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Can payments solve the problem of undersupply of ecosystem services? ☆

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ABSTRACT

Profits from forest management generally originate from harvested wood products or hunting leases. Other joint services such as biodiversity protection or landscape beauty are rarely paid for and are insufficiently provided. Payment schemes are designed to reduce this undersupply. In this paper, we analyze how paying for the additional provision of some services might affect the production of joint services. Payments should at least compensate for the loss of revenue resulting from providing more services. These opportunity costs can be estimated using a production possibility frontier in which the maximum profit from currently marketed outputs is a function of the externalities. We show that payment for a single service can threaten other services if there are diseconomies of scope. If at least two services are considered, then payments can either be made independently for each of them (stacking) or simultaneously in a bundle. In the case of bundling, the minimum payment amount corresponds the total opportunity cost whatever the interactions between services. In the case of stacking, if there are diseconomies of scope and if the amount paid for increasing each service equals the individual opportunity cost, then the total payment would not compensate for the total cost. Some services might remain undersupplied. On the contrary, if there are economies of scope then the total stacked amount will be greater than the total opportunity cost. Hence, it is critical to analyze interactions between ecosystem services because they are likely to change the profitability or the opportunity costs related to increasing the production of the ecosystem services and so the schemes of payments.

1. Introduction

Many production processes, in particular agriculture and forestry, both consume and supply public and private goods. Policy makers could use market-based instruments to encourage producers to reduce their impact on the environment or to increase the provision of not marketed environmental services.[1] Payment schemes can be designed to promote the supply of these environmental services, but decision makers, for the purpose of economic efficiency, should take into account many environmental services at the same time as well as interactions between them and with the marketed environmental services.

Natural and semi-natural ecosystems provide a wide variety of services (de Groot et al., 2002). The value of these services is very difficult to estimate, especially when public goods or non-used goods[2] are concerned. Environmental services benefit people differently; consequently, acceptable prices for these goods will vary. For example, the quality of the landscape is of higher value to people living in it than to the people who are only passing through. Moreover, some environmental services (e.g., carbon storage or biodiversity) provide indirect benefits, which remain unperceived and unvalued until a decrease in the level of the service finally ends up affecting human well-being.

Numerous studies have attempted to estimate the economic value of environmental services. Many of them estimate the willingness to pay (WTP) for environmental services from the demand side (e.g., Hotelling, 1947; Knetsch, 1963; Peters et al., 1989) or the willingness to accept compensation (WTA) for damaged ES from the supply side (e.g., Kline et al., 2000; Wossink and Swinton, 2007; Martinez Cruz et al., 2010). These values can be estimated either with revealed preferences or with stated preferences. As a result, pricing levels for these environmental services can be quite contrasted and are often disconnected from the real costs of providing them. The demand-side based non-market valuation approach is a partial valuation as the supply side is ignored. As many non-marketable and non-extractive forest ecosystem services are concerned, it is often the supply side – the opportunity costs of resources used to produce these services – that determines the market value of these services. Thus, a production function approach based on models that include quantifiable ecological/economic feedback is the preferred approach in valuing many non-market forest ecosystem services (Zhang and

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[1] We use ecosystem services when we refer to all the forest or agriculture services (Millennium Ecosystem Assessment, 2005; TEEB, 2010). Otherwise, we use environmental services (Bishop and Landell-Mills, 2002).
[2] Goods that are not used by individuals may be given an option, bequest or altruistic value.

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Stenger, 2012). If payment mechanisms were set to promote environmental service production or to ensure the sustainability of their provision, what values would be appropriate? If we assume that the need for environmental services is identified and that the methodologies to measure and secure the provision exist, then the existence of a payment requires an agreement between buyers and providers (Wunder, 2007). Theoretically, a payment for the provision of environmental services can take place if the proposed amount is lower than (or equal to) the beneficiary's willingness to pay (WTP) and at least as high as the supplier's willingness to accept compensation (WTA). In reality, because of the existence of transaction costs, WTP must be at least equal to WTA plus transaction costs (Coase, 1960; Stenger, 2012). However, due to asymmetry in the treatment of gains and losses, also called the endowment effect,[3] estimates for WTP are often lower than WTA (Knetsch and Sinden, 1984; Mitchell and Carson, 1988; Burton et al., 2000). This does not necessarily mean that payment is impossible. When real cases are at stake, consumers might accept to pay more than what they had planned to and providers might accept lower compensation.

PES can have two different objectives: (i) to maintain the level of environmental services or to avoid their degradation. Such payments are already taking place to protect the tropical forest in order to preserve its biodiversity and carbon storage capacity. The aim of the payment is to discourage potential users from degrading their environment; (ii) to restore or to increase the provision of environmental services. The goal of this payment is to encourage potential producers to increase their provision of environmental services. This often involves modifying practices that induced a reduction in the services in the past, for example to favor afforestation or forest restoration.

These two PES objectives differ in that their status within the current context is not the same. In the first case, the provision of the environmental services is under threat; whereas in the second case, there is a potential gain in them. However, the payment plays the same role in both cases: it compensates the producer for the reduction in profits resulting from sustaining their provision. From the demand side (WTP), the maximum payment acceptable corresponds to the difference in value between the maximum profit scenario and the environmental service protection scenario. From the supplier's point of view (WTA), the minimum payment acceptable corresponds to the difference in profit between the ES protection scenario and the maximum profit scenario (see Pagiola and Platais, 2002). In the forest sector, where most producers also benefit from non-monetary values, the scope of the theoretical framework should be enlarged: the opportunity cost should be measured in terms of the reduction in the producer's total benefit (monetary and non-monetary), not only in terms of the loss of net monetary profits. The end result would be similar — i.e. the PES objective would be attained, but the amount paid would be higher or lower depending on how the producer values the non-monetary services provided (e.g., scenic beauty and environment).

Estimating the total environmental service benefit is particularly complex because of the diversity of the producers' utility functions. As a first step toward such an estimate, we consider industrial forest owners whose objective is to maximize their profit. In this case, the payment should at least compensate for the loss of profit resulting from a management which takes environmental services into account. This approach is valid for industrial forest owners who tend to base their profit on timber production, but is valid as well for non-industrial forest owners who tend to integrate environmental services in their management and in their utility. The difference is the reference scenario and resulting productions.

In this paper, we propose an analytical framework which is valid for any production process incorporating linked public goods. We examine the implications of different payment schemes in the provision of environmental services when multiple outputs are at stake. We show that, when there is a complementarity in the provision of two services, economies of scope are made if both services increase at the same time. On the contrary, if the interaction between them makes it more costly to provide them simultaneously, then the optimum solution is to specialize the management in order to provide one service at a time. Finally, we show how paying to increase the supply of one service can lead to a degradation of another one if this degradation reduces the monetary opportunity cost, which corresponds to the reduction in income that is necessary to provide environmental services.

We define a multiple output production framework and derive the profit function that gives opportunity cost estimates. We characterize the maximum profit as a function of the provision of two ES and analyze the impact of an increase in the provision of one of the ES according to hypotheses concerning the interactions involved in the provision of both ES. The following development addresses the provision of multiple environmental services at the management unit level. In forestry, this would typically correspond to the forest stand, when the output concerned can be observed and estimated at that scale (e.g. harvested wood value, quantity of carbon stored). Some services require a landscape level approach and even information on the spatial organization of the land such as the preservation of edges. In this case, the production unit is the landscape, and so the area on which the framework shall be used.

2. Opportunity costs of ES provision: an analytical approach

2.1. Single ES transformation function

Several attempts to estimate the environmental performance and efficiency of production processes have been made. In one approach, environmental goods or services are considered to be inputs in the production process: costs for energy consumption (Giampietro, 1997), or waste assimilation (Jaffe et al., 2002) or pollution costs (Hailu, 2003). Other authors integrate environmental services in terms of pollution or environmental degradation. This approach considers these environmental services to be outputs, specifically undesirable outputs (e.g., production of a pollutant; see Fare et al., 1989; Piot-Lepetit and Le Moing, 2007). These outputs are weakly disposable[4] and null-joint[5] with desirable outputs.

To evaluate the cost-efficiency of the provision of environmental services, some authors have used a profit function π instead of a production function (see for example Lichtenstein and Montgomery, 2003; Nalle et al., 2004; Polasky et al., 2008), as follows:

$$\pi(y, e) = py - c(y, e), (y, e) \in P(x) \qquad (1)$$

where p is the vector of output prices and $c(y, e)$ is the cost function of producing the output vector y subject to a vector of externalities e, $P(x)$ is the production possibility set subject to a maximum quantity of inputs x. $c(y, e)$ increases with the increase in the production of one or several outputs; it also increases with the provision of environmental services.[6] The profit function $\pi(y, e)$ is the maximum possible profit when producing output quantities y and environmental services e. Analyzing the maximum of this function subject to different levels of e ($\pi_y(e) = \max_e (\pi(y, e))$) allows us to make a direct estimate of the monetary opportunity cost of the ES as presented in Montgomery et al. (1994), Stone and Reid (1997) and Kant (2002).

[3] The endowment effect is observed because potential gains are less valued than losses: people give more value to what they own than to what they can acquire.

[4] Weak disposability of environmental outputs implies that it is impossible to reduce the harm done to the environment without reducing the production of the desired output, when the production process is efficiently operated.

[5] If outputs are null-joint, then it is impossible to produce one output without producing the other. Here, this corresponds to the impossibility of producing the desired product without harming the environment.

[6] $\frac{\partial c(y,e)}{\partial y} > 0$ and $\frac{\partial c(y,e)}{\partial e} > 0$.