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Potential Economic Effectiveness of Payment for Environmental Services in a Protected Area in the State of Amazonas (Brazil)

Potencial efectividad económica de los Pagos por Servicios Ambientales en un área protegida en el estado de Amazonas (Brasil)

Eficácia Econômica Potencial do Pagamento por Serviços Ambientais em uma área protegida no estado do Amazonas (Brasil)

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ABSTRACT:
The implementation of payment for environmental services (PES) schemes in public protected areas raises several questions in economic, social, and environmental domains. In this paper, we analyze the case of Brazil's Bolsa Floresta Program (BFP), established in the Protected Areas of the state of Amazonas and considered one of the largest programs in the world in terms of area of coverage. First, we verify whether the program meets the requirements of a typical PES: conditionality, additionality, and voluntariness. Secondly, we seek to evaluate the two key requirements for a PES to perform well: economic effectiveness and ecological sustainability. Studying the case of the Uatumã Sustainable Development Reserve (Uatumã SDR), we determine that the payments made do not cover the provider–receivers' opportunity costs, which results in non-delivery of the contracted environmental services. The total area of secondary forest (SF) available to be incorporated into successive crop cycles might not be large enough to allow fallow periods of a long enough duration for soil fertility to recover fully. The intensification of agricultural activities in SF areas may lead to a degradation of the traditional agricultural system and a consequent loss of the ecosystem services that this system can potentially provide. In sum, these negative impacts indicate that, at least in the Uatumã SDR, the BFP might not be effective in the medium to long term.

RESUMEN:
La implementación de esquemas de pago por servicios ambientales (PSA) en áreas públicas protegidas plantea varias preguntas en los ámbitos económico, social y ambiental. En este documento, analizamos el caso del Programa Bolsa Floresta (PBF) de Brasil, establecido en las Unidades de Conservación de la Naturaleza del estado de Amazonas y considerado uno de los programas más grandes del mundo en términos de área de cobertura. Primero, verificamos si el programa realmente cumple con los requisitos de un PSA típico: condicionalidad, adicionalidad y voluntariedad. En segundo lugar, buscamos evaluar los dos requisitos clave para que un PSA funcione bien: efectividad económica y sostenibilidad ecológica. Al estudiar el caso de la Reserva de Desarrollo Sostenible de Uatumã, determinamos que los pagos realizados no cubren los costos de oportunidad del proveedor-receptor, lo que resulta en la no entrega de los servicios ambientales contratados. El área total de bosque secundario (SF) disponible para ser incorporada en sucesivos ciclos de cultivo puede no ser lo suficientemente grande como para permitir períodos de barbecho de una duración lo suficientemente larga para que la fertilidad del suelo se recupere

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completamente. La intensificación de las actividades agrícolas en las áreas de SF puede conducir a una degradación del sistema agrícola tradicional y la consecuente pérdida de los servicios ecosistémicos que este sistema puede proporcionar potencialmente. En resumen, estos impactos negativos indican que, al menos en el DEG de Uatumã, el BFP podría no ser efectivo a medio o largo plazo.

RESUMO:

A implementação de pagamento por serviços ambientais (PSA) em áreas públicas protegidas levanta várias questões nos domínios econômico, social e ambiental. Neste artigo, analisamos o caso do Programa Bolsa Floresta (PBF) do Brasil, estabelecido nas Unidades de Conservação da Natureza do estado do Amazonas e considerado um dos maiores programas do mundo em termos de área de cobertura. Primeiro, verificamos se o programa realmente atende aos requisitos de um PSA típico: condicionalidade, adicionalidade e voluntariedade. Em segundo lugar, procuramos avaliar os dois requisitos principais para que um PSA tenha um bom desempenho: eficácia econômica e sustentabilidade ecológica. Estudando o caso da Reserva de Desenvolvimento Sustentável de Uatumã, determinamos que os pagamentos feitos não cobrem os custos de oportunidade dos prestadores-receptores, o que resulta na não prestação dos serviços ambientais contratados. A área total de floresta secundária (FS) disponível para ser incorporada em sucessivos ciclos de cultivo pode não ser grande o suficiente para permitir períodos de pousio de uma duração longa o suficiente para que a fertilidade do solo se recupere totalmente. A intensificação das atividades agrícolas em áreas de FS pode levar à degradação do sistema agrícola tradicional e a consequente perda dos serviços ecossistêmicos que esse sistema pode potencialmente fornecer. Em suma, esses impactos negativos indicam que, pelo menos na RDS do Uatumã, o PBF pode não ser efetivo a médio e longo prazo.

KEYWORDS
Payment for environmental services; additionality; opportunity cost; Uatumã; Brazilian Amazon; Bolsa Floresta.

PALABRAS CLAVE
Pago por servicios ambientales; adicionalidad costo de oportunidad; unidades de conservación de la naturaleza; Amazonia brasileña.

PALAVRAS-CHAVE:
Pagamento por serviços ambientais; adicionalidade; custo de oportunidade; unidades de conservação da natureza; Amazônia brasileira.

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1. Introduction

A recent study based on a broad and in-depth review suggested that the effectiveness of Payment for Environmental Services (PES) was usually less than initially expected (Börner *et al*., 2017). Additionally, Samii *et al*. (2014) concluded that studies on the effects of PES on deforestation and poverty in low- and middle-income countries were weakly evidence-based and with methodological shortcomings. Such findings may compromise motivation of operators, payers, and providers in keeping their engagements in the payment agreement. Thus, a critical and holistic evaluation of the effectiveness of a given PES becomes essential to ensure participation of stakeholders in its subsequent stages. An effectiveness analysis of a PES scheme must consider not only its ability to financially compensate the opportunity costs of providers (Börner *et al.*, 2010), but also to evaluate the socio-environmental impact of the PES programme on the affected socioecological systems, in other words, recognizing the existence of tradeoffs and its negative impacts (Landell-Mills and Porras, 2002; Pagiola *et al.*, 2005; Börner *et al.*, 2017). By taking the case of the *Bolsa Floresta* Program (Brazil), we present a contribution to both theorical and methodological debate on analysis of the effectiveness of environmental public policies.

The *Bolsa Floresta* Program (BFP) is one of the world's largest PES programmes in terms of coverage area, encompassing 16 public protected areas (PA) in the state of Amazonas, in the Brazilian Amazon. These 16 state-protected areas occupy around 10.9 million hectares, a significant portion of the 18.9 million hectares of forest protected by the state-protected areas (Pereira, 2010; Viana *et al.*, 2012; 2013; Amazonas, 2018). With more than 35,000 beneficiaries, the BFP objective is "to compensate, through investments in income generation and social development, traditional populations for the willingness to conserve forests, in order to guarantee the provision of environmental services locally and globally" (FAS, 2017).

PES outcomes depend on the political, sociocultural, and institutional contexts in which they operate (Murdian *et al.*, 2013). And we should also consider that PES relevance to biodiversity conservation depend on what way and how much their implementations alter the reciprocal relationships that exist on the local socioecological system. To evaluate the BFP economic effectiveness as a financial compensation for environmental services we must identify its constituent parts, according to a set of defining criteria of a typical PES. A PES programme must meet the following eligibility criteria: (1) the service must be provided by a natural or legal person; (2) the activity must involve the protection, maintenance, preservation, conservation, recovery or management of a natural good or an ecosystem that is a provider of services; (3) it must provide investments in capital expenditures and current expenditures; and (4) it must generate benefits to third parties, beyond those who provide the environmental service (i.e. positive externalities; Camargo and Pereira, 2015; Lant *et al.*, 2008).

Environmental services and ecosystem services terms are often taken as synonymous (Lamarque *et al.*, 2011; Tacconi, 2012; Vatn, 2010). However, we argue that they should be considered distinguishable as they designate services that emerge from opposite flows. Swallow *et al.* (2009) argued that the main difference between ecosystem services and environmental services would be the inclusion or exclusion of provisioning ecosystem services, such as food, fiber, timber for which markets develop most readily. That is why environmental services are been considered by these authors a positive benefit that people obtain from the environment. In a different perspective, ecosystem services could be considered as "provided" by the ecological interactions and biogeochemical cycles of nature, benefiting humans indirectly (Costanza *et al.*, 2011), while environmental services would be carried out by humans (as organizations, communities, or individuals) through the aggregation of capital and labour for the benefit of

nature (Gomes *et al.*, 2019). Aligned to this last framework, Wunder (2015) defined Payment for Environmental Services as "voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services". Thus, any natural or legal person who protects, maintains, preserves, or directly manages a natural good or an ecosystem that benefits third parties is providing an environmental service. In other words, in a PES scheme it must be perfect clear for those involved who pays, when and who gets paid and what is being paid for, as a systemic Environmental-Economic Accounting.

Based on the principle of the protector–receiver (Gutierrez *et al.*, 2017), the provider may be rewarded for the environmental service itself, but not for ecosystem services arising from it. In a compensation system, such rewards may be provided by different economic instruments, such as incentives or payments, and law or contract must define the paying beneficiaries. These compensation systems, however, should not be considered PES schemes, since they are the genus of which PES is only a species. PES effectiveness exists only when there is additionality (Engel *et al.*, 2008) and voluntariness in the provision of the environmental service (Börner *et al.*, 2010). Environmental Additionality refers to the adoption of practices that result in environmental gains greater than those of an established baseline, and which would not have been adopted if compensation did not exist (Fasiaben *et al.*, 2009; García-Amado *et al.*, 2011; Pascual *et al.*, 2010).

A PES must be neutral with respect to the distribution of well-being, i. e. not affecting Pareto's equilibrium condition. To do this, it must be voluntary so that service providers are not required to bear high conservation opportunity costs compared to the most profitable land use options (Börner *et al.*, 2010). If they do not meet one of these conditions, PES programmes may involve forms of environmental compensation other than payment or compensate for or repay activities that cannot be considered an environmental service. In the PES contractual relationship, provider-receivers, and payer–beneficiaries must be clearly identifiable in addition to clearly identifying what is being paid and how payments are made (Pagiola *et al.*, 2004).

Although the term "payment for environmental service" was not well known at the time, some consider the Brazil's Ministry of the Environment's Socio Environmental Development Program for Rural Family Production, or *Proambiente*, launched in 2003, to be the first Brazilian PES initiative (Hall, 2008). In 2006, several pilot PES experiments were launched at the local level in Brazil. Pagiola *et al.* (2013) analyzed 14 PES schemes in Brazil, both at the local (municipal) level and the state and national levels, including the Bolsa Floresta Program in Amazonas. After 10 years of implementation, it is necessary to evaluate its contribution to the conservation of forests in the protected areas where it has been in effect.

To date, there has been no independent study evaluating the performance of the BFP as a PES. This independent study therefore intends to analyze how the BFP fits into the PES framework and assess its impact on environmental conservation and the lives of rural populations. We evaluated the program's effectiveness not only in institutional (in relation to voluntariness, conditionality, and additionality) and economic terms by comparing the amounts actually paid with the providers' opportunity costs (Börner *et al.*, 2010), but also from the point of view of ecological sustainability, by considering the expected impact of the action taken by farmer–providers on the managed socioecological systems (McGinnis & Ostrom, 2014). In other words, to verify ecological effectiveness of PES program we theoretically assess the potential of BFP to improve forest protection and reduce deforestation taxes in a more effective way than the long existing traditional shifting agriculture system. In addition, we empirically examine the willingness of the participants to receive for and to provide the alleged environmental services, as much as the alternative free riders' position of continuing to accept the payment without providing their individual contribution to the service provisioning service.

2. Materials and Methods

The Amazonas State Policy on Climate Change, Environmental Conservation, and Sustainable Development has created different programs aimed at reducing emissions from deforestation and net emissions of greenhouse gases, as well as establishing incentive instruments to enable its implementation. The *Bolsa*

Floresta Program has gained prominence because it specifically addresses payment for environmental services. In compliance with legal requirements, the Amazonas Sustainable Foundation (FAS) was created on December 20, 2007, as a nonprofit private foundation based in Manaus to implement and administrate the BFP. Its initial capital base resulted from a partnership between the government of the state of Amazonas and a private bank.

The programme has four grant components:
• *Bolsa Floresta Renda* (BF Income): Investment in productive inclusion to fight against poverty and preserve the environment.
• *Bolsa Floresta Social* (BF Social): Improvement in quality of life through investments in the community, designed to reverse the situation of social vulnerability that compromises the survival of citizens and families.
• *Bolsa Floresta Associação* (BF Association): Investments designed to strengthen community associations concerning claim, participation, and social control.
• *Bolsa Floresta Familiar* (BF Family): Incentives for family involvement in environmental conservation, focused on survival security (income and autonomy) (FAS, 2015, p. 1).

BFP locally starts when the FAS offers an introductory workshop on the BFP and training on climate change in the chosen PA. Then, the mothers of the families that participate in the program sign a commitment agreement to start receiving a fixed amount per month. In this way, the program begins with implementation of the BF Family component, the only payment modality in which each family receives the money directly.

The Uatumã Sustainable Development Reserve (Uatumã SDR) was chosen as case study. It was created in June 2004 by the signing of State Decree No. 24,295 of 25 June 2004; it has a total area of 424,430 ha and it covers parts of the municipalities of São Sebastião do Uatumã and Itapiranga, as well as the Uatumã and Jatapu rivers and their tributaries (Amazonas, 2017; Figure 1). The Uatumã SDR is one of the 42 Protected Areas (PAs) created and managed by the government of the state of Amazonas, and it was chosen as it was the first in which the BFP was implemented.

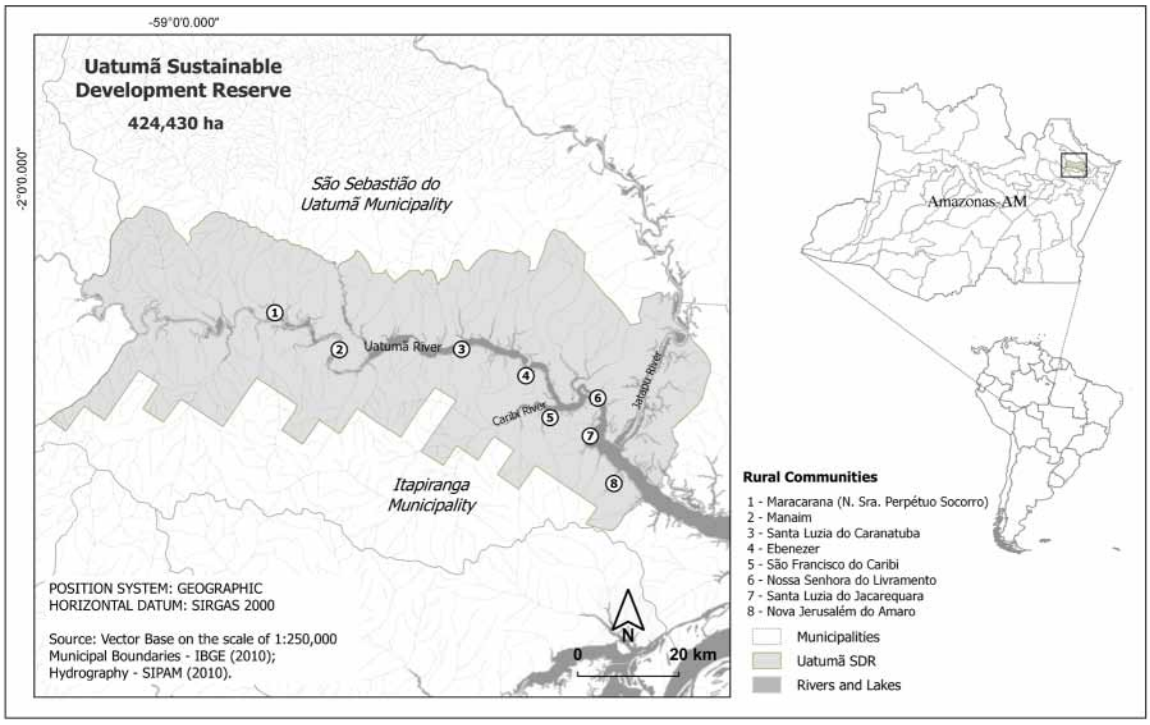

Figure 1. Location of the study area: Uatumã Sustainable Development Reserve, Amazonas, Brazil, with emphasis on the reserve's area of intensive use. Source: Authors.

The research assumption is the fact that families sign up for the BFP on a voluntary basis (not obliged to participate), and from this assumption, in order to verify whether the BFP meets the additionality requirement, it is necessary to first identify which environmental service would be provided by the PA's residents. In order to verify that the BFP meets the requirements of a typical PES scheme, an operational analysis of the program was conducted to analyze its contractual nature and whether voluntariness, conditionality and additionality exist in the relationship between the contracting parties, following Börner *et al.* (2010). Since BFP receivers are farmer families who are resident of protected areas, program conditionality present in the PBF contract were compared vis-a-vis legal environmental restrictions imposed by the PA management plan.

To analyze the economic effectiveness of the program, an estimation of the providers' opportunity cost was made to determine the minimum amount that should be paid. In order to calculate the minimum compensation that should be paid to traditional farmers (swidden-fallow horticulturalists; Coomes *et al.*, 2000), it was reasoned that establishing a *roça* (swidden) in a *capoeira* (secondary forest, hereafter SF) area rather than a primary forest area would lead to a decrease in swidden productivity (Jakovac *et al.*, 2015) and an increase in the cost of production. This latter consequence is mainly due to the increased amount of weeding needed to control invasive species and the regrowth of secondary vegetation (Pereira & Lescure, 1994). When summed up, these changes be a good estimate of the opportunity cost. As a basis for the calculation used in this study, we considered that in the state of Amazonas, on average, a family of traditional farmers creates one hectare of new swidden plots each year (Pereira & Pereira, 2015). It was estimated that production could be reduced by 50%, and at least a second weeding would be required during a production cycle of two years on average (Pereira, 1996; Jakovac *et al.*, 2015).

To compare the estimated opportunity cost with the amount actually paid to BFP providers, we audited the FAS's report for previous years. In order to record the participants' perception of the economic effectiveness and social and environmental impacts of the BFP, during two field expeditions in October 2017 and October 2018, we visited eight communities (Nossa Senhora do Perpétuo Socorro, Manaim, Santa Luzia do Caracarana, Ebenezer, São Francisco do Caribi, Nossa Senhora do Livramento, Santa Luzia do Jacarequara and Nova Jerusalém do Amaro) of the 20 in the PA. In these communities, we conducted in-depth interviews with the PBF receiver families of 15 different households in 2018. This research was approved by the Amazonas State Secretary for the Environment (DEMUC/SEMA #21/2016 and #131/2018) and by the Ethical Committee of the researcher´s organization which stablished that interviewees should sign a previously informed consent (IRB approval # 96583618.2.0000.0006).

To estimate the willingness to receive payment from the BFP, we directly asked 15 BFP participants how much they would accept individually as payment for complying with BFP rules. Using an ordinary least squares regression model, we verified whether these values were influenced by age, number of family members, source of income, total income, or per capita income (Xiong & Kong, 2017). For the statistical analysis of quantitative questionnaire responses, we used version 3.21 of the PAST program (Hammer *et al.*, 2001). Based on a conceptual model of ecological succession in traditional fallow farming systems (Marquardt *et al.*, 2013), the socio-environmental impact of the BFP in terms of maintaining the ecosystem services associated with these agricultural systems is hypothetically discussed.

3. Results

3.1. Voluntariness and conditionality of the BFP

The rules included in the Uatumã SDR management plan that could relate to environmental services refer to restrictions on the use of certain forest resources and changes in land use (Table 1). It is important to bear in mind that under the PA management plan, each family is allowed to cut up to three ha of secondary forest per year; however, there is no prohibition on creating new swidden plots in parcels of mature primary forest. Such a prohibition is present only in terms of the BFP's commitment to achieving the goal of zero deforestation in primary forest areas.

By signing the BFP terms of commitment, the family agrees to: (1) avoid opening new swiddens in primary forest parcels (goal of zero net deforestation), (2) adequately manage fires of slashed vegetation when preparing land for farming, (3) obey all other rules under the PA management plan, and (4) keep children in school. Zero net deforestation of primary forested areas is the BFP most important condition and additionality. The BFP rule most spontaneously quoted is related to the commitment to zero deforestation, followed by fire management. Compliance with the management plan and keeping children in schools were the rules that were least mentioned. As with the management plan rules, there was no significant correlation between frequency of citation and either self-assessed (r= 0.17; p=0.59) or collectively assessed compliance (r = -0,26; p = 0.38) with the rules.

3.2. Willingness to accept the BFP

The willingness to accept (WTA) values ranged from US$22.17 to US$611,09 (the annual average exchange rate in 2017 was R$2.30 = US$1.00, calculated using Brazilian Central Bank data). Ten income-generating occupation types were identified, the most frequent being in agriculture (mainly cassava cultivation), followed by public sector jobs, which provided the second highest annual income. Of typical rural activities, sport fishing was the most profitable, providing twice the income obtained from agriculture or extractivism. The least profitable activity was raising cattle (Table 2). The average of WTA values was equal to US$168.44 and the standard deviation US$132.22. The residents WTA values are ten times higher than the actual BFP payment.

Table 1. Rules under the Uatumã SDR management plan that restrict the use of forest resources and changes in land use.

USE OF FOREST RESOURCES	"It is prohibited to fell *açai* palm (*Euterpe* sp.), *buriti* (*Mauritia sp.*), *pataúá* (*Oenocarpus bataua*), *cumaru* (*Dipteryx odorata*), *breu-branco* (*Protium heptaphyllum*), *sorva* (*Couma sp.*), *uxi* (*Endopleura uchi*), *piquiá* (*Caryocar villosum*), *tucumã* (*Astrocaryum aculeatum*), *samaúma* (*Ceiba pentandra*), *bacaba* (*Oenocarpus bacaba*), *caju-açu* (*Anacardium giganteum*), *carapanauba* (*Aspidosperma nitidum*) and *jatobá* (*Hymenaea courbaril*), as well as other species considered of interest by residents." "In *campina* and *campinarana* fields, no exploitation of timber is permitted."
LAND USE AND CHANGES IN LAND USE	"Clearing areas up to 3 hectares per year per family is permitted, and beyond that: • Above 3 hectares and opening new areas of forest requires approval by the deliberative council and the consent of the State Secretariat for the Environment (SEMA). • Community´s requests to opening new field plots must be submitted to the Amazonas State Secretariat for the Environment (SEMA). • Clearing swiddens in areas of young secondary forest requires the consent of the SEMA. • Annual crop rotation in swidden areas is recommended." "Prioritize fallows and old swiddens for agricultural activity and animal husbandry." "The clear cutting of Permanently Protect Areas (PPA) [riparian forests, steep sloped areas, etc.] is prohibited in accordance with this legislation." "It is forbidden to clear a field plot in areas with Brazil nut trees (Bertholletia excelsa), rubber trees (*Hevea* sp.), *copaiba* (*Copaifera* sp.) and andiroba (*Carapa guianensis*)." "For large and medium [sized animals], the clearing of new pasture areas is not permitted. Breeders are responsible for fence construction and damage caused due to escape and invasion".

Source: Amazonas (2017).

3.3. Opportunity cost calculation and economic effectiveness of the BFP

The cultivation of one hectare of primary forest swidden can yield 14 tons of fresh cassava root, which, when processed in the form of manioc flour, would result in seven tons of final product. Thus, this share of the opportunity cost corresponds to the purchase or sale value of 3.5 tons of flour (this value representing total annual production, given that productivity in SFs is 50% lower than in primary forests). While SF fields require a greater amount of work to weed them, they do not require as much soil preparation prior to planting, since the smaller size of the tree canopy in SF means that less work is needed to open them compared to primary forest swiddens. The increased amount of weeding and reduced effort to prepare the land therefore

Table 2. Annual average income by source or occupation for families in the Uatumã SDR in 2018.

SOURCE OR OCCUPATION	ANNUAL INCOME PER FAMILY AVERAGE (US$)	STANDARD DEVIATION	Nº
Pension	7.012.50	-	2
Public service	2.863.39	1821.70	9
Sport fishing	2.093.75	1542.68	6
Horticulture	1.081.77	717.90	14
Extractivism	962.50	1020.57	6
*Bolsa Família**	824.33	408.48	8
Other	414.06	335.94	4
Commercial fishing	394.31	302.81	7
Temporary farm work	231.25	9.48	6
Cattle	122.22	345.70	3
Total	4.199.71	2931.63	-
Total per capita	1.052.80	872.61	-

* Federal conditional cash transfer *program.*

cancel each other out in terms of impact on the cost of production. Thus, only the reduction in productivity is accounted for in estimating the BFP opportunity cost.

In this way, the opportunity cost can be estimated in terms of the loss of productivity only. If flour is traded at the official minimum price of US$0.31/kg (CONAB, 2018), divided into monthly instalments, the cost for each family for one ha would be US$91.14 per month (multiplying the 3.5 tons, or 3,500 kg, per year by US$0.31/kg, and dividing the result by 12). This amount is 22% higher than the average value of US$74.38 invested per beneficiary family across all PAs in 2016, when all BFP payment categories are considered. BFP monthly payments per family also fall short of those estimated in a study that looked at the opportunity cost across all traditional agriculture areas in the region, according to which providers could make a profit of between US$209.38 (conservative estimate) and US$453.12 (optimistic estimate) per hectare of area in which deforestation was avoided, based on a scenario involving uniform payments (Wunder *et al.*, 2008). The choice to make the swidden size per family limited to one hectare, based on Pereira and Pereira (2015), was confirmed as the correct one, as this size of family swidden was the one most frequently indicated by the interviewees during the 2018 field work.

This opportunity cost corresponds to the minimum amount that should be paid by the BFP as compensation for the 50% reduction in cassava's productivity. This value paid by the BFP, added to the value that the family can obtain from the sale of products cultivated in SF swiddens, should be equal to the value that the farmer would obtain from old-growth primary forest (OGPF) swiddens. That is, the production value of 3.5 tons of flour per year, added to the 12 monthly BFP payments, should be equal to the total value of income that could be generated from 7 tons of manioc flour obtained from OGPF swiddens (Figure 2).

In 2016, the average amount paid out per family participating in the BFP was just over US$189.06 per year, which is lower than the opportunity cost to the families of that PA even if familial and collective grant components are accounted for. This value of opportunity cost, if taken as a value of WTA, would also fall short of the participants' expectations:

> I do not [consider it sufficient], because the amount paid of 50 *reais* [US$15.62 per month], it is not enough, because I still have to pay the associations and, after all, when the land does not provide, one cannot enter the forest. However, we have already talked in a meeting about increasing this amount to the value of three minimum wages, and that would be a negotiation to use only *capoeira* (Mr. C.S.S., Uatumã SDR resident, 2017).

In fact, in an opinion poll of SDR residents conducted in 2010, only two years after the implementation of the program, increasing BFP Family grant was seen as a priority for 19% of participants (Viana *et al.*, 2013), a result which has also been observed in other PES contexts (García-Amado *et al.*, 2011; Feng & Xu, 2015). The opinions of the beneficiaries may have been based solely on their perception of the amounts paid individually to each family, as was observed among the survey pool in the Rio Negro SDR (Vatn *et al.*, 2013), and may not have taken into consideration the investments from the other BFP grant components. These investments are aimed at strengthening alternative economic activities to those that depend on the substitution of the forest for other land uses, such as timber and non-timber forest management activities, and tourism. In the case of the Uatumã SDR, sport fishing has been encouraged as a tourism activity. Even so, in the opinion of the residents, such alternative activities are not profitable or attractive enough to motivate their engagement:

> The highest household income comes from the planting of cassava. The value of 50 *reais* [US$15.62] a month cannot maintain the forest. An amount equal to the minimum wage per month would be necessary, since sport fishing only occurs during three months of the year and wood extraction is very *labor* intensive (Mr. O.S.B., Uatumã SDR resident, 2017).

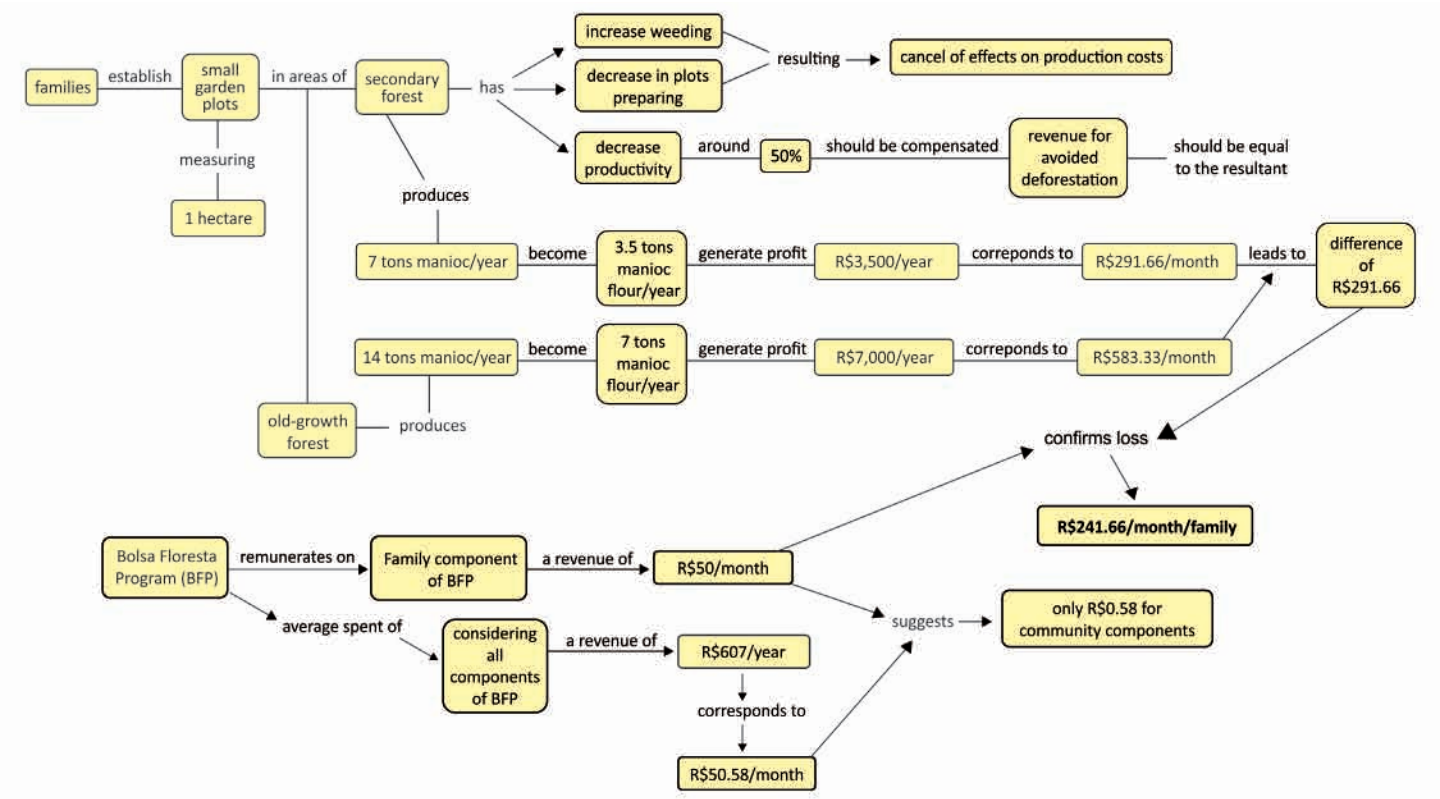

Figure 2. Conceptual model for estimating the opportunity cost of the *Bolsa Floresta Program*. Source: Authors.

Table 3. Distribution of resources paid by the Bolsa Floresta Program (BFP) in 2016.

	BFP CATEGORY (IN US$ THOUSANDS)				
GEOGRAPHIC SCOPE	FAMILY	INCOME	SOCIAL	ASSOCIATION	TOTAL
All 16 PAs	1,550.53	362.24	62.56	92.62	2,067.95
Uatumã SDR	54.09	6.64	-	2.99	63.72

Source: FAS (2017).

In 2016, the various program grant components provided beneficiaries with a total of approximately US$2.06 million, 75% of which was for the BF Family category, 17.5% for BF Income, 3% for BF Social, and 4.5% for BF Association (FAS, 2017). This percentage pattern is reproduced across all PAs. In this way, it can be seen that a large portion of the payments of the BFP goes towards directly transferring cash to families through the BF Family category. This percentage is even higher for the Uatumã SDR, where 85% of the resources were allocated to BF Family in 2016 (Table 3). Another significant portion of investment went towards the implementation of productive infrastructure in the communities, with the percentage attributed to the Social and Association grant components being much smaller compared to the Family component.

4. Discussion

In the case of the BFP, services cannot be individualized and verified directly as in the case of programs such as Grain for Green (Gauvin *et al.*, 2010; Deng *et al.*, 2014). However, the right of each BFP beneficiary family to open new swidden plots in areas of primary forest is waived, as program's main conditionality and source of additionality. BFP could be classified as an environmental service based on the reduction of negative externalities by mitigation (Pereira & Camargo, 2014). A mitigation service is related to changes in ecosystem management practices or resources that reduce the negative impact on the integrity of associated ecosystems, or else that reduce the demand for ecosystem services, such as when technology manufacturers adopt "cleaner" production methods.

A socioeconomic survey conducted during a review of the PA management plan also indicated that the residents' main sources of income were agriculture, pensions, wage labor, river activities, tourism, fishing, extractivism and livestock. Communities' average monthly income per family ranged from US$86.50 to US$494.83, with an overall average of US$285.31, which is close to the national minimum wage (Amazonas, 2017). The lower value in the range is very close to the estimated value for the opportunity cost of the BFP; that is, the cost of renouncing the right to OGPF swiddens. As in similar situations, where farmers are faced with payment proposal for forest conservation (Asquith *et al.*, 2008), in purely economic terms, the current amounts paid by the BFP are not a competitive alternative to forest conversion.

While it is recognized that the BFP can contribute to forest conservation, the suspension of payments as a penalty for non-compliance is not being properly enforced (Gebara & Agrawak, 2017). This results in PES users realizing that they are unlikely to be punished and therefore preferring to continue to convert forest to other land uses even if they have received payment, which residents think as additional income. As noted, in the Uatumã SDR, legal sanctions are rarely enforced.

The BFP encourages farmers not only to shorten the fallow period on swidden plots (Figure 3, Trajectory 4), but also to not expand areas of pasture for animal husbandry. Thus, already established pasture areas will tend to become degraded due to prolonged use uninterrupted by the fallow periods that would allow the natural regeneration necessary for system recovery (Figure 3, Trajectory 8). In the long term, the total area of SF

available to be incorporated into successive crop cycles will not be large enough to allow fallow periods of a long enough duration for soil fertility to recover fully. The intensification of agricultural activities in SF areas may lead to a degradation of the traditional agricultural system and a consequent loss of the ecosystem services that this system can potentially provide, mainly services related to soil recovery and increases in root carbon. In addition, reduced fallow periods will lead to a reduction in plant diversity, lower labor productivity, and lower household income (Börner *et al.*, 2007, Jakovac *et al.*, 2016). In sum, these negative impacts (or side effects) indicate that, at least in the Uatumã SDR, the BFP might not be effective in the medium to long term.

The ecological function of SF within a fallow agriculture system is the gradual restoration of the soil's chemical and physical fertility levels, as well as reduced infestation of its seed bank by invasive species (Massoca *et al.*, 2012). In addition, SFs are home to a significant number of multiuse species exploited by farmers. Costa and Mitja (2010) reported that of the 173 species of useful plants, 18 species (10.4%) were from SFs and used mainly for the extraction of firewood.

The zoning established in the management plan sets out an area of intensive use (Figure 1) corresponding to 15,748.65 ha (Amazonas, 2017). Given that in 2016 there were 361 families living in the SDR who would be allowed to clear up to three hectares of crops per year, the maximum fallow time would be 14.5 years. In this period, the entire area of forest available in the intensive use area would have been converted into swiddens. In a long-term study conducted in the Manaus region, SF with 20 fallow years had reached only 50% of the biomass of the adjacent primary forest (Massoca *et al.*, 2012), indicating the need for a longer fallow period for complete restoration of the system. In addition, to accomplish longer fallow periods (such as 40 years), a larger area (at least 43,000 ha) of regenerative forested land would be needed. This requires reviewing the management plan to increase the area of intensive use three times its actual size.

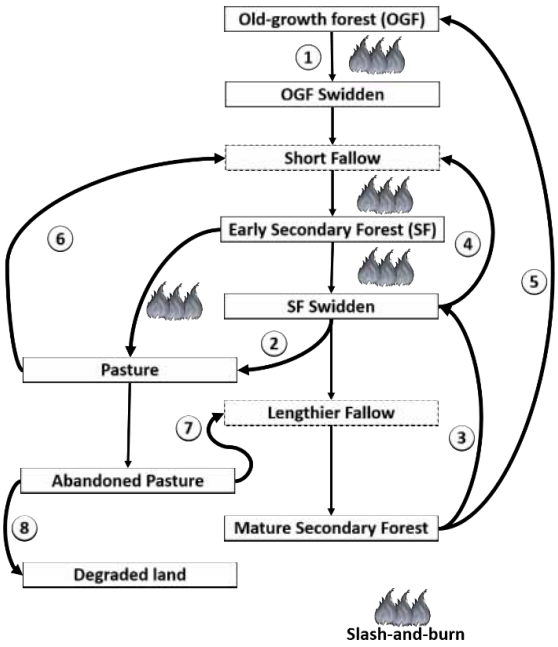

Figure. 3. Ecological succession trajectories observed in areas in the intensive use zone occupied by traditional slash-and-burn agriculture.

Notes: Numbers in circles represent successional trajectories. The succession begins with the clearing of a portion of old-growth forest (OGPF; 1) to create an OGPF swidden. After one or two years of cultivating crops – mainly manioc plants (*Manihot esculenta* Crantz) – cultivation practices are suspended, and the area is left to regenerate for a short period of time, producing an area of shrub vegetation referred to as young SF. The area is then converted to cultivation, creating what is known as a *roça de capoeira* (SF swidden), which after the last harvest is left fallow for a longer period (decades) until it reaches the stage of a mature SF. The time required for a mature SF to reach the OGPF stage may take 100 years (5; Finegan, 1996; Peña-Claros, 2003). Farmers can establish pastures in areas that have already been altered (2). Pastures are managed using fire (6), and after a few years become less productive and are left to regenerate (7). The BFP's environmental service would result from farmers' voluntary commitment to avoiding clearing areas of forest (i.e. removing Trajectory 1) and restricting the planting of new crops to areas of SF (3).

5. Conclusions

BFP potentially has elements of voluntariness and potential additionality that constitute a typical system of payment for environmental services (PES) and could be classified as an environmental service due to the "reduction of negative externalities by mitigation". Although the BFP has four grant components, and for three of these components the community defines how resources will be used, there is no variation in the amounts paid to each family. Payments are fixed for all categories, regardless of their individual contributions for service provision. What the BFP managers consider is the total amount of program's funds available, not the effectiveness of the provision of an environmental service, nor the needs of families who have complained that the amount is too low. The transfer of resources is not based on results, on the valuation of services provided, but only on the needs of the residents. Our estimation of opportunity costs confirms the residents' point of view that the amount paid is too low: the BFP should pay at least an additional

US$75.52 per month/family if it is to provide real compensation for residents voluntarily renouncing their right to clear forest to create swiddens.

From the point of view of the economic effectiveness of the program, it can be said that the amounts paid out each year fall short of the estimated opportunity costs, which may, in the long term, result in a high dropout rate and the acceptance of payments without the environmental service being provided in return, as it has been observed. Under the BFP, payment is continuous, unlike most functioning PES schemes, which can be a positive element for its greater attractiveness. On the other hand, this requires that the sources of funds be secured so that the same amount for each year can be paid out. Infrastructure projects financed by BF *social* and BF *renda* components are aimed to incentivizing alternative economic activities. Although such alternative activities could reduce pressure on forest resources and favor the conversion of primary forest to other uses, they are still not attractive enough according to Uatumã SDR residents.

In terms of the BFP's ecological sustainability, we can conclude that the stability of the system will depend on cultivation periods being sufficiently short and fallow periods sufficiently long to allow SF to fully develop, thereby providing farmers with areas in which soils have recovered, are suitable for cultivation and more productive. This adjustment in the system could be achieved through a review of the zoning of the PA when updating its management plan. Increasing access to primary forest areas would allow for the formation of a larger stock of mature SF to ensure longer fallow periods after each cropping cycle.

It is crucial that policy- and decision-makers have a full and correct understanding of environmental processes if the BFP and other similar programs are to be well designed. Since the program's main objective is to compensate farmers for agreeing to renounce their forest access rights, our conclusions suggest that the amount of BFP payments should be raised to compensate them for the opportunity cost of only opening swiddens in secondary forest areas.

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