Forest Policy and Economics 72 (2016) 78–84

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Payments for forest-based environmental services: A close look☆,☆☆

Daowei Zhang

School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849-5418, USA

article info

Article history:
Received 8 June 2015
Received in revised form 1 December 2015
Accepted 26 March 2016
Available online 8 July 2016

Keywords:
Payment for environmental services
Joint production
Public goods
Property rule
Liability rule
Private forest owners

abstract

In this paper, I look at Payments for Environmental Services (PES) under property protection rules and in consideration of the marketability of these services. I then investigate the joint production process of timber and environmental services and identify a critical choice facing the buyers of forest environmental services—either incurring transaction costs by studying the opportunity costs of landowners and the environmental benefits their lands could provide, or losing efficiencies by paying some landowners free money and by not being able to induce socially desirable land use changes. Finally, I compare PES with other policy and market mechanisms that encourage the provisions of environmental services.

1. Introduction

Forests produce many beneficial outputs, such as timber, forage, water, recreation, habitats for species, and carbon sequestration in a jointly manner. Traditionally, many of these outputs are non-marketed environmental services. As many forests have been degraded and even converted to other uses, these valuable services have been impaired or eliminated. Consequently, there are increasing efforts being put forward toward searching for solutions. Among these, Payments for Environmental Services (PES) has been promoted around the world in recent years (Engel et al., 2008).

Wunder (2005) defines PES as "a voluntary transaction where a well-defined environmental service or a land use likely to secure that service being bought by a service buyer (or buyers) from a service provider (or providers) if and only if the service provider(s) secures service provision". Thus, PES sound like voluntary market transactions. Yet, PES literatures include both user-financed programs where buyers are actual users of environmental services who negotiate with the service provider(s) as envisaged in the Coase Theorem (Coase, 1960) and government-financed programs where governments act on behalf of the service users and finance the payments through taxes or compulsory fees charged from the service users. In the latter case, the demand side includes coercive and centralized Pigouvian solutions as well as coercive consumption. Yet, under certain institutional arrangements the supply side could be required to supply environmental services.

The purpose of this paper is on the economics of forest-based environmental services. In particular, I discuss PES under the framework of property protection rules and in consideration of the marketability of these services. Further, by analysing the joint-production process of timber, a private good, and environmental services, which are collective goods and/or public goods, I intend to identify critical issues for implementing PES programs. Finally, I compare PES with other market and policy instruments that encourage the provisions of environmental services and look into the pros and cons of each instrument. I start, in the next section, with the value of a forest and the logic of PES, and then proceed with these objectives in sequence before concluding.

2. The logic of PES under property protection rules and varying marketability

Fig. 1 shows the total economic value of a forest, which is similar to the total economic value concept of the London School of Economics in the 1990s (e.g., Turner et al., 1994; Pearce, 2001). Basically, the value of a forest can be grouped into two main, and, in most cases, mutually exclusive categories. Extractive values involve physically harvesting and removing resources for uses, often outside of the forest. Non-extractive values are often realized without extracting resources from the forest, including environmental service values such as soil and water conservation, biodiversity, and climate mitigation; and preservation values, which include existence value, option value, and bequest value (Zhang and Pearse, 2011). Recreational or cultural uses of forests can have extractive value (such as hunting), non-extractive value (bird-watching, hiking, and spiritual renewal), or both. As a forest is an ecosystem, forest-based

☆ The author would like to acknowledge Peter Deegen, Martin Hostettler, Shashi Kant and other participants of the 2nd International Conference on "New Frontiers of Forest Economics" for their helpful comments. All remaining errors belong to the author.
☆☆ This article is part of a special section entitled "New Frontiers of Forest Economics: Forest Economics beyond the Perfectly Competitive Commodity Markets", published in the journal Forest Policy and Economics 72, 2016.
E-mail address: zhangdw@auburn.edu.

http://dx.doi.org/10.1016/j.forpol.2016.06.017
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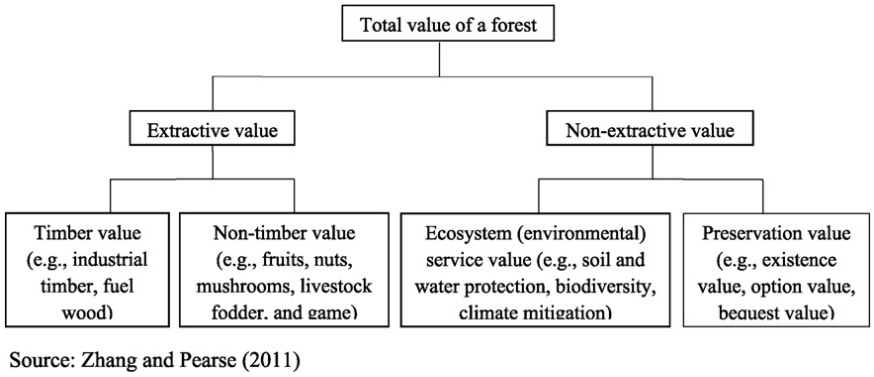

Fig. 1. A forest's economic value.

environmental services are often called ecosystem services. However, in this paper, I define environmental services as all goods and services produced from a forest other than extractive values. This differs from the most broadly encompassing definition of ecosystem services in the United Nations Millennium Ecosystem Assessment (2005), which embraces all benefits listed in Fig. 1 and thus overshadows the challenges for measurement and for marking trade-offs among services.

As environmental services are mostly external to private forest landowners, their supply often lag behind their demand over time and space. To meet the demand, there must be incentives for the landowners to internalize the positive externality in environmental services and to boost their supply. PES is just one of these incentives that help landowners internalize (Pagiola and Platais, 2007) and market these services.

Fig. 2 shows the logic of PES. Landowners who put their lands in forestry uses may receive less benefit than under alternative uses such as cropland or pasture. But deforestation often imposes costs to downstream populations who no longer receive the benefits of services such as water filtration and to the general public of the nation and global community because of reductions in biodiversity and carbon storage. Payments by the service users could help make forestry uses the most attractive option to landowners (Pagiola and Platais, 2007; Engel et al., 2008). The same logic applies to attract landowners to do more conservation forestry practices, that is, to induce them to produce more environmental services by scarifying some of their own timber income.

However, PES is possible only under certain property right arrangements that are protected by certain property or liability rules. In the case where a landowner produces a positive externality from his forest to his neighbor(s), the first rule is that the landowner may produce the externality at will and/or sell it to his neighbor(s) at his acceptable price, if he could. Here a property rule applies, and the landowner firstly is entitled to the property right for the positive externality and secondly is able to negotiate with the neighbor(s) for a price. This is the only case where a voluntary PES, as defined by Wunder (2005), can be implemented. The second rule is that his neighbor(s) or the state makes the landowner produce the positive externality and offer him a fair compensation. In this second case, the landowner is protected by a liability rule as he cannot set his own price for the positive externality but his property right for the positive externality is still recognized and protected; if his property right is violated, he would receive a fair price determined by the state. In practice, this second rule often means that the state prescribes the actions for the landowner and pays him for doing so.

In other cases, the landowner would have an obligation to supply the externality without payments or has to pay his neighbor(s) if he does not supply. Thus, the third rule is that the landowner is obliged to produce such an externality with no compensation unless his neighbor(s) allows him to do otherwise. In this third case, his neighbor(s) holds the property rights for the positive externality and is entitled to use injunction to force him to supply it without payment.

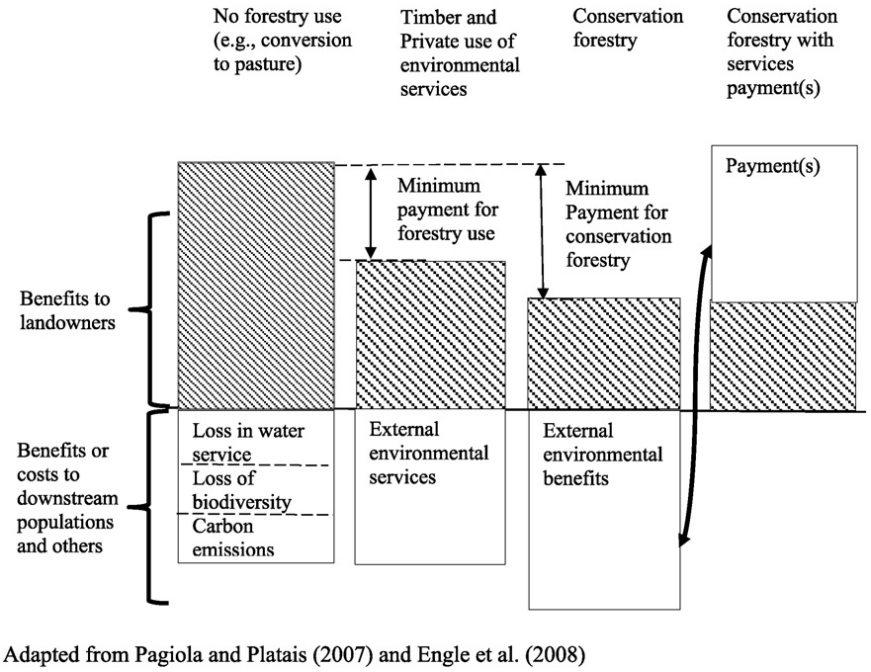

Fig. 2. The logic of payments for environmental services.

Here, the neighbor(s)' right is also protected by a property rule. In modern world, this third rule is similar to regulations where the state on behalf of the public holds the property right of the positive externality and requires or enjoins the landowner to produce it. Finally, the fourth rule—another liability rule—means that, if the landowner does not produce the externality, he has to pay his neighbor(s) for lack of service or the damages suffered. In practice, this fourth rule means to be a fine on the landowner determined by the state.

Thus, the applicability of PES in encouraging the supply of positive externality depends firstly on the rules applied in specific institutional settings—the initial allocation of property rights for the positive externality and the rule for protecting such property rights. Calabresi and Melamed (1972) point out that the initial allocation of property rights (or the setting of entitlements) is mostly based on economic efficiency, distributional goals and other justice reasons. They state: "[property rules] gives rise to the least amount of state intervention: once the original entitlement is decided upon, the state does not try to decide its value. It lets each of the parties say how much the entitlement is worth to him, and gives the seller a veto if the buyer does not offer enough. Property rules involve a collective decision as to who is to be given an initial entitlement but not as to the value of the entitlement (Calabresi and Melamed, 1972, p. 1092). On the other hand, "liability rules involve an additional stage of state intervention: not only are entitlements protected, but their transfer or destruction is allowed on the basis of a value determined by some organ of the state rather than by the parties themselves" (Calabresi and Melamed, 1972, p. 1092). Thus, property rules mean voluntary exchange between parties, and liability rules imply coercive transfers. Mixed rules also exist. For example, in some countries, property rules apply to the sale of a private property, and liability rules apply when the state uses eminent domain to buy it.

Calabresi and Melamed (1972), Morris (1993), and Krier and Schwab (1995) argue that, with the opportunity to use either liability or property-based rules, the key to figuring out which rule to use turns on transaction costs. Specifically, property rule-based voluntary exchange is likely to happen when transaction costs are low, and liability rules will facilitate coercive exchanges if transaction costs are high. Here transaction costs are defined broadly as the costs of creating and maintaining property rights (Allen, 1991). Transaction costs include, at minimum, the cost (and possibility) of bargaining, measurement cost (of damage), and administrative costs. Ayres (2005), on the other hand, demonstrates that there is not a parsimonious and convincing explanation on which rules to use.

Even if a landowner has the property right for environmental services and is allowed to sell them or be compensated, whether or not he could actually profit from these services depending on the marketability of these services. Many environmental services have collective good and public good characteristics that considerably limit their marketability and which is why public policies are applied to secure their provision (Weiss et al., 2011). In contrast to private goods, a collective good has high degree of excludability but has no rivalry, and a public good has a low degree of excludability and a low degree of rivalry. Between pure private goods and pure public goods there is a continuum of imprecise public goods that institutional and economic measures can change their characteristics—to high degree of rivalry or excludability—and thus increasing their marketability. We shall discuss some of these measures that make environmental services readily marketable in Section 4.

Still, a number of preconditions, such as scarcity and low transaction costs, need to be fulfilled before markets for environmental services may develop; otherwise nobody is willing to pay for them. Arguably, the scarcity for environmental services is on the rise as the demand for them increases along with population and income growth and as their supply is limited. Similarly, if transaction costs of marketing are too high, state intervention is needed for securing the efficient allocation of the desired environmental services.

Only when all of these conditions—landowners having a clearly defined property right that is unambiguous, transferable, and enforced, the environmental services being marketable, increasing scarcity that leads to adequate willingness to pay by the users, and low transaction costs of marketing—this internalization of positive environmental services by private landowners may become a reality. Positive and negative externality exists as long as humans interact with each other. Not all externality needs to be internalized; internalization only occurs when the benefits of doing so exceed the associate costs (Demsetz, 1967).

3. The joint-production of timber and environmental services: Critical issues in setting up a payment scheme

In this section, I consider the design of appropriate payment mechanisms for one or more environmental services from private forests whose owners have the rights to either sell these services based on rule one or to receive fair compensation under rule two. I will start with one environmental service before considering two or more environmental services.

Fig. 3 illustrates the supply and demand of an environmental service from a private forest. As the aggregate supply curve is a horizontal summation of supply curve from individual forests, Fig. 3 could also be seen as the interaction between the aggregate supply of the environmental service from all private forests and its aggregate demand. This is what we will do in the following discussion.

Although the exact production function for a particular environmental service is often complicated and even unknown (Hyde, 2013), it is jointly produced with timber. The demand of such a service is usually downward sloping, and the supply (S) of such a service is upward sloping. However, because of its joint production process with timber—a private good—the supply curve of the environmental service has a portion that moves along with the horizontal axis. In other words, the price of the environmental service in this portion is zero, and the users (buyers) can freely enjoy this service up to a certain point (point F). Thus, the environmental service is not an ordinary private good which can hardly be supplied when price is zero. For any amount of service that is beyond point F, there would be an opportunity cost for the landowners. What we are interested are who pays for the landowners for supplying the environmental service beyond point F and what the price would be.

If the environmental service were a good in a competitive market, the supply and demand curves would meet at point E, and the equilibrium price for such a service would be P, and the equilibrium quantity would be Q. This would be a voluntary exchange of property rights under rule one. From the buyers' perspective, a critical question is what is the most effective and efficient way to ensure that landowners to supply to the equilibrium quantity, Q, if they want to offer compensation to landowners under rule two. We do not consider the extreme case where timber and the provision of additional environmental service are completely complementary, completely independent, constantly substitutable, or highly conflicting, because the decision-making for resource allocations under these circumstances is straightforward (Zhang and Pearse, 2011). However, as we shall show below, paying price P for Q amount of environmental service would be an overpayment for the environmental service, from a liability-rule or compensation perspective.

Often, a portion of the environmental service may be captured by their providers in the form of amenity, recreation opportunity, enhanced land productivity, or bequest value. Assuming that the providers' (landowners') aggregate private demand for this service is D_L, which meets the supply curve at point H, the equilibrium quantity for the private landowners would be at point G. In other words, the landowners are willing to forgo FGH amount of costs to produce G amount of environmental service on their own. For any additional quantity of environmental service beyond point G, it is external to the landowners and beyond their own "business as usual" benefit-cost

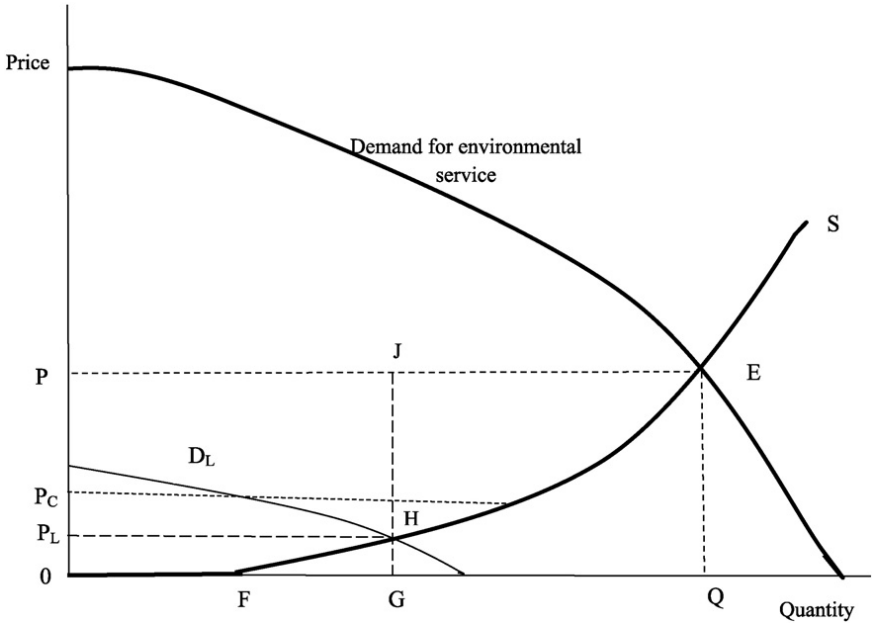

Fig. 3. The joint production process of timber and one environmental service.

calculus, and the users must pay. If not, they would only supply to point G, which is a classic undersupply of the environmental service.

This analysis shows that identifying the point G and the whole supply schedule is critical and the first step in setting up an effective PES program. This boils down to analysing the joint-production process of timber and the environmental service. In the extreme case where timber and the provision of additional environmental service are complementary, but the environmental service is still undersupplied, insufficient knowledge of the production possibilities or lack of skill or capital on the part of the providers is likely to be responsible. Proposing compensation payment would not be financially efficient because the payment would not induce an increase in the production of environmental service. Rather, better information, education, and technology transfer would be more appropriate (Roberts and Stenger, 2013).

In most cases, timber and environmental services would be complementary uses up to point F, after which they become competing uses, and the provision of additional environmental service would change the profitability or induce opportunity costs to the landowners. Assuming that the users could determine the point G (or the opportunity cost that landowners are willing to pay for their own benefits) and estimate their demand curve for the environmental service with reasonable accuracy at reasonable cost, how could they pay for this additional service so that the landowners would supply it to point Q?

One way would be just paying the opportunity costs of the landowners, that is, the area of GHEQ. This would require the users of such a service—whether private parties or the state—to identify the opportunity costs of each individual landowner along the supply curve, distinguish these landowners who need to be paid from these need not, and sign and enforce payment contracts with the former. All these efforts would induce transaction costs, which the buyers (and providers) must bear. Yet, as long as the transaction costs are not higher than the area of HJE, the users gain. In the famous Vittel case, the user—Nestle Water Company—just pays "a little more than the opportunity cost" to landowners (Perrot-Maître, 2006; Depres et al., 2008), rather than the whole area of HJE + GHEG, or the whole area of 0PEQ.

Otherwise, the buyers could pay price P only to the landowners who supply beyond point G, and the total payment would be the area of GJEQ. Again, the critical question is to determine the point G as well as the equilibrium quantity, Q. In this case, the landowners who supply the environmental service at no cost and who are willing to supply it to point G voluntarily would not be paid.

Should the payment price P be paid to all landowners irrespective of their costs of producing the environmental service, the total payment would be the area of 0PEQ, which is much larger that the opportunity costs of supplying the additional and external environmental service. From the users' perspective, this would be economically inefficient as the 0PJG portion is "money for nothing" for some landowners. Further, the budget for the payments would be far larger than needed, leading to a misallocation of resources. On the other hand, if the budget is limited and the payments are evenly set for all forest lands, the payment per unit of forestland (such as Pc in Fig. 3) would tend to be too low to induce the total supply to Q even though a portion of the payment would still be unnecessary.

Thus, from the users' perspective, there exist two possible inefficiencies in designing PES programs. One is that some landowners would have "windfall profits" for not incurring any opportunity costs in providing the environmental service. The other is that the offered payment is insufficient to induce adoption of socially-desirable land uses, causing socially undesirable land uses and inadequate environmental services to continue.

A successful PES program would induce adequate number of landowners to adopt socially desirable land uses to produce Q amount (or close to Q amount) of the environmental service and reduce these two inefficiencies to the minimum. Again, to reduce these two inefficiencies, it is necessary to find the opportunity costs of individual landowners and the environmental benefits that their lands could provide, which would induce research expenses or transaction costs on the part of the users. Here lies a major trade-off facing the users—choosing to incur the transaction costs for identifying landowners' aggregate supply curve for the environmental service, or to suffer when these two inefficiencies occur. This is perhaps the most important choice facing the users, and the guiding rule is to choose the option that costs them less.

Empirically, the Conservation Reserve Program in the U.S. (Wunder et al. 2008), which is a reverse auction program, is one in which the state chooses to incur the transaction costs (of studying the landowners' opportunity costs and the environmental benefits their lands could provide and of implementing a reverse auction system) instead of facing the two inefficiencies. Again, the effectiveness of this approach hinges on the government's ability to discern the opportunity costs of individual landowners based on the location and natural productivity of the land and other factors. China's Green for Grains Program where a flat amount is offered to all landowners irrespectively is other way around;

it avoids transaction costs but loses efficiencies by paying free money to some landowners and by not having enough money to induce other landowners to make necessary land use changes. In theory, farmers whose opportunity costs are higher than the offered payments will not participate. But the Chinese government has sometimes used regulations to force them into the Program.

So far, we have assumed that the users know their collective demand in Fig. 3. This assumption is valid only when the environmental service is collectively demanded though market offers where every user pays a fee—the Lindahl tax or Lindahl price—that is equal to his marginal value for the environmental service (Buchanan, 1999). This may be possible for a voluntary collective demand for collective goods. However, when the state acts as the demander for public goods with coercive power, the demand curve is merely a political demand curve resulting of a complex political-bureaucratic procedure. It thus only represents the market offers of legislators and a public administration (Kraan, 1996). As legislators are, in many cases, captured by special interest groups and made decisions at the expense of public interests (e.g., Stigler, 1971; Gardner, 1987; Mehmood and Zhang, 2001; Zhang, 2007) and as bureaucrats spend someone else's money for someone else' wants (Friedman and Friedman, 1980), the political demand curve is, at best, a proxy of societal demand for the environmental service. In these cases, PES are subject to political commons or government failure.

Now consider two environmental services. Payment for only one environmental service has often effects on other service. If the production of two environmental services is complementary, paying for one of them would simultaneously increase the second environmental service. In this case, no additional finance is needed for increasing the provision of the second service. If they are competing uses, compensating for one of them would lead to a reduction of the other service. To avoid this situation, policy-makers could either set regulatory constraints on the minimum provision of the second service or to offer to pay for it as well. If the regulatory approach is taken, it could raise the cost of the target increase in the first environmental service and potentially the payment for the first service (Robert and Stenger, 2013).

If one chooses to pay for both services, then there are two options: one is to pay for both services in aggregate (bundling), and the other is to pay for each environmental service independently (stacking). Bundling is likely to happen if the total payment could be supported by a single buyer (most likely the state) and if the sum of the increase in value of the services provided is higher than the total payments and the associated transaction costs. Stacking is likely to happen if payment is subject to output levels and the delineation of property rights for each service is possible and does not involve huge transaction costs (Roberts and Stenger, 2013). Stacking could be a complicated matter if many buyers and sellers are involved in multiple environmental services. Thus, many government- and NGO-financed PES programs are bundling payments such as land purchase, land set-aside, and conservation easements.

The principles for paying for multiple environmental services should be similar to that for two environmental services, Fortunately, managing public forests often only involves two or three benefits (Bowes and Krutilla, 1989), and managing most private forests should be comparable to managing public forests which, by definition, are for multiple uses. However, transaction costs grow exponentially and private bargaining would be increasingly difficult as the number of environmental services increase, as the number of users and/or providers grows, and as the geographical area that provides these services expands. Therefore, the only way that PES work is for the state to provide finance and to set up a public payment scheme to service providers under rule two. The Green for Green Program in China and the Conservation Reserve Program in the U.S. are PES examples that have multiple environmental services, involve many users and providers, and cover large geographical areas.

4. Other market and policy tools that ensure adequate supply of environmental services

As we have noted, PES can only take place in certain institutional settings. How would the users of environmental services ensure that the amount of environmental service reaches to the desirable equilibrium quantity in other institutional settings? Fig. 3 may help us understand other means of "internalization of externality". Again, although a single environmental service is used here, the principle applies to cases where multiple environmental services are involved. Here we assume that the users of the service know that their desired equilibrium quantity is at Q.

4.1. Public ownership (of both timber and environmental service)

One often used means of internalizing the externality is public ownership of forests or public purchase of land and the forest-based environmental services together from private landowners (or making public forests stay public). If the state purchases land or these services from willing private owners, rule one applies. If the government uses its power of eminent domain, rule two applies.

Under public ownership, a social planner would assess the trade-off between timber production and the provision of environmental service and ensure the amount of the environmental service being provided at point Q, or somewhere between G and Q considering the trade-off between timber and the environmental service. Public forests are typically used for more than one benefit. In reality, competing interest groups often lobby and advocate for the allocation of public forests toward their favourite uses, while elected officials and public forest managers respond to these demands (Stigler, 1971; Gardner, 1987; Mehmood and Zhang, 2001).

A critical issue with public ownership of forests is that citizens rarely want big bureaucratic agencies to manage them. Speaking for natural resource-related property rights development in Canada, Pearse (1988, p. 313–314) states, "the preference of Canadians for public ownership of resources is not matched by an enthusiasm for big bureaucracies to manage them". Thus, a forest tenure system could be set up where private users would use and manage the private good—timber—and be required to comply with government regulations for the provision of environmental services.

4.2. Regulations (public property rights of environmental services)

The state could regulate private landowners to supply the environmental service to point Q. This approach assumes that the users of environmental services have the property rights over them. The users could enjoin private landowners to supply the services under rule three or force them to pay if they do not provide the service under rule four. The latter means that private landowners face liabilities for not providing government-imposed level of environmental services (Kline et al., 2000; Matta et al., 2009). As public ownership, regulations often cover multiple environmental services. Examples of this approach include the Oregon Forest Practices Act of 1971, the Endangered Species Act (ESA) of 1973 in the United States, the Forest Conservation Act 1980 in India, and the Private Managed Forest Land Act of 2003 in British Columbia, Canada.

However, regulations without compensation would reduce the value of private forests. More importantly, regulations without compensation often induce pervasive incentive to landowners who would avoid providing the environmental service altogether (e.g., Zhang, 2004; McCarthy, 2012). It is paradox that, despite increasing regulatory measures and calls for strict standards, conflicts over forestland and their loss or conversion to other uses continue to proliferate. These results point out to an "incommensurability of values and interests that reflect underlying structural problems" (McCarthy, 2012).

Thus, many economists and policy-makers have advocated the use of market mechanisms such as PES or modification of existing property rights to reduce the dependence on government controls and regulations. Nonetheless, command-and-control is widely used to define, modify, and limit (private and public) property rights.

4.3. Subsidies

Subsidizing landowners who produce positive environmental benefits is a Pigouvian solution for solving environmental problems. It is similar to PES in that landowners are recognized to have the property rights for the environmental benefits, but the terms of trade are not voluntarily negotiated. As most subsidies are financed by taxes, they are coercive transfers and the second rule applies. In practice, subsidies are implemented in a similar fashion as government sponsored PES programs. But subsidies may only provide a portion of the expenses (such as reforestation costs) that landowners incur in their forest management and are subject to variations of government budget. Subsidies may make forest uses more competitive than other uses, but the target of environmental service (point Q in Fig. 3) is hardly quantified explicitly.

4.4. Conservation easements

As mentioned earlier, a special case of PES is conservation easements (or conservation covenants), where private landowners donate or sell certain land rights to qualified private land conservations (often called land trusts, which are environmental NGOs) or governments. Under conservation easements, landowners agree to constrain some of their rights in a specified land area as to achieve certain conservation purposes. In Fig. 3, this means that the landowners agree to restrict their land uses and to practice sustainable forestry so that certain environmental services (water quality, healthy forest, wildlife habitat and migration corridors, scenic beauty, open space, or a combination) could be supplied to point Q. In return, the landowners get satisfaction in leaving a legacy, reducing their income and estate tax bills, and/or receiving outright payments for giving up these rights. The decision to place a conservation easement on a property is strictly voluntary whether the easement is sold or donated; so rule one applies.

The most distinguishing feature of conservation easements is that they enable the users to achieve specific conservation objectives on the land while keeping the land in the ownership and control of private landowners for uses consistent with the conservation objectives. This is a "bundle of rights" approach. The landowners contribute to the provision of certain public goods by preserving the conservation values associated with their land. The restrictions of the easement, once set in place, are perpetual. In accepting the conservation easement, the easement holder has a responsibility to monitor future uses of the land to ensure compliance with the terms of the easement and to enforce the terms if a violation occurs.

The funding for conservation easements often comes from both private and public sources. Between 1998 and 2013, the U.S. government has invested, through more than 20 federal conservation programs, some $4 billion and secured conservation easements on more than 8 million acres of lands (DuMoulin, 2015). Various states and NGOs also have conservation programs that support conservation easements that enhance multiple environmental services.

4.5. Cap and trade (or floor and trade, tradable credits)

Cap and trade is a regulation-induced compliance market where the state determines the cap via regulations and private parties carry out trades based on their respective opportunity costs of complying with the regulations. For a positive environmental service, this is a floor-and-trade system as the floor is a mandatory minimum amount of environmental service. Those landowners who have low opportunity costs of compliance could profit by selling credits to others who have high opportunity costs of compliance. In Fig. 3, the floor is set at point Q. But landowners who happen to produce the needed environmental service at near or to the right of point Q are allowed to pay for/trade with landowners that could produce the same environmental service at a lower cost. This floor-and-trade system essentially turns an environmental service into a commodity. Under such a system, the users have the property right for the environmental service up to certain amount (say, Q), and some landowners could profit from selling credits on the environmental service if they could produce such a service at a lower cost than other landowners.

The Acid Rain Program implemented in the Great Lakes Region of the U.S. and Canada and the NOx Budget Trading Program in the U.S. Northeast are good examples of cap and trade. The Wetland Mitigation Banking Program which was created under the "no net loss of wetland" policy of the Clean Water Act, and the Conservation Mitigation Banking Program which has been created under the "no taking" clause of the Endangered Species Act in the U.S. are examples of floor-and-trade.

4.6. All are about property rights

All these market and policy instruments are about, work through, and affect property rights. Obviously private ownership and public ownership are fundamentally different property rights arrangements. Laws and regulations assign, divide, modify, enhance, and restrict property rights. Government incentive programs, such as tax credits, subsidies, and technical assistance increase the value of forest landowners' property rights, whereas taxes and fees have the opposite effect. PES and conservation easements are exchange of property rights. Cap and trade is a combination of restricting and exchanging property rights. In fact, externality occurs just because property rights are missing (Demsetz, 1967).

Thus, to ensure the supply of forest environmental services meet the societal demand starts with analysing the property rights that landowners and the users have over private and public forests and the goods and services from these forests. From a societal perspective, it is critical to find a least cost way to adequately supply environmental services. The least cost way may not be always in increasing public ownership or adding regulations and limitation over private forestry, but in recognition that landowners have the rights to be compensated for the services produced from their lands. In short, rule two may work better than rule three or four in some cases.

5. Conclusions and discussion

In this paper I look into the logic and economics of PES through property rule, marketability of environmental services, and a broad perspective of market and public policy. The facts that there is little incentive to provide most environmental services that are collective goods and public goods and that a growing population and rising personal income increase the demand for these services create an imbalance. This imbalance means scarcity and calls for new property rights arrangements through market and policy interventions. PES, which include voluntary bargaining and coercive transfers, is one of many market mechanisms and government actions that intend to induce socially appropriate changes in production and consumption of these services. They are often used along with regulations and public ownership programs.

PES range from pure private market transactions to government-induced market actions, from a single buyer/provider to many buyers/providers, from a single service to multiple services, and from a single forested watershed to a region, a country, or the whole global ecosystem. Market transactions work for a single service whose benefits and production function are well defined, when transaction costs are relatively low and distribution of income is not an issue, and where contract and property rights laws are strong. Government-sponsored PES programs, which are subject to

political commons, generally work better for single and especially multiple services whose benefits are large but less measurable, whose production functions are complex or unknown, and for cases when transaction costs are high. PES may take the form of cap-and-trade or conservation easements. But for true global public goods such as climate change, the transaction costs are so high that there needs to be a global political commitment before any meaningful markets for these services could emerge. All PES mechanisms depend on well-defined property rights as well as well functioning governments.

The joint-production process of timber and an environmental service make it difficult to identify the point that separates the free and privately-driven portion of the supply curve of the environmental service from the portion that needs payment from the users. Paying for multiple environmental services would be even more complicated. Inefficiency occurs when some service providers receive free money or when payments do not induce meaningful land use changes. The buyers of environmental services need to choose whether to spend money to find the supply schedule of the environmental services or to suffer losses associated with these inefficiencies.

Further study in PES includes the aggregate supply function of various environmental services in relation to timber production as well as their aggregate demand. Further study could also be made by comparing how country-specific and global institutional arrangements relate to the provision of environmental services. Exploring the political and institutional dimensions and finding the lessons learned from implementing PES in various countries would help answer the question of why market-based instruments work in some countries but not in others.

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