PAYMENT FOR ENVIRONMENTAL SERVICES: GUIDELINES FOR IDENTIFYING PRIORITY AREAS FOCUSING ON BIODIVERSITY*

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Introduction

Human well-being and the economic system are heavily dependent on natural capital (i.e., water, air, soil, fauna, and flora) and the services resulting from the operation of the ecosystem (COSTANZA et al., 1997). Ecosystem services are the benefits that the human population receives from ecosystems, such as soil fertility, pollination, maintenance of water and air quality, and erosion control (MEA, 2005). It is noteworthy that ecosystem services are commonly used as synonyms for environmental services (MURADIAN et al., 2010), but differ from ecosystem services because they are generated through anthropic actions, i.e., they correspond to the benefits derived from the management and sustainable handling of natural systems (MURADIAN et al., 2010; WUNDER, 2015).

For an ecosystem good or service to be efficiently allocated by the private market, it must be both excludable and rival. An excludable good or service is one whose ownership is possible; that is, an individual must be able to use the good or service in question and prevent other individuals from using it. Excludability is virtually considered synonymous with property rights. In this sense, the establishment of an institutional regime, whether political, religious, or cultural, is required to guarantee the right of ownership of resources (FARLEY, 2010). According to Farley (2010), a good or rival service, in turn, is one in which the use of a unit by one individual prevents the use of the same unit simultaneously by another individual. Unlike excludability, rivalry is an inherent property of the good or service in question and not related to institutional arrangements (FARLEY, 2010).

Private markets fail to efficiently allocate goods or services whose property rights are not clearly established. This is the case with public goods (e.g., climate regulation), which are nonexcludable and nonrival. The consumer of a public good cannot be prevented from enjoying the benefits generated by the goods in question, even if the consumer does

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not pay for its use (i.e., free-rider problem) (FARLEY, 2010). In the case of commons (i.e., nonexcludable but rival), in turn, the consumer of the good or service cannot be prevented from using it, but its use will prevent other users from enjoying the benefit with equivalent quality and quantity. The idea of individuals using too much of common resources may culminate in the unavailability of those resources for society (i.e., tragedy of the commons) (HARDIN, 2009).

In the case that property rights cannot be assigned, market forces will produce few effective results for the conservation of natural resources. Thus, to correct this market failure, governments can "intervene" and act on behalf of public goods and commons to preserve ecosystem services on private land (FARLEY, 2010). The government may, for example, assign a set of rules aimed at controlling the use of natural resources and ensuring their efficient allocation at a lower cost than would otherwise occur in the private market (COASE, 2009).

Many governmental interventions regarding externality control have taken the form of command-and-control regulations (e.g., prescription and financial sanctions). Some authors argue that it is through incentive-based policies (e.g., tax cuts, subsidies, and payments) that externalities are internalized (JACK; KOUSKY; SIMS, 2008). It is in this context that the economic incentive Payment for Environmental Services (PES) instrument is inserted. PES can be defined as a voluntary transaction between users and suppliers of environmental services, such that suppliers are subject to natural resource management and handling rules within and outside of service provision areas (WUNDER, 2015).

Among the existing PES markets (i.e., water, carbon, scenic beauty, and biodiversity), biodiversity-related markets find development more difficult (ENGEL; PAGIOLA; WUNDER, 2008), particularly as landowners do not receive direct financial compensation for protection services with nonexcludable and nonrivalry characteristics (HANLEY et al., 2012). In other words, biodiversity, understood as a public good, depends on the attribution of values and rights of use to become excludable (FARLEY, 2010).

Nevertheless, natural processes depend substantially on biodiversity in terms of the functional characteristics of organisms and their distribution and abundance in space and time. Thus, biodiversity plays an important role at different hierarchical levels of service provision and can be considered as a regulator of ecosystem processes (e.g., soil nutrient cycles), as a final ecosystem service (e.g., species richness as a proxy for genetic diversity contributes to the production of medicines), or even as a good (e.g., biodiversity has cultural, aesthetic, spiritual, educational values). The fact is that ecosystem services are affected by changes in biological diversity, which are often nonlinear and difficult to predict (MACE; NORRIS; FITTER, 2012).

It is also noteworthy that low scientific basis (NAEEM et al., 2015), absence of data and symmetric information among economic agents (FERRARO, 2008), and low ability to monitor and evaluate the effectiveness of the PES schemes, coupled with limited budgets, have led to a mismatch between optimal design and viability of payment schemes as effective conservation mechanisms (NAEEM et al., 2015). Thus, there is a need to guide decision-makers in the process of identifying priority areas for the implementation of

PES schemes, to direct the appropriate distribution of generally scarce financial resources for this purpose and optimize the provision of ecosystem services on private land (HEIN; MILLER; DE GROOT, 2013; WÜNSCHER; ENGEL, 2012).

Therefore, considering that the structure of ecosystems underpins biological diversity, which, in turn, underpins the provision of ecosystem services, the aim of this paper is to identify in the scientific literature the important elements to prioritize areas for the implementation of PES-biodiversity schemes on private land. Although the focus of the review of this article may be on PES-biodiversity schemes, it is argued that the identified elements should be used as a reference to guide the implementation of other PES schemes based on restoration and maintenance of natural areas (e.g., water, carbon, scenic beauty), to ensure the sustainability and effectiveness of PES schemes over time.

Method

To identify which elements are indicated by the scientific literature to prioritize areas for the implementation of PES-biodiversity schemes, we used systematic literature review (SLR) as a method of data collection and synthesis. SLR aims to inform the best available evidence in the literature of interest to optimize the decision-making process. The main characteristics of an SLR are the transparency and replicability of the adopted procedures, which set them apart from most traditional reviews published in the environmental sciences (COOK; POSSINGHAM; FULLER, 2013). The SLR steps applied in this research were adapted from the recommendations in the "Guidelines for Systematic Reviews on Environmental Management" version 4.2 of the Collaboration for Environmental Evidence (CEE, 2013).

Thus, the first step of the SLR execution process was to delimit the guiding question of the research, from which the search terms and eligibility questions for the selection of relevant works were established, namely: "*What are the elements indicated by the scientific literature to prioritize areas for the implementation of payment for environmental services schemes aimed at biodiversity conservation?*".

Searches for relevant studies were restricted to the two major scientific platforms for environmental science and engineering, namely *Scopus* and *Web of Science*. Searches were performed for all types of documents indexed in the respective scientific platforms and for all years until March 2017. The adopted search terms are presented in Table 1.

Table 1 - Terms used in the search for relevant works inserted in the scientific platform *Scopus* and *Web of Science*

Pay*	AND	Environmental OR Ecosystem	AND	Services	AND	Biodiversity	AND	Priorit* areas OR Target* OR Prioriti*ation OR Design

Source: Own Elaboration.
Note: *The asterisk (*) at the end and middle of the word allows the system to find derivations of the word. For example: for the term pay* the system finds pay, pays, paying, payment, payments, payoff; for the term priorit* finds priorities and priority; for the term target* finds target, targets, targeted and targeting; for the term prioriti*ation locates prioritization and prioritisation.*

We highlight the insertion of the term *Design* in the search process for relevant works, as it is not synonymous and also does not correspond to an alternative spelling of the terms *Priorit* areas*, *Target** or *Prioriti*ation*. One of the main issues to consider when designing an efficient PES program is the selection of areas for contract allocation (ENGEL; PAGIOLA; WUNDER, 2008). Thus, it is assumed that works related to the design of a PES program could contribute with information relevant to the research objective.

The screening of the most relevant works considered two types of filters: in the first filter (Filter I), the works were evaluated according to the title, abstract, and keywords, and those that apparently had the potential for research were selected; in the second filter (Filter II), the works selected in Filter I were fully evaluated. The selection of works in Filter II was performed to answer the eligibility questions presented in Table 2; that is, the works for which a positive answer to one of these questions would apply were considered relevant to the research.

In addition, some of the works selected in Filter II referred to others that presented potential to the research objective but were not returned by the consulted databases. Thus, it was considered pertinent to pursue the search for relevant works by analyzing the bibliographic references of previously selected ones. At this time, the selection in Filter I was made by title only. Subsequently, the studies were fully evaluated according to the procedures adopted in Filter II.

Table 2 - Eligibility questions for the selection of relevant works

ID	Questions	Situation	
		Selected	Excluded
(1)	Is this work about the prioritization of areas for the implementation of PES schemes that is exclusive for the biodiversity conservation or that also comprises other services?	Yes	No
(2)	Is this work about the biodiversity conservation in private lands, from where it is possible to extract elements for the prioritization process of areas for the implementation of payment schemes?*	Yes	No
(3)	Is this the kind of work that describes a practical case of PES-biodiversity, from where it is possible to extract elements for the prioritization process of areas for the implementation of payment schemes?	Yes	No

Source: Own Elaboration.
*The focus of the work is not on the prioritization of areas for the implementation of PES schemes, but it recommends the use or indicates the areas where this economic instrument could be more effective for the conservation of the biodiversity.

The elements extracted from the relevant works correspond to: (i) criteria for allocating contracts or selecting landowners; (ii) indicators and/or variables used in area prioritization models; (iii) recommendations suggested by the researchers to optimize the area prioritization models or contract allocation processes. To standardize the results obtained, all extracted elements were rewritten to indicate what can be prioritized. Subsequently, elements with similar meanings were grouped into representative thematic categories, resulting in the so-called “Prioritization Elements”. In addition, the prioritization elements were divided into two distinct groups. The first group considered only the important elements for the conservation of biological diversity, labelled “Group I - Ecological elements of the landscape”, while the second group included the elements directed toward social, economic, and political issues, labelled “Group II - Socioeconomic and governance elements”. Finally, the results were discussed together.

Results and Discussion

Considering the search terms adopted, 333 works were returned from the consulted scientific platforms, excluding duplicates. Of this total, 151 works were returned by the *Scopus* platform and 182 by the *Web of Science* platform. In Filter I, 81 works with research potential were selected, and in Filter II, the eligibility questions presented in Table 2 were answered positively for only 24 works. Regarding the screening performed from the bibliographic references, seven additional works were included in the final selection, totaling 31 works considered relevant to the research (Table 3). It is noteworthy that among the seven additional works, some were not returned to the initial search owing to the absence of one or more search terms (Table 1) in the title, abstract, or keywords (e.g., CHEN et al., 2010; CLAASSEN; CATTANEO; JOHANSSON, 2008; WÜNSCHER;

ENGEL; WUNDER, 2006, 2008; EGOH et al., 2011; PAGIOLA et al., 2007) or because they were not indexed in the respective scientific platforms (e.g., BARTON et al., 2003).

This result reflects the possibility of future expansion of SLR, particularly with regard to the insertion of new search terms and consultation with other scientific work indexing platforms.

Table 3 – Works selected as relevant for the research

Selected works	(ID)*
Barton et al. (2003)	(1)
Barton et al. (2009)	(1)
Bateman et al. (2015)	(2)
Bryan et al. (2011)	(2)
Chen et al. (2010)	(1)
Cimon-Morin, Darveau, and Poulin (2013)	(2)
Claassen, Cattaneo, and Johansson (2008)	(3)
Clements et al. (2013)	(3)
De Leeuw et al. (2014)	(3)
Dickman, Macdonald, and Macdonald (2011)	(3)
Duarte, Ribeiro, and Paglia (2016)	(2)
Egoh et al. (2010)	(2)
Egoh et al. (2011)	(2)
Hajkowicz et al. (2008)	(1)
Hily et al. (2015)	(1)
Klimek et al. (2008)	(3)
La Notte et al. (2014)	(1)
Larsen, Londoño-Murcia, and Turner (2011)	(2)
Narloch, Pascual, and Drucker (2011)	(3)
Nelson et al. (2008)	(2)
Pagiola et al. (2007)	(3)
Sierra and Russman (2006)	(3)
Ulber et al. (2011)	(3)
Von Haaren et al. (2012)	(1)
Wätzold and Drechsler (2014)	(1)
Wendland et al. (2010)	(1)
Wünscher and Engel (2012)	(1)
Wünscher, Engel, and Wunder (2006)	(1)
Wünscher, Engel, and Wunder (2008)	(1)
Zabel and Engel (2010)	(3)
Zhang and Pagiola (2011)	(1)

Source: Own Elaboration.

Note: * Identifier of the eligibility questions shown in Table 2.

Altogether, 15 prioritization elements from Group I (i.e., Ecological elements of the landscape) and 10 prioritization elements from Group II (i.e., Socioeconomic and governance elements) were obtained. Table 4 presents the elements that can be considered in the area prioritization process for the implementation of PES-biodiversity schemes.

Table 4 – Prioritization elements for the implementation of PES-Biodiversity schemes

Groups	Prioritization Elements
Group I – Ecological elements of the landscape	Prioritize areas with the highest richness of species.
	Prioritize areas with the highest number of threatened, vulnerable, and rare species.
	Prioritize areas for the conservation of endemic species.
	Prioritize areas for the conservation of flagship species.
	Prioritize areas for the conservation of species with commercial or culture value.
	Prioritize areas for the conservation of medium and large carnivores.
	Prioritize the functional diversity of the species.
	Prioritize areas with more complementarity and representativeness of biodiversity in relation to the already existing system of reserves.
	Prioritize the areas required for persistence and survival of the species.
	Prioritize the areas with high degree of connectivity.
	Prioritize the areas located farther from highways and urban centers.
	Prioritize the conservation of threatened, vulnerable, and rare habitats.
	Prioritize the fragments of vegetation with high degree of naturalness.
	Prioritize habitat spots with less complex shape.
	Prioritize important areas for the restoration and recovery of habitats and forest coverage.
Group II – Socioeconomic and governance elements.	Prioritize the areas with the lowest land opportunity costs.
	Prioritize the areas with the highest additionality.
	Prioritize the areas with land tenure guarantee.
	Prioritize the areas with lower social development patterns.
	Prioritize the areas where there is integration of the concerned parties.
	Prioritize the areas where there are social organizations.
	Prioritize the areas with more political and institutional capacity.
	Prioritize the areas that adopt sustainable handling practices.
	Prioritize heterogeneous landscapes.
	Prioritize the areas with more spatial congruence between biodiversity conservation and other ecosystem services.

Source: Own Elaboration.

Ecological elements of the landscape

Species richness is a commonly used element in PES-biodiversity schemes, with a predominant focus on conserving plant species diversity (BRYAN et al., 2011; CLA-ASSEN; CATTANEO; JOHANSSON, 2008; KLIMEK et al., 2008; LA NOTTE et al.,

2014; NARLOCH; PASCUAL; DRUCKER, 2011; PAGIOLA et al., 2007; ULBER et al., 2011). This result can be attributed, in particular, to the implementation of agri--environmental schemes in Europe and in the United States, which aim to reconcile agricultural production and biodiversity conservation. In these cases, increased diversity of plant species in agricultural fields (e.g., leguminous plants) means increased provision of environmental services (KLIMEK et al., 2008; ULBER et al., 2011).

Areas with the highest number of threatened, vulnerable and rare species (CLA-ASSEN; CATTANEO; JOHANSSON, 2008; NELSON et al., 2008; HAJKOWICZ et al., 2008; WENDLAND et al., 2010; BRYAN et al., 2011; EGOH et al., 2011; LARSON; LONDOÑO-MURCIA; TURNER, 2011; BATEMAN et al., 2015; HILY et al., 2015), as well as the presence of endemic species (BARTON et al., 2009; EGOH et al., 2011) and flagship species (WENDLAND et al., 2010), can also be prioritized. In addition, PES schemes can be directed to the conservation of species with local value (e.g., medicinal, religious use) or global value (e.g., bioprospecting, observation tourism) (WENDLAND et al., 2010; NARLOCH; PASCUAL; DRUCKER, 2011; DICKMAN; MACDONALD; MACDONALD, 2011).

Specifically, for medium and large carnivores, conservation has been considered in the design of the PES-biodiversity schemes (ZABEL; ENGEL, 2010; DICKMAN; MACDONALD; MACDONALD, 2011), as they play the role of "umbrella species" (DICKMAN; MACDONALD; MACDONALD, 2011), indirectly contributing to the conservation of other less targeted species. In addition, fragmentation and habitat loss have led to the decline of carnivorous populations, as these animals require large areas of land to survive, leading to conflicts with farmers mainly due to attack on herds. Thus, payment schemes have emerged to promote the coexistence between wildlife and farmers (ZABEL; ENGEL, 2010; DICKMAN; MACDONALD; MACDONALD, 2011). Prioritizing areas for contract allocation could consider, for example, the areas with the highest carnivore density (ZABEL; ENGEL, 2010) or the living area needed to keep the minimum viable population size in its natural habitat.

Species persistence is associated with the amount of natural habitat area required for species reproduction, feeding, or migration/dispersal (NELSON et al., 2008), such that their survival is not threatened over time (BARTON et al., 2003; BARTON et al.,2009; CLEMENTS et al., 2013; EGOH et al., 2010; NARLOCH; PASCUAL; DRUCKER, 2011). The probability of persistence of a species in its natural habitat can be adopted as the inverse of the "probability of extinction", in which isolated and smaller areas have a high probability of extinction (BARTON et al., 2003). Thus, a larger number of species can be conserved if a larger habitat area is conserved (EGOH et al., 2010).

Considering the conservation perspective, larger areas of native vegetation should be prioritized, as they have intrinsic value in terms of evolution and persistence of biological diversity (SIERRA; RUSSMAN, 2006). Higher priority should be given to remnants of intact primary forests or those with low anthropogenic (i.e., closer to natural) intervention, followed by secondary forests (BATEMAN et al., 2015; BRYAN et al., 2011; EGOH et al., 2010; PAGIOLA et al., 2007; VON HAAREN et al., 2012; SIERRA; RUSSMAN, 2006). In addition, less complex vegetation patches have higher ecological value than more complex vegetation patches (BRYAN et al., 2011) and may, therefore, receive higher conservation priority.

Nevertheless, habitat functions for species depend not only on the individual quality of the spots but also on landscape connectivity patterns (VON HAAREN et al., 2012). To define connectivity patterns, one must consider the dispersal capacity of species well investigated in the scientific literature, because changes in the displacement of species have important impacts on the connectivity effect and can substantially change conservation priorities (VON HAAREN, et al., 2012; WÄTZOLD; DRECHSLER, 2014; DUARTE; RIBEIRO; PAGLIA, 2016). Considering the ability of individual members of a population to move between habitat patches, it can be argued that connected habitats are more valuable for conservation than isolated habitats. In addition, the increase in conservation budgets implies that more spots may exist in the landscape, increasing the network of connected spots. Thus, selecting areas with the highest degree of landscape connectivity is a key consideration in the design of PES schemes (WÄTZOLD; DRECHSLER, 2014).

In addition, ecological benefits to the landscape increase with the amount and proximity of well-preserved patches (CHEN et al., 2010; WÄTZOLD; DRECHSLER, 2014), which favors the directing of contracts to properties near protected areas (HAJKOWICZ et al., 2008; PAGIOLA et al., 2007; WÜNSCHER; ENGEL; WUNDER, 2006, 2008; ZABEL; ENGEL, 2010; ZHANG; ENGEL, 2011). An area not legally protected may reflect marginal gain in biodiversity when an environmental attribute (e.g., habitat, species, or even a feature of the physical environment) not sufficiently represented within legally protected areas complements the existing reserve system (WÜNSCHER; ENGEL; WUNDER, 2006, 2008). That is, payments can be directed to areas that present greater complementarity and representativity of biodiversity in relation to protected areas.

It is noteworthy that, as ecological benefits increase with the proximity of well-preserved patches, they decrease with the proximity of anthropogenic land uses, especially highways and urban centers (DUARTE; RIBEIRO; PAGLIA, 2016; ZABEL; ENGEL, 2010). In addition, properties close to major highways and urban centers have lower transportation costs for the flow of production, which implies a higher opportunity cost of land and, consequently, less willingness from rural producers to receive PES resources (SIERRA; RUSSMAN, 2006; DE LEEUW et al., 2014; BATEMAN et al., 2015). Thus, payment contracts should be directed to the farthest properties from densely urbanized areas.

From a restoration perspective, PES could be directed to the restoration or rehabilitation of degraded areas on private land (SIERRA; RUSSMAN, 2006; WENDLAND et al., 2010), particularly relatively rare natural habitats in the landscape (NELSON et al., 2008; HILY et al., 2015). Some types of habitats are more vulnerable than others, implying the necessity of targeting available resources for the recovery of the most critical ones (SIERRA; RUSSMAN, 2006).

Finally, Wendland et al. (2010) and Cimon-Morin, Darveau, and Poulin (2013) recommend the incorporation of ecosystem functionality assessments and exchanges between ecosystem services in conservation area prioritization models. According to the authors, functional diversity (i.e., characteristics of organisms that constitute an ecosystem) is the most significant element of biodiversity that explains the presence and production of an ecosystem service at a specific location and time, and may be associated with functional characteristics of a single species or a variety of functional attributes (WENDLAND et al., 2010; CIMON-MORIN; DARVEAU; POULIN, 2013).

Socioeconomic and governance elements

For landowners to be interested in adhering to PES schemes, payments must be greater than the income obtained from the best land use alternative (EGOH et al., 2010; PAGIOLA et al., 2007; SIERRA; RUSSMAN, 2006; WÜNSCHER; ENGEL; WUNDER, 2006, 2008; BATEMAN et al., 2015; ULBER et al., 2011) and less than the value of the benefit provided (PAGIOLA et al., 2007; WÜNSCHER; ENGEL, 2012). However, in practice, the value of the benefit is more difficult to estimate than the value of opportunity costs (PAGIOLA et al., 2007). Thus, to achieve the most cost-effective implementation of PES schemes, priority should be given to areas with the lowest opportunity cost of land (BARTON et al., 2003; BARTON et al., 2009; NELSON et al., 2008; WENDLAND et al., 2010; CHEN et al., 2010; HILY et al., 2015).

The opportunity costs of land can be estimated, for example, by calculating the average annual yield of a given agricultural activity, weighted by the relative area occupied by that activity (BARTON et al., 2003; BARTON et al., 2009; WENDLAND et al., 2010). However, to obtain the actual land costs observed at the property level, it would be ideal to calculate the individual opportunity costs, which consider not only the physical characteristics of the property itself but also the socioeconomic conditions of the farmer and production system adopted (CHEN et al., 2010; ULBER et al., 2011; WÜNSCHER; ENGEL, 2012).

While opportunity costs indicate the areas that may be most cost-effective for a PES scheme to be implemented, additionality indicates potential areas for intervention by showing where conservation can achieve the best results (WENDLAND et al., 2010), once targeting payments to areas where there is no risk of loss of biodiversity or ecosystem services is ineffective (WÜNSCHER; ENGEL; WUNDER, 2008). Generally, the probability of deforestation is calculated as a proxy for additionality (WÜNSCHER; ENGEL; WUNDER, 2008; WÜNSCHER; ENGEL, 2012; WENDLAND et al., 2010). In this sense, areas with a higher probability of deforestation (i.e., greater additionality) are considered priorities for conservation (WÜNSCHER; ENGEL, 2012).

Another important element to be considered in the process of prioritizing areas for the implementation of PES schemes is the guarantee of land tenure. Securing land tenure does not mean the privatization of ecosystem service but rather the recognition of individuals or the community for the protection of services against third party action (WENDLAND et al., 2010). In addition, poorly clarified property rights make it difficult to legalize payment contracts, contributing to a minority elite appropriating the benefits of conservation to the detriment of disadvantaged populations (CLEMENTS et al., 2013). Thus, the actions of local collective organizations, as well as government institutions, can contribute substantially to the equitable distribution of the benefits of the schemes

(DICKMAN; MACDONALD; MACDONALD, 2011; NARLOCK; PASCUAL; DRUCKER, 2011; CLEMENTS et al., 2013).

Thus, there are important elements to be considered in the process of contract allocation, such as (i) prioritizing the areas with land tenure guarantee, (ii) prioritizing the areas with the highest performance of local collectives, (iii) prioritizing the areas with greater interaction between the parties involved, and (iv) prioritizing the areas that have better governance and political stability. It is noteworthy that, generally, regions with weak institutions and political conflicts correspond to those with favorable levels of service provision and additionality (WÜNSCHER; ENGEL, 2012). Thus, areas with greater political stability should be prioritized; however, the strengthening of such institutions in regions of great importance for the conservation of biological diversity should also be considered.

As noted earlier, conservation benefits often do not reach the most disadvantaged populations (CLEMENTS et al., 2013). Thus, payments should be designed to facilitate enrollment of the poorest landowners to achieve greater synergy between poverty reduction and environmental conservation, as well as provide technical and financial assistance (ZHANG; PAGIOLA, 2011). Some authors use social development indices based on indicators such as health, education, and income to indicate priority areas for conservation (WÜNSCHER; ENGEL; WUNDER, 2006; ZHANG; PAGIOLA, 2011). However, market and political factors should also be added to the calculation, as should distinctions be made between transient poverty, which affects several people temporarily, and chronic poverty, where a population remains at the same level of poverty for a long period (DICKMAN; MACDONALD; MACDONALD, 2011).

To achieve the highest environmental benefit per dollar spent, agri-environmental programs, such as the Conservation Reserve Program in the United States (CLAASSEN; CATTANEO; JOHANSSON, 2008), direct payments to farmers who combine management practices and specific soil treatment in increasing ecological levels (CLAASSEN; CATTANEO; JOHANSSON, 2008; KLIMEK et al., 2008), such as the adoption of adequate amounts of fertilizers (ULBER et al., 2011; LA NOTTE et al., 2014; VON HAAREN et al., 2012) and the appropriate harvest regime (SIERRA; RUSSMAN, 2006; LA NOTTE et al., 2014).

In addition, a regionally designed payment scheme could underpin agricultural systems that must be managed to meet both conservation objectives and agricultural production objectives (CLAASSEN; CATTANEO; JOHANSSON, 2008; WÄTZOLD; DRECHSLER, 2014). In this way, landowners would be less likely to lose production owing to crop diversification while promoting increased environmental quality (KLIMEK et al., 2008) and the flow of ecosystem services (CIMON-MORIN; DARVEAU; POULIN, 2013; DUARTE; RIBEIRO; PAGLIA, 2016) at the landscape level (CLAASSEN; CATTANEO; JOHANSSON, 2008; CHEN et al., 2010).

Finally, integrating biodiversity conservation with one or more ecosystem services can be beneficial in the sense that biodiversity is often more difficult to monetize compared with other services such as water and carbon, and thus, to obtain local and global beneficiaries willing to pay for its maintenance (WENDLAND et al., 2010). In addition, spatial congruence methodologies between ecosystem services and biodiversity can contribute significantly to the increase in conservation target areas (DUARTE, RIBEIRO, PAGLIA, 2016) and also to the diversification of financial funds (WENDLAND et al., 2010).

General Considerations

PES contract prioritization models should examine "biodiversity production" at the property level, while appropriating information on local agricultural production (i.e., individual opportunity costs). This approach would allow the marginal costs of the farmer to be obtained and optimize the conservation of biological diversity (ARMSWORTH et al., 2012). However, the contractual relationships of the PES are subject to the insufficiencies of symmetric information among economic actors; that is, landowners obtain better information on the provenance and price of environmental services provided on their land than that obtained by regulators. This phenomenon may limit the effectiveness of PES schemes and make them more expensive to implement, because, unaware of the real opportunity costs of farmers, regulators can allocate payment contracts to areas where opportunity costs are high (FERRARO, 2008).

In the process of selecting priority areas for PES schemes, transaction costs should also be considered, which correspond to the costs of negotiating, administrating, monitoring, and executing payment contracts. Generally, such operations are costly for landowners. Thus, to obtain greater scheme effectiveness (benefit-cost), the production value of a unit of the good should be greater than the costs incurred to implement it (COASE, 2009). Conservation contracts with complex ecological objectives (e.g., monitoring of rare species) may increase transaction costs and, consequently, discourage the participation of landowners in schemes (HANLEY et al., 2012).

The insertion of the biological aspect in the process of identifying PES priority areas becomes a challenge as data on species, populations, or even habitats are scarce (CULLEN, 2013). In addition, collecting and measuring biological resources from a region or even a plot of land is often costly and time consuming (CHEN et al., 2010). In these cases, biodiversity proxies are used, which act as a type of "substitute" for biological data, and may include both a single biological feature and a combination of several features (CHEN et al., 2010).

Also noteworthy is the inclusion of social (e.g., poverty) and economic (e.g., additionality, opportunity cost of land) aspects to the processes of area prioritization. Targeting payments without considering local culture, population poverty, or the existence of political, institutional, and participatory relationships may lead to program inefficiency over time (KOLINJIVADI et al., 2015).

Recommendations

Ultimately, data are not available for all the elements listed in this article. Therefore, developing a well-organized and articulated database between the parties involved, which is sufficiently flexible to allow more data to be inserted as they are being produced and refined, is recommended.

It is also recommended that the elements used to identify priority areas for the implementation of PES-biodiversity schemes should be considered in the process of developing other PES schemes based on the restoration and maintenance of natural areas, as ecosystem services are affected by changes in biological diversity. Therefore, including biodiversity elements in PES schemes will ensure the maintenance of other ecosystem services, such as climate regulation, water supply, and carbon sequestration, and hence, the sustainability of the schemes over time.

It is also noteworthy that the identification of relevant elements for the prioritization of areas is only the first step of a more cost-effective conservation plan. From the results obtained in this work, it is possible to define which elements should have more or less priority in relation to each other, according to the objectives of conservation actions. At this time, hierarchical methods can be applied, as well as workshops or consultations with specialists, to establish priority weights among the selected elements. Only after the hierarchy stage, can the amounts to be paid for the provision of the environmental service be defined.

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Original Article

PAYMENT FOR ENVIRONMENTAL SERVICES: GUIDELINES FOR IDENTIFYING PRIORITY AREAS FOCUSING ON BIODIVERSITY

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PAYMENT FOR ENVIRONMENTAL SERVICES: GUIDELINES FOR IDENTIFYING PRIORITY AREAS FOCUSING ON BIODIVERSITY

Abstract: The economic tool of Payment for Environmental Services (PES) has been considered as an alternative for the conservation of the biodiversity and ecosystem services in private lands. To guide decision makers in implementing PES schemes, this paper aimed to identify in the scientific literature the important elements to prioritize areas in the implementation of PES-biodiversity schemes. It is claimed that the elements extracted from PES-biodiversity schemes must be used as a reference to guide the implementation of other PES schemes based on the recovery and maintenance of natural areas (e.g. water, carbon, environmental aesthetics conditions). Thus, the sustainability of PES schemes can be guaranteed over time.

Keywords: Biodiversity. Economic tool. Environmental management.

PAGAMENTO POR SERVIÇOS AMBIENTAIS: ORIENTAÇÕES PARA A IDENTIFICAÇÃO DE ÁREAS PRIORITÁRIAS COM FOCO NA BIODIVERSIDADE

Resumo: O instrumento econômico de Pagamento por Serviços Ambientais (PSA) tem sido considerado uma alternativa para a conservação da biodiversidade e dos serviços ecossistêmicos em terras privadas. Com a finalidade de orientar os tomadores de decisão no processo de implantação de esquemas de PSA, este artigo teve por objetivo identificar na literatura científica os elementos importantes para se priorizar áreas para a implantação de esquemas de PSA-biodiversidade. Parte-se do argumento de que os elementos extraídos dos esquemas de PSA-biodiversidade devem ser utilizados como referência para orientar a implantação de outros esquemas de PSA baseados na recuperação e manutenção de áreas naturais (e.g. água, carbono, beleza cênica). Dessa forma, a sustentabilidade dos esquemas de PSA poderá ser garantida ao longo do tempo.

Palavras-chave: Biodiversidade. Instrumento econômico. Gestão ambiental.

PAGO POR SERVICIOS AMBIENTALES: DIRECTRICES PARA LA IDENTIFICACIÓN DE ÁREAS PRIORITARIAS ENFOCADAS EN LA BIODIVERSIDAD

Resumen: El instrumento económico de Pago por Servicios Ambientales (PSA) es una alternativa para la conservación de la biodiversidad y de los servicios ecosistémicos en terrenos privados. Con la finalidad de orientar a tomadores de decisión, en el proceso de implementación de esquemas de PSA, este trabajo tiene como objetivo identificar en la literatura científica elementos importantes para la priorización de áreas en la implementación de esquemas de PSA-biodiversidad. La condicionante de partida es, que los elementos extraídos de los esquemas de PSA-biodiversidad tienen que ser utilizados como referencia para orientar la implantación de otro esquema de PSA basados en la recuperación y manutención de las áreas naturales (p.e. agua, carbón, belleza escénica). De esta forma la sustentabilidad de los esquemas de PSA pueden garantizarse a lo largo del tiempo.

Palabras clave: Biodiversidad. Instrumento económico. Gestión ambiental.