Ecological Economics 69 (2010) 1626–1638

Contents lists available at ScienceDirect

Ecological Economics

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

Analysis

User financing in a national payments for environmental services program: Costa Rican hydropower

Allen Blackman [a,b,1,2], Richard T. Woodward [b,c,*,1]

[a] Resources for the Future, 1616 P Street, N.W., Washington, DC 20036, United States
[b] Environment for Development Center for Central America, Turrialba, Costa Rica
[c] Department of Agricultural Economics, Texas A&M University, 2124 TAMU, College Station, TX 77843-2124, United States

ARTICLE INFO

Article history:
Received 11 February 2009
Received in revised form 4 March 2010
Accepted 4 March 2010
Available online 21 April 2010

JEL classification:
Q23
Q24
Q28

Keywords:
Payments for environmental services
Voluntary regulation
Hydroelectricity
Costa Rica

ABSTRACT

National government-funded payments for environmental services (PES) programs often lack sustainable financing and fail to target payments to providers of important environmental services. In principle, these problems can be mitigated by supplementing government financing with contributions from leading environmental service users. We use original survey data and official statistics to analyze user financing in Costa Rica's renowned national PES program, focusing on the amounts and sources of user financing, the drivers of contributions, and contributors' perceptions of the PES program. We find that user financing has supported less than 3% of the acres enrolled in the program and that hydroelectric plants are the largest private sector contributors. Large hydroelectric plants tend to contribute while small ones do not. The weight of evidence suggests that in addition to ensuring the provision of forest environmental services, hydroelectric plants' motives for contributing to the PES program include improving relations with local communities and government regulators—common drivers of participation in all manner of voluntary environmental programs. These findings raise questions about the potential of user financing to improve the efficiency and financial sustainability of national PES programs.

1. Introduction

Payments for environmental services (PES)–cash transfers from users of environmental services to providers of these services conditional upon continued provision–are an increasingly popular environmental management tool.[3] More than 300 PES programs have been implemented worldwide (Pagiola and Platais, 2002; Wunder et al., 2008). Most have a limited geographic scope and are financed directly by users of specific environmental services—for example, payments by downstream users of hydrological services to upstream land managers in a single watershed. However, a handful of programs–including in China, Costa Rica, Mexico, and South Africa–have a national scope and are financed by the government acting on behalf of users of environmental services throughout the country (Wunder, 2005; Engel et al., 2008; Pagiola, 2007).

Compared with more common user-financed initiatives, national government-financed PES programs have advantages and disadvantages (Engel et al., 2008; Wunder et al., 2008; Pagiola and Platais, 2007; Mayrand and Paquin, 2004; FAO, 2003). The main advantage is economies of scale. PES programs entail significant transaction costs that stem from identifying and matching service providers and users, negotiating conditional contracts, monitoring compliance, and enforcing contract terms. National programs are able to spread these costs over a large number of agents, in theory facilitating PES agreements that would be too costly for private parties, and even subnational entities, to negotiate on their own.[4] An important disadvantage is inefficiency. Because national governments are not direct users of environmental services, they generally do not have detailed local knowledge about the value, provision, and use of these services. In addition, they are swayed by political and bureaucratic interests. As a result, as discussed in the

* Corresponding author. Tel.: +1 979 845 5864.
E-mail addresses: r-woodward@tamu.edu (R.T. Woodward).

[1] Senior authorship is shared. Blackman is a Senior Fellow at Resources for the Future and a Research Fellow at the Environment for Development Center for Central America. Woodward is an Associate Professor in the Department of Agricultural Economics at Texas A&M University and a Research Associate with the Environment for Development Center for Central America.

[2] Tel.: +1 202 328 5073.

[3] The term PES has been applied somewhat indiscriminately to a wide range of economic incentive policies from national park entrance fees to ecocertification (Engel et al., 2008). According to Wunder (2005), a payment for environmental services is defined as (i) a voluntary transaction where (ii) a well-defined environmental service (or a land use likely to secure that service) (iii) is being "bought" by a (minimum one) service buyer (iv) from a (minimum one) service provider and (v) if and only if the service provider secures service provision (conditionality).

[4] Transaction cost advantages depend on the type of environmental service on which the PES program focuses. For example, transaction costs associated with conditional payments for global environmental services such as carbon sequestration and biodiversity preservation are likely to be higher than those associated with payments for local environmental services like facilitating aquifer recharge, since the cost of linking service providers and users is likely to be higher in the case of global services. We are grateful to an anonymous reviewer for this point.

0921-8009/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2010.03.004

next section, they often do a poor job of identifying providers of important environmental services, negotiating cost-effective contracts, and monitoring compliance. A second potential disadvantage of national PES programs, also discussed in the next section, is that they may lack sustainable long-term financing. They depend principally on national tax revenues and international assistance, which are vulnerable to changing political and macroeconomic conditions.

In theory, those problems could be mitigated by expanding what is typically a minor component of national PES programs: voluntary payments by individual users of specific environmental services to government administrators to underwrite PES contracts with providers of these services. For example, breweries that depend on forest hydrological services might make payments that enable government administrators to underwrite PES contracts with upstream land managers. Such user financing could augment the above-mentioned advantages of national PES programs in several ways. First, environmental service users that voluntarily contribute to the system could help identify the most important service providers. Second, volunteers' contributions to the program could shed light on the value of these services. Third, volunteers would have both clear incentives to help monitor compliance with PES contracts and the means to enforce them: they could discontinue funding if payees do not meet their commitments (Pagiola and Platais, 2007). Improved efficiency aside, user financing would help extend and diversify financing in a national program. The potential benefits of expanding user financing in national PES program have not been lost on policymakers. For example, in order to realize these benefits, the World Bank is currently supporting the expansion of the user-financed components of national PES programs in Costa Rica and Mexico.

Nevertheless, it is not clear that voluntary user financing would actually confer those benefits. It is a type of voluntary environmental regulatory program—that is, a program that provides incentives but not mandates for agents to protect the environment. Considerable research suggests that that firms and farms participate in such programs for reasons that may have little to do with their stated goals, including winning favor with regulators, consumers, and local communities (de Leon and Rivera, 2009; Lyon and Maxwell, 2002). If environmental service users contribute to a national PES program for these reasons, then it is less clear that the efficiency benefits noted above will be achieved, although such contributions would certainly help diversify the program's funding base.

The best-known national government-financed PES system with a user-financed component is Costa Rica's Payments for Environmental Services (*Pagos por Servicios Ambientales*, PSA) program.[5] Initiated in 1997, this program pays land managers to conserve and restore forest cover. Most of the payment contracts are negotiated between land managers and the National Forest Finance Fund (*Fondo Nacional de Financiamento Forestal*, FONAFIFO), the government agency that administers the program. Funded by national fuel tax revenue and grants and loans from bilateral and multilateral donors, for the most part the program operates without direct input from users of environmental services. However, the program invites individual hydroelectric plants, breweries, irrigated farms, and other organizations that benefit from environmental services to pay FONAFIFO to negotiate contracts with the providers of these services. To date, more than 40 entities have voluntarily contributed some US$8 million to FONAFIFO under these provisions (Table 2). Although numerous studies have examined Costa Rica's PSA program, empirical analysis of the user-financed component is limited.[6] We believe further study is needed to understand the potential benefits of user financing in national PES programs. Toward this end, we address three questions about the user financing in Costa Rica's PSA program:

i. How many and what types of environmental service users are participating?
ii. What factors are driving participation?
iii. In the view of environmental service users, how has the program performed?

To answer the first question, we use data on PSA program finances provided by FONAFIFO. To answer the remaining questions, we rely principally on an original 2008 survey of Costa Rica's private hydroelectricity plants. We focus on these plants for several reasons. They constitute the plurality of participants in the user-financed component of the PSA program. In addition, some plants have participated in the program and others have not, variation that can help identify the drivers of participation. Moreover, the total number of plants is small enough that we have been able to conduct in-person interviews with virtually all of them. Finally, these plants are arguably less likely than government-owned hydroelectric plants to be influenced mainly by political pressures.

We find that direct user financing from all sources has funded less than 3% of the area enrolled in the PSA program. After publicly owned hydroelectric plants, private hydroelectric companies have been the largest contributor of user financing. We find that large private hydroelectric plants are much more likely to contribute than small ones. Their motives for participation in the PSA program are mixed. In addition to ensuring the provision of forest environmental services, motives for contributing to the PSA program include improving relations with local communities and government regulators—common drivers of participation in most voluntary environmental programs. Despite generally positive views about its performance, some hydroelectric plants favor direct investment in watershed protection over voluntary contributions to the program. Together, these findings raise questions about the potential of user financing to improve the efficiency and financial sustainability of national PES programs for hydrological services.

The remainder of the paper is organized as follows. Section 2 reviews the literature on national PES programs and on the drivers of participation in voluntary environmental programs in general. Section 3 provides background on Costa Rica's PSA program and private hydroelectricity sector. Sections 4, 5, and 6 address the three focus questions listed above. The last section summarizes our findings and considers their policy implications.

2. Literature

The first part of this section reviews the empirical literature on national government-financed PES programs, focusing on the two weaknesses discussed above–inefficiency and unsustainable financing–and on the two national PES programs in developing countries that have been evaluated extensively: Costa Rica's PSA program and Mexico's Payment for Environmental Hydrological Services (*Pago de Servicios Ambientales Hidrológicos*, PSAH) program. The second part of this section reviews the literature on the drivers of participation in voluntary environmental programs.

2.1. National Government-Financed PES Programs

There is an emerging consensus in the literature that in their early incarnations, both Costa Rica's PSA program and Mexico's PSAH program were not as effective as they could have been at targeting forested areas that both provide important environmental services and face a significant risk of deforestation (Robalino et al., 2008; Wünscher et al., 2008; Hartshorn et al., 2005; Sierra and Russman, 2006). As discussed below, the main component of Costa Rica's PSA

[5] South Africa's Working for Water program also has a small user-financed component (Turpie et al., 2008).

[6] Pagiola (2008) includes an overview of the user-financed component of the FONAFIFO program primarily using publicly available data, and Miranda et al. (2007) present qualitative case studies of the first seven agreements between users of environmental services and FONAFIFO. By contrast, we focus principally on agreements with hydroelectric plants and we use original quantitative and qualitative survey data.

program aims to provide hydrological benefits, biodiversity, and other environmental services by paying managers of forested lands to retain forest cover. Yet as of 2005, only 35% of the land participating in the PSA program was in a watershed with downstream users of hydrological services, and depending on the definition of biodiversity priority areas, 30–65% of PSA land was in biodiversity priority areas (Pagiola, 2008). Targeting of payments to land that provides important ecosystem services has improved over time (Pagiola, 2008; Barton et al., 2009). However, the challenge of targeting for additionality remains. Virtually all rigorous statistical analyses based on forest cover data derived from satellite images find that the PSA program has done little to slow deforestation, largely because land at high risk of deforestation has not been volunteered into the program. Rather, the lion's share of land enrolled in the program has been ill-suited for agriculture, pasture, and other cleared land uses and very probably would have remained forested absent the program (Pfaff et al., 2008; Robalino et al., 2008; Arriagada et al., 2008; Sills et al., forthcoming).[7] Wünscher et al. (2008), Hartshorn et al. (2005), and Sierra and Russman (2006) all find that the PSA program could benefit from improved targeting.[8]

Mexico's PSAH program shares many of PSA's design elements, including a focus on forest conservation and voluntary enrollment. However, as its name suggests, the program aims specifically at ensuring the provision of hydrological benefits. Also, its administrators have made an effort to target high-benefit areas. Evaluations of the early years of the program (to our knowledge, the only evaluations currently available) suggest that initial targeting efforts were disappointing. In 2006, 51% of land enrolled in the program was in watersheds classified as "not overexploited," and 68% was deemed to have low or very low deforestation risk (Muñoz-Piña et al., 2008; Alix-Garcia et al., 2005). Subsequent targeting efforts may have been more effective.

Concerns have also been raised about the sustainability of the financing for Costa Rica's PSA program and Mexico's PSAH program. As discussed below, Costa Rica's PSA program is financed by national fuel and water taxes as dictated by a 1997 Costa Rican law, and by grants and loans from bilateral and multilateral donors. However, these funds have not been nearly sufficient to enroll all the landowners who have applied to the program (Pagiola, 2008). For example, in 2006, one of FONAFIFO's principal regional offices had enough funds to enroll only one-sixth of the hectares for which it received applications (Wünscher et al., 2008). Whereas funding for Costa Rica's PSA program is theoretically guaranteed by 1997 legislation, funding for the PSAH program must be approved each year. According to Alix-Garcia et al. (2005, p.70), "This does probably not qualify as a sustainable financial arrangement since, though it has been written into law, it is decoupled from the intentions of the program and subject to the political process." In the end, the sustainability and sufficiency of government funding for these programs depend on political will. To date, that will has endured in both countries, but there is no guarantee that it will continue to do so.

2.2. Voluntary Environmental Programs

As noted in Section 1, the user-financed component of Costa Rica's PSA program is a type of voluntary environmental program. Empirical research on the drivers of participation in such programs suggests that pressures applied by regulators and communities drive participation, as does variation in transaction costs associated with joining these programs. The first type of pressure probably has attracted the most attention. Considerable research suggests that private parties participate in voluntary regulatory programs to preempt more stringent mandatory regulation or–particularly germane for our analysis–to obtain preferential treatment from regulators (Segerson and Miceli, 1998; Maxwell et al., 2000). For example, anecdotal evidence about Project XL, the U.S. Environmental Protection Agency's flagship voluntary program during the 1990's, suggests that firms obtained significant production cost advantages from participation because EPA provided preferential "regulatory relief" (Marcus et al., 2002). Similarly, studies have found that U.S. firms that engage in voluntary abatement obtain regulatory permits more quickly than those that have not (Cothran, 1993; Decker, 2003).

Pressures generated by communities and nongovernmental organizations may also create incentives for firms to join voluntary programs. Such pressures are the focus of the literature on so-called informal regulation, which mostly consists of cross-sectional, plant-level econometric analyses of environmental performance in developing countries (see Blackman, in press for a review). For example, in the early 1990's, pressures applied by industry and neighborhood organizations spurred participation in voluntary clean fuels initiatives targeting small brick kilns in Mexico (Blackman and Bannister, 1998).

Finally, differences across firms in transaction costs associated with joining voluntary regulatory programs due to, among other things, differences in human capital may help explain participation (Delmas and Marcus, 2004). For example, transaction costs associated with participating in Project XL averaged more than $450,000 per firm, varied considerably across firms, and deterred some firms from participating (Blackman and Mazurek, 2001).

3. Background

3.1. Costa Rica's PSA Program

Costa Rica's program is one of the oldest and most extensive PES programs and has been widely studied (Pagiola, 2008; Robalino et al., 2008; Rojas and Aylward, 2003; Rodríguez, 2005; Kosoy et al., 2007). Along with Costa Rica's system of protected areas, it is a testament to the country's unusually strong commitment to forest conservation.

Costa Rica's policies have not always been so forest friendly, however. For example, the Forestry Act of 1969 (No. 4475) authorized subsidies for converting forest to pasture. It was not until the 1980's, in the wake of growing domestic and international concern over reports that Costa Rica's forest cover had shrunk to just over a quarter of its land area, that the government reversed course and began providing subsidies to encourage reforestation (for commercial timber production) and the conservation of existing forests (Pagiola, 2008). The Forestry Act of 1996 (No. 7575) transformed this system of subsidies into national payments for an ecosystem services program and created FONAFIFO, a semiautonomous branch of the Ministry of Environment, Energy and Telecommunications (*Ministerio de Ambiente, Energía y Telecomunicaciones*, MINAET), to manage the new program.[9] A major motive for creating the PSA program was to recast reforestation and conservation subsidies as payments for environmental services—namely biodiversity, carbon sequestration, scenic beauty, and hydrological benefits (Pagiola, 2008). The Forestry Act of 1996 also prohibited conversion of forest to any other type of land use, a provision that has

[7] A second reason the program has had little impact on deforestation is that there has been little deforestation. As Pagiola (2008) notes, it is difficult to disentangle the effect of the program from other factors that have contributed to reduced deforestation, including strict command-and-control regulations and declining returns to pasture.

[8] An exception is Tattenbach et al. (2007).

[9] When the PSA program first started, land managers' participation was solicited by the National System of Protected Areas (*Sistema Nacional de Areas de Conservacion*, SINAC) and by nongovernmental organizations, most notably the Foundation for the Development of the Central Range (*Fundación para el Desarrollo de la Cordillera Central*, FUNDECOR). In 2003, FONAFIFO took over this function (Pagiola, 2008). In this paper we do not differentiate between FUNDECOR projects and those of FONAFIFO.

significantly slowed deforestation and also has made disentangling the independent effect of the PSA program problematic.

Although the PSA initiative is not the only one involving payments for ecosystem services in Costa Rica, it is by far the largest.[10] It has comprised a number of modalities targeting different types of activities and land uses. In each, a landowner receives annual payments to carry out specified practices, such as preserving existing forest cover or planting new trees. As of June 2009, FONAFIFO had made payments through these programs on a cumulative total of nearly 430,000 ha (Table 1). By far the most important of the modalities is Forest Protection, which accounts for 85% of all land that has received FONAFIFO payments. Two other modalities–Reforestation and Forest Management–have accounted for 9% and 3% of all hectares receiving payments, respectively, and the rest have collectively accounted for 2%.[11]

The Forest Protection modality requires landowners to preserve primary or secondary forest cover on their land for five years, a commitment that can be renewed. FONAFIFO makes a partial payment to the landowner when she signs a program contract. Subsequent payments are made only after a third party verifies that tree cover has not been cleared.[12] With a few minor exceptions, payments are the same everywhere in the country. They have increased over time partly to account for inflation. Annual per hectare payments were US$40 in 1997, when the PSA program was created, rose to US$43 in 2005, and to US$64 in 2006 (Pagiola, 2008).

FONAFIFO's funding for payments to land managers has been derived from four sources (Table 1). Tax revenue–from a national tax on gasoline (3.5% of the total gasoline tax), supplemented since 2006 by revenue from a national tariff on water-use (25% of the total tariff)–is the main continuing source of funds for the program. Other sources of funds have played an important role as well. As Table 1 indicates, loans (to be repaid with tax revenues) and grants from the International Bank for Reconstruction and Development and grants from the Global Environment Facility have financed payments for 45% of all hectares enrolled in FONAFIFO programs.[13] The German International Development Bank (*Kreditanstalt für Wiederaufbau*) has financed another 10%. FONAFIFO's ordinary budget, derived from taxes and tariffs, has paid for 41% of all participating hectares. Finally, a variety of users have financed FONAFIFO payments to 3% of total hectares. The present paper focuses on this last portion: user-financed funding.[14,15]

Table 1
Cumulative enrollment in PSA program: percentage of all (429,361) hectares enrolled from 1997 to June 2009, by modality and funding source.
Source: FONAFIFO (2009).

	Funding source				
Modality	IBRD[a], GEF[b]	KfW[c]	Ordinary budget	User financed[d]	All
Forest protection	38	7	37	3	85
Reforestation	4	2	3	0	9
Forest management	2	1	0	0	3
Others	1	0	1	0	2
All modalities	45	10	41	3	100

[a] International Bank for Reconstruction and Development.
[b] Global Environment Facility.
[c] German International Development Bank (*Kreditanstalt für Wiederaufbau*).
[d] See Table 2 and discussion in text.

FONAFIFO has offered users of hydrological environmental services two types of contractual arrangements for making voluntary contributions to fund payments for environmental services. Early contributions were made through ad hoc agreements in which both the number of hectares receiving payments and the amount paid per hectare were negotiated by FONAFIFO and the volunteer contributor. Starting in 2003, FONAFIFO introduced a standard payment, a certificate of environmental service (*Certificado de Servicio Ambientale*, CSA) to facilitate relatively small contributions. A CSA covers the full cost of a payment for a single year for a single hectare. A CSA cost $43 in 2005 and $64 in 2007.

In addition to these two voluntary options for contributing to the PSA program, a recent law created a mandatory user contribution. The 2006 water law (*Canon de Agua*) significantly raised water-use tariffs (starting from a very low level) and required that a quarter of the revenue from these tariffs be transferred to FONAFIFO to help finance PSA contracts. Under this law, individual water users can deduct from their tariff obligations any monies paid directly to FONAFIFO's PSA program. This provision creates incentives for water users to make direct contributions to the program and purports to give them more input into how and where FONAFIFO uses their funds from the tariff.

3.2. Costa Rica's Private Hydroelectric Sector

Although Costa Rican private hydroelectric plants have clear profit motives, their history suggests that regulation and politics also have considerable influence on their decision making. The U.S.-based Electric Bond and Share Company was the first major producer in the country, operating as a monopoly (Quesada Mateo et al., 2002). It was nationalized in 1928 and eventually evolved into the National Power and Light Company (*Compañia Nacional de Fuerza y Luz*, CNFL) and the Costa Rican Electric Institute (*Instituto Costarricense de Electricidad*, ICE), the two government-owned electric companies that produce and distribute the vast majority of Costa Rica's electricity.

Private energy producers, including regional energy cooperatives, have always operated alongside the public sector. Nonetheless, their legal status was ambiguous until a 1990 law formalized their right to generate power and required them to sell all their output to ICE. This law spurred the construction of numerous small private plants during the 1990's. In recent years, electricity has been produced by 35 private plants, including wind, geothermal, and biomass plants (see Appendix). Twenty-four private hydroelectric plants owned by 18 firms were operating in 2007. All are relatively small run-of-the-river plants ranging in size from 0.6 MW to 17.3 MW (Table A1). Of the plants for which we have data, all have a reservoir volume equivalent to eight hours or less of water supply.

Politically, private electricity generation in Costa Rica is highly contentious. The 1990 law that authorized private generation encountered stiff opposition for at least four reasons. First, even small run-of-

[10] The PES agreement between the La Esperanza hydroelectric plant and the Monteverde Conservation League does not involve FONAFIFO (Rojas and Aylward 2002).
[11] The remaining 2% includes the agroforestry program, which pays landowners based on number of trees planted rather than the number of hectares enrolled.
[12] Monitoring of compliance by landowners participating in the FONAFIFO program is the responsibility of MINAET and SINAC. Pagiola (2008) considers this monitoring system "strong" and calls the database used to track compliance "state-of-the-art." Monitoring records for at least some of the program's contracts can be accessed online (http://www.catie.ac.cr/BancoConocimiento/E/econofor_-_verificacion_csa/econofor_-_verificacion_csa.asp).
[13] A $32.6 million loan from the International Bank for Reconstruction and Development is to be repaid by FONAFIFO with fuel tax revenues over a 12-year period starting in 2006.
[14] Although we do not count them as user financing, GEF grants used to support payments for environmental service could be considered as such, since the PSA program aims to preserve biodiversity, a global public good, and GEF purports to be biodiversity service users' agent.
[15] User financing was not an original feature of the PSA program. However, soon after the program was created in 1996, FONAFIFO began to search for additional sources of funding. This effort quickly led to the hydroelectric sector, one of the most easily identified users of environmental services (Rodríguez, 2005). With the assistance of FUNDECOR, the Costa Rican nongovernmental organization, FONAFIFO's first contacted Energía Global, then owner of the Volcan and Don Pedro hydroelectric plants (Chomitz et al., 1999). Discussions with FONAFIFO staff, along with information on the organization's website, suggest that soliciting user financing remains an important activity.

Table 2
User-financed contributions to FONAFIFO, 2003–2009.
Source: Authors' analysis of data from Garcia (2009).

Type of user	Amount (000 US$)	Percentage of total from all donors	Percentage of total from purely private sources[a]	Percentage of funds targeting hydrological services
Hydroelectric , government-owned*	5,825	71.4	–	99.9
Hydroelectric, private	919	11.3	41.2	100.0
Brewery	273	3.3	12.2	100.0
Carbon	216	2.6	9.7	0.0
Agriculture related	201	2.5	9.0	99.5
Tourism	189	2.3	8.5	59.6
Agricultural cooperative	154	1.9	6.9	73.2
Airline	122	1.5	5.5	23.3
Carbon, NGO*[b]	100	1.2	–	0.0
Association, individual	67	0.8	3.0	2.5
Construction	57	0.7	2.6	100.0
Hydroelectric, cooperative	22	0.3	1.0	100.0
Public utility*	9	0.1	–	100.0
Plastics	9	0.1	0.4	100.0
Consulting, advertising	1	0.0	0.0	0.0
Total	8,164	100.0	–	92.6
Total from purely private sources	2,230	27.3	100.0	77.8

[a] Excludes funds from three categories of users (indicated with asterisk): government-owned hydroelectric firms, a government-owned utility, and a carbon NGO.
[b] Pax Natura, a Utah-based NGO that sells personal carbon credits. Because of its close ties to the Costa Rican government, we do not categorize it as purely private.

the-river hydroelectric plants have significant adverse environmental impacts, including reducing in-stream flows in a portion of the river, disturbing forest cover in construction sites, and damaging aquatic life, all of which can create tension with local communities. As a result, national environmental NGOs initially opposed private hydroelectricity (Miranda et al., 2007). Second, leading politicians invested heavily in new private generating plants, raising concerns about undue political influence on the granting of water concessions, environmental licensing, and regulation (Romero-Pérez, 2004). Third, investors proposed building plants in indigenous reserves (Marchamalo and Romero, 2007). Finally, a continuing concern has also been that allowing private investment in the power sector would have adverse economic consequences for ICE and CNFL (Estaban, 2009).

Opposition to private hydroelectricity has stifled new investment and created considerable regulatory and economic uncertainty for existing plants. In 1996, shortly after most existing private hydroelectric plants were established, a new law reorganized regulatory authority for electricity but created a legal vacuum by neglecting to assign authority for reauthorizing existing water concessions (which have a 15-year term) and granting new ones. Despite lobbying by the private hydroelectric sector, opponents of private hydroelectricity helped stall legislation needed to fill this vacuum until 2009, just before many concessions expired. MINAET, the same agency that houses FONAFIFO, now has responsibility for water concessions. Hence, between 1996 and 2009, existing private plants operated under the threat that their water concessions would not be renewed (Oviedo, 2005; Agüero, 2006; Estaban, 2009).

All electricity generated in Costa Rica must be sold to a government-owned monopsonistic buyer (ICE), and electricity prices are fixed by the Public Services Regulatory Authority (*Autoridad Reguladora de los Servicios Públicos*, ARESEP). For most plants, ARESEP uses complicated pricing formulas tied to the long-term marginal costs of production to ICE (ARESEP, 2002, 2007). However, prices can vary significantly from one plant to the next.[16] Although certified "green" electric power has made significant inroads in industrialized countries (Menz, 2005; Kotchen and Moore, 2007), to our knowledge, it has yet to be introduced in Costa Rica.

Conventional wisdom, including within the hydroelectric sector, holds that forest conservation benefits hydroelectric plants by regulating in-stream flows, reducing sedimentation, and in some cases, increasing dry-season flows. As one interviewee remarked, "The watershed is doing the work for you—it's part of the machine." For this reason, the hydroelectric sector was targeted early for participation in the PSA program. It is worth noting, however, that contrary to conventional wisdom, the effect of forest cover on hydrology is complex and dependent on specific local conditions. The scientific foundation for some general relationships between forest cover and hydrology, including negative correlations between forest cover on one hand and sedimentation and peak flows on the other, are reasonably well established. However, evidence for other general relationships, including that between forest cover and total annual flows, is much weaker (Stadtmüller, 1994; Kaimowitz, 2004).[17] Small run-of-the-river plants, like the private plants in Costa Rica, are principally concerned with regulating in-stream flow and reducing sedimentation, and less with total annual flows.

4. How Many and What Types of Environmental Service Users are Participating?

This section focuses on the number and type of environmental service users that have voluntarily contributed to the user-financed component of the PSA program. We first examine contributions from all sources, and then focus on contributions from private hydroelectric plants.

4.1. All Sources

According to FONAFIFO, as of 2009, US$8.2 million in payments for environmental services has come from user financing (Table 2). These

[16] Three types of contracts predominated in 2008. "Variable" contracts are fixed in dollars at a "theoretical" rate of $0.06/kWh, but vary in colones. The theoretical rate is that which a plant would be paid on average if it generated at full capacity for the entire year (Barrantes-Chaves, 2008). "Fixed" contracts are paid based on an ARESEP formula that periodically adjusts to estimate the long-term marginal costs of production to ICE. Finally, two private plants (El General and La Joya) operate under "build–operate-and-transfer" contracts at prices that were bid for a fixed term, after which ownership of the plant is transferred to the government.

[17] Indeed, Rojas and Aylward (2003, 79) argue that popular thinking about the relationship between forest cover and hydrology is suffused with "a series of assumptions, invalid methodologies and erroneous results and conclusions being cited over and over again, all of which seemingly builds a basis on which further [PES] market development is based." Aylward et al. (1999) suggest that forest cover may be less beneficial to a hydroelectric plant than other land uses.

Table 3
FONAFIFO payments for environmental services contracts signed by private hydroelectric plants, by type 1997–2009.
Sources: Rojas and Aylward (2003); Garcia (2009); Pagiola (2008).

Firm, plant	Year(s)	Hectares protected[a]	Contribution per year per hectare (US$)	Contribution per year (US$)
Negotiated agreements with FONAFIFO				
Energía Global/Enel,[b] Don Pedro	1997, 2003, 2009	1000	10, 12, 16	12,000–16,000
Energía Global/Enel,[b] Volcán	1997, 2003, 2009	1000	10, 12, 16	12,000–16,000
Matamoros, Platanar	2000, 2003	750	15, 30[c]	22,500
Holcim, Aguas Zarcas	2005	1666	30	52,500
FONAFIFO CSAs				
Tuis, Tuis	2005	75	57	4286
Direct payment of water tariff to FONAFIFO				
Enel,[a] Don Pedro	2007	10	64	620
Enel,[a] Rio Volcán	2007	11	64	716
Matamoros, Platanar	2007	24	64	1528

[a] Figures are from FONAFIFO contract; actual hectares enrolled may differ.
[b] In 2001, Enel GreenPower, an Italian energy firm, purchased Energía Global, a Costa Rican firm (Business Wire, 2001).
[c] At the end of 2004, Platanar was paying US$15/ha for 284 ha with land title (285 ha at the end of 2004) and US$30/ha for 385 ha without title.

monies have funded 3% of the hectares enrolled in the program (Table 1). However, of all the funding that FONAFIFO categorizes as user financing, 73% has come from sources that are not purely private in nature. Government-owned electric companies (CNFL and ICE) have provided 71%, and a nongovernmental organization with close ties to the government, together with a public utility, provided another 2%.[18] Excluding these sources, 41 private firms, organizations, and individuals have contributed a total $2.2 million, which amounts to 27% of total user financing.

As noted above, the PSA program aims to ensure the provision of four forest environmental services: biodiversity, carbon sequestration, scenic beauty, and hydrological benefits. FONAFIFO keeps track of which of these services are targeted by environmental service users that contribute to the PSA program. These data are reported in the last column of Table 2. Overall, 93% of all funds, and 78% of funds from purely private sources, targeted hydrological services. These services were the sole stated concern of the hydroelectric plants, the brewery, the construction firms, and the plastics firms. Carbon sequestration was the only other environmental service targeted by more than 1% of the program's funds.

4.2. Private Hydroelectric Sector

As of June 2009, private hydroelectric plants had contributed US $919,000 to FONAFIFO (Table 2). These funds represent 41% of all financing from purely private resource users, the largest share from any economic sector. They were contributed by five plants owned by four firms (Table 3).[19] Twenty-four private hydroelectric plants were active in 2007 (Table A1). Hence, slightly less than one-quarter of the private hydroelectric plants active in 2007 had signed contracts with FONAFIFO. The five private hydroelectric plants that made payments to FONAFIFO all participated in the agency's Forest Protection program. However, the contractual basis of the contributions differed (Table 3). Four plants contributed via a negotiated payment. In most cases, they negotiated a per hectare contribution that was less than FONAFIFO's actual payment (on the grounds that they were paying only for hydrological benefits, one of the four environmental services provided by forests). In each case, FONAFIFO contributed the difference between the negotiated contribution and the actual payment. One plant purchased CSAs. Finally, three plants have paid 25% of their mandatory water tariff directly to FONAFIFO (instead of to tax authorities) under provisions of the 2006 water law, in addition to making voluntary payments through the PSA program.

Private hydroelectric firms' contributions to FONAFIFO were a relatively small percentage of their revenues. In each case, annual contributions constituted less than 1% of annual revenues (Table 4). For the two firms that were first to participate (Energía Global and Matamoros), contributions were roughly equivalent to the average revenue from a single day of operation. Firms that contributed later gave substantially larger amounts, both in absolute terms and as a percentage of their annual revenue. This may suggest that FONAFIFO's ability to negotiate improved over time.

5. What Factors Drive Participation in the Private Hydroelectric Sector?

To identify the drivers of private hydroelectric plants' participation in the PES program, we undertook two types of analyses. First, we asked plant owners and managers about the importance of various benefits of participation. Second, we compared average characteristics of program participants and nonparticipants to identify characteristics correlated with participation. Below, we discuss the data used for each analysis and then present results from each. We find that in addition to the provision of forest environmental services, an important motive for participation was the desire to improve relations with regulators and local communities. Participants tended to be large and/or to have characteristics associated with large plants, and they tended to be located in lightly deforested watersheds with a relatively low proportion of land in protected areas.

5.1. Data

Between February and June 2008, we conducted in-person interviews with owners or managers of 17 of the 18 companies that owned the 24 active private hydroelectric plants in Costa Rica.[20] When one

[18] FONAFIFO also classifies as user financing $441,000 from Global Environment Facility (GEF) channeled through *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), a multilateral agricultural research and education institution. However, as a reviewer points out, given their source, these funds are distinct from the others listed in Table 2. Therefore, we exclude them from the table.

[19] In addition, in 1998 one private hydroelectric plant, La Esperanza, signed a contract for payments (on 3000 ha) directly with a local environmental NGO, the Monteverde Conservation League, to settle a land dispute. See Rojas and Aylward (2003). We do not count this plant as a PSA participant because its contract did not involve FONAFIFO.

[20] See list of interviewees in the Appendix. In all but two cases, we interviewed the manager of the plant, and in five cases, the manager was also one of the plant's owners. We could not obtain an in-person interview with the manager of one firm and therefore conducted a telephone interview with a former manager who had been involved in the PES program; this interview did not cover all the questions asked of the other firms. Anonymity was guaranteed to all respondents.

Table 4
Annual PSA payments as percentage of annual revenues.
Sources: Own calculation from data in Rojas and Aylward (2002), ARESEP (2008), and Garcia (2009).

Firm, plant(s)	Year of first agreement	Annual PSA contributions as percentage of average annual revenues[a]
Energía Global, Don Pedro, and Volcán	1997	0.24
Matamoros, Platanar	1999	0.29
Holcim, Aguas Zarcas	2005	0.94
Tuis, Tuis	2007	0.78
Average		0.56

[a] PSA expenditure data from Table 3 are converted to 2000 US$. Revenue data calculated using ARESEP (2008), are converted to 2000 US$, and averaged for all years from 1996 to 2007 for which plants operated a full year.

firm owned two or more plants in the same watershed, we treated them as a single production unit.[21] The interviews were semistructured and included both closed-ended and open-ended questions about respondents' perceptions, plant and watershed characteristics, and contacts with FONAFIFO. Because the respondents were not able or willing to answer all of our closed-ended questions, the number of responses varies by question. The interview data are supplemented by official statistics on plants' contributions to FONAFIFO, pricing, and revenues.[22]

We exclude two nonparticipant plants–the large La Joya and El General plants–from the analysis because unusual institutional circumstances may have driven their decisions to participate or not participate. Both were developed and are operating under build–operate-and-transfer (BOT) contracts in which, after a defined period, plant ownership will be transferred to ICE. These contracts create incentives that differ from those for the remaining 22 private hydroelectric plants. These 22 plants are all relatively small run-of-the-river plants. All have either no reservoir at all or very small reservoirs that are filled during off-peak hours and then used to generate electricity during the peak hours (when the electricity rates are higher).

5.2. Perceived Benefits of Participation

To shed light on the private hydroelectric plants' motives for participation in the PSA program, we asked our interviewees about the importance of the following seven potential benefits, which we identified in open-ended preliminary interviews:

- forest protection and provision of environmental services;
- improved relations with local communities;
- improved political prospects at the national level;
- improved relations with other businesses;
- improved relations with government regulators;
- improved relations with ICE; and
- a catchall "other" category.

The interviewees were given a printed list of these possible benefits and then asked to assess the importance of each benefit in two ways. First, we asked them to indicate the likelihood that PSA participation provides each benefit using a five-point Likert scale (with 1 representing "definitely no" and 5 representing "definitely yes"). Second, we asked interviewees to rank the first, second, and third most important benefit for their plant. The Likert exercise was partly meant to oblige respondents to briefly reflect on each potential benefit before ranking them. Table 5 presents results for all of our interviewees, and for subpopulations of participants and nonparticipants.

Regarding the Likert rankings, our results suggest that virtually all of our interviewees believed PSA participation would provide each benefit (which is perhaps unsurprising, since the list of benefits was compiled from responses to a pilot survey's open-ended questions about PSA benefits). For the population of all interviewees, the average Likert ranking ranged from 3.3 to 4.1. Average rankings were higher for participants than for nonparticipants, however, suggesting that participants were more convinced of these benefits.

Regarding the relative ranking of the benefits, 80% of all interviewees chose "forest protection and provision environmental services" as the most important benefit of the program. The percentage was higher among participants (100%) than nonparticipants (75%). At least four-fifths of all interviewees and of subpopulations of participants and nonparticipants chose "improved relations with local communities" as the second most important reason for participation. Finally, at least half of all respondents and of subpopulations of participants and nonparticipants chose "improved relations with government regulators" as the third most important benefit.

On their face, these relative ranking results suggest that hydroelectric plants participate in the PSA program mainly to obtain environmental services related to forest protection. However, these results must be interpreted with caution. Several strands of policy and economics literature support the idea that firms' stated reasons for environmentally friendly actions often differ from their underlying reasons and that in interviews, firm managers may not be forthcoming about the latter. A growing literature examines corporate greenwashing—firms' participation in environmental activities for reasons other than concern about environment (Laufer, 2003; Lyon and Maxwell, 2006; Greer and Bruno, 1996). In addition, economic research has demonstrated that survey respondents derive a "warm glow" from exhibiting environmentally friendly attitudes, a factor that biases their responses (Kahneman and Knetsch, 1992; Nunes and Schokkaert, 2003). Finally, both psychologists and economists have documented "cognitive dissonance," the tendency of people to seek consistency among their beliefs, including by mirroring what they perceive to be opinions that are socially acceptable and those that they believe their interviewers expect (Akerlof and Dickens, 1982; Rabin, 1994).

Given these confounding issues, we are not able to determine with certainty whether hydroelectric plants participated in the PSA program mainly to secure environmental services, as our rankings results suggest, or mainly for other reasons. However, our interviewees' answers to other open-ended questions reinforce the hypothesis that–as Miranda et al. (2007) conclude–improving relations with communities and regulators were significant motives for participation. Responses to open-ended questions about the benefits of PSA participation often focused on tensions with local communities resulting from hydroelectric plants' adverse environmental impacts, particularly reduced in-stream flows. For example, the manager of one participating plant commented that PSA contributions, in essence a transfer of funds from the plant to local land managers, help "improve the image of the common people about private energy plants in our area."[23]

Responses to open-ended questions about the reasons for PSA participation also highlighted the national political and regulatory climate for private hydroelectricity. As discussed in Section 3.2, private hydroelectricity in Costa Rica is highly contentious politically because of concerns about undue political influence on contracting and licensing, environmental degradation, and ICE's financial sustainability. Partly as a result, a de facto moratorium on water concessions

[21] Three firms owned more than one plant in a single watershed: Energía Global/Enel (Don Pedro and Volcan plants), O&M Eléctrica Matamoros S.A. (Matamoros and Plantar plants), and Edificadora Beta (Caño Grande and HidroVenecia plants).

[22] Because prices are set by ARESEP and all output is sold to ICE, revenue data are publicly available.

[23] All translations are done by the authors.

Table 5
Rankings of importance of different benefits provided by PSA program as perceived by participants (Parts.) and nonparticipants (Non.).
Source: Authors' survey.

	Program provide this benefit? 1 = definitely no 5 = definitely yes			Percentage who said this was 1st most important			Percentage who said this was 2nd most important			Percentage who said this was 3rd most important		
Benefit	All	Parts.	Non.	All	Parts.	Non.	All	Parts.	Non.	All	Parts.	Non.
Forest protection and provision of environmental services	4.1	5.0	3.8	80	100	75	0	0	0	14	0	20
Improved relations with local communities	4.1	4.3	4.0	7	0	8	80	67	83	0	0	0
Improved political prospects at national level	3.3	4.0	3.1	7	0	8	13	33	8	14	25	10
Improved relations with other businesses	3.5	3.7	3.5	0	0	0	0	0	0	7	0	10
Improved relations with government regulators	4.0	5.0	3.8	0	0	0	7	0	8	57	50	60
Improved relations with ICE	3.6	5.0	3.2	0	0	0	0	0	0	7	25	0
Other				7	0	8	0	0	0	0	0	0
Total*				100	100	100	100	100	100	100	100	100
Number of observations	15	3	12	15	3	12	15	3	12	14	4**	10

* Some columns do not sum to 100 due to rounding.
** One respondent ranked two benefits as the third most important.

for private hydroelectricity prevailed between 1996 and 2009, during which time plants operated under the threat that their water concessions would not be renewed. Plant managers' interview comments suggested that some viewed PSA participation a means of softening political opposition and improving prospects for reauthorization of water concessions. For example, the manager of one participating plant said, "For the image of the company, the fact that we are in the PSA program will facilitate opportunities in the future."[24]

5.3. Participants versus Nonparticipants

Multivariate regression analysis would be the ideal method of identifying the characteristics of hydroelectric plants that are correlated with participation. However, with a maximum of 18 observations, more than 15 explanatory variables, and some missing observations, we simply do not have enough data for econometric analysis. Therefore, we use the second-best approach: we compare average characteristics of participants and nonparticipants. Differences between these averages indicate direct or indirect correlation between a characteristic and participation, although it is not possible to determine whether there is a causal relationship. As discussed below, a drawback of this method is that we are not able to control for correlations between the plant characteristics.[25]

We examine a wide variety of characteristics listed in Table 6, including the plant's (i) technical, financial, and contractual features (power output, annual revenue, and ownership); (ii) relationship with FONAFIFO (simple knowledge of the institution and prior contacts); and (iii) watershed (forest cover and legal protection).

5.3.1. Size, Revenue, Ownership, and Relationship with FONAFIFO

Our data show that average participant plants tend to be larger than average nonparticipants and to have characteristics associated with large plants, including relatively high revenues, corporate ownership, and direct contact with FONAFIFO (Table 6). Differences in all of these average characteristics are statistically significant. The generating capacity of the average participant is 16.2 MW, while that of the average nonparticipant is 4.2 MW, almost a fourfold difference. Annual revenue for average participants is $6.1 million per year, while that for average nonparticipants is $1.9 million, a threefold difference. Three of the five plants with highest annual revenue are participants (Fig. 1). It is also noteworthy that two of the four participating plants are owned by international corporations (and another is owned by a Costa Rican family that owns or operates five hydroelectric plants in Costa Rica and has developed plants internationally). By contrast, none of the nonparticipants are owned by international companies. Finally, 100% of participants surveyed reported having been asked by FONAFIFO to join the PSA program, while only 45% of nonparticipants said they had been contacted. The plants not contacted tend to be among the smallest plants in the sector. Of the 17 plants for which we have data, 10 of the 11 plants larger than 1 MW were contacted by FONAFIFO, and 5 of the 6 smaller plants were not.[26]

Unfortunately, it is not possible to determine whether plant size, revenues, ownership, or contact with FONAFIFO are actually driving participation because these characteristics are highly correlated with each other: large plants generate more revenue, are more likely to be owned by corporations, and are more likely to have been contacted by FONAFIFO. That being said, each characteristic could, in theory, have an independent effect on participation. Plants contacted by FONAFIFO may be more likely to participate because such contacts reduce transaction and informational costs. In addition to the fact that larger plants were more likely to be contacted, these plants also tend to have dedicated environmental staff and might be more likely to participate because they are able to afford costs of participation, including transaction costs and payments to FONAFIFO. Revenues aside, large plants may also be more likely to participate because they have more serious environmental impacts and, therefore, perceive greater benefits from participation or are under greater pressure from regulators, local communities, and national environmental activists. It is also plausible that larger plants and those owned by corporations may derive greater benefits from participation if they are particularly concerned about their national and international reputations.

5.3.2. Watershed

Our survey responses indicate that participating plants tend to be located in heavily forested, lightly protected watersheds, whereas nonparticipants tend to be located either in heavily forested, heavily

[24] Note that the link between PSA participation and improving relations with regulators is weakened somewhat by the fact that participation has a strong public goods aspect: one plant's participation presumably has spillover benefits for all plants. We are grateful to a reviewer for this point.

[25] For example, say we find a positive correlation between plant size and participation and a second positive correlation between public ownership of the plant and participation. Further, say we know that these two explanatory variables are correlated; that is, large firms tend to be publicly owned. We are not able to determine whether there is a causal relationship between public ownership and participation, or just a correlation between public ownership and firm size.

[26] Several plants with little knowledge of the program indicated that they might be willing to participate in the program. It would seem, therefore, that there may be potential for the program to generate greater participation through more aggressive marketing. However, since the remaining plants are quite small, the cost to FONAFIFO of initiating those contacts may be great relative to the benefits that might be obtained.

Table 6
Average characteristics and perceptions of private hydroelectric firms and plants by subpopulation (n).
Sources: Authors' survey; ARESEP (2008).

Characteristic/perception	Units	All	Participants	Nonparticipants	Difference in means test p-value[a]
Firm, plant[b]					
Power output [plant]	MW/year	6.9 (18)	16.2 (4)	4.2 (14)	0.069
Annual revenue [firm]	Year 2000 US$	2957.0 (16)	6057.4 (4)	1923.6 (12)	0.074
Owned by foreign holding [firm]	Yes/no	13% (16)	50% (4)	0% (12)	0.091
FONAFIFO					
Contacted by FONAFIFO re: PSA participation? [firm]	Yes/no	57% (14)	100% (3)	45% (11)	0.003
Watershed					
Portion forested [plant]	%	58% (17)	76% (3)	54% (14)	0.136
Portion legally protected [plant]	%	40% (17)	33% (3)	41% (14)	0.391
PSA program performance					
How well is PSA program administered? [firm]	1 = bad➔5 = good	3.64 (12)	3.67 (3)	3.63 (8)	0.479
Likely to reenroll in PSA program? [firm]	1 = no➔5 = yes	n/a	4.33 (3)	n/a	n/a

[a] Test for difference in means between the participant and nonparticipant plants using one-tailed t-tests with heteroscedastic variances.
[b] Firms with multiple plants are treated as a single unit. Analysis excludes the two BOT plants and La Esperanza.

protected watersheds or in heavily deforested, lightly protected watersheds (Table 6, Figs. 2 and 3). Of the 3 participating plants for which we have data on forest cover and protection, all are located in watersheds with substantial forest cover, and 2 are in watersheds that are lightly protected (Fig. 2). The watershed of a third participant is mostly inside a national park, but the plant has worked with FONAFIFO to ensure that the hectares that receive payments are outside the park.[27] As for the nonparticipants, the distribution of forest cover and protection is bimodal (Fig. 2). Among the 12 nonparticipants for which we have data on watershed forest cover and protection, 58% were sited in watersheds that either were almost completely forested and completed protected by law, or were almost completely deforested with little or no protection.

What might explain the observed relationship between PSA participation and watershed characteristics summarized in Fig. 3? For the sake of argument, in answering this question we leave aside the evidence cited above—that plants' participation decisions are driven by local and national politics instead of concerns about hydrological services. Also, it is important to note that PSA participation is very unlikely to have caused low rates of deforestation. Only 1 of the 18 firms we surveyed, including both PSA participants and nonparticipants, reported more than 1% change in forest cover in the watershed since 1998. This finding comports with data derived from satellite images indicating that net deforestation nationwide has been minimal since the passage of new forestry laws in 1996 (Sánchez-Azofeifa et al., 2007; Pfaff et al., 2008).

Having said that, the relationship between participation and watershed characteristics can be explained by expected benefits and costs of participation, where expected benefits are a function of both the level of forest cover and the risk that it will be lost absent PSA contracts. For plants in quadrant B of Fig. 3 (high forest cover, low legal protection), expected benefits of PSA participation are relatively high because plentiful forest cover is providing important hydrological services that could theoretically be lost because the forest is not legally protected. As Pagiola (2008, 719) notes, in heavily forested watersheds, a strong precautionary principle argument can be made for PSA contracts to avoid changes that might threaten the provision of ecosystem services. For plants in quadrant A (high forest cover, high legal protection), expected benefits are low because even though forest cover is plentiful, there is little risk of deforestation. In addition, FONAFIFO does not negotiate PSA contracts with landowners in protected areas (unless they have not been compensated by the state for their land). For plants in quadrant C, expected benefits are low because forest cover is limited, and expected costs are high because reforestation is expensive relative to forest protection. Indeed, in open-ended responses, representatives of plants in quadrants A and C stated that with a watershed either completely deforested or completely protected, there was very little that FONAFIFO could do. Finally, presumably little land in hydroelectric plants' watersheds falls into the last quadrant (low forest cover, high legal protection).

6. In the View of Environmental Service Users, How Has the Program Performed?

The survey included two questions about the performance of the PSA program (Table 6). We asked respondents to use a Likert scale to indicate how well the PSA program is administered (with 1 signifying "very poorly" and 5 signifying the opposite). The average respondent ranked program administration between "ok" and "good" (3.64). Average rankings of participants and nonparticipants (3.67 versus 3.63) were not very different. We also asked participants to use a Likert scale to indicate how likely they were to participate in the PSA program once their current five-year commitment expired (with 1 signifying "definitely no" and 5 signifying the opposite). The three participants who responded all answered "probably yes" or "definitely yes," and the fourth plant, which we were unable to interview, renewed its participation for the second time in 2009. In sum, most participants and nonparticipants believe that the administration of the PSA program is at least adequate, and participants believe that the benefits of contributing to the user-financed component of the program exceed the costs.

That being said, positive views of the program were not unanimous. In response to an open-ended question, one nonparticipant said his plant has not participated because "We don't like to give money away that will be wasted," and another said, "I don't trust MINAE; that's why I'm paying park guards directly."

Survey data on plants' private investments in forest conservation provide additional nuance. Seventy-three percent of the plants surveyed reported having made such investments. All three PSA participants who responded to our questions on the matter said they invest in conservation activities independent of the PSA program by,

[27] FONAFIFO allows landowners inside protected areas to participate in the PSA program only if they have not yet been compensated for their land. Such landowners, however, have highest priority for FONAFIFO funding (Sánchez Chávez, 2008).

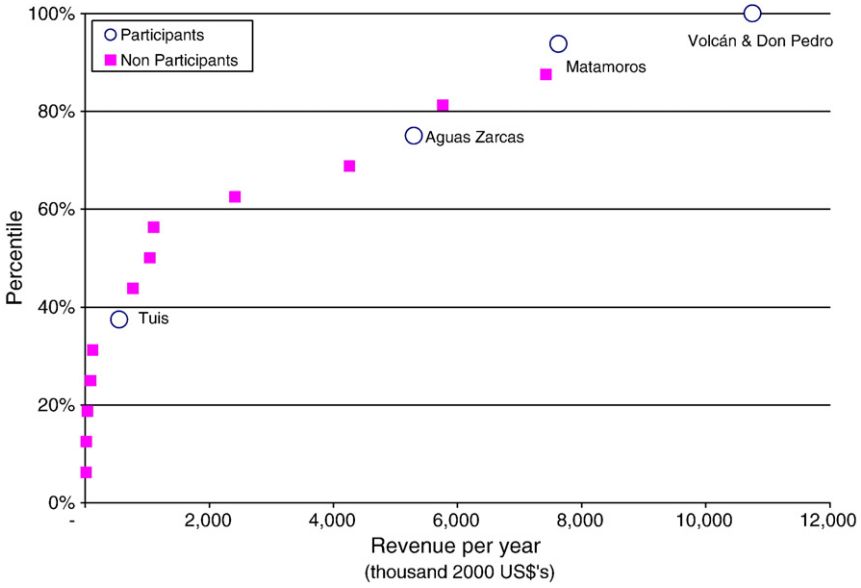

Fig. 1. Cumulative distribution of revenue per year for private hydroelectric plants, 1997–2007, in 2000 US$ per year. The first year of operation of a plant is excluded so that only full years are counted. Multiple plants owned by a single owner are treated as a single unit.
Sources: authors' survey; ARESEP (Autoridad Reguladora de los Servicios Públicos, Dirección de Energía y Concesión de Obra Pública) (2008).

for example, conducting conservation education in local communities and planting trees in their watersheds. Such activities were also quite common among nonparticipants. Eight of the 13 managers of nonparticipating plants who responded to this question said they invested in forest protection outside the PSA program, including by paying the legal expenses of park managers fighting land claims, funding the demarcation of park boundaries, paying for park guards, and helping to finance paving an access road to a nearby national park in hopes that it would boost ecotourism and dampen incentives to clear tree cover.

Managers of some plants participating in the PSA program indicated that they viewed these activities as complements to the program, as in the case of a plant that provides environmental tours highlighting its participation in the PSA program. However, managers of some nonparticipating plants made clear they viewed these private conservation investments as substitutes for participation in the PSA program. In some cases, their investments had the same broad objective as the PSA program—protecting forest on private land. In other cases, the private investments by nonparticipating plants aimed at ensuring benefits not provided by the PSA program. Examples include plants that invested in stemming the dumping of trash in rivers in urban areas, and in improving management of nearby national parks. The implication of these private investments is that notwithstanding their positive ratings of the PSA program's administration, not all of the plant managers believe the program is the only or most cost-effective means of ensuring the environmental health of their watersheds.

7. Conclusion

We have used an original survey of Costa Rica's private hydroelectric plants along with government statistics to analyze the user-financed component of the country's payments for ecosystem services program. We focused on three issues: (i) the number and type of environmental service users that participate; (ii) the factors driving participation in the private hydroelectricity sector; and (iii)

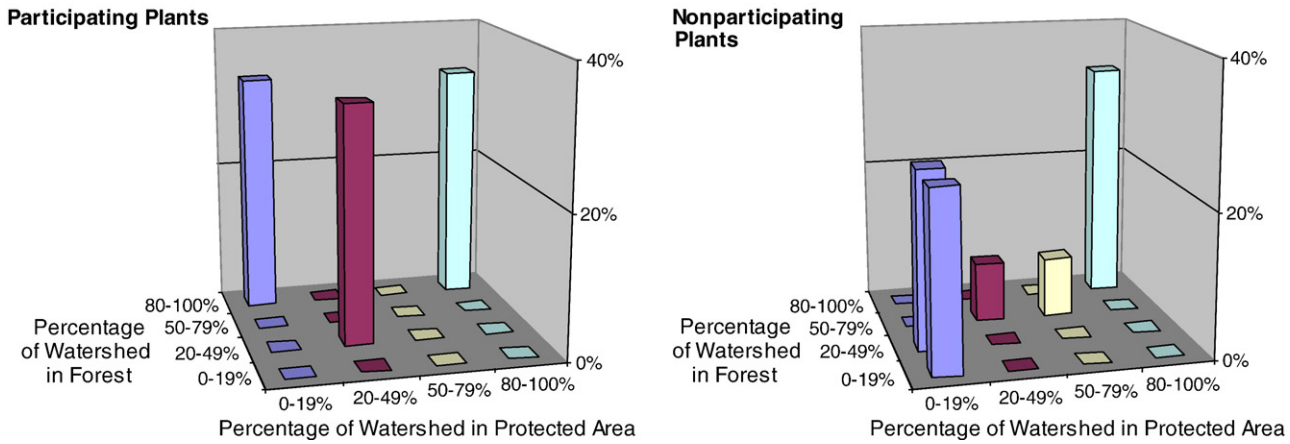

Fig. 2. Watershed protection and forest cover percentages for participating and nonparticipating plants.
Source: Authors' survey.

		Forest cover: High	Forest cover: Low
Legal protection	High	A. Nonparticipants	n/a
	Low	B. Participants	C. Nonparticipants

Fig. 3. Breakdown of PSA participation and nonparticipation by private hydroelectric plants by watershed characteristics: forest cover and legal protection.

the perceptions of plant managers in this sector regarding the performance of the program. As for the first issue, we found that thus far, user financing represents a small fraction of total funding for the PSA program and that what funding has been obtained has come largely from users interested in hydrological services.

Regarding the drivers of participation in the private hydroelectric sector, we found that although most plant managers interviewed–including both participants and nonparticipants–cited forest protection and the provision of environmental services as the main benefit of participation, they also emphasized improved relations with local communities and with government regulators—both factors that researchers repeatedly have identified as drivers of participation in other voluntary environmental programs. We also found that the following types of plants were more likely to participate: large plants, those with characteristics associated with large plants (including relatively high revenues, corporate ownership, and direct contact with FONAFIFO), and plants in heavily forested but lightly protected watersheds.

The data do not permit us to identify with certainty plants' motives for participating. However, we can draw two broad conclusions. First, the prominence among participants of large plants that had been contacted by FONAFIFO suggests that transaction costs may be an important barrier to participation. Second, the weight of evidence suggests that improved relations with communities and regulators are significant motives, along with the desire to protect the forest and provide environmental services. In both closed-ended questions and (especially) open-ended questions, interviewees highlighted the importance of improved relations with communities and regulators.

Finally, as for the perceived performance of the PSA program, the average environmental service users we interviewed reported a more or less favorable impression. However, the fact that some plants are making their own private investments in forest conservation in their watersheds, instead of paying FONAFIFO to do this, suggests that plants do not view the PSA program as the only or most cost-effective means of achieving their environmental goals.

What are the policy implications of these findings for national PES program generally and for Costa Rica's PSA program more specifically? We hypothesized that user financing might improve the efficiency of national PES programs. Our findings raise questions about this hypothesis. If environmental service users participate in hybrid PES programs for reasons other than ensuring the provision of environmental services, then they are less likely to help government administrators identify providers of important environmental services, value these services, or monitor compliance with PES contracts. In fact, their participation could contribute to inefficiency. For example, if a large private hydroelectric plant in a heavily protected watershed contributes to a PES program mainly to win political points with national regulatory authorities, then FONAFIFO's scarce financial and human resources would be wasted in the sense that they are used to prevent deforestation where it is unlikely to occur. On the other hand, we did find that the majority of the nonparticipants are located in areas where the program is unlikely to provide any benefits, while participants were in areas where benefits were at least possible (Fig. 3).

We also hypothesized that private financing might improve the financial sustainability of a national PES program. In this case, our conclusions are mixed. Despite the widespread perception that the PSA program offers hydrological benefits, we find little evidence that participation in the program has actually generated such benefits or that nonparticipation has led to hydrological costs or higher rates of deforestation. The failure of the PSA program to affect deforestation has been shown by others (Robalino et al., 2008; Arriagada, 2008) and is confirmed here: neither participants nor nonparticipants reported significant deforestation in their watersheds. This does not bode well for the sustainability of voluntary contributions; if hydrological benefits are not eventually substantiated by plants' experiences then favorable perceptions of the program are unlikely to persist. Furthermore, if finite political and reputational objectives instead of demand for environmental services drive private contributions to a national PES program, then there may be a limit on the amount that private parties are willing to contribute. For example, in Costa Rica, if contributions by private hydroelectric plants have been motivated by a need to soften political opposition, they may no longer be needed now that this opposition has diminished and the de facto ban on reauthorizing existing plants and building new ones has been lifted.

But on the other hand, if political and reputational benefits drive contributions, then program administrators can encourage contributions by enhancing these benefits. This can be accomplished by raising the public profile of the user-financed component of the PES programs, following the lead of well-known voluntary environmental programs like ISO 14001 and the U.S. EPA "partnership" programs. In addition, if participation is driven by variations in transaction costs across ecosystem service providers, then program administrators can expand participation by seeking to lower these costs by, for example, improving marketing.

As for Costa Rica, now that hydroelectric plants and other water users are essentially required to pay part of their water tariff to FONAFIFO, and now that the deforestation rate has declined dramatically nationwide, the era of purely voluntary contributions from users of hydrological services may be nearing an end.[28] However, there is still room for FONAFIFO to improve targeting of payments for environmental services and to provide environmental services that benefit a wider range of users. FONAFIFO could do this by reaching out to the many hydroelectric plants that have not yet participated and identifying how environmental services in their watersheds could be improved. This may involve activities other than paying private landowners not to clear forests. Although Costa Rica's net deforestation rate has been substantially reduced, there remain activities that can increase the supply of environmental services, such as improving monitoring of parks or improving environmental education. Some hydroelectric plants already fund such activities voluntarily. The government can use these investments to indicate how the PSA program might be modified to provide the environmental services that Costa Ricans need most.

Acknowledgments

Blackman received financial support from the EfD Initiative and Resources for the Future. Woodward received financial support from a Fulbright fellowship and Texas AgriLife Research with support from the Cooperative State Research, Education and Extension Service, Hatch Project, TEX8604. We thank our interviewees, particularly Alberto Garcia and Alexandra Saenz of FONAFIFO and Manrique Rojas of Edificadora Beta, for sharing insights and data, Rebecca Osakwe at CATIE for research assistance, Sally Atwater for editorial assistance and two anonymous reviewers for helpful comments and suggestions.

[28] Direct payments to FONAFIFO of *Canon de Agua* fees from all economic sectors may be poised to replace purely voluntary contributions as the primary source of FONAFIFO user financing. In the hydroelectric sector, however, these direct payments have thus far been small compared with purely voluntary contributions (Table 3). The reason may be that in this sector, plants' willingness to contribute exceeds their *Canon de Agua* obligations. Water-use fees have been rising over time, so this trend may create incentives for more substantive direct payments.

Appendix

Private electricity providers in Costa Rica.
Sources: ARESEP (2008); authors' survey data and calculations.

Firm surveyed	Owner	Plant name	Type of plant	Started operation	Operating in 2007	Power (KW)	PSA participant
No	Aeroenergía S.A.	Aeroenergía S.A.	Wind	1998	Yes	6750	No
No	Azucarera el Viejo S.A.	El Viejo	Biomass	≤1996	No	866[a]	No
Yes	Coneléctricas R. L.	Coneléctricas R. L.	Hydro	1997	Yes	17,299	No
Yes	Desarrollos Energéticos MW S.A.	San Gabriel	Hydro	≤1996	Yes	395	No
Yes	Doña Julia	Doña Julia	Hydro	1999	Yes	16,470	No
Yes	Edificadora Beta	Caño Grande	Hydro	≤1996	Yes	2905	No
"	"	El Embalse	Hydro	1997	Yes	2000	No
"	"	HidroVenecia	Hydro	1999	Yes	3375	No
Yes	El Angel	El Angel	Hydro	≤1996	Yes	3424	No
Yes[b]	Enel GreenPower	Don Pedro	Hydro	≤1996	Yes	14,000	Yes
"	"	Volcán	Hydro	1997	Yes	17,000	Yes
Yes	Hidroeléctrica Tuis S.A.	Tuis	Hydro	1999	Yes	1799	Yes
Yes	Holcim of Costa Rica	Aguas Zarcas	Hydro	≤1996	Yes	14,208	Yes
Yes	Ingenio Quebrada Azul Ltda.	Quebrada Azul	Hydro	1998	Yes	300	No
No	Ingenio Taboga S.A.	Ingenio Taboga S.A.	Biomass	2006	Yes	20,000	No
Yes[c]	Inversiones La Manguera S.A.	La Esperanza	Hydro	2000	Yes	5506	Yes[c]
Yes	La Lucha	La Lucha	Hydro	≤1996	Yes	339	No
Yes	La Rebeca	La Rebeca	Hydro	≤1996	Yes	60	No
Yes	Hidroeléctrica Rio Lajas	Rio Lajas	Hydro	1997	Yes	11,000	No
Yes	Losko S.A	Poas	Hydro	1997	Yes	2125	No
"	"	Rio Segundo	Hydro	1998	Yes	628	No
Yes	O&M Eléctrica Matamoros S.A.	El General	Hydro (BOT)	2006	Yes	39,000	No
"	"	Matamoros (various)	Hydro	1997	Yes	3819	No
"	"	Platanar	Hydro	≤1996	Yes	14,594	Yes
No	Miravalles III	Miravalles III	Geothermal (BOT)	2000	Yes	29,500	No
No	Molinos de Viento Arenal S.A.	Tierras Morenas	Wind	1999	Yes	9480[a]	No
No	Not active	Los Negritos	Hydro	≤1996	No	39[a]	No
No	Not active	Montezuma	Hydro	≤1996	No	981	No
No	Not active	Pejibaye	Hydro	≤1996	No	49[a]	No
No	Not active	San Rafael	Hydro	≤1996	No	189[a]	No
No	Not active	Santa Rufina	Hydro	≤1996	No	292[a]	No
No	Plantas Eólicas	Plantas Eólicas	Wind	≤1996	Yes	23,370	No
Yes	Sociedad Planta Eléctrica Tapezco	Tapezco	Hydro	≤1996	Yes	136	No
Yes	Suerkata S.R.L.	Suerkata S.R.L.	Hydro	≤1996	Yes	3000	No
Yes[c]	Union Fenosa	La Joya	Hydro (BOT)	2006	Yes	51,000	No

[a] Estimate based on maximum actual production between 1997 and 2007 and assuming 100% operation.
[b] Former manager was interviewed, but not all questions covered in survey were asked. Current management could not be interviewed.
[c] Plant excluded from analysis for reasons discussed in Section 5.1.

References

Agüero, M. 2006. ICE perdiría oportunidad de comprar energía a precio bajo. *La Nación* March 20. Available at www.nacion.com.

Akerlof, G., Dickens, W., 1982. The economic consequences of cognitive dissonance. American Economic Review 72, 307–319.

Alix-Garcia, J., de Janvry, A., Sadoulet, E., Torres, J.M., 2005. An Assessment of Mexico's Payment for Environmental Services Program. UN Food and Agriculture Organization, Rome.

ARESEP (Autoridad Reguladora de los Servicios Públicos, Dirección de Energía y Concesión de Obra Pública). 2002. Política Y Metodologías Tarifarias del Sector Energía. Draft subject to revision. San José, Costa Rica.

ARESEP (Autoridad Reguladora de los Servicios Públicos, Dirección de Energía y Concesión de Obra Pública), 2007. Tarifa Promedio Teórica, Vigente En USS $. Generadores Privados Con Contratos Con Tarifa Fija Y Tarifa Anual. http://www.aresep.go.cr/docs/datos percent20website percent2011-07-07.xls, accessed June 3, 2008.

ARESEP (Autoridad Reguladora de los Servicios Públicos, Dirección de Energía y Concesión de Obra Pública), 2008. Costa Rica: Compras del ICE a los Generadores Privados en Unidades Físicas y Monetarias, Precio del KWH, Según Planta, Por Año 1996–2007. http://www.aresep.go.cr/docs/GENERACION_PRIVADA.xls , accessed April 23, 2008

Arriagada, R., Sills, E., Pattanayak, S., Ferraro, P., 2008. Evaluating initiatives with direct conservation payments: econometric analysis of the Costa Rican program of payments for environmental services. Sylvanet 21, 24–31.

Arriagada, R., Sills, E., Pattanayak, E., Ferraro, P., 2009. Combining qualitative and quantitative methods to evaluate participation in Costa Rica's program of payments for environmental services. Journal of Sustainable Forestry 28 (3–5), 343–367.

Aylward, B., Echeverría, J., Allen, K., Mejías, R., Porras, I.T., 1999. Market and policy incentives for livestock production and watershed protection in Arenal, Costa Rica. CREED Working Paper No.25. IIED, London.

Barrantes-Chaves, Á. 2008. Autoridad Reguladora de los Servicios Públicos, Dirección de Servicios de Energía. Personal communication (telephone), June 3.

Barton, D.N., Faith, D., Rusch, G., Acevedo, H., Paniagua, L., Castro, M., 2009. Environmental service payments: evaluating biodiversity conservation trade-offs and cost efficiency in the Osa Conservation Area, Costa Rica. Journal of Environmental Management 90, 901–911.

Blackman, A. in press. Alternative pollution control policies in developing countries. Review of Environmental Economics and Policy.

Blackman, A., Bannister, G.J., 1998. Community pressure and clean technology in the informal sector: an econometric analysis of the adoption of propane by traditional Mexican brickmakers. Journal of Environmental Economics and Management 35, 1–21.

Blackman, A., Mazurek, J., 2001. The cost of developing site-specific environmental regulations: evidence from EPA's project XL. Environmental Management 271, 109–121.

Business Wire. 2001. Erga to Acquire Energía Global International; Second acquisition of leading renewable energy company in six months; Expands Erga's Global Renewable Energy Portfolio in Latin America. http://findarticles.com/p/articles/mi_m0EIN/is_2001_May_2/ai_73971736, accessed September 8, 2008.

Chomitz, K., Brenes, E., Constantino, L., 1999. Financing environmental services: the Costa Rican experience and its implications. The Science of the Total Environment 240 (1), 157–169.

Cothran, M.C., 1993. Pro-active environmental activity eases permitting process. Journal of Environmental Permitting 2, 293–300.

de Leon, P., Rivera, J., 2009. Voluntary Environmental Programs: A Policy Perspective. Lexington Books, Lanham, MD.

Decker, C.S., 2003. Corporate environmentalism and environmental statutory permitting. Journal of Law and Economics 46, 103–129.

Delmas, M., Marcus, A., 2004. Firms' choice of regulatory instruments to reduce pollution: a transaction cost approach. Business and Politics 6 (3), 1–20.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: an overview of the issues. Ecological Economics 65, 663–674.

Estaban, M. 2009. MINAET concessionará aguas para hidroeléctricas privadas. La Nación, March 17. Available at www.nacion.com.

FONAFIFO, 2009. Online database: SIAP_PSA Reporte de Contratos de Costa Rica http://www.fonafifo.com/mapas/index_datos.php. Accessed June 26, 2009.

Food and Agriculture Organization (FAO), 2003. Payments schemes for environmental services in watersheds. Regional forum, Arequipa, Peru, June 9–12.

Garcia, A. (FONAFIFO). 2009. Spreadsheet data (CONVENIOS Y CSA.xls, May 8, 2009).
Greer, J. and K. Bruno. 1996. Greenwash: The reality behind corporate environmentalism. Penang, Malaysia: Third World Network, and New York: Apex Press.
Hartshorn, G., Ferraro, P., Spergel, B., 2005. Evaluation of the World Bank: GEF Ecomarkets Project in Costa Rica. World Bank, Washington, DC.
Kahneman, D., Knetsch, J., 1992. Valuing public goods: the purchase of moral satisfaction. Journal of Environmental Economics and Management 22, 57–70.
Kaimowitz, D., 2004. Forest and water: a policy perspective. Journal for Forest Research 9, 289–291.
Kotchen, M., Moore, M., 2007. Private provision of environmental public goods: household participation in green-electricity programs. Journal of Environmental Economics and Management 53 (1), 1–16.
Kosoy, N., Martinez-Tuna, M., Muradian, R., Martinez-Alier, J., 2007. Payments for environmental services in watersheds: insights from a comparative study of three cases in Central America. Ecological Economics 61 (2–3), 446–455.
Laufer, W.S., 2003. Social accountability and corporate greenwashing. Journal of Business Ethics 43 (3), 253–261.
Lyon, T., Maxwell, J., 2002. Voluntary approaches to environmental regulation: a survey. In: Frazini, M., Nicita, A. (Eds.), Economic Institutions and Environmental Policy. Ashgate Publishing, Aldershot and Hampshire.
Lyon, T., Maxwell, J., 2006. Greenwash: Corporate Environmental Disclosure under Threat of Audit. Working Paper 1055. University of Michigan, Ross School of Business.
Marchamalo, M., Romero, C., 2007. Participatory decision-making in land use planning: an application in Costa Rica. Ecological Economics 63 (4), 740–748.
Marcus, A., Geffen, D., Sexton, K., 2002. Reinventing environmental regulation: lessons from project XL. Resources for the Future Press, Washington, DC.
Mayrand, K., Paquin, M., 2004. Payments for environmental services: a survey and assessment of current schemes. Unisfera International Center (for the Commission for Environmental Cooperation of North America). http://www.cec.org/files/PDF/ECONOMY/PES-Unisfera_en.pdf.
Maxwell, J., Lyon, T., Hackett, S., 2000. Self-regulation and social welfare: the political economy of corporate environmentalism. Journal of Law and Economics 43 (2), 583–618.
Menz, F., 2005. Green electricity policies in the United States: case study. Energy Policy 33 (18), 2398–2410.
Miranda, M., Dieperink, C., Glasbergen, P., 2007. Voluntary agreements in watershed protection in Costa Rica. Environment, Development and Sustainability 9, 1–19.
Muñoz-Piña, C., Guevara, A., Torres, J.M., Braña, J., 2008. Paying for the hydrological services of Mexico's forests: analysis, negotiations, and results. Ecological Economics 65 (4), 725–736.
Nunes, P., Schokkaert, E., 2003. Identifying the warm glow effect in contingent valuation. Journal of Environmental Economics and Management 45 (2), 231–245.
Oviedo, E. 2005. ICE limita generación de energía a empresas privadas. La Nación November 16. Available at www.nacion.com.
Pagiola, S., 2007. Using markets to preserve forests and the services they provide. PowerPoint presentation at International Union of Forest Research Organizations (IUFRO) Symposium, Saariselkä, Finland, August 17.
Pagiola, S., 2008. Payments for environmental services in Costa Rica. Ecological Economics 65 (4), 712–724.
Pagiola, S., Platais, G., 2002. Market-based mechanisms for conservation and development: the simple logic of payments for environmental services. : Environmental Matters-Annual Review, July 2001–June 2002 (FY 2002), vol. 6. Environment Department, World Bank, Washington, DC.
Pagiola, S., Platais, G., 2007. Payments for Environmental Services: From Theory to Practice. World Bank, Washington, DC.
Pfaff, A., Robalino, J., Sánchez-Azofeifa, G.A., 2008. Payments for environmental services: empirical analysis for Costa Rica. Working Paper SANO8-05. Terry Sanford School of Public Policy, Duke University, Durham, NC.
Quesada Mateo, C., et al., 2002. Evolución, estado actual y futuro de la electricidad y las telecomunicaciones en Costa Rica. Universidad de Costa Rica, Rectoria, San José, C.R.
Rabin, M., 1994. Cognitive dissonance and social change. Journal of Economic Behavior and Organization 23 (2), 177–194.
Robalino, J., Pfaff, A., Sánchez-Azofeifa, G.A., Alpízar, F., León, C., Rodríguez, C.M., 2008. Deforestation impacts of environmental services payments: Costa Rica's PSA Program 2000–2005. Discussion Paper 08-24: Environment for Development.
Rodríguez, J.M. (Ed.), 2005. The Environmental Services Payment Program: A Success Story of Sustainable Development Implementation in Costa Rica, FONAFIFO: Over a Decade of Action. FONAFIFO, San José, Costa Rica.
Rojas, M., Aylward, B., 2002. Cooperation between a small private hydropower producer and a conservation NGO for forest protection: The case of La Esperanza, Costa Rica. Food and Agriculture Organization of the United Nations, Land-Water Linkages in Rural Watersheds Case Study Series, Rome.
Rojas, M., Aylward, B., 2003. What are we learning from experiences with markets for environmental services in Costa Rica? A review and critique of the literature. International Institute for Environment and Development, London.
Romero-Pérez, J.E., 2004. La Generación Eléctrica Privada en Costa Rica. Revista de ciencias jurídicas 104, 91–130.
Sánchez Chávez, O. 2008. FONAFIFO Coordinator of Environmental Services. Personal communication, April 2.
Sánchez-Azofeifa, G.A., Pfaff, A., Robalino, J., Boomhower, J., 2007. Costa Rica's payment for environmental services program: intention, implementation, and impact. Conservation Biology 21 (5), 1165–1173.
Segerson, K., Miceli, T., 1998. Voluntary environmental agreements: good or bad news for environmental protection? Journal of Environmental Economics and Management 36 (2), 109–130.
Sierra, R., Russman, E., 2006. On the efficiency of environmental service payments: a forest conservation assessment in the Osa Peninsula, Costa Rica. Ecological Economics 59 (1), 131–141.
Sills, E., R. Arriagada, S.K. Pattanayak, P. Ferraro, L. Carrasco, E. Ortiz, S. Cordero, and K. Andam, forthcoming. Impact of the PSA Program on Land Use. In G. Platais and S. Pagiola (eds.), Ecomarkets: Costa Rica's Experience with Payments for Environmental Services. Washington, DC: World Bank.
Stadtmüller, T. 1994. Impacto Hidrológico del Manejo Forestal de Bosques Naturales Tropicales: Medidas Para Mitigarlo. Serie técnica Informe técnico No. 246, Colección Silvicultura y Manejo de Bosques Naturales No. 10 Centro Agronómico Tropical de investigación y Enseñanza, CATIE. Turrialba, Costa Rica.
Tattenbach, F., Obando, G., Rodríguez, J., 2007. Generación de Servicios Ambientales (In Spanish) In: Platais, G., Pagiola, S. (Eds.), Draft chapter 10 for G. Platais and S. Pagiola: Ecomarkets: Costa Rica's Experience with Payments for Environmental Services. Available at: http://go.worldbank.org/W7OO30QLM0.
Turpie, J., Maraisb, C., Blignaut, J., 2008. The working for water programme: evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. Ecological Economics 65, 788–798.
Wunder, S., 2005. Payments for Environmental Services: Some Nuts and Bolts. Occasional Paper 42. Center for International Forestry Research, Bogor.
Wunder, S., Engel, S., Pagiola, S., 2008. Taking stock: a comparative analysis of payments for environmental services programs in developed and developing countries. Ecological Economics 65 (4), 834–852.
Wünscher, T., Engel, S., Wunder, S., 2008. Spatial targeting of payments for environmental services: a tool for boosting conservation benefits. Ecological Economics 64 (4), 822–833.