverting natural and environmental resources to the provision of environmental services rather than short term economic growth could generate high opportunity costs from foregone development in the short run. The poorest people within developing countries are the most highly dependent on direct use of natural resources and the environment for their subsistence, although they often are not the owners of these resources. (WRI 2005) If PES programs result in the reduction or loss of access to the resource by the poor they could exacerbate poverty. Despite their low production costs for ES, developing countries may not be very competitive in the market for their supply due to poor institutional and physical infrastructure that results in high transactions costs.

The objective of this paper is to apply economic concepts, particularly those from natural resource and environmental economics, to a wide range of issues associated with the introduction of ES programs in the context of economic development. First, we

introduce a typology of ES based upon economic reasoning, showing that payments for ES provide a solution to externalities and public good problems within the bounds of political economic constraints. Secondly, we focus on the problem of who should pay for ES: to what extent are payments likely to be covered within a global framework rather within a national or regional framework? Third, we will turn to issues of program design. We present some answers to the questions of how to target payments to achieve their objectives efficiently, and what the implications of alternative design schemes are. In particular, we focus upon the equity implications of ES programs and how can they affect poverty alleviation. The final section addresses issues of monitoring and enforcement of ES contracts, and we summarize the key findings in the conclusion.

II. What Are Environmental Services?

Environmental services can be thought of as a set of biophysical outcomes generated by the management of natural resources and the environment. These outcomes have impacts on human well-being, as well as on wider natural processes. For example, standing forests may regulate water quality and storage capacity. Deforestation thus results in the elimination or reduction of these services, generating soil erosion and contamination of water quality. The conservation of wetlands areas may provide significant flood protection, enhance water quality and protect wildlife habitat, all of which would be lost if wetlands were to be converted to other land uses.

When moving to the concept of payments for ES, the role of humans as both provider and beneficiaries is key, as is the concept of externalities. Humans, as economic agents, manage natural resources and the environment in ways that frequently

generate either positive or negative externalities[1] that impact others in society or future generations. The basic premise of payments for ES is rewarding economic agents for managing the environment and natural resources to generate environmental goods and services that benefit others. These goods and services may also have private benefits, but the primary impetus of PES programs is the provision of private incentives to generate a positive externality. Thus, when someone plants a tree that provides carbon sequestration, or eliminates a source of pollution affecting a wider community, or generates a habitat for wildlife, she or he is a provider of ES.

We identify three categories of ES, based on their justification and potential source of funding. These categories are (1) pollution control, (2) conservation, and (3) amenities creation. We will discuss each of these categories, provide an economic rationale for their emergence, and discuss some implications with respect to the schemes that will be used to pay for them.

A. Pollution Control

Traditionally, pollution has been viewed as a negative externality caused by a missing market for a side effect of production activities, with the logical response being the introduction of remedies such as pollution taxes (Baumol and Oates 1974; Pigou). However in many cases, the "polluter pays" principle is difficult to introduce and implement effectively. Then it was recognized that pollution is actually the outcome of a property rights problem (Coase 1960). Coase's analysis suggests that in a world with well-defined and enforced property rights and relatively low transaction costs, side

[1] Externalities defined as the supplier or consumer of a good does not bear all the costs of its production or consumption, e.g. Marginal private costs are less than marginal social costs of production or consumption.

payments will be established and optimality will prevail whether polluters own the right to pollute or the polluter owns the right for a clean environment. Quite frequently, society explicitly or implicitly gives the polluter the right to pollute. To solve the pollution problem in this case, the beneficiaries from pollution reduction need to pay polluters to not exercise their rights to pollute. If pollution harms a large number of individuals and the cost of negotiating directly with polluters is very high, it may be more expedient to use the political process and enact subsidies for pollution reduction.

While the assumptions behind the Coase theory are restrictive, the spirit of analysis applies to a wide arrange of circumstances. Historically, farmers have been given the implicit right to produce food and fiber in ways that are known to cause environmental problems. It is quite clear, for example, that intensive production systems of milk and other livestock products results in problems of animal waste management. Residues from such production systems have ended up in nearby bodies of water, causing damage to wildlife and reducing water quality. The problem was not very significant when the human population and livestock production density was low, but population growth coupled with the increase in intensive production systems has resulted in increased problems.

Externalities represent a transfer of welfare between groups and individuals in society, thus political economic considerations are important in determining their solution. (Buchanan and Tullock 1975). Polluters may not have the ability to pay or may have sufficient political muscle to force legislative outcomes in which they are paid for pollution reduction rather than being subjected to the polluter-pay principle. This is particularly important in developing countries where environmental regulations restrict

the use of natural resources that poor people rely upon for subsistence. For example, penalizing low income farmers who cause soil erosion and downstream siltation by cultivating on steep slopes is not likely to be an effective means of controlling the problem, unless some alternative income generating strategy is possible.

In the developed world, particularly the U.S. and European Union, PES is often used to subsidize pollution reduction in agriculture. For example, the Environmental Quality Incentives Program (EQIP**)** in the United States is being used to subsidize the introduction of technologies that reduce the damages associated with animal waste.

B. Conservation

ES may be used to pay for the conservation of natural resources, ecosystems including forest resources and wetlands, as well as wild flora and fauna species, and agricultural crop and livestock species. Payments for conservation are generally introduced to correct a situation of dynamic social inefficiency where the owners of the resource, or the people who control its utilization, are likely to modify use patterns in a way that would reduce or eliminate the potential of supplying public goods to future generations. For the purposes of this paper we consider the goal of conservation to be the protection of a sufficient quantity and distribution of natural resources themselves, so they may provide amenities to future generations. The service is the preservation itself, as compared with other categories of environmental services where the goal is to generate positive externalities or mitigate negative externalities in the present.

One example of how this service is generated is through payments to reduce the incentives for deforestation, with the objective of conserving habitats and biological diversity found in forest ecosystems. Payment to the “de facto” owners of the resource,

be it a single company or a forest community, may be used to assure that the forest resources are left in their natural state or managed in a way that provides conservation. Where the existing bundle of ownership rights allows holders the option to modify the use of owned resources, a payment for ES is a means of motivating owners to not exercise these rights, while maintaining the existing property rights structure. The obvious examples are payments to individuals, forest communities, and even governments (e.g., the debt for nature program) to control deforestation. The establishment of wildlife conservation corridors through various payments to rights holders is another example of growing importance in both developed and developing countries. Payments to farmers to maintain traditional crop varieties in production is yet another form of conservation payment that has been implemented. (GEF website)

Conservation programs are justified on several grounds. The primary justification is the presence of uncertainty about future needs for environmental goods and services, and the constellation of natural resources needed to provide them. For example, the genetic resources contained in the current global set of plants and animals, even if they are not utilized at present, could provide an important future use as further information becomes available or as conditions change. (Zilberman and Lipper 1998) Maintaining a bank of such resources results in a wider set of future options for the utilization of genetic resources, and this is an important environmental service. Conserving genetic resources in situ generates not only the preservation of the genetic resources, but also a dynamic evolutionary process, combining the effects of human and natural selection.

Besides options value, the conservation of natural resources generates existence values, where humans derive benefits, and are willing to pay for the preservation of

natural resources, even if there is no current or potential future use. For example, conservation efforts that protect endangered wildlife (e.g. the black Rhino) generate existence values. The benefits of conserving a species and the values they generate are dependent on the individual preferences of humans which are highly variable. This implies significant variability in the willingness to pay for environmental services among potential consumers.

C. Amenities Creation

In this category of ES, the services are a means of generating current public benefits at local, regional and global scales. Examples include planting trees to sequester carbon to reduce greenhouse gases in the atmosphere (a global public good), and /or to regulate water flows and soil erosion to improve watershed function (a local or regional public good). The adoption of contour tillage and bunds may reduce soil erosion and improve watershed functions. In addition to payment programs structured to promote the adoption of various activities ES amenities as illustrated above, other programs focus on giving incentives for users to change management or use rates. For example, overpumping of groundwater from a shared aquifer is an example of a common-pool resource problem that may well have negative spillover effects not only on those with recognized rights to use the water for irrigation, but also to urban consumers of drinking water. ES programs that allocate water resources to restore the aquifer combined with regulation that will prevent future misallocation can be very effective and beneficial.

III. The demand for environmental services

Most of the research regarding PES addresses the challenging questions of design, assessment, and utilization to attain the desired environmental objectives. A fundamental question that remains to be answered is how to finance PES programs, particularly those which are intended to also contribute to poverty reduction. In particular, who should and would pay to support these programs, and how can we increase the resources available for the payment of environmental services if they are underfinanced?

Welfare theory provides us some suggestions of where funding should be sought. One important question in determining the source of funding to pay for the provision of environmental services is the type and distribution of benefits they generate, be they at local, national, or global scales. A second key factor is identifying the sources of effective demand. In the next section we identify three broad categories of ES purchasers: private firms, governments and NGOs and consider the scale at which demand might operate.

A. Public Sector

National and regional government agencies are paying for a variety of programs for environmental quality improvement and restoration. The Conservation Reserve Program in the United States and various payment schemes for multi-functionality in Europe are models of government-financed agricultural ES programs. While the official objectives of these programs are environmental, they also serve as mechanisms to transfer payments to support the farm sector. This is not surprising, since legislative packages require construction of coalitions that carry majorities (Fischhendler and Zilberman), and these programs can thus cater both to environmental and agricultural

interests. This is an increasingly important issue as pressures mount to cut agricultural subsidies under trade liberalization. ES payments to the agricultural sector are not constrained by WTO rules, since they are not linked to production or price of a commodity. (ERS 2001) Meeting multiple objectives is also likely to affect the design and implementation of government funded ES programs in developing countries as well, as can be seen in the case of China's sloping land conversion program which has been cited as a means of subsidizing the ailing State Grain Bureau. (Bennet and Xu 2005)

In addition to large ES programs that are part of national agricultural programs in developed countries, PES programs are being used as tools for implementing local and regional environmental policies. For example in the U.S. there are also state funds, sometimes in the form of tax incentives to facilitate purchases of resources to protect endangered species via wetland banking and conservation easements. (Ecosystem Marketplace Website) In Brazil, the ICMS is a state level tax on the sales of goods and services which some states are using to fund watershed protection and land retirement to conserve biodiversity. (Grieg-Gran 2001)

The capacity of governments in the developed countries to tax a relatively rich population allows them to establish large funds for ES, but this is not the case in many developing countries. Zilberman and Parker 1998 argue that environmental policy tools used by richer governments with large tax revenue bases are necessarily different than the environmental policies of poorer countries so caution is required when drawing lessons from those well-documented experiences.

One potential source of public sector funding for ES programs in developing nations is overseas development aid, although this is controversial. Developing countries have

raised concerns about the potential problem of PES diverting overseas development assistance from their priorities for economic development to the priorities of the donors. One example of how this concern has been manifested is in the design of the CDM under the Kyoto Protocol which requires certification that the public funds used for CDM projects are not diverted from official development assistance. (CDM website) Donor support for ES programs in developing nations is likely to involve yet additional pressures to meet multiple objectives. Programs that combine the pursuit of development and environmental objectives may have higher likelihood of support as they may appeal to several constituencies.

The Global Environmental Facility (GEF) is another major source of international public sector funds for projects that generate global environmental goods such as climate change mitigation, biodiversity conservation and the management of international water bodies. (GEF website) GEF funds are being used for the purchase of environmental services in PES programs, as well as for capacity building for the establishment of PES programs with a wide range of purchasers.

B. Demand from the Private Sector

Private firms are already purchasing ES that result in higher profits by reducing production or environmental regulation compliance costs or increasing the sales value of their products on the market. Water utilities and bottlers pay nearby landowners to plant and maintain trees or reduce livestock grazing in the upper reaches of a watershed, generating improved water quality and flow (Heal 2003). Some firms may contribute to environmental programs to generate goodwill or improved reputation, as the literature on

voluntary compliance with environmental standards suggests (Anton, Deltas, and Khanna 2004). Goodwill reduces the costs firms face in obtaining a license to operate, if it results in reduced community opposition to the activities of the firm. (ten Kate 2005) Improved reputation can generate increased market share for the product, or a higher sales price per unit sold if consumers are willing to pay for the added value of the companies' support of ES activities. Additionally, firms may generate product value by meeting consumer demands for attributes associated with a production process that generates ES, such as organic or shade grown coffee, by developing niche markets through labeling, certification and advertising. Another important potential private sector purchaser of ES are the developers of recreation facilities and tourism, who rely upon environmental amenities in the areas where they operate to attract clientele. Ecotourism obviously falls in this category, but even mainstream tourist operations rely upon environmental amenities and can be a potential source of payments, as are hunting operators.

Private firms may also be willing to pay for biodiversity conservation as a means of obtaining the rights to explore and exploit potential benefits from the environment, as in the case of bio-prospecting, where pharmaceutical companies pay for the right to explore and develop the genetic resources contained in a reserve. (ten Kate 2005)

Private firms may purchase ES as a least cost means of complying with an environmental regulation. Tradeable permit schemes such as the Clean Development Mechanism of the Kyoto Protocol facilitate this type of exchange by allowing firms in developed countries to purchase credits for reducing carbon emissions through activities in developing countries that reduce emissions or sequester carbon. At present, the purchase price of these credits is lower than the costs many firms face if they were to

reduce the emissions from their own production processes, and this cost differential is the basis of their demand for such services from developing countries. (Lipper and Cavatassi 2003)

C. NGOs as Purchasers

Individuals with strong preferences for various kinds of environmental amenities have realized that governments will not provide the amount of the specific ES they desire, and in response have established NGOs that pursue their interest. Some of the most effective ES funds are managed NGOs that represent groups with specific environmental interests. The Nature Conservancy has invested millions of dollars in various programs that buy or lease land and purchase development rights and other assets in order to provide ES. American Farmland Trust and the Trust for Public Lands are investing in purchases of land and development rights to slow urban sprawl. Ducks Unlimited is another group that is interested in the development of wetlands or other reserves that provide ES for its members. World Wildlife Fund has an active program developing PES in both developed and developing countries as a means of attaining sustainable agricultural development and poverty reduction objectives. The environmental and development programs of some major foundations (Packard, Rockefeller, and Moore) have shown willingness to support expansion of various types of PES programs.

D. Demand for ES from Wetlands Conservation: an illustrated example

In this section we illustrate the concepts described above on the scale and source or demand for ES by identifying the environmental services and their potential purchasers

from the conservation of wetlands. Table 1 summarizes the various ES wetlands can provide and their attributes. Where wetlands support birds that can be hunted, individuals, or members of a local private club, can be expected to pay for the conservation of the wetland. Wetland habitats supporting birds and other species that provide a utilitarian benefit to all the population generate local public goods that should be supported by local governments or a non-government organization (NGO); and wetlands that provide a habitat and shelter to migrating birds -- generating a global public good -- should be supported by an international agreement or NGO. Recreational amenities may generate local, regional or even global benefits to individuals who access wetlands for these services, and thus the private sector should be willing to pay. Wetlands also provide existence values by supporting endangered species and wildlife which existence provide utility to various people. In this case either government agencies or NGOs can pay for the ES.

Table 1

The Dimensions of Wetland Services

	Local	National	International
Wildlife habitat	Public Private	Public	Public
Flood control	Public Private	Public Private	Public Private
Water purification	Private Public	Public Private	
Aesthetic value	Public Private	Public	Public
Recreation	Private	Private	Private
Existence	Public	Public	Public

E. Developing the Market for ES

ES is an emerging market, thus engaging in marketing programs to generate awareness and a willingness to pay for these programs is necessary. One of the challenges of the marketing effort is to develop a new mechanism of payment and identify new sources of money that will be available for ES programs that would also aim to reduce poverty. Once resources are available for ES programs, it is crucial to develop mechanisms to target these resources so that they will attain the objective of these programs.

An important source of demand for ES is the establishment of tradeable permit programs to address environmental problems. Tradable permits have been successfully used to meet air quality targets in the United States, and they are a crucial element of the Kyoto Protocol to reduce greenhouse gas emissions. Tradable permits programs establish an aggregate level of the activity to be controlled (pollution, emission of a gas) and distribute pollution permits, allowing trade in these permits. These programs provide the financial incentives to reduce pollution or provide environmental amenities, but unlike taxes or subsidies, they do not transfer financial resources from the affected industry to the government or vice versa. Thus, they may be preferable to taxes or subsidies on distributional grounds.

The demand for environmental services may also be derived from non-environmental objectives. Environmental service provision may be a least cost means of achieving a development goal such as maintaining irrigation efficiency, provision of clean drinking water and disaster preparedness. For example, reducing siltation in major waterways in China under the sloping lands conversion program provides significant economic benefits to the country in terms of hydro-electric power and improved navigability and obtaining these benefits through an alternative means, such as dredging, is likely to be more expensive and less effective. Thus the demand for environmental services in the public sector may arise from either environmental or broader development objectives. Likewise in the private sector, the demand may arise from the existence of environmental regulations that allow market based compliance, but demand may also arise for other motivations such as improving public image and relations, or reducing production costs. Quantitative understanding of the sources of demand for ES programs

that can benefit the poor is an important area for future research. It is especially important for assessing the extent and potential of ES programs in financing development efforts. There is not sufficient knowledge of the factors that affect the willingness of public and private sector firms (both in developed and developing countries) to support ES programs in the developing world, and this is an important area for future research. For example, reducing risk is an increasingly important source of demand for environmental services but relatively little work has been done on the topic. The following section outlines some of the key issues.

F. Restoration and risk management as sources of demand

As discussed above, much of the rationale for ES programs is presented within a dynamic framework of natural resource management, particularly those concerned with conservation and reducing exposure to risks. In this section, we consider more fully the implications of dynamic externalities and mitigating exposure to risk, and the implications for the demand for environmental services, particularly from poorer producers in developing countries.

i. Restoration

Many development projects have tended to divert natural resources to directly productive agricultural activities, thus reducing the capacity of the natural resource base to provide ES required for sustainability of the ecosystem as a whole. For example, large-scale drainage projects that led to the conversion of wetlands to farmlands have increased societal vulnerability to floods (U.S. Department of Interior 1994), and deforestation can reduce protection against floods. In addition to increasing the exposure of people to greater risk, such programs have often completely ignored the potential public goods

benefits from conservation and thus underestimated the opportunity costs of changing land and resource use in terms of existence and option values. Often, decisions about new investments in development projects have been made in a static framework, reflecting the current state of preferences, knowledge, and technology. However, as technology improves and the marginal benefits of environmental services increase, a society's demand for ES increases.

The use of incorrect decision criteria has lead to the overinvestment in development projects (Arrow and Fisher 1974), which may justify restoration efforts. (Zhao and Zilberman 1999) PES programs may be the least cost option to achieve objectives of these restoration efforts. Zhao and Zilberman (1999) argue that in situations where uncertain but promising technological prospects are present, there is a case for restoration of environmental amenities. Critical evaluation of past choices, combined with increased environmental awareness, leads to demand for polices that will reverse past choices and restore natural capital.

Restoration projects that obtain ES by removal of structures or capital goods that serve development objectives may result in significant loss of economic opportunities to the poor that have to be recognized. Compensation payments have to take into account all of the losses -- losses that affect both current and future income streams. In some cases, it may well be cost effective, then, for the compensation scheme to include the provision of new sources of income and new opportunities to the affected population. The latter is especially important, if, without new sources of income, the population increases its reliance on natural resources not affected by the restoration program (e.g. leakage). Additionally, it is important to realize who benefits from the restoration efforts.

Are they the poor or indigenous people who gain access to improved ecosystem functions or natural resources, or are they citizens of developed countries who accrue "existence value"? The value of the project and the computation and distribution of the ES payment should consider the distribution of benefits and costs.

An alternative interpretation of restoration, the restoration of functions provided by an ecosystem, targeting those with the highest potential benefit in terms of economic development and poverty reduction, might be more consistent with the pursuit of poverty alleviation by ES programs. When the emphasis is on functional restoration (restoration of flood control, role of wetlands, or water purification role of forests), economic considerations and constraints should affect the design of the restoration projects. Functional restoration may mean redesign of ecosystems or environment, both to provide environmental amenities and to provide economic opportunities to the affected population. In designing projects aimed at restoring the function of an ecosystem, it may be worthwhile to spend some money to reduce the impact of the restoration effort of the livelihood of local populations.

ii. Risk Considerations

Many of the policy tools (projects, regulations, incentives, and institutions) that societies utilize are aimed at reducing risks and adverse situations. Some of these tools are aimed at physical risks (dams against floods) and others against monetary risks (various insurance schemes against loss of incomes or assets). Some environmental services can be very valuable as tools for risk reduction. The assessment of their value and determination of payments for these ES should be derived from the value they provide in controlling risks. One obvious case sited above is wetlands that serve as

buffer zones for flood control. The expectation of the losses they prevent is one measure of the value they provide. However, if flood protection can be achieved by other means, for example a dam, then the saved costs of the dam (construction, operation and environmental side effects) provide a measure of the value of the ES of the wetland that replaces the dam. Knowledge of the expected damage prevented by ES and costs of alternative means for damage control are essential for assessment of the value of ES.

The value of ES may thus be affected by changes in the risks or damage they control or the costs of alternative means of risk and damage reduction. The value of water quality protection provided by wetlands or forests is enhanced as the value of water quality increases (incomes are rising and people are ready to pay more for it) or when the cost of alternative filtering systems increases. Crop genetic diversity conservation is another environmental service with an element of risk reduction. The genetic material conserved provides options for future, but currently unknown, crop breeding needs. The value of their conservation should thus reflect the expected values of beneficial traits that they may contain. At least part of the computation of the conservation value is dependant on the likelihood that the benefits of the conserved resources will be utilized. Genetic resources that are less likely to be utilized because of constraints on access or management are likely to be less valuable than those that are accessible and well managed.

The recognition of the risk reduction value of ES is important in the identification of the entities willing to pay for ES. Insurance companies will be willing to pay for ES that will reduce the financial risks they are exposed to; so in principle, they have positive willingness to pay for the ES of a wetland that reduce their exposure to a flood.

Governments and international agencies responsible for responding to natural disasters should also be willing to pay for ES to reduce exposure to these disasters.

Those living in locations most prone to such risks will also gain. In this case, if ES programs to reduce risk are to work, the must understand if and why local people "appear" to be under-providing ES that reduce their exposure to risks, both idiosyncratic and generalized. Coordination amongst a large number of smallholders is likely to be a key transaction cost that will need to be surmounted. Various property rights issues, as discussed above, may also lead to the under-provision of ES that generate local benefits in terms of reduced risk. Additionally, certain activities, such as wide-scale reforestation or construction of stone terraces or bunds may simply require cash outlays that are far too great, given the imperfect -- or entirely -- missing credit markets in many developing country contexts.

F) Demand and Market Power

One issue that needs careful attention in the developing country context is the "market" power of the demander. If the hydroelectric company is the main -- or indeed the only -- purchaser of upstream ES services, then the company can exploit its power as the sole purchaser, and will subsequently pay less per unit land area and enroll fewer hectares than would be the case if there was a competitive market for these services. This is a bit of an odd story, to be sure; we are discussing the creation of markets for ES for which, heretofore, markets have been entirely absent. The point is that creating an imperfect market on the part of purchasers may well increase inequality, even if all participants will gain absolutely. There is also a question of "fairness" in an absolute sense, irrespective of whether those who voluntary enroll in an ES scheme receive

enough benefits to leave them "at least as well off" as before, in addition to the fact that fewer units will be purchased than would be the case under a perfect market.

On a more global scale, the issue of whether to have several large funds vs. many smaller ones is related to another issue raised by Wu et al. 2001. If the manager of the fund has a good understanding of industry behavior, and can use their market power in establishing a payment for resources that are diverted from production, it will lead to underpayment for the diverted resources and suboptimality of resource allocation that in this case will lead to over-diversion of land to ES provision.

IV. Issues in the Design of PES programs

A. Targeting ES Funds

Targeting is a critical element in designing programs that effectively meet the desired objectives of PES programs. This is true whether demand is from the private, government or NGO sector, as in each case the purchaser will be interested in obtaining the highest returns to their investment, although how the returns are defined varies according to the objectives. As already noted above, PES programs frequently have multiple objectives, with some more explicit than others. In some cases PES programs have multiple environmental objectives; seeking to generate more than one service. Combining environmental with economic objectives, especially poverty reduction, is commonly found in the design of PES programs, particularly those in developing countries.

In this section we start with a discussion of targeting criteria for a program with a single environmental objective, then expand the discussion to consider programs that

have multiple environmental objectives, finishing with those that have both environmental and economic objectives, focusing on poverty reduction for the latter. A framework for the targeting of ES payment in situations where only one environmental objective is being pursued has been developed by Wu et al.(2000) and applied to the CRP by Wu, Zilberman, and Babcock(2001). In their analysis the distribution of property rights over land and the heterogeneity of environmental conditions are important elements in designing the optimal targeting strategy. They consider the case where land or other resources are owned by many small producers, and analyze the spatial correlation of the economic benefit (ECB) of farming per unit of land and environmental benefit (ENB) per unit of land, arriving at four possible combinations of high and low benefits for each type of benefit. The authors give the conditions under which the "win-win" situations of high ECB and ENB are likely to be found, as well as conditions that generate the trade-off situations.

As Illustrated in Figure 1 below, Wu et al. (2000) show that the gains from using any one of the possible targeting strategies depend on several elements, in particular, the degree of heterogeneity of ENB and/or ECB over land and the correlation between ENB and ECB. For example, consider the case with (1) significant heterogeneity of ENB, but ECB does not vary significantly across lands and (2) there is a positive correlation between ENB and ECB. If the program has a land-maximization objective, the result is a low amount of aggregate ES generation, as the cheaper lands have low ENB and the transition to environmental benefit maximization or cost-benefit strategies may result in significant gains in ES. The cost of selecting the wrong strategy depends on the correlation between ENB and ECB. In cases where there is a strong negative correlation,

the land-maximization strategy and the benefit targeting may be maximizing the ES obtained with the budget and be identical to the benefit-cost strategy. When the correlation is small or positive, the cost of the wrong targeting strategy may be substantial.

Wu, Zilberman, and Babcock (2001) argue that the benefit cost strategy provides the maximum environmental benefit for a given budget, but other strategies have merits as well. The land-maximization strategy will be most preferred by the landowners, as they will maximize the overall revenue (since the ES fund will be spent on the least productive land). Indeed, when farm interests dominate control of the ES fund, they may well target land of lowest productivity. Targeting land with the higher ENB will result in the smallest land area and may be pursued by policymakers that are looking only for the environmental crown jewels, without quantification of benefit. Alix, de Janvry, and Sadoulet (2005) also note that in the case of programs that pay for conservation of existing services, the highest efficiency results from paying according to the highest *expected* benefit cost ratio. That is to say, payments should only be given for benefits that are at risk of being lost.

B. Targeting for Poverty Reduction and Environmental Objectives

A controversial issue is the extent to which poverty reduction and agricultural development objectives could, and should, be incorporated into PES programs. The controversy goes back to the issue of efficiency – programs with dual or multiple objectives are likely to be less efficient in achieving any one of the objectives than if they were pursued individually (Tinbergen 1956). Pagiolia (2005) argue that if the policy objective is to reduce poverty, then a different set of tools may well be far more effective

than environmental service payments – which are designed to address a specific types of market failure that results in the under provision of ES. Nonetheless, there are possibilities to meet both goals, and a need to target such opportunities, as well as mitigate negative effects where trade-offs do occur.

There are three groups of the poor that need to be considered when considering a program with joint poverty reduction and ES provision objectives; those who are owners or users of the resources that are needed to supply the ES, the landless or those without access to resources who cannot be direct suppliers, but could be impacted by changes in labor markets, and the urban poor who could be impacted through a general equilibrium effects of a PES program on food supply or prices. The poor are more likely to gain from ES programs that generate environmental amenities that are not luxury goods, provide more employment opportunities (through eco-tourism, for example), or income for landless poor. Programs that take resources out of production by paying resource owners are less likely to benefit to be beneficial. (Mayrand and Paquin, 2005)

Our primary focus here is on the poor as potential suppliers of ES. We consider two possible scenarios for the supply of ES from a poor land owner: the first is where land is sold or taken out of production (e.g. retiring lands from agricultural production) and the second is where production is continued but modified so as to provide ES (e.g. adoption of no tillage systems of production) We assume that the landowner cultivates L hectares of land and receives a rent of R per hectare. Each hectare can generate B quantity of ES which will be purchased for the price of V. The income of the farmer before participating in the ES program is L*R. Poor farmers are assumed to have small

quantities of land with low rents. If the land is retired or sold, then farm labor will be released which has a value of W.

The landowner will sell or retire the land if:

$$\mathbf{VB+W > R}$$

Their gain will be:

$$\mathbf{VB - R + W.}$$

The spatial correlation between wealth and land quality is a critical determinant of whether poor land owners can benefit from ES programs. If there is a positive correlation between the owner's wealth and the rent from agricultural production, e.g. poor farmers are located on poor quality land for agricultural production, but these lands have a high capacity to generate ES (e.g. high B) the poor could gain substantially from participating in an ES program. Gains will be higher of course if V and W are higher as well.

The poor are less likely to benefit from land diverting ES programs where there is no correlation between the rents from agricultural production and ES provision or where they are positively correlated. The poor are not likely to gain much from ES programs if they are operating on lands which generate a high rent from agriculture.

Now take the case where ES provision is made through a change of agricultural production, as opposed to land use change. The payment per hectare is still VB, but here the landowner also experiences some change in returns to agricultural production R due to changes in production costs as well as output. The landowner will participate in the ES program if:

$$VB \geq P\Delta Y + \Delta C$$

The poor will benefit if the ratio of changes in net revenue from agriculture to net revenues from ES provision is negative, e.g. if $P\Delta Y + \Delta C / VB$ is negatively correlated to income.

This analysis suggests that PES programs with dual objectives of poverty reduction and ES provision need to take into account the spatial distribution of poverty and land quality as it relates to the production of agriculture and ES. Situations where the returns to ES and agriculture are negatively correlated over space and that between poverty and the returns to ES production are positively correlated are the best candidates for targeting to meet the dual program objectives. This was verified by an empirical study of potential supply response to carbon payments in Costa Rica, however land quality was not the only determinant of the supply response. Kerr, Lipper and Pfaff (2004) found that the poor were more likely to be located on lands that were poor in agricultural quality, but which had a high potential for providing sequestration in the form of avoided deforestation or reforestation. The analysis indicated however, that the poor were likely to be less responsive to carbon payments due to a range of barriers in switching land uses that wealthier suppliers would not face. The paper concludes that targeting the poor is not the optimal strategy if the efficient provision of sequestration is the only objective of the program. Given a program with dual poverty reduction and sequestration objectives however, the targeting strategy should concentrate on areas where the returns to agriculture are low, but ES high.

C. Factors Conditioning ES Supply Response

The targeting section above emphasizes the need to consider the conditions under which the dual goals of generating environmental and economic efficiency benefits, or environment and poverty objects, are complimentary or face trade-offs. To highlight these potential regions, we ignored several other elements that may be very important in determining the benefits realized from ES programs, and/or the supply response to these programs. Below we consider a number of factors we consider to be particularly important for designing ES programs in a developing country context; though, as above, we use developed country examples where empirically relevant.

i. Output and Price Effects, and Slippage

When programs lead to significant reduction in the production of certain goods as land goes out of production, this reduction in supply may lead to increase in output price with unexpected negative consequences (Wu et al. 2000) for consumers of those products. In the larger developing countries, such as China and Brazil, large ES programs could well have these type of general equilibrium effects. In addition, certain ES schemes have led to changing land use practices on lands not enrolled in the project, often with unintended negative consequences. Enrolling some land in the program can lead to opening up marginal land to cultivation; lands that were previously never cropped in the past because of low profitability. Such indirect impacts on land use change may well reduce environmental quality thereby mitigating overall gains from the program. Clearly, if the environmental benefits provided by these resources when they are idle are substantial, the net environmental benefit from the ES program may be negative. For example, PES programs such as the China Sloping Lands Program, which aims to reduce soil erosion through a variety of changes in land use practices on specific hilly lands, may well

initially reduce output supply enough to lead to price increases, which in turn may lead to the reutilization of previously idle erosive land not within the program area.

ii) Scale or Agglomeration Effect and Location Specificity

Both economic and especially environmental benefits may be dependent on scale of resources allocated to these activities. For example, a certain amount of land is needed to provide the critical mass to support wildlife populations; and, the spatial configuration of that land may also matter in addition to an absolute size. In other cases, marginal environmental benefits may be increasing over some size range, before then decreasing. Both the discrete and marginal scale effects need to be taken into account in order to determine the benefits of the program, and also identify whether and which specific land resources need to be enrolled in order to generate these benefits. As Wu and Boggess argue, in some cases it will be worthwhile for ES purchasers to concentrate purchases in a certain location in order to take advantage of scale effects. In terms of targeting, accounting for scale effects can clearly change priority areas; and furthermore, the rankings themselves can change with changes in budget constraints. For instance, certain locations that generate the greatest ES for a given budget may well lose priority as larger budgets enable the purchasers to "switch" to locations that generate much greater environmental benefits but on a much larger scale.

Particularly in the case of biodiversity conservation, the biological and geographical requirements for the resources may be very explicit, implying a good deal less flexibility in allowing voluntary, self-selection of individuals into programs aimed at generating these ES. Designing a reserve is a challenging interdisciplinary exercise. As Parkhust et. al. 2002 argue, the spatial pattern of land needed to sustain various populations differs by

ecosystem and species. In some cases it is useful to have a large contiguous critical mass of lands, while in other cases, having several separate locations is preferable. Sometimes, it is useful to establish corridors to allow movement among populations. Some species require being located near bodies of water and others on hills farther away, and then there are species that need to move between topographies.

In experimental studies Smith and Shogren 2002 have demonstrated that it is feasible to establish the incentive scheme that will induce landowners to sell lands with desired specifications to meet various requirements for natural reserves. Their studies showed the power of incentives but also demonstrated that obtaining the right land-use patterns may be a time-consuming exercise that will require continuous effort and significant adjustments. This suggests the need to establish an administrative structure that will enable negotiating effectively, will integrate bidding with negotiation, and enable obtaining land resources in a timely and reasonable manner.

iii. Property Rights to Land and Water Resources

Another issue of particular relevance to developing countries hoping to provide ES is the issue of property rights to land and water resources. Many analyses assume that rights to the resources required to generate ES are characterized by well-defined property rights and by well-functioning markets in those rights. In practice, "ownership" of resources is often a pre-requisite for entering into ES contracts (Grieg-Gran et al., 2005; Landel-Mills & Porras, 2002)[2]. But the bundle of property rights to various land and water based resources in many developing countries is often very complex, incorporating multiple layers of claims for access, use, exclusion and management rights amongst both well-

[2] Even so, there are already PES programs targeting community groups, and not individuals; c.f. Munoz-Pina et al., 2006; Forest Trends and CIFOR, 2002; Swallow et al., 2005; and, van Noordwijk et al., 2004.

defined and very “fuzzily” defined groups; rights to alienate are often highly restricted. For instance, forest or pastures may be held in common (well-defined, exclusive group of users over a well-defined resource, e.g. Mexican *ejido* land), or rights may be held by a tribal group where access, use, and exclusion rights differ among different tribal members and, indeed, such rights might be both incomplete and conditional at the level of the individual or household (Niamir-Fuller, 1999; Livingstone, 1991; Sandford, 1983) Alternatively, the state itself is often the *de jure* owner of many forest, pasture, and water resources, though certain rights are also often devolved to different users, either informally through tacit recognition of longstanding claims or formally through long-term leases, for instance. State and tribal land can also degenerate into open-access situations when institutions responsible for managing and enforcing property rights break down.

The first difficulty posed by the lack of individual property rights is simply that negotiating with a group may be more difficult than negotiating with individuals; though there would be trade-offs with number of negotiations that would need to be undertaken if a group could act on behalf of a large number of people. For instance, land degradation or deforestation upstream may be leading to reduced water flow and quality for downstream users. If the land upstream is held by private individuals, then payments could be made to these individuals in order to change practices; we assume that it is not in their own interest to provide the services without compensation. However, if the lands upstream are common pastures or forests, it may be the case that individuals themselves would benefit by reducing overgrazing or excessive cutting or by making more investments in soil erosion control for instance. Thus, there is an additional layer of

complexity; given the property rights to resources, users may be under-providing ES even against their own joint best interests because of externalities generated among users due to the non-private nature of the property rights to these resources. At this point, however, it is worth noting that groups of users often can and due surmount the problems of coordination and cooperation in managing these resources jointly and do provide the "local social optimum" of these services. However, ES payment programs aimed at communities that currently have difficulties providing the local optimum are going to have to address the incentive issues in joint management—incentives that do not arise when individual's hold a private title to the resource.

One possible solution -- often proposed for other reasons -- is to privatize the commons. This does happen, of course, often as a result of increasing population pressure and concomitant increase in relative scarcity of land, and ES service programs might be used as yet another rallying cry for privatization. There are many good reasons that such lands remain under some form of common tenure, including prohibitively high costs of issuing private title deeds and enforcing private claims[3], the fact that such resources often provide a buffer or safety-net for many community members in times of either idiosyncratic or generalized shocks, the strength of socio-cultural norms embodied in non-private property rights systems, and the fact that flexible access to a wide range of resources can increase average production and reduce variability in production as is often the case of livestock in semi-arid and arid environments. Many of these lands offer the potential for increased ES, and they are often used by some of the poorest people. For those concerned with finding opportunities to combine the twin goals of increasing ES

[3] E.g. enclosure or defining individual rights can be prohibitively expensive, also privatization can lead to a loss of access to land resources on the part of the poor as elites move to capture the increased benefits.

and reducing poverty, understanding the added complexity involved, when both the resources and the externalities generated by their use and management are not private "commodities", becomes crucial.

Under this more complex situation, it is necessary to evaluate how the efficacy of different mechanisms for promoting each type of ES (reducing pollution, conservation, amenities, etc.) is affected by the distribution of property rights to resources. Returning to the example of upstream-downstream users of water resources, consider a payment scheme to reforest or invest in agro-forestry break lines to reduce soil erosion and improve water quality and flow downstream. In the case of common land upstream -- and where the demander is concerned that all those with claims to a resource are adequately compensated for a change in those claims -- the demander would need to identify the primary, secondary, and tertiary claims to various resources, which often poses significant problems. The group would then need to negotiate internally; incentives to break agreements and/or free-ride on provision will simply be greater in groups—especially heterogeneous groups —than is the case with individual ownership of resources; and this increases transactions costs of providing the ES. Devising enforcement schemes and penalty clauses also poses additional difficulties—should the group be punished for any individual infraction, following the group-credit rationale? Unlike credit groups, where members choose to work together, communities have members with existing rights to resources, and self-selection into groups simply cannot follow a similar pattern; membership is likely to be more heterogeneous and power-relations are likely to be far more important. Thus, it remains an open question as to under what circumstances which ES mechanisms would increase self-monitoring and

enforcement rather than engender conflicts and hasten a breakdown in collective management.

There are some interesting empirical studies evaluating different mechanisms for increasing ES in areas where many resources are not privately held. For instance, Alix, de Janvry, and Sadoulet (2005) developed a framework to analyze several targeting schemes to prevent deforestation in the context of *ejidos* in Mexico. They emphasize the importance of designing payment schemes that are based on variables that cannot be manipulated by the recipient. Their analyses also emphasize comparing both environmental outcomes with distributional outcomes. It's often not sufficient to consider targeting of ES funds for resources that are managed collectively in order to best achieve both objectives. In some cases, land may not have formally defined ownership, but nonetheless has been cultivated for a very long time. Understanding the traditional rules and institutions that have been used to control land can be used to structure ES programs to generate incentives compatible with the institutional structure and thus promote the provision of ES more effectively.

iv. Risk and Supply Response

Taking land out of food production to set aside for conservation ES may well increase the variability of agricultural production on remaining cultivated lands. If payments for ES are based only on the "average" returns to such lands, fewer people will enroll than expected; how many fewer will depend on such things as the proportion of new income generated by the "safe" ES payment, access to other risk coping and management mechanisms, and risk preferences, as well as the extent of the increased variability in agricultural production. The poor are likely to be more risk averse, and have less options

in terms of managing risk, thus their supply response to risk increasing activities can be expected to be lower than the average. Additionally, dynamic considerations may well come into play. To the extent that ES programs promote a change in management and perhaps input use (e.g. switching from pesticides to an integrated pest management strategy, or from conventional tillage to reduced or no-tillage), adopters may face increased risks as they learn about these new management and input use practices (Zivin and Lipper 2006). ES programs should recognize that learning takes time, and that production variability -- as well as subjective assessments of risk and uncertainty -- are likely to be quite high, at least initially. Such information may well lead to the design of an ES program that has higher initial payouts.

IV. Conclusions

ES programs can play a major role in improving global and local environmental conditions, protecting endangered species, and sustaining biodiversity and wildlife. They also offer the potential for improving the lot of the poor in developing countries as both suppliers and consumers of environmental services. The analyses in this paper suggest that successfully establishing of these programs is a major challenge, and designing them for dual environmental and social objectives is even more difficult.

Our analysis has indicated that payments for environmental services can be categorized by the type of environmental externality they address: reducing negative externalities from pollution, correcting dynamic social inefficiencies and generating positive externalities. These categories have implications for the design of PES programs, as well as for the source of payments.

The discussion on demand in the paper indicates that there is still considerable research needed on the issue, and this is an important contribution to the creation of demand and willingness to pay for environmental services. Our analysis suggests that the demand for environmental services may stem from environmental as well as broader development objectives and there is a need for better information on the role of PES in both – but particularly the latter. Better information on the potential for environmental services to contribute to agricultural productivity increases, human health improvement and risk management are three important areas where further research is merited. Creating demand for environmental services through the development and dissemination of this type of information, and its subsequent incorporation into broad public policy making is critical for realizing the full potential of this new instrument to contribute to social welfare.

We discuss several supply side issues that need to be taken into account when designing PES programs for environmental and broader development objectives, including effective targeting, scale and location effects, property rights to land and water, and risk to the suppliers. Our analysis indicates the importance of explicitly defining the objectives of the program, albeit solely environmental or with the incorporation of other social objectives. The discussion in sections III A and B indicates the significant differences in targeting strategy associated with the variation in program objective. Clearly a major challenge is developing a design that will allow for the targeting of resources in an efficient manner that is both useful for the environment and equitable. There are many issues of design that have to be addressed, that will be specific to the ecological and social conditions present, but it is clear that effective ES programs cannot

be established without significant interdisciplinary cooperation and organizational entrepreneurship to generate environmental resources that will enhance the economic well-being of the population involved.

Our analysis indicates that designing efficient PES programs requires consideration of traditional issues of market functions – such as market power, as well as non-traditional issues associated specifically with environmental service provision such as scale and agglomeration effects, and location specificity. For programs designed to address economic development and poverty reduction objectives, consideration of incomplete or problematic property rights to land and water, as well as the issues of risk in impacting supply response are necessary as well.

We recognize that not all ES programs are useful for poverty alleviation; in some cases they may hurt the poor and that this possibility must be acknowledged and addressed in advance. It is not sufficient to have good design of payment mechanisms; the actual challenge is development of effective implementation systems that will obtain reliable data on performance, dispense money fairly, and monitor outcomes effectively. Further research on ES should both address some of the major conceptual issues, as well as case studies and policy analyses that will provide insight into the realities on the ground.

References

Alix-Garcia, J., A. de Janvry , and E. Sadoulet. 2005. The Role of Risk in Targeting Payments for Environmental Services. Available at SSRN: http://ssrn.com/abstract=836144

Anton, Wilma Rose Q., George Deltas, and Madhu Khanna. "Incentives for Environmental Self-Regulation and Implications for Environmental Performance," *Journal of Environmental Economics and Management*, Vol. 48, No. 1 (July, 2004), pp. 632-654.

Arrow, Kenneth J., and Anthony C. Fisher. "Environmental Preservation, Uncertainty, and Irreversibility," *Quarterly Journal of Economics*, Vol. 88, No. 2 (May, 1974), pp. 312-319.

Baumol, William. J., and Wallace. E. Oates. *The Theory of Environmental Policy*. Englewood Cliffs, New Jersey, Prentice Hall, 1974.

Bennett, Michael T. and Jintao Xu. *China's Sloping Land Conversion Program: Institutional Innovation or Business as usual?* in Workshop on "Payments for Environmental Services (PES) – Methods and Design in Developing and Developed Countries."

Buchanan, James. M., and Gordon Tullock. "Polluters' Profits and Political Response: Direct Control Versus Taxes," *American Economic Review*, Vol. 65, No. 1 (1975), pp. 139-147.

Clean Development Mechanism (CDM) website. (http://cdm.unfccc.int/)

Coase, Ronald H., "The Problem of Social Cost," *Journal of Law and Economics*, Vol. 3 (1960), pp. 1-44.

Economic Research Service 2001 Agricultural Outlook September Issue. US Department of Agriculture Washington DC

Ecosystem Marketplace Website (http://ecosystemmarketplace.com)*Easements and tradable tax credits: bursting bubble or self-correcting mechanism?* undated article by Amanda Hawn

Fischhendler, Itay, and David Zilberman. "Packaging Policies to Reform the Water Sector: The Case of the Central Valley Project Improvement Act," *Water Resources Research* (forthcoming).

Global Environmental Facility website (http://www.gefweb.org/).

Grieg-Gran 2000 Fiscal Incentives for Biodiversity Conservation: The ICMS Ecológico in Brazil DP 00-01 International Institute of Environment and Development

Grieg-Gran, M., I.T. Porras, and S. Wunder. 2005. How Can Market Mechanisms for Forest Environmental Services Help the Poor? Preliminary Lessons from Latin America. *World Development* (accepted).

Heal, Geoffrey. "Bundling Biodiversity," *Journal of the European Economic Association*, Vol. 1, No. 2-3 (April-May, 2003), pp. 553-560.

Kerr, S., L. Lipper, and A. Pfaff, with R. Cavatassi, B. Davis, J. Hendy and A. Sanchez (accepted 2003). "Purchasing Carbon Services in Tropical Forests: environment and whose development?" *Journal of Sustainable Forestry* (invited for special issue: payments for environmental services). 2004.

Landell-Mills, N. and I. Porras. 2002. Silver Bullet or Fool's Gold: A Global Review of Markets for Forest Environmental Services and their Impact on the Poor. London: International Institute for Environment and Development.

Lipper, Leslie and Cavatassi, Romina. "Land Use Change, Carbon Sequestration, and Poverty Alleviation."*ESA Working Paper No. 03-13.* www.fao.org/es/esa. July 2003.

Livingstone, I. 1991. Livestock Management and "Overgrazing" Among Pastoralists. *Ambio*, 20 (2): 80-85.

Mayrand K. and M. Paquin 2005 *Payments for Environmental Services: a Survey and Assessment of Current Schemes* Montreal, Commission for Environmental Cooperation

Niamir-Fuller, M. (Ed.). 1999. Managing Mobility in African Rangelands: The Legitimization of Transhumance. London: Intermediate Technology Publications, Ltd.

Pagiola, Stefano, Arcenas, Agustin and Platais, Gunars. "Can payments for environmental services help reduce poverty? An exploration of the Issues and the Evidence to Date from Latin America." *World Development*33 (2) 237-253. 2005.

Parkhurst, Gregory M. & Shogren, Jason F. & Bastian, Chris & Kivi, Paul & Donner, Jennifer & Smith,, 2002. "Agglomeration bonus: an incentive mechanism to reunite fragmented habitat for biodiversity conservation," Ecological Economics, Elsevier, vol. 41(2), pages 305-328, May.

Pigou, A.C. 1932. The Economics of Welfare. 4th Ed. Section II. London: Macmillan & Co. Ltd.

Sandford, S. 1983. *Management of Pastoral Development in the Third World*. New York: John Wiley and Sons.

Smith, Rodney B. W. & Shogren, Jason F., 2002. "**Voluntary Incentive Design for Endangered Species Protection**," Journal of Environmental Economics and Management, Elsevier, vol. 43(2), pages 169-187, March.

ten Kate, Kerry 2005 Biodiversity Offsets: Good for Business and Biodiversity? Presentation at the Conference on Payments for Environmental Services and Poverty Reduction Titisee Germany June 2005

Tinbergen, J. (1956), Economic *Policy: Principles and Design*. Amsterdam: North-Holland.

Wu, JunJie, Richard M. Adams, David Zilberman, and Bruce Babcock. "Targeting Resource Conservation Expenditures," *Choices* (Second Quarter, 2000), pp. 33-38.

Wu, JunJie, David Zilberman, and Bruce A. Babcock. "Environmental and Distributional Impacts of Conservation Targeting Strategies," *Journal of Environmental Economics and Management*, Vol. 41, No. 3 (May, 2001), pp. 333-350.

Zhao, Jinhua, and David Zilberman. "Irreversibility and Restoration in Natural Resource Development," *Oxford Economic Papers*, Vol. 51, No. 3 (July 1999), pp. 559-573.

Zhao, Jinhua, and David Zilberman. "Fixed Costs, Efficient Resource Management, and Conservation," *American Journal of Agricultural Economics*, Vol. 83, No. 4 (November, 2001), pp. 942-957.

Zilberman, David, and Douglas Parker. "Internal Water Disputes: Causes and Solutions," *Conflict and Cooperation on Trans-Boundary Water Resources*, ed. Richard Just and Sinaia Netanyahu (Boston: Kluwer Academic Publishers, 1998), pp. 89-107.

Zilberman, David, and Leslie Lipper. "Sustainability and Information," *Sustainability in Agricultural and Rural Development*, ed. Gerard E. D'Souza and Tesfa G. Gebremedhin (Aldershot, England: Ashgate Publishing Ltd., 1998), pp. 193-216

Zivin and Lipper 2006

World Resources 2005 -- The Wealth of the Poor: Managing Ecosystems to Fight Poverty WRI Washington DC.

U.S. Department of Interior 1994 "The Impact of Federal Programs on Wetlands" A report by the Secretary of the Interior to Congress http://www.doi.gov/oepc/wetlands2/index.html

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