



## **Analysis of programs of payment for environmental services in southern Brazil: identifying strategies for the conservation of *Araucaria angustifolia***

### **Análise de programas de pagamento por serviços ambientais no sul do Brasil: identificando estratégias para a conservação da *Araucaria angustifolia***

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**ABSTRACT:** Brazilian's conservation strategies are not limited only by the creation of Protected Areas, either Integral Protection or Sustainable Use. There are distinct strategies that aim to value services provided by ecosystems, combining conservation to the access of environmental services provided by biodiversity. In this context, there are the Payments for Environmental Services (PES). Throughout the Mixed Ombrophilous Forest (MOF), the plant species *Araucaria angustifolia*, known as Pinheiro-do-Paraná, is as threatened as the MOF ecosystem itself. Consequently, PES programs appear as an alternative tool to the main strategies for the preservation and conservation of biodiversity. In order to evaluate the PES programs created at the MOF that contribute to the species' conservation, we evaluated four PES projects in southern Brazil: "Desmatamento Evitado", "Araucária+", "Corredor Ecológico Chapecó" and "Estrada com Araucárias", all of them distributed in Paraná and Santa Catarina states. The basis for the programs' selection was a literature review. Once we selected them, we identified the indicators and topologies of each one, as well as an index indicating positive and negative points between the selected PES programs. The results showed that the selected PES have broad objectives, which value differently the indicators of additionality, permanence, transaction, but showed little evidence to the spillover indicator. The mostly contemplated typologies are support and regulation. Cultural services typology could be contemplated more frequently, for instance. Finally, by analyzing these four programs, despite few indicators and typologies that

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involve a PES, there are different possibilities that align conservation and valuation of biodiversity positively, since the programs have different methodologies, scopes, and objectives in general.

*Keywords:* PES; Araucaria; conservation; indicators; typologies.

**RESUMO:** As estratégias de conservação no Brasil não se limitam à criação de Unidades de Conservação, seja de Proteção Integral ou de Uso Sustentável. Há abordagens distintas, que aliam conservação ao acesso aos serviços ambientais que decorrem da biodiversidade, como por exemplo Pagamento por Serviços Ambientais (PSA). Ao longo da Floresta Ombrófila Mista (FOM), a *Araucaria angustifolia*, ou Pinheiro-do-Paraná, encontra-se tão ameaçada quanto o próprio ecossistema no qual está inserida. Com o intuito de avaliar os programas de PSA criados na FOM que contribuem na conservação da espécie, este estudo avaliou quatro programas de PSA: “Desmatamento Evitado”, “Araucária+”, “Corredor Ecológico Chapecó” e “Estrada com Araucárias”, distribuídos nos estados do Paraná e Santa Catarina. Foi feita uma revisão bibliográfica para a seleção desses programas e, uma vez selecionados, foram levantados seus indicadores e tipologias, além de ser feito um índice apontando pontos positivos e negativos entre os programas selecionados. Esses projetos possuem objetivos amplos, que valorizam os indicadores de adicionalidade, permanência, transação, e com pouca evidência ao indicador de vazamento (*spillover*). As tipologias são contempladas em sua maioria, como suporte e regulação, porém os serviços culturais poderiam ser contemplados com uma frequência maior, por exemplo. Por fim, ao analisar esses quatro projetos, foi observado que, apesar de poucos indicadores e tipologias que envolvem um PSA, há possibilidades distintas para aliar conservação e valoração da biodiversidade positivamente, pois os programas possuem metodologias e objetivos distintos em geral.

*Palavras-chave:* PSA; Araucária; conservação; indicadores; tipologias.

## 1. Introduction

The Atlantic Forest is the second largest tropical forest biome in South America, whose coverage reaches approximately 1.5 million km<sup>2</sup> along the Brazilian coast, with extension to regions in Argentina and Paraguay (Ribeiro *et al.*, 2009). Its biodiversity of more than 20,000 plant species is greater than that of the Amazon forest (Colombo & Joly, 2010), and approximately 50% of the species found in the Atlantic Forest are endemic (Myers *et al.*, 2000).

A major challenge for the conservation of this biome is the fact that 60% of the Brazilian population lives in its distribution range, producing

70% of the national gross domestic product and 66% of the country's industrial economy, in addition to encompassing two major Brazilian cities: São Paulo and Rio de Janeiro (Scarano & Ceotto, 2015). Consequently, the degradation of natural ecosystems is the main cause of biodiversity loss, combining urbanization, industrialization, and agricultural expansion within the Atlantic Forest domain (Scarano & Ceotto, 2015). This scenario of degradation results in a high level of threatened and endangered species (Ribeiro *et al.*, 2009; 2011), thus classifying the Atlantic Forest as a *hotspot*. In addition, the effects of climate change (Colombo & Joly, 2010; Lemes & Loyola, 2013; Ferro *et al.*, 2014; Scarano & Ceotto, 2015), have contributed to its classifica-

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tion among the three *hotspots* most vulnerable to climate change (Bellard *et al.*, 2014), out of 35 in the world, despite the fact that it contains over 700 Conservation Units (CUs) throughout its distribution (Galindo-Leal & Câmara, 2003), which occupies only 1.5% of the Atlantic Forest total area (Ribeiro *et al.*, 2009).

There are three predominant phytophysiognomies in the Atlantic Forest: Dense Ombrophylous Forest (DOF), Deciduous and Semideciduous Stationary Forests (FEDS), and Mixed Ombrophilous Forest (MOF), also known as Araucaria Forest. The MOF had initially 200,000 km<sup>2</sup> of total area, distributed between the states of Paraná - PR (40% of the territory), Santa Catarina - SC (30%) and Rio Grande do Sul - RS (25%). Moreover, according to Carvalho (1994), the Araucaria Forest was present in small spots at specific regions in the states of Rio de Janeiro, São Paulo, and Minas Gerais (see also Reis *et al.*, 2014). The species distributed throughout the MOF are adapted to milder temperatures, with frequent frosts in the winter (Roderjan *et al.*, 2002; Wrege *et al.*, 2016), and it is found in a wide range of altitude, from 500 to 1200 meters (Duarte *et al.*, 2012). The most emblematic species is *Araucaria angustifolia*, popularly known as Araucaria, Pine tree or Pinheiro-do-Paraná, which is the dominant species of the MOF canopy due to its height and shape of the candelabra canopy (Gasper *et al.*, 2013; Meyer *et al.*, 2013; Adan *et al.*, 2016).

The intensive logging of Araucaria during the 20th century, in spite of being an economically relevant aspect in South Brazil, combined with the agricultural expansion and, later on, to urbanization, caused a drastic reduction of the species' population (Da Silva & Reis, 2009) and

the original remnants of the MOF, leaving between 5% (Guerra *et al.*, 2002) up to 12% of the original ecosystem (Ribeiro *et al.*, 2009). Through the analysis of images from satellites and field data, Vibrans *et al.* (2013) estimated more accurately the remaining area of the MOF, concluding that less than 25% of the original distribution still remains. This scenario of exploitation, agricultural expansion, and urbanization classifies the phytophysiognomy of this biome as highly threatened (Kanieski *et al.*, 2010). Overexploitation demanded legal mechanisms to the conservation of the species, due to its ecological and cultural relevance (Machado Mello & Peroni, 2015). One example is the CONAMA Resolution No. 278 (Conama, 2001), which prohibits the logging and exploitation of endangered species, making sustainable exploration more flexible once technical and scientific criteria are established (Da Silva & Reis, 2009). Another example is Law No. 11.428 from 2006, which regulates the use and conservation of the Atlantic Forest vegetation (Brazil, 2006).

The handling and consumption of Araucaria seeds (pine nuts, or “pinhão”) have historically shaped cultural landscapes and transformed the MOF ecosystem, with strong influence of local communities distributed in southern Brazil (Reis *et al.*, 2014; Machado Mello & Peroni, 2015; Adan *et al.*, 2016; Zechini *et al.*, 2018; Lauterjung *et al.*, 2018). The consumption of pine nuts as a food resource, the historical exploitation of the species, as well as cultural and environmental influence in the MOF area, are examples of how the use, managing, and conservation of Araucária directly or indirectly provide environmental services. Yet, the scenario of instability, degradation and environmental fragmentation of the MOF (Vibrans *et al.*,

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2011) may influence the quality and functionality of the environmental services provided by this important ecosystem.

### *1.1. Environmental Services in the Mixed Ombrophilous Forest*

Environmental services (or ecosystem services) concept is defined by Daily (1997, p.3) as "conditions and processes through which ecosystems, and the species that compose it, sustain human life on the planet." Environmental services generate benefits that result from the healthy functioning of ecosystems, which are directly or indirectly appropriated to and by humans (Costanza, 1998; De Groot *et al.*, 2002), now or in the future (Daly & Farley, 2004). Despite the use of distinct concepts for environmental services and ecosystem services, the arguments used to define them change according to who defines these services (Chaudhary *et al.*, 2015). This is due to the constant evolution of the concept, which at first was more academic, used especially among ecologists and economists, but at the beginning of the XXI Century began to be incorporated into political and social agendas, transforming its meaning into a multidisciplinary, institutional and global concept (Chaudhary *et al.*, 2015). Therefore, environmental services and ecosystem services can be conceptualized in a similar way (Prado, 2014; Bernardo, 2016).

Environmental services are grouped into four distinct classifications, according to the Millennium Ecosystem Assessment (MEA): (i) regulation

- which is related to the quality and maintenance of ecosystem processes; (ii) provision - is the product of ecosystems, such as food, timber resources, fibers, etc.; (iii) cultural - the contribution to ethnic and social values of communities; and (iv) support - the contribution to other ecosystem services, such as nutrient cycling, soil quality, and seed dispersal (AEM, 2005).

The MOF provides several environmental services, including support and regulation, which play an important role in the maintenance of ecosystems, climate and biogeochemical cycles (Joly *et al.*, 2014). Concerning provision services, they may be highlighted in the provision of food and plant genetic resources (Vieira da Silva & Reis, 2009). Araucaria and Mate (*Ilex paraguariensis*), native plants of the MOF, for example, produce food resources for their associated fauna and for the ecological community, as well as provide important cultural services, as can be seen in the habit of human-consumption of Araucária pine nuts and drinking chimarrão<sup>1</sup> (Souza *et al.*, 2010; Moreira, 2014).

### *1.2. Payment for Environmental Services*

The use of integrated economic mechanisms for the valuation of environmental services has become a recurrent practice as a conservation strategy and as a complementary alternative to biological conservation since they generate economic assets for the environmental services provided (Daily *et al.*, 2000).

<sup>1</sup> t/n: Chimarrão or mate is a typical drink of the Southern culture of South America. A gourd vessel, which can be simple or decorated, is filled with ground yerba mate and added hot water.

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One of the economic mechanisms is Payments for Environmental Services (PES). PESs are defined by Wunder (2005, p.3) as "a voluntary transaction or a payment that one or more beneficiaries of environmental services grants to a provider of such environmental services, should this provider ensure the provision of these services for a long period of time". Thus, a supplier of an environmental service (such as a typical MOF farmer) could change their behavior if the additional cost of the change (conservation of biodiversity) was covered by the economic incentive to the service provided (Wunder, 2005).

In the scope of a PES project, it is necessary to identify the following items in its arrangement and governance: (i) at least one well-defined environmental service; (ii) at least one supplier; (iii) at least one buyer; (iv) voluntary transactions; and (v) evidence of conditionality (Wunder, 2005). In addition, the following quality indicators are found in the PES, which influences the effectiveness of the programs (Santos & Silvano, 2016): (i) additionality - the PES program should induce changes in land and water usage on rural properties; (ii) transaction cost - survey of all the values resulting from the process of creating the PES: negotiation, monitoring, control, that is, actions that are not the payments themselves; (iii) opportunity cost - is the calculation of the burden (or bonuses) in exchange of the production of one product for the supply of another, in this case, the PES; (iv) permanence - which is the continuity of the environmental service after the completion of payments; (v) leakage - which is the displacement of a generator of negative externalities to an area beyond the reach of the PES (Wunder, 2005; Young *et al.*, 2007; Engel *et al.*, 2008; Wunder *et*

*al.*, 2009; White & Minang, 2011; Plumb *et al.*, 2012; Wunder, 2015; Santos & Silvano, 2016).

For the Araucaria conservation, the PES can be an alternative option to the Conservation Units (CUs), which are the most common strategy used for conservation in Brazil. In the MOF, the historical (Bitencourt & Krauspenhar, 2006) or current (Adan *et al.*, 2016) human influence on Araucaria handling has historically shaped its landscape (Reis *et al.*, 2014). The demarcation of CUs in this phytophysiognomy has caused and still generates conflicts of interest between conservation of biodiversity and management of resources by small-farmers. However, human influence can contribute to generate direct and indirect environmental services (Brandt, 2012; Peroni *et al.*, 2013; Machado Mello & Peroni, 2015; Adan *et al.*, 2016), mainly through actions that continuously favor the interest for pine nuts consumption, common in areas surrounding CUs, such as in the mountain region of the state of Santa Catarina by means of traditional management systems (Adan *et al.*, 2016; Zechini *et al.*, 2018). The PES in this region are pointed out as a mechanism that allows a greater balance of interests with wider impact than the limited space bounded by the protected areas (i.e. Full Protection CUs) which, restrict the sustainable use of the species and its resources. Based on this theoretical approach of PES and economic valuation of biodiversity, there are PES projects and proposals, both public and private, developed with the aim of conserving biodiversity in the MOF. The great diversity of PES results in multiple PES projects and initiatives that were created and established in the MOF, specifically focusing or just involving Araucária, as well as there are projects still being

developed. This paper aims to contribute to these ongoing projects, focusing on further projects to be developed. Thus, what are the characteristics of PES programs in the Mixed Ombrophilous Forest regarding the conservation of *Araucaria angustifolia*? Which attributes and indicators determine the effectiveness of these programs? How to optimize new PES projects? Analyzing PES case studies currently implemented, we intend to identify the main economic valuation strategies of the PESs in progress at the MOF, as well as their main positive and negative points, and to propose suggestions for future projects of Payment Programs for Environmental Services.

## 2. Material and methods

### 2.1. Selection of PES projects

For the theoretical basis and selection of the projects, we conducted a keyword survey (Araucária, MOF, Payments for Environmental Services) through scientific production database platforms: Capes Periodical Portal, Web of Science, and the Institutional Digital Repositories of the Federal University of Paraná, Federal University of Santa Catarina, and Federal Technological University of Paraná. Additionally, to these platforms, we also used Google Scholar.

The criteria of project selection was based on the fulfillment of the following premises: (i) established compensation for those involved and

with a defined methodology (original or not); (ii) signed institutional arrangement, i.e. public-private partnership agreement, private-only, or public-only; and (iii) projects mandatorily involving payment for environmental services that require the conservation and / or the sustainable use of non-timber forest products of *Araucaria angustifolia*. In addition, the information available regarding the scope of the PES, the type of environmental service provided, the institutional arrangement, the potential value of the payments/remuneration, and the target public were prerequisites for the final selection of the programs. This information was also complemented by access to public documents with open-access (Environment Foundation - FATMA, O Boticário Foundation, Centers of Reference in Innovative Technologies - CERTI, Society for Wildlife Research and Environmental Education - SPVS, Secretariat of Environment and Water Resources - SEMA<sup>2</sup>). This stage allowed the elaboration of a comparative table between the programs, according to the methodology used by Santos & Silvano (2016).

Following the methods described above, the following four PES projects were selected: 1) The "*Avoided Deforestation Program*" (Programa Desmatamento Evitado), developed by the Society for Wildlife Research and Environmental Education - SPVS, through the creation of Private Natural Heritage Reserves - RPPN (Seehusen *et al.*, 2011); 2) The implantation of a PES in the "Chapécó Ecological Corridor - Santa Catarina"; developed under the Program of Environmental

<sup>2</sup> t/n: Chimarrão or mate is a typical drink of the Southern culture of South America. A gourd vessel, which can be simple or decorated, is filled with ground yerba mate and added hot water.

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Recovery and Support to Small Rural Producers (Microbacias 2 Project, under the responsibility of FATMA/IMA - Santa Catarina Environmental Institute, Alarcon *et al.*, 2013); 3) The "Araucária+ Initiative", between the municipalities of Paineira, Lages, Urubici, Urupema and Bom Jardim da Serra, with the Sustainable Production Bonus, executed in partnership between "O Boticário Foundation for Nature Protection" and "Fundação Certi" (Moreira, 2014); 4) PES State Systems Project in Paraná and Santa Catarina: analysis of the "*Roads with Araucaria Project*" (Estradas com Araucárias), part of the Bioclim Program of the Environmental Secretariat - SEMA and the Environmental Institute of Paraná – IAP (Santos & Silvano, 2016).

## 2.2. Evaluation of PES effectiveness

Some of the following factors were taken into consideration to assess the effectiveness of a PES. First, the existence of additionality, i.e. whether the PES project activity produces changes in land usage (or water) by the landowners (Engel *et al.*, 2008). Second, the permanence rate, which is the potential for continuity of quality maintenance of the environmental service provided during and after the end of the PES intervention. We also assessed the transaction costs, meaning all costs that are not the payments themselves, such as monitoring, control, supervision, and validation of defined environmental services (Wunder *et al.*, 2009; Santos & Silvano, 2016). The existence of the opportunity cost approach was evaluated to determine whether the programs take into account the opportunity cost of land use in the processes of valuation of environmental services and the respective payments (Young

*et al.*, 2007; White & Minang, 2011; Plumb *et al.*, 2012), and, finally, the spillover, which is identified when activities generating negative externalities are displaced beyond the scope of an implemented PES program (Wunder, 2005).

For each evaluated project, a score was given for the presence of the indicator (note 1) or for its absence (note 0, zero). Cases with insufficient information enough information were considered as "not assessed" (NA). Likewise, service typology classifications (regulation, provision, cultural, and support) were used to analyze the selected PES projects, using an adaptation of the approach presented by Santos & Silvano (2016), which used the indicators of additionality, transaction cost, opportunity cost, and spillover.

## 3. Results and discussion

### 3.1. "Deforestation Program Avoided"

Regarding the "Avoided Deforestation Program" (Table 1), created by SPVS in 2003, one of its main objectives is the conservation of the Araucaria Forest, as well as the protection of environmental remnants in the south of Brazil and the restoration of degraded areas (Seehusen *et al.*, 2011; SPVS, 2013), with projects in two municipalities in the state of Santa Catarina (Itaiópolis and Alfredo Wagner), and three in the state of Paraná (Ponta Grossa, Lapa, and Prudentópolis).

It is a program that values the continuity of its projects, seeking means to extend, in the long term, certain PES, serving as a model that may be followed by the State (SPVS, 2013).

TABLE 1 – PES summarized the description of the Environmental Service Program<sup>3</sup>.

<b>Scope</b>	Paraná and Santa Catarina (mainly) and up to 5000 hectares (ha) conserved <sup>1</sup> .
<b>Environmental Service in focus</b>	Carbon storage; Fauna and flora conservation; Creation of Private Natural Heritage Reserves (RPPN) <sup>1</sup> , <sup>2</sup> .
<b>Institutional Arrangement</b>	Implementation and monitoring: SPVS (Society for Wildlife Research and Environmental Education); Sponsors: private segment. Agreements: public-private model <sup>2</sup> .
<b>Potential value of PES and environmental valuation methodology</b>	R\$ 500.00 ha/year. Involving value transfer to owner and project management <sup>1</sup> .
<b>Types of Compensation</b>	Private companies "adopt" the preserved area and owners receive "awards".
<b>Target Audience</b>	Small farmers - private areas.

### 3.2. PES in the "Chapecó Ecological Corridor"

Implemented in 2014 by the Santa Catarina Environment Institute (FATMA / IMA), the Agricultural Research and Rural Extension Company of Santa Catarina - EPAGRI, and the State Secretariat for Sustainable Economic Development (SDS)

within the Santa Catarina Rural Program project, this PES (Table 2) allocates financial resources to rural landowners who maintain areas of native forest or who intend to recover degraded areas. It has the goal of reaching 1000 hectares of preserved area (Alarcon *et al.*, 2013).

TABLE 2 – Description of “Chapecó Ecological Corridor” PES , Santa Catarina state, Brazil. Adapted from the State Secretary for Agriculture and Fisheries of Santa Catarina<sup>4</sup>.

<b>Scope</b>	Santa Catarina (western regions and northern plateau); future extension of up to 1000 ha.
<b>Environmental service in focus</b>	Conservation of native forest and recovery of degraded areas of MOF in surplus areas of preservation and legal reservation.
<b>Institutional arrangement</b>	Implementation and monitoring: FATMA; Sponsors: public segment (SDS), with resources from the World Bank; Renewable projects for up to 3 years.
<b>Potential value of PES and environmental valuation methodology</b>	From R\$ 87.50 up to R \$350 per ha. It uses the Oasis Method <sup>1</sup> .
<b>Types of compensation</b>	Compensation per hectare preserved or recovered
<b>Target Audience</b>	Small farmers - private areas and voluntary participation

<sup>3</sup> Source: Seehusen et al. (2011);<sup>2</sup> SPVS (2013).

<sup>4</sup> SCRural (2014).



3.3. "Araucária+ Program: Sustainable Production Bonus"

The "Araucária+" initiative aims the conservation of the MOF's biodiversity under the approach of the Sustainable Production Model of Mate and Pinhão (Fundação Certi, 2014), in which, along with this model, the Sustainable Production Bonus is the PES tool created to economically promote the non-extraction of pine nuts and Mate, as well as to restrict the practice of extensive cattle raising, in remnants of the Araucaria Forest with high need for conservation (Fundação Certi, 2014).

3.4. Project "Roads with Araucaria and the Bioclima Program"

This PES project (Table 4) is an incentive to the Araucaria cultivation in border areas of family farms along roads regions (Oliveira, 2015). It is a compensation project, in which private companies pay for their greenhouse gas (GG) emissions to farmers who plant Araucarias along with their roadside border areas. This allows a series of indirect benefits, such as conservation, connectivity among protected areas, landscaping, pine nut production, wildlife resources, among others (Oliveira, 2015).

TABLE 3 – Description of the "Araucária+" PES initiative, through the Sustainable Production Bonus method . TABLE 3 – Description of the "Araucária+" PES initiative, through the Sustainable Production Bonus method<sup>5</sup>.

Scope	Santa Catarina (Serra Geral plateau region): Urubici, Lages, Urupema, Paineira and Bom Jardim da Serra.
Environmental Service in focus	Maintenance of MOF remnants not used for pine nut extraction and/or livestock.
Institutional Arrangement	The CERTI Foundation carries out the program management. The resources for the payments come from companies integrated with the Araucária+ initiative, in which they allocate a percentage of resources to the PES program in each commercial transaction that is done within the Sustainable Production Standard.
Potential value of PES and environmental valuation methodology	From R\$69.13 to R\$414.79 per ha/year, with potential for increasing over time to R\$829.58. Inspired by the Oasis method
Types of Compensation	Award for maintaining the quality of environmental services (i.e. compensation for the opportunity cost of the economic activities done in the target area, in addition to the valuation criteria).
Target Audience	Agricultural properties that adopt the Araucária+ initiative Sustainable Production Standard.

<sup>5</sup> Certi Foundation (2014); Moreira (2014).

The project started in 2011 and currently includes more than 60 units in the municipalities of Paraná (Lapa and Irati) and Santa Catarina (Caçador).

In evaluating the environmental services contemplated by the selected programs, we noted that the ecological potential of Araucaria is exploited in different ways (Table 6), either through regulation services – stratification of the MOF canopy (Ribeiro *et al.*, 2013) or forest regeneration in clearing areas, due to its heliophilous character (Avila *et al.*, 2016) –, and through environmental provision services such as the historical use of wood or the handling and trade of pine nuts (pinhão). The management and trade of Pinhão, both currently and historically, as well as the landscape of the MOF itself, reflect in a local cultural identity, mainly in the south of Brazil, where Araucaria and pinhão are symbols of cities, states and even cultural traditional festivals

(Peroni *et al.*, 2013; Reis *et al.*, 2014; Machado Mello & Peroni, 2015). Thus, actions and / or programs aimed at the conservation of Araucaria benefit the existence and permanence of cultural services, such as the involvement of small farmers in the use, handling and trade of pine trees in southern Brazil, an agricultural activity that also involves a lifestyle which values traditions and the environment of Southern Brazil (Reis *et al.*, 2014). In addition, Araucaria seeds dispersal can be classified as an environmental support service (Iob & Vieira, 2008; Wrege *et al.*, 2016), besides serving as food for the fauna (Duarte *et al.*, 2002; Bogoni *et al.*, 2018). Providing these environmental services, directly or indirectly, is a positive aspect of the PES presented, as it grants assurance and support to the Araucaria species so that environmental services continue to be developed where these trees are found.

TABLE 4 – Description of the "Roads Project with Araucaria"<sup>6</sup> PES.

<b>Scope</b>	Municipalities of Paraná and Santa Catarina
<b>Environmental Service in focus</b>	Preservation of Araucaria, green corridors, pine nut production, carbon storage, scenic beauty.
<b>Institutional Arrangement</b>	Payments are directly done between private companies and participating farmers: public-private
<b>Potential value of PES and environmental valuation methodology</b>	Up to 200 seedlings planted per property with a bonus of R\$5.00 per seedling. Maximum of R\$1.000/property, up to the productive stage of Araucaria. No valuation methodology.
<b>Types of Compensation</b>	Financial compensation for the storage of GHG via direct payment.
<b>Target Audience</b>	Agricultural properties along road domains in Paraná and Santa Catarina, Brazil.

<sup>6</sup>Oliveira (2015).

Wunder (2005) points out that, in order to verify whether PES programs are achieving their goals, they must meet the maximum of effectiveness indicators (see Table 5). Based on the literature, we verified that the selected programs must present at least the concept of additionality, which means they must result in actions that induce changes in land use or water. These changes need to be done by the rural landowners, in order to preserve an environmental asset (Engel *et al.*, 2008) such as Araucaria at MOF. However, the additionality must not be a mandatory premise, as there may be farmers who conserve the remaining forests on their properties without the PES program financial benefits. Farmers in MOF, who fit in this case, provide environmental services

without PES compensation and could be contemplated by it, because, on the contrary, a PES would only compensate those who previously generated damage to the ecosystem (Seehusen *et al.*, 2011; Santos and Silvano, 2016). This specific case must be valued, in which a PES program would reward producers/farmers who already conserve and/or restore, not only for legal matters but also for their own motivations.

The spillover monitoring has not been described and/or identified in the selected programs. As this indicator requires direct monitoring outside the program geographic range, which means beyond the real range of the created PES, it must be less frequently added to new programs. Nonetheless, in a context of reduced financial

TABLE 5 – Indicators evaluated (0 = absence of indicator, 1 = presence of an indicator, NE = non-evaluated, for not finding information) for PES in MOF involving Araucaria. We classified the typologies after the interpretation of the activity and result descriptions of each program<sup>7</sup>.

PES at MOF	Addi-tionality	Oppor-tunity	Transaction	Permanence	Spillover	Typology
Environmental Service Program	1	1	1	1	0	Provision, regulation, support and cultural (+4)
PES Ecological Corridor of Chapecó, Santa Catarina, Brazil	1	1	1	1	0	Provision, regulation, support and cultural (+3)
Araucária+ Program	1	1	1	1	0	Provision, regulation, support and cultural (+4)
Roads with Araucaria Project	1	0	1	1	NE	Provision and support (+2)

<sup>7</sup> Santos and Silvano (2016).

resources, monitoring beyond the PES range may increase even more the maintenance costs, consequently influencing the permanence indicator that is the environmental service provided after the end of the program. In Brazil, there are few studies that discuss or critically systematize PES instruments (Seehusen *et al.*, 2011). Regarding the permanence indicator, available PES documents analyzed show that only the “Avoided Deforestation Program” highlighted the goal of extending itself. Short-term programs may have limited effectiveness, due to the absence of a schedule for activities when the PES is ended (Pagiola *et al.*, 2007), besides the expiration or temporary suspension of payments, which may discourage beneficiaries to maintain conservation (Santos & Silvano, 2016). The “Avoided Deforestation Program” physical range was also the largest among the selected PES, with up to 5,000 ha for potential use. The program also targets the creation of Private Natural Heritage Reserves (RPPN) in places where there are PES already established.

Transaction costs, which are extra costs beyond the payment for the service itself, have been identified in all programs. The service includes inspection, prior feasibility, validation of the services provided during the program and negotiation between those involved (Wunder *et al.*, 2009). For Chapecó Ecological Corridor – Santa Catarina, we identified properties with natural areas surpassing the Permanent Preservation Areas (APPs) and the Legal Reserve (RL) within areas with potential or existing ecological corridors (SCRural, 2014). They indirectly involve prior feasibility analysis for potential sites that receive payment.

Among the indicators evaluated, the opportunity cost is the one which must attract the attention of owners, since the same place with a relevant environmental service also has an alternative place for

use of resources, such as water and soil (Santos & Silvano, 2016). Similarly, all programs have relative opportunity costs, although in different ways. PES “Roads with Araucaria project”, for instance, offers a maximum of R\$1000.00 ha/year/property.

Two programs use the Oasis methodology (Young & De Bakker, 2014) to calculate the PES payment value: “Araucária+” and “Chapecó Ecological Corridor – Santa Catarina”. This methodology presents the valuation function adaptable to different scenarios and contexts, taking into account the opportunity cost for conservation, rewarding environmental services identified in the ownership and/or adoption of best practices in agriculture (Young & De Bakker, 2014). In these programs, the opportunity cost is valued by a percentage and this amount is added to the payment calculation, ranging from R\$69.13 to R\$414.79 ha/year, using 25% of the opportunity cost, as in the “Araucaria+ PES project - Sustainable Production Bonus (Moreira, 2014). The advantage of having a specific methodology and, in this case, the valuation of opportunity cost, makes it possible to increase the percentage of opportunity cost according to the PES (Moreira, 2014).

We identified typologies of environmental services found in each PES program - provision, support, regulation and cultural (AEM, 2005) - for each project analyzed. As for provision and regulation services, except for the “Roads with Araucaria project”, whether directly or indirectly, all presented services that can produce/recycle structural elements of ecosystems, such as energy sources, genetic and medicinal resources (i.e. provision) and promote the continuity and development of ecological processes (i.e. regulation; Rebollar *et al.*, 2013). Support services, such as water cycling, photosynthesis, soil formation, nutrient cycling, and ecosystem develop-

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ment, were identified in all programs. Finally, cultural service, which is related to immaterial benefits for human well-being as well as the scenic beauty of ecosystems (AEM, 2005), was not explicitly discussed in the “Road with Araucaria project”.

#### ***4. Conclusion and final recommendations***

From the PES program analysis, we verified that services provided in the Mixed Ombrophylous Forest (MOF) involving Araucaria have been used within the valuation scope and monitoring of PES arrangements. “Avoided Deforestation Program”, for example, uses PES to encourage the creation of Private Natural Heritage Reserves (RPPNs), which can increase the permanence of a program and provide long-term provision, support, regulation, and even cultural services. It would be very beneficial if more PESs had as their final goal the creation of new RPPNs. Nevertheless, the permanence PES issue, when reconciled with the creation of RPPN, may be negative from an economic point of view for owners, since the owner abdicates the financial use of their property once it is transformed into RPPN, often decreasing the market value owing to the characteristic restriction of these conservation areas.

PESs should not focus solely on the recovery of degraded areas, as there are a number of small farmers who conserve their remnants through the use and sustainable management of resources. In fact, PES can serve as a rewarding factor for the conservation and/or incentive to adopt sustainable practices for the conservation of forest remnants. Even in cases where there is no additionality, MOF farmers who conserve a remnant without ever having degraded it could benefit from some PES program, not to

mention the maintenance of ecological processes. This would prevent, therefore, that only those who have generated degradation of biodiversity receive the incentive via PES. “Avoided Deforestation Program” and “Chapecó Ecological Corridor – Santa Catarina” programs, for example, seek the recovery of degraded areas, but they aim to maintain forest remnants as a strategy to value projects without the criterion of additionality.

PES programs should first and foremost target the broad scope of application and valuation of their indicators: permanence, spillover, additionality, transaction, and opportunity. Spillover, where negative externalities occur outside the PES range, may be one of the indicators that should be better used, as it would serve as a parameter of comparison between regions with and without PES. We suggest that new PESs should plan the program permanence, value those involved that do not generate negative externalities (without additionality) and watch the spillovers. In addition to other services provided, PES will become more effective, longer lasting and economically viable, for the attractiveness of rural landowners and for consequent benefits to the environment. Regardless of the typology involved in a PES, it is important that future studies describe what services or typologies will be related in the new program, in an objective and systematic way. Cultural services should be explicitly cited in PES programs, as scenic beauty, for instance, is a personal interpretation of a specific area, which is difficult to evaluate. It is also very important to discuss with future PES programs the existence of other conservation tools that may include intrinsic values, as well as cultural services, that motivate owners to conserve their remnants also for personal reasons, and not only for money received.

MOF suffers the reduction of its original area of extension, with the continuous increase of pressure on the ecosystem as a whole. The scenario of ecosystem fragmentation, the mosaic of small properties characteristic of the southern region of Brazil and the conflict of interests between resource use and conservation, are some examples of the complexity of this phytophysiognomy. PES programs act as local or even regional mechanisms for the conservation of Araucaria forests, and serve as an alternative to other mechanisms used by Brazilian legislation for biodiversity conservation, such as the Forest Code or the Atlantic Forest Law, as well as to the National System of Conservation Units (SNUC), through the CU of Integral Protection and Sustainable Use. By valuing biodiversity for protection of a species and, consequently, a fragile ecosystem, a strong context of biodiversity mercantilization is inserted, which can cause divergent opinions and criticism on this delicate subject. Nonetheless, in a scenario of constant pressure to MOF, alternative strategies of conservation, allied to sustainable use and maintenance of resources, favor and amplify the strategies that aim at Araucaria and the MOF conservation as a whole.

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