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Payments for Environmental Services: Past Performance and Pending Potentials

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Abstract

We develop a theory of change for payments for environmental services (PES) to review their imminent strengths and weaknesses in light of a growing body of impact evaluation studies. We show that PES are probably at least as environmentally additional as other conservation tools, based on the limited evidence. The original vision of PES as being direct, flexible, and potentially effective remains valid, but PES design and implementation have to be upgraded in their economic functioning to better realize this potential. Adverse self-selection, inadequate administrative targeting, and ill-enforced conditionality constitute three key obstacles that may considerably hamper PES success. Policies such as spatial targeting to service density, threat and cost levels, and payment differentiation can alleviate the design challenges. PES site selection needs to further move into high-threat areas. Making adequate PES design choices also requires the political will to boost environmental effects.

1. INTRODUCTION

Conservation practitioners worldwide are searching for more cost-effective and equitable ways of using scarce funds. Payments for environmental services (PES), also sometimes referred to as payments for ecosystem services,[1] are an important attempt in this direction, having become increasingly popular over the last few decades. They aim to incentivize landholders and other resource stewards to adopt environmentally friendlier practices of protection or restoration. PES are paid for voluntarily by either private service users or public entities, compensating resource stewards contingent upon their contractual compliance. We can see PES as a predominantly private-lands counterpart to public protected areas,[2] although in most countries PES cover a smaller area. PES contracts can range from short term to the indefinite duration of perpetual conservation easements (Kay 2016).

We define PES narrowly as voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services (Wunder 2015). Various broader, more inclusive definitions exist, encompassing at the extreme all economic incentives. Where environmental services (ES) instead are provided onsite (e.g., ecotourism on private lands), easier charging mechanisms exist (e.g., site entrance fees or hedonic accommodation surcharges for surrounding natural beauty). Furthermore, onsite ES from which landholders themselves benefit, such as conserving on-farm soil fertility, arguably do not need payments: Landholders should be sufficiently intrinsically motivated to self-provide these ES. PES were instead conceived for the more difficult scenario where extrinsic rewards are needed for safeguarding positive spatial externalities from landholders and resource stewards to society at large, whether near or far: Watershed protection, biodiversity conservation, and climate change mitigation are all prime externality-driven ES.[3]

While some PES started as long-term environmental subsidy programs, e.g., the US Conservation Reserve Program (Claassen et al. 2008), the big push for PES in this millennium came from economists. They argued, based on the seminal work of Coase (1960), that direct payments from ES users to providers could be more cost-efficient than indirect approaches (Simpson & Sedjo 1996, Ferraro 2001, Ferraro & Kiss 2002, Ferraro & Simpson 2002, Pagiola & Platais 2002, Wunder 2005). Most PES programs have focused on forest conservation (Alston et al. 2013). Geographically, PES have been most popular in the Americas (North, South, Central) and in China (Börner et al. 2017, Salzman et al. 2018, Snilsveit et al. 2019).

A defining feature of PES is conditionality: the quid pro quo principle of reducing or stopping payments when ES are not being adequately provided. PES thus represent a new paradigm of voluntary, contractual conservation, where ES providers choose whether or not to join a PES scheme, but ES users or funders in principle only pay for what they get (Angelsen 2017). However, PES are not the only incentive mechanisms using conditionality. First, forest-based climate change mitigation known as REDD+[4] can be seen as a PES-like arrangement between industrial greenhouse gas (GHG) high-emitting countries and forest-rich countries (Wertz-Kanounnikoff & Angelsen 2009). Second, green certification is also a voluntary, conditional mechanism in promise of market

[1] Like Wunder (2015), we treat the two terms in this review as quasi-synonyms. Ecocompensation, rewards, and cash transfers are examples of other terms being used.

[2] Private would then need to be amply defined, e.g., including community lands, NGO-owned lands, or company-owned lands. PES may also pay private individuals or communities residing on public land, including protected areas or sustainable use reserves with clearly demarcated private entitlements.

[3] While these three ES types have dominated as raisons d'être behind PES, others form part of the joint motives behind public PES schemes, including the offsite visual landscape and recreational benefits.

[4] Reducing Emissions from Deforestation and forest Degradation, and fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks.

access and price premiums for environmentally benign production, linked to product markets (van der Ven & Cashore 2018), where PES are typically area based and instead spatially specific. Third, environmental fiscal transfers, such as Brazil's ecological value-added tax (Grieg-Gran 2000) or India's annual US$7–12 billion transfers (Busch & Mukherjee 2018), represent fiscal revenues transferred conditionally from higher- (e.g., national) to lower-level (e.g., municipalities) jurisdictions, depending on the size and quality of protected area management—a kind of PES between government bodies.

Finally, conditionality is also being used in biodiversity offsets but, unlike for PES, here an up-front biodiversity loss from development activities is being permitted (Vaissiere et al. 2020), thus having closer ties with the environmentally regulated polluter-pays principle. Conversely, PES follow the provider-gets principle, building on different entitlements in natural resource management (Mauerhofer et al. 2013). Various cap-and-trade mechanisms around legal (or business self-imposed) environmental regulations can share some PES features, but are all focused on an initial pollution problem. Some global PES assessments are all inclusive of these so-called market-based mechanisms (e.g., Salzman et al. 2018), yet noteworthy differences in goals, functions, and impacts persist.

PES attempt to align private land- and resource-use decisions with broader societal interests. Their potential to act in direct, performance-based, yet potentially negotiated, flexible, and fair ways has been attractive (Brouwer et al. 2011, Muradian et al. 2013). ES users effectively rent out certain partial land rights from landholders, e.g., the right to deforest. This only works when ES provision can be well-monitored and enforced and when landholders can flexibly change their preferred modes of production. Otherwise, ES users might prefer to buy out environmentally sensitive lands entirely (e.g., creating municipal reserves for spring protection), although becoming responsible for land stewardship may be costly.

The literature distinguishes between several types of PES. First and foremost, in so-called user-financed PES the ES users pay directly, while in government-financed PES a public body pays on their behalf (Engel et al. 2008). User-financed PES may often be more effective in directly overseeing contractual delivery; on the other hand, government-financed PES may more effectively address imminent ES free-rider problems by taxing multiple users (e.g., for biodiversity protection) and be more cost-efficient in organizing payment programs at scale. Some PES initiatives are environmentally asset building (e.g., planting trees), while others are activity reducing (e.g., avoiding deforestation for conversion to alternative land uses), having different implications for local livelihoods (Wunder 2005).

A novel aspect of this PES review is that we develop an elaborate theory of change for PES, serving as the organizing principle for this article (Section 2). This allows us to functionally examine the strengths and weaknesses of PES, flagging key causal-chain transitions and revealing critical assumptions. We focus our attention on selected topics where recent research has brought new insights and the importance of which for PES outcomes may not have been sufficiently acknowledged: adverse self-selection of participants, targeting issues, and motivation crowding. We then discuss PES preconditions (Section 3), emerging design lessons (Section 4), and influential contextual factors (Section 5). In Section 6, we juxtapose these considerations to PES impact evaluations, focusing on environmental effects. In Section 7, we summarize and discuss the findings and point to implications for environmental policies.

2. A THEORY OF CHANGE FOR PAYMENTS FOR ENVIRONMENTAL SERVICES

A theory of change is a tool for making explicit the linkages between the causal chain elements of inputs, treatments, output, outcomes, and impacts (Weiss 1997). It can be useful for planning

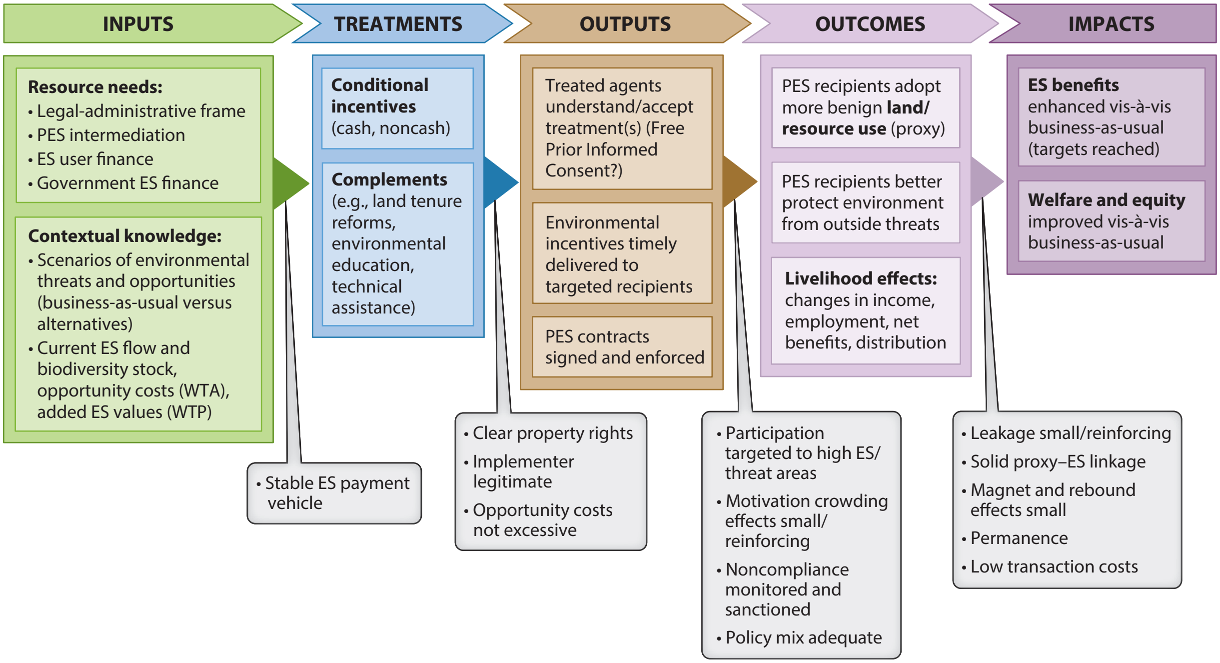

Figure 1

A theory of change for payments for environmental services. Abbreviations: ES, environmental services; PES, payments for environmental services; WTA, willingness to accept; WTP, willingness to pay.

conservation or development actions, and tracking their progress in implementation, but here we use it analytically to deduce what contextual preconditions, preparatory steps, and implementation arrangements need to be in place to achieve the desired ES outcomes and impacts (**Figure 1**).

The PES theory of change has the following structure. Prior to designing and implementing any PES action, typically a series of financial, legal-institutional, and knowledge-oriented inputs are needed. Once in place, the PES treatment can be designed and executed. The output level will tell us whether this treatment was effectively implemented, reaching targeted stakeholders as planned. The outcomes refer to actual changes on the ground, typically in targeted land-use proxies (e.g., trees planted, forest cover enhanced, habitat preserved) for the eventual ES delivery. The latter is described in the final level of impacts: Given that, for instance, deforestation was halved, what incremental forest carbon stock was preserved, how many species could locally survive, and how much was drinking water quality from the watershed improved? We also flag key stage-specific assumptions to be discussed below (see gray callout boxes in **Figure 1**).

If PES is about ES delivery, is conditionality then also applied at the final impact level? In fact, at least three different scenarios exist. In some forest carbon projects, the incremental carbon captured is measured and paid for (Tacconi et al. 2010). However, many REDD+ projects using PES pilots have paid at the input level, e.g., for communities adopting revised land-use plans featuring more forest conservation (Sills et al. 2014). However, PES conditionality is most commonly applied at the intermediate level of outcomes: Landholders will get paid once they have complied with agreed-upon land- and resource-use proxies (e.g., protecting a certain on-farm forest area). This often constitutes a convenient Goldilocks solution between ES users having full certainty about ES delivery (impact-level payments) and ES providers assuming zero risk in ES delivery (input-based payments).

3. PRECONDITIONS

3.1. Basic Economic Rationale for PES

PES are based on a voluntary willingness to pay (WTP) on behalf of ES users (or their government-financed representatives) and a corresponding willingness to accept (WTA) payments on behalf of ES providers. **Figure 2** depicts different WTA scenarios from the perspective of landholders providing ES. **Figure 2*a*** shows the logic of using PES for conservation, featuring the net benefits to landholders of undertaking a given activity. The benefits to downstream users or the global community of undertaking activities such as forests or agroforestry are not shown, and neither are the costs imposed on others by environmentally harmful activities. For concreteness, the environmentally damaging activity is labeled here as pasture, and the ecosystem to be conserved is labeled forest.

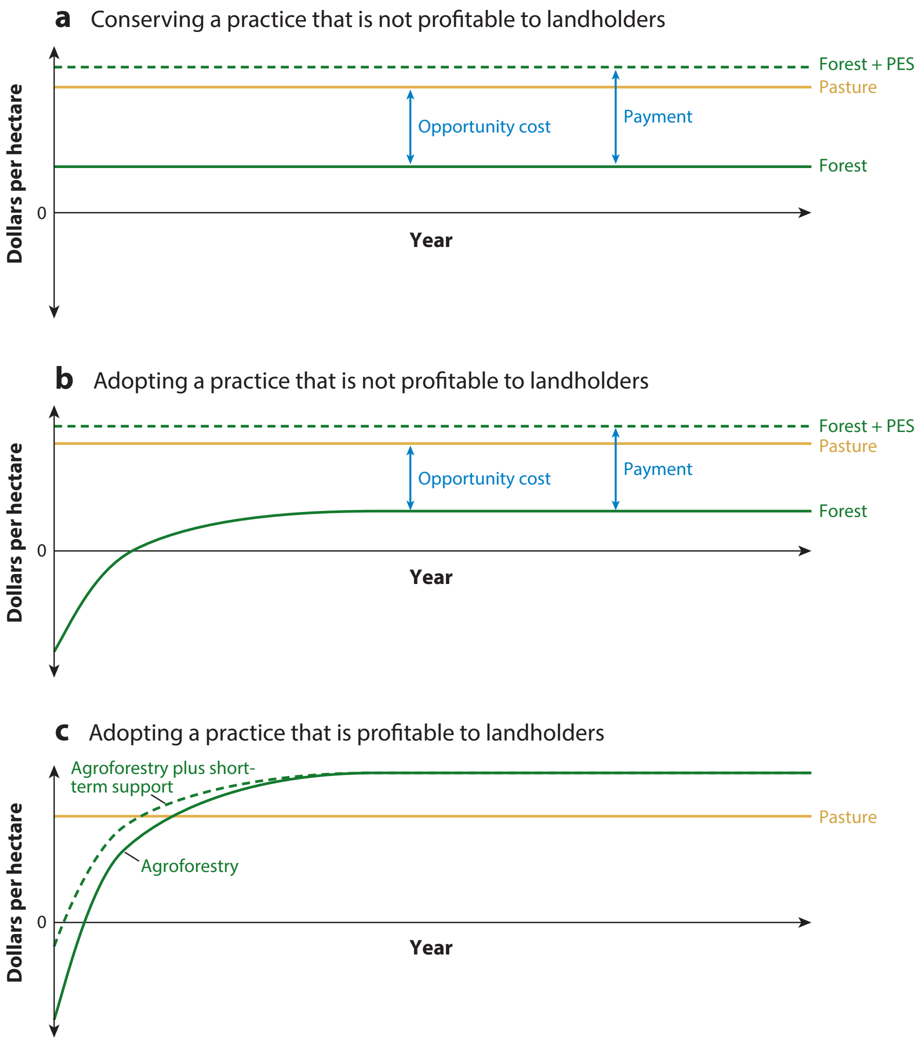

Figure 2

Payments for environmental services (PES) and landholder practices: stylized profitability scenarios.

Forests generate lower benefits for landholders than pasture. Landholders thus have strong incentives to convert forests to pasture and would bear opportunity costs otherwise. PES work by sufficiently increasing the net benefits to landholders of conserving forest to equal or exceed conservation opportunity costs. Real-world examples are various government-financed forest conservation PES programs, such as in Costa Rica (Pagiola 2008) or Mexico (Muñoz-Piña et al. 2008).

Figure 2*b*,*c* shows the logic of two cases of using PES for restoration: one where the restored land use, though it provides more ES, is not profitable per se for landholders vis-à-vis current pasture use (**Figure 2*b***), and one where the high-ES land is more profitable for landholders once established (**Figure 2*c***). In both cases, there is an initial cost of making the change (i.e., planting the trees). In **Figure 2*b***, there is also an opportunity cost for landholders. For PES to be effective in this case, it must pay both for the short-term cost of switching and for the long-term opportunity cost. The Reflorestar Program in Espírito Santo (Brazil) is an example of a PES program that does so (Pagiola et al. 2019). The Chinese Sloping Land Conversion Program (also known as Grain for Green), on the other hand, only pays for a limited time, raising concerns that reforested areas may not be maintained (Bennett 2008, Fu et al. 2019).

If pasture is replaced by productive yet ES-friendly practices (agroforestry) that are more profitable for landholders once established, as in **Figure 2*c***, there is no long-term opportunity cost; on the contrary, there is a net benefit for landholders. In this case, a short-term, time-limited PES can be sufficient to persuade landholders to establish and maintain agroforestry. The Global Environment Facility-financed silvopastoral project in Colombia and Nicaragua used this approach, and it was found that farmers did in fact maintain the practices they had adopted (Pagiola et al. 2016, 2017).

3.2. Binding Versus Favorable Conditions

In **Figure 1** we argue that appropriate contexts for PES typically contain a mixture of factors, ranging from socioeconomic and biophysical knowledge about baseline and projected scenarios, to the presence of (or the possibility of establishing) economic, legal-administrative, and institutional resources needed for implementing PES. Based on the literature about failed PES attempts (e.g., Wunder et al. 2008a), institutional PES requirements (Farley et al. 2010, Vatn 2010), critical assessments of PES processes in general (e.g., Pascual et al. 2010, Muradian et al. 2013, Wunder 2013), and our economic reasoning in the previous subsection, we can point to some conditions of singular importance influencing whether or not a PES scheme will emerge.

1. Expected added ES value (driving WTP) exceeds expected ES provisioning costs (driving WTA): If the expected environmental gains are lower than the costs, especially the opportunity costs, PES will not materialize. The economic benefits from conservation, and the corresponding ES user's WTP for these, are not always sufficient to buy out landholder losses.
2. Payments can be organized: Not only does there need to be a genuine economic argument for PES (cf. point 1), but the often multiple ES beneficiaries also need to, first, collectively recognize their self-interest in PES and, second, practically organize payments (including control of ES free-riding), or, alternatively, rely on government assistance in doing so. Collective action to transform clear economic arguments into actionable WTP is notoriously failing for global ES such as biodiversity conservation (Barbier et al. 2018).
3. Implementer/intermediary institutions are seen as legitimate: Most PES programs work with institutions acting as intermediaries between ES providers and users (e.g., Landell-Mills & Porras 2002). Whether direct implementers or intermediaries, they need to be

seen by ES providers as legitimate actors, which may involve lengthy negotiations and trust building.

4. Potential ES providers have sufficiently clear property rights to their land and resources: Within the layered bundle of property rights (Schlager & Ostrom 1992), potential ES providers need to have at least the right to exclude externals, which needs not entail formal land titles; informally recognized but secure rights may suffice. In tropical forest frontiers with problematic governance, this can be a killer assumption for PES.

Other PES-preconditioning factors have been identified in meta- and cross-country studies. Bösch et al. (2019), for example, found that the likelihood of watershed PES emergence significantly increased with strong legal and property rights systems (reconfirming point 4), a rugged topography (stronger upstream-downstream dimensions), high water quality and quantity (high ES at stake), and elevated urbanization rates (relatively more downstream payers, vis-à-vis fewer upstream payment recipients). Biophysical and socioeconomic context alike thus codetermined the likelihood of PES establishment.

4. DESIGN AND IMPLEMENTATION

Although we typically do not have experimental evidence allowing us to separate out the impacts of different PES design modalities, the theory about PES design (Engel 2016), case-study comparisons (Wunder et al. 2008b, Brouwer et al. 2011, Sattler et al. 2013), and experiences from other incentives (Jack et al. 2008) make the specific PES design and implementation features that are likely to strongly influence PES outcomes and impacts increasingly clear. The meta-study by Ezzine-de-Blas et al. (2016) attempted a binary classification of expert-perceived environmental additionality (i.e., a significant ES impact or not?) of 55 PES cases worldwide. Three design and implementation factors stood out as significant for determining additionality (Wunder et al. 2018), to be discussed below:

- Participation targeted to high-ES and high-threat areas (counteracting adverse selection biases);
- Cost-efficient payments (aligned to provider opportunity costs and ES values); and
- Noncompliance monitored effectively and sanctioned (i.e., enforced conditionality).

4.1. Spatial Targeting

First, ES are usually distributed heterogeneously in space: Biodiversity hotspot areas exist, carbon densities vary across the landscape, and critical hydrological response units (e.g., steep slope, erodible soils) are disproportionally important for downstream hydrological services. The corresponding ES peaks usually do not coincide in space (Chan et al. 2006, Wünscher et al. 2008, Locatelli et al. 2014). Bundling different ES into one PES intervention requires a good understanding of the underlying biophysical trade-offs (Naeem et al. 2015). Second, the degree of environmental threat (e.g., risk of deforestation or habitat degradation), or more generally, the ex ante degree of leverage[5] also distributes unevenly in space, often in predictable manners (e.g., near cities, roads, in areas with fertile soils) (Geist & Lambin 2002).

The ex ante potential of a place to make an ES difference can thus be estimated as its ES density multiplied by the spatialized projected threat of land- or resource-use change to change

[5]Leverage refers more generally to the probability of achieving change vis-à-vis variable laissez-faire scenarios. For example, a PES program financing reforestation would need to preassess to what extent (some) of the incentivized reforestation would have happened even without PES.

Question 1: Meet desired conditions without payments?

Question 2: Apply for payment?	No		Yes
No	① "Not interested on the cheap": Excess ES provision costs		② "Intrinsically good guys": Money doesn't matter
Yes	⑤ "Complying" → Additionality	④ "Cheating" Moral hazard	③ "Rewarding good guys" (or "hot air"): → Adverse selection bias

Figure 3

Additionality of potential environmental service (ES) providers: categorizing ex ante compliance status and interest in applying for payments.

ES provision. When budget limits prevent the enrollment of all potentially eligible landholders, to prioritize areas with the expectedly highest ES gains vis-à-vis baseline becomes important for PES design (Alix-Garcia et al. 2008), or, for that matter, for any spatially explicit conservation action (Carwardine et al. 2012).

Figure 3, inspired by the classification in Persson & Alpízar (2013), spells out some behavioral considerations about the ex ante additionality of an ES provider. The 2 × 2 table registers answers to two questions:

- Q1: Does the potential ES provider already (plan to) meet PES-stipulated environmental conditions (yes or no)?
- Q2: Does the potential ES provider apply for PES participation (yes or no)?

Going clockwise from cell ① (Q1: no; Q2: no), ex ante noncompliant landholders that do not apply for payments often face excessive opportunity costs[6] (cf. Section 2). Cell ② (meets conditions already, but will not apply for PES) holds altruistically motivated landholders who conserve for intrinsic reasons, thus rejecting extrinsic motivations. Cell ③ landholders precomply and apply for PES as rewards for good stewardship, serving also as a positive example to others. However, paying these landholders will not deliver additional ES: They are being paid for status quo ("hot air"). Cells ④ and ⑤ comprise the environmental impact–oriented segment of PES: those who did not comply before, but are willing to sign PES contracts. Yet, while some PES recipients will change land use accordingly (⑤), others may remain incompliant unless they get caught (④). A moral hazard problem emerges if the monitoring and sanctions system does not work adequately, implying that the overall additionality of PES will be reduced (Hart & Latacz-Lohmann 2005). Notably, only landholder group ⑤ will produce additionality, i.e., ES provision over and above the business-as-usual baseline.

Hence, there is a risk that PES will enroll too many precompliant (cell ③) and too few prenoncompliant (cells ④ and ⑤) participants: The former precompliant "anyway" candidates will likely be the most eager to enroll in PES, given their zero opportunity costs, and thus, transaction costs apart, prospects for receiving an economic rent (Ferraro 2018). This is what is referred to as adverse self-selection bias in the PES literature (Burke 2016, Sims & Alix-Garcia 2017, Bottazzi et al. 2018, Giudice et al. 2019), which refers to the danger of getting a structurally inadequate composition of participants in PES programs.

[6]Alternatively, landholders could also lack confidence in PES implementers, resent the loss of flexibility in PES contracts, etc.

How serious a problem is adverse self-selection of ES providers? We argue below that selection biases may be the single biggest design challenge for PES implementation. It is difficult to analytically separate groups ③, ④, and ⑤ because often (unobservable) intentions and plans for future land-use decisions are involved. Bottazzi et al. (2018) found for a regionally scaled-out watershed PES protection program in Bolivia that only 39% of contracts to exclude cattle from riparian areas, and 14% of those to prevent deforestation, appear to have been additional, at least according to self-stated declarations of what farmers would have done without PES.

It is important to note that PES are not alone in facing this adverse self-selection challenge: Any instrument with voluntary agent participation (i.e., REDD+, certification) is subject to the same problem of having "anyway" participants sign up preferentially. Although some observers refer to additionality as the holy grail of PES (Bottazzi et al. 2018, p. 11), it should be a concern for any conservation instrument such as a protected area, a certification scheme, or a new forest law: How much real difference a particular instrument makes should be the holy grail of conservation per se. Active threat-oriented targeting efforts are thus needed to counteract an excessive degree of adverse participant self-selection.

Finally, other targeting efforts may include proxies for provision costs, especially when budgets are scarce and provision costs heterogeneous, so that cost-efficiency becomes important (Ferraro 2008, Engel 2016). However, focusing on low-cost providers alone may screen in precisely those providers who, having low or negative opportunity costs, are ex ante compliant. For biodiversity-focused payments in particular, targeting requirements of spatial contiguity or minimum area size may also feature agglomeration bonuses for the enrolment of collective providers (Jack et al. 2008, Polasky et al. 2014, Fooks et al. 2016).

How much is spatial targeting applied in practice? In a global sample of 70 cases, half used ES-based targeting criteria, i.e., proxies for ES density—some, such as the Mexican national PES scheme, as a multicriteria ES function (Muñoz-Piña et al. 2008)—though most targeted just a single criterion. Threat targeting was much less common (9% of cases). About one-third of cases used no targeting at all; only 14% of cases combined ES density and threat in their spatial targeting, Mexico among them (Wunder et al. 2018).

4.2. Payment Differentiation

When costs of provision are heterogeneous, differentiated payments are usually preferable (Engel 2016). This requires proxies that can be used to address problems of asymmetric information about these costs (Ferraro 2008), including types of agricultural or forestry producers, proximity to roads and other infrastructure, and soil fertility. Differentiated payments can of course also be a tool to attract high-ES providing lands, e.g., paying more for primary than for secondary forest conservation.

A particular way of aligning payments to costs are conservation tenders, i.e., inverse procurement auctions where landholders bid for and are awarded contracts according to cost effectiveness, as specified in preset rules (Khalumba et al. 2014, Polasky et al. 2014, Fooks et al. 2015, Burke 2016, Whitten et al. 2017). Auctions can be complex to organize, require good ES-related information about bidders, and thus may be difficult to take to the scale of national programs. However, this has been done in the United States and Australia, taking advantage of rich biophysical information about land characteristics. Concerns about auctions, basically designed to minimize informational rents among ES providers, may surface on equity grounds when ES providers are predominantly poor. Auctions have thus been less applied in developing countries compared to developed countries. Still, small-scale auctions can be used to extract ES provision cost information in PES pilot phases, allowing a few simple payment tiers to be defined (Wünscher & Wunder 2017).

In the aforementioned 70-case PES sample, half of the cases used some payment differentiation (Wunder et al. 2018), yet not in developing countries. Equity and poverty alleviation concerns act here as strong resistance against diversified payments, typically based on arguments about administrative ease and horizontal equity, i.e., that (assumedly) equal landholders should be treated alike (McDaniel & Repetti 1993, Pascual et al. 2014), even when their costs of provision differ (McGrath et al. 2017).

4.3. Enforcing Conditionality

As stated in Section 1, conditionality is a defining feature in PES. However, to be effective, conditionality must also be enforced in cases of noncompliance. Enforcing conditionality has two elements. First, compliance has to be monitored (i.e., detecting noncomplying participants, typically through remote-sensing techniques and/or on-site verification). Second, observed noncompliance has to trigger sanctions, i.e., threats of and eventually enactment of penalties, such as the partial or full discontinuation of payments (Kerr et al. 2014).[7] If PES participants expect defaulting on contracts to be a profitable strategy, they will likely spill over from cell ⑤ into cell ④ (**Figure 3**), jeopardizing the environmental impact of PES.

In the global sample from Wunder et al. (2018), 63% of the investigated PES initiatives monitored compliance of service providers closely; the rest monitored to some extent. However, only about one-fourth of cases (26%) had consistently sanctioned noncompliance when detected. Another 26% had occasionally applied sanctions. In turn, almost half of the cases (48%) had never sanctioned any contracted participant. It is common at least in PES schemes in developing countries that rules are being tested (Wunder & Albán 2008, Honey-Roses et al. 2009). However, withholding payments to contracted participants may have costs for implementers' social capital built with local people (Ferraro 2018): They may thus prefer to close their eyes to some degree of noncompliance (Ezzine-de-Blas et al. 2016).

4.4. Other Design Issues

Various other practically oriented design factors are discussed by Engel (2016). For instance, the duration of contracts is a recurring issue: Contracts that are too short may not be seen as worthwhile by landholders in terms of transaction costs involved, whereas contracts that are too long, in turn, may not allow for changes of opportunity costs or be seen as a substantive reduction in the flexibility of land-use decisions. Although Ecuador's Socio Bosque Program adopted a 20-year horizon, many PES programs worldwide have followed the example of Costa Rica's national PES program, with a five-year duration as a Goldilocks solution (Pagiola 2008).

Cash versus in-kind payments is another frequently discussed topic. The preferences of recipients for one or the other should be the prime consideration. The cost of paying in kind also needs to be taken into account. However, if in-kind transfers form part of a more integrated project activity (e.g., Asquith et al. 2008 for such a case in Bolivia), implementers should consider whether the transfer could be potentially discontinued, in case contract terms become disputed. Similarly, some Asian PES schemes have used the provision of conditional land rights as the currency of payment (Suyanto 2007, van Noordwijk et al. 2012). The de facto reversibility of such conditional rights needs to be considered from a PES perspective.

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[7] Very few PES schemes are able to enact penalties that exceed payment levels due. One such example is carbon forestry schemes with high initial investments in tree plantation, protected through upfront bank guarantees issued by private landholders (Wunder & Albán 2008).

5. CONTEXTUAL FACTORS SHAPING IMPACTS

5.1. Motivation Crowding

In our theory of change, one crucial assumption is that PES recipients will actually feel positively motivated in their environmental actions (land and resource uses) by the extrinsic PES rewards they receive. However, there is concern that their aggregate environmental effort could actually go down vis-à-vis prepayment levels, because their intrinsic motivations to do good environmentally are being undermined by new attitudes to just do it for money. In **Figure 3**, some landholders who already "meet desired conditions" prepayment might shift toward the two cells where incentives are needed, whether they are receiving PES or not.[8] When extrinsic PES incentives cause intrinsic motivations to go down, PES is said to be crowding out conservation; conversely, when PES incentives enhance intrinsic motivations (e.g., because landholders become more aware and/or proud of something external agents are willing to pay for), we label them crowding-in effects. The ES commodification literature has suggested motivational crowding out as a major PES risk (Farley & Costanza 2010, Kosoy & Corbera 2010, Vatn 2010). Motivational crowding in either direction can occur both at the individual recipient level and for collective motivations (e.g., on community lands).

By nature, motivations are physically unobservable; we have to rely on stated attitudes and reactions. Empirical tests for crowding are often done through lab-in-the-field and other framed field tests, though few of these have been experimentally designed or have explicitly looked at motivational impacts after PES ended (Andersson et al. 2018, p. 131). Existing studies thus typically conduct payment games, rather than accompany the impacts of real-world PES transfers. Hence, even though more case studies have recently become available, our in-depth understanding about motivation crowding remains incomplete.

In a literature survey, Rode et al. (2015) found some crowding effects from economic incentives but no significant ones in either direction for those few cases that related to PES specifically. Similarly, Ezzine-de-Blas et al. (2019) found in a new case collection mixing framed-field experiments with empirical studies that PES influence on motivations could not clearly be asserted: Intrinsic motivations are seemingly impacted only when some specific design or contextual conditions prevail. For example, crowding out is only likely to occur when local people prior to receiving PES held strong intact environmental motivations. This holds especially true in settings where no or few market transactions pre-existed (Frey 1994, Deci et al. 1999, Chervier et al. 2019) and where small extrinsic rewards were introduced—enough to change motivational perceptions but insufficient to change the system's economic logic (Gneezy & Rustichini 2000).

A fully intrinsically governed world is seldom relevant as a backdrop to PES, which typically act in settings where markets have already exercised significant pressure on the environment. That said, contexts and design may well be taken into account by PES implementers to minimize the risk of crowding-out effects. As for contexts, crowding out seems generally more likely when intrinsic motives and social norms were previously strong (Vollan 2008). For instance, framed agrobiodiversity-focused PES field experiments in the Andes found collective payments in communities with strong pre-established collective conservation attitudes to cause crowding out; in those with weak intrinsic norms, payments caused crowding in (Narloch et al. 2012). In a similar way, the odds of motivation crowding out are also bigger when PES contribute to already divided social contexts. Correspondingly, "individual-level payments appear to stabilize conservation

[8]This could refer both to those already good stewards that accept payments (treated) and to those that were not interested in the money in the first place (nontreated), yet who might experience a commodification of environmental attitudes among their PES-receiving peers, which may demotivate them from providing environmental efforts for the common good.

levels above critical thresholds by strengthening reciprocity-based behavior, and thus crowding in prosocial dynamics" (Narloch 2011, p. 121).

In addition to context, the design of the proper PES intervention also matters for the motivational outcomes: When interventions are perceived as "externally controlling," crowding out is more likely than when they are seen as "locally supportive" (Andersson et al. 2018, SI, p. 1). For example, ample communication and trust-building activities may enable collective PES to increase intrinsic motivations (Andersson et al. 2018, Bottazzi et al. 2018, Grillos et al. 2019) and, conversely, harm them when community leaders are not trusted (Costedoat et al. 2016). Relying on individual PES may then be a better alternative (van Hecken et al. 2019). Inclusive participation may also favor intrinsic motivations (Dedeurwaerdere et al. 2016), whereas top-down conservation, applied in a market-remote setting, may favor crowding out (Chervier et al. 2019).

The growing body of empirical work shows that, while both crowding out and crowding in are feasible, no effect is the most likely scenario. Hence, the menace of PES crowding out intrinsic motives has been exaggerated. Care might be taken, though, in nonmarket contexts, and with PES design modalities that may be seen as externally controlling rather than locally supportive.

5.2. Policy Mixes

Economic incentives for the environment have originally been developed mainly as an alternative to a traditional regulatory approach (e.g., Hahn & Stavins 1992). Within the family of incentives, PES have been conceptualized as a direct alternative to integrated conservation and development projects (ICDPs) (Simpson & Sedjo 1996, Ferraro 2001, Ferraro & Kiss 2002). Conceptually, we should distinguish these tools (Börner & Vosti 2013) and evaluate their impacts separately (Börner et al. 2020), including by comparing their impacts within the same jurisdiction (Sims & Alix-Garcia 2017).

Nevertheless, real-world conservation policies more often than not work as policy mixes, i.e., several possibly interconnected treatments are being applied simultaneously to the same geographical sites, ecosystems, and sets of agents (Ring & Barton 2015, Bouma et al. 2019). PES are no exception in that regard (Barton et al. 2017). Costa Rica's PSA program was introduced as part of a new forest law that also prohibited most land-use-changing deforestation. Politically, PES made the extension of Costa Rica's protected area network more palatable to society (Pagiola 2008, Porras et al. 2011, Barton et al. 2017). PSA also contains cross-compliance provisions, e.g., to the legality of land claims and social security payments for employees (Barton et al. 2017).

Similar observations apply elsewhere in Latin America. In Pimampiro (Ecuador), a municipal watershed PES was introduced on top of a previously ill-enforced but then reinvigorated forest protection law prohibiting commercial timber extraction (Wunder & Albán 2008). Similarly, in the municipal watershed program in Moyobamba (Peru), law enforcement was also strengthened simultaneously with PES (Montoya-Zumaeta et al. 2019). Brazil's oldest PES initiative, the Bolsa Floresta Program (Amazonas state), set compliance rules just marginally more restrictive than preexisting regulations for the local sustainable development reserves, and project staff monitor both (Börner et al. 2013). Furthermore, all three cases also included strong ICDP components in their implementation, arguing that market-remote settings would make pure PES inviable, but probably equally reflecting a limited faith among implementers that PES would be a more adequate tool than ICDP.

In other words, rather than a switch from command-and-control policies (sticks) to PES incentives (carrots), not only do sticks and carrots more frequently continue to coexist in the same jurisdiction, but they may both simultaneously be intensified and fine-tuned to each other, increasing rewards for good environmental stewardship but also raising penalties for breaking (new or pre-existing) laws. Börner et al. (2015) simulated impacts of introducing PES on top of command-and-control policies in Brazil. PES increased policy implementation cost but also reduced income losses for those hit hardest by law enforcement—a trade-off that varies in space according to deforestation pressures, conservation opportunity, and enforcement costs.

For the less-developed PES impact evaluation literature, taking into account the different policy mixes of which PES form part (heavily mixed-in regulation and ICDP) certainly multiplies the analytical challenges of attributing impacts to interventions. Important, however, for the PES theory of change is that these other policies at least remain synergistic with the basic PES objectives.

5.3. Leakage

Leakage effects refer to the impacts of a PES intervention on its target variable(s) occurring outside its spatial scope of action. Leakage belongs under the larger umbrella of so-called spillover effects of an intervention, occurring on people, places, or processes other than those directly targeted, which may also contain motivation crowding (see above), as well as magnet and rebound effects (see below) (Pfaff & Robalino 2017).

The traditional PES leakage effect manifests itself from activity-reducing programs, such as forest conservation set-aside areas reducing agricultural expansion, compared to the baseline scenario. Agricultural workers engaged in this capped activity might move outside the PES program boundaries (i.e., spillovers to nonparticipants), as may also happen with mobile capital (financial, machinery, animals, etc.). This activity leakage can happen through a channel of direct input reallocation. A complementary channel would be through market prices for the agricultural outputs, which may rise locally due to the PES-induced supply shortfall.

How large is leakage? Many scenarios apply regarding the size of the project and its restrictions, the price elasticity on output and input markets (including land and labor), or ease of access to alternative lands. In general, we can identify sliding scales of economic and technological parameters determining leakage (Wunder 2008): The higher the value of the PES-restricted activity (e.g., soybeans or oil palm), and the more flexible the technological reaction to increased land scarcity, the higher the leakage effects may be. For restricting access to log valuable tropical timbers in Bolivia's Noel Kempff project, leakage was estimated in the (vast) 2–42% range, depending heavily on assumptions about demand elasticities (Sohngen & Brown 2004). For the US Conservation Reserve Program, retiring marginal agricultural land for conservation purposes, leakage estimates have ranged from 4% (Fleming 2010) to 14–20% (Wu 2000).

In summary, leakage is indeed a concern but often difficult to quantify precisely. Leakage has been a main recent argument against subnational REDD+ and other forest carbon projects to mitigate climate change, with jurisdictional approaches that would allegedly address climate problems at larger and more holistic scales being preferred. However, as the Conservation Reserve Program estimates indicate, for setting aside low-return agricultural or forested land, we should not expect huge leakage, and thus also not become paranoid about leakage as a game-changing parameter. Sometimes leakage effects could reinforce the targeted ES effect: When PES programs are asset-building, e.g., a labor-demanding forest plantation project, drawing labor out of other, potentially degrading activities could ease environmental pressures and lead to further forest gains.

Finally, a PES-specific form of on-farm leakage occurs when contracts are made for only part of a landholder's or a community's lands, so that pressures can be shifted to nonenrolled sections. This has been observed especially for community-level PES programs, e.g., in Mexico (Alix-Garcia et al. 2012) and Peru (Giudice et al. 2019). Having PES contracts cover the entire farm area may avoid this potentially nontrivial problem, though it may also increase costs.

5.4. Magnet and Rebound Effects

In the family of spillovers are two additional developmentally induced side-effects of higher incomes generated by PES: magnet and rebound effects. Magnet effects occur when the spending on PES raises incomes locally, thus attracting migrants from outside (Wittemyer et al. 2008). If PES are asset building, e.g., for the aforementioned tree-planting example, incremental employment generation could further contribute to immigration pressures or curb past out-migration. With more people locally present, pressures on the environment may also accelerate. A second income spillover can occur through rebound effects: When PES recipient households face higher net incomes (payments minus ES provision costs), the secured income flow could ease credit constraints and expand consumption and land use. Alix-Garcia et al. (2012) found a small effect for Mexico's national PES program: 4% for all spillover effects combined.

In practice, most PES programs do not face large magnet or rebound effects, principally because their impacts on recipient incomes is small, though typically positive (see below). But what if these income gains were large instead? Alix-Garcia et al. (2013) looked at Mexico's Oportunidades poverty-alleviation program of conditional cash transfers, finding it had (counterfactually assessed) raised recipients' household income by one-third. Household consumption of meat (+29%) and milk (+23%) rose proportionally vis-à-vis baseline in response, causing 15–33% incremental deforestation. This cautions us that PES programs with large poverty-alleviating effects could potentially also have large consumption-led rebound effects on their environmental targets.

5.5. Solid Proxy-Environmental Service Linkage

Ideally, ES users would pay directly for impacts (actual ES delivery), rather than outcomes (land-use proxies); cf. **Figure 1**. This would minimize their risk of not getting what they paid for (Ferraro 2011). But landholders often cannot manage their land in ways that guarantee ES delivery. Hydrological services, in particular, are often enjoyed downstream at large distances from upstream management. Moreover, natural variations (e.g., fluctuating weather) make it difficult to determine the ES impacts and to attribute them to land management or even to know for sure whether ES delivery has improved through PES-induced land use changes. One option is to use hydrological models such as SWAT or InVEST to simulate this linkage to water supplies (Pagiola et al. 2019).

Payments for actual service delivery may be practical for forest carbon sequestration—being proportional to biomass—and some cases of biodiversity conservation, for example, a PES program in Cambodia that pays local communities to protect the nests of threatened bird species (Clements et al. 2013).

5.6. Permanence

A key concern of PES programs is whether their effects persist when the programs end, i.e., whether the effects will be permanent.[9] The logic of PES suggests that once payments cease, forests would likely no longer be conserved, as they would once again be less profitable than alternative uses (see **Figure 2*a***).[10] Conservation-focused PES programs try to make PES contracts renewable, yet loss of funding may mean that payments, in fact, cease. One single empirical study

[9]The term permanence originates from the carbon sequestration literature.

[10]The exception is when PES have caused strong motivational crowding-in (see above), they have bought enough time for context conditions to turn more conservation friendly, e.g., through higher rural wages, and/or more modern agricultural technologies make conversion of productively marginal lands uninteresting.

examined permanence from a randomized controlled trial evaluating a PES conservation program implemented in Uganda from 2011 to 2013. Jayachandran et al. (2017) found that the program had reduced deforestation substantially. The follow-up study using satellite imagery from 2016 found that—as predicted—former PES recipients had resumed deforesting at similar rates to control group members once payments ended (World Bank 2018).

When PES are used as an adoption subsidy for environmentally friendly practices that are profitable for landholders (**Figure 2*c***), on the other hand, adoption should persist after payments end. Here, too, there has been a dearth of empirical studies, but some existing studies found that the silvopastoral practices adopted thanks to PES at sites in Colombia and Nicaragua had been retained four years after payments ended (Pagiola et al. 2016, 2017).

5.7. Welfare Effects

Many PES programs have not only environmental but also welfare-related objectives, which in PES start-up and design decisions might even have been politically dominant (Rosa da Conceição et al. 2015, 2018). Whether intentional or not, PES typically produce livelihood outcomes, such as changes in incomes, employment, and assets and subsequently welfare/equity impacts (cf. Section 2 and **Figure 1**). Although our main focus here is on environmental effects, the socioeconomic, potentially poverty-alleviating outcomes from PES are especially of great interest in developing countries.

Conceptually, we distinguish between livelihood effects on PES participants and nonparticipants. For most small and medium-sized PES programs, participant effects on ES providers will dominate. But to what extent can poor land stewards actually participate (Pagiola et al. 2005, Wunder 2008)? Many disadvantaged landowners live remotely in agriculturally marginal, yet environmentally sensitive, ES-rich areas (e.g., upper watershed, protected-area buffer zones). This combined endowment essentially constitutes a propoor PES filter. But corresponding antipoor participation filters apply if their land tenure is insecure or if atomized tiny landholdings exhibit little land-use flexibility, and high transaction costs for ES buyers to enroll them into PES programs. Notwithstanding, PES programs may be customized or targeted to enhance propoor participation, propoor benefits, or more generally toward locally perceived equity (Mahanty et al. 2013). Perceived equity in PES may also become a legitimacy precondition for achieving environmental efficiency (Pascual et al. 2014).

Once enrolled, PES voluntariness has us expect propoor benefits for participants: Whoever was to lose out would seemingly have self-exited the PES contract. On the other hand, ES buyers tend to organize PES schemes and have dominating market power, so that outsized payments to the ES provider would be surprising (Bulte et al. 2008). Poor ES users could also gain much from PES, e.g., poor urban water consumers achieving a cleaner, safer water supply (Wunder 2008).

Finally, derived welfare effects on nonparticipants can come to work through output or factor markets. For instance, poor landless charcoal makers or illegal timber harvesters may lose out from land-diverting, activity-restoring PES programs. Conversely, the landless may benefit from working-land, asset-building PES such as improved agriculture or tree-planting programs (Wunder 2005, Zilberman et al. 2008).

Empirically, two recent systematic reviews basically confirm our conceptually substantiated expectations. A quantitatively focused survey of strictly rigorous impact evaluations by Snilsveit et al. (2019) found mixed, yet predominantly small positive effects on ES providers' household incomes; seven of only eight studies considered rigorous were from China. They concluded: "it is plausible [PES] led to an increase in overall household income." Blundo-Canto et al. (2018) cast their net wider toward qualitative assessments, including 46 studies. Again, they found on average more positive than negative, but typically numerically small effects, also depending on the selected livelihoods indicator (incomes, consumption, assets). While 26 of these studies used some sort of counterfactual scenario, many lacked solid data on landowner opportunity costs, leaving the overall results highly tentative.

6. ENVIRONMENTAL IMPACTS

6.1. Recent Systematic Reviews of Forest Impacts

Given our theory of change, assumptions, and impact pathways discussed above, how well have PES programs been performing in terms of achieving their environmental targets? In this section, we concentrate on forest-cover effects, which have been the dominant target for PES schemes. Although various PES meta-studies have been conducted in the past, only the most recent systematic reviews contain rigorously, counterfactually evaluated impacts. Pattanayak et al. (2010) could only identify six studies with rigorous forest-cover results, all from either Costa Rica or Mexico, and called urgently for more impact evaluations. Samii et al. (2015) found nine studies from four PES programs that satisfied their stringent methodological criteria for rigor, again all in Costa Rica or Mexico. Obviously, such an extremely narrow empirical base raises serious questions about the external validity of the systematic review. Still, they concluded that PES programs had, on average, reduced annual deforestation rates by 0.21 percentage points. "The effect is modest however and seems to come with high levels of inefficiency," which, to the authors, was one of several "troubling findings" (Samii et al. 2015).

In a recent follow-up systematic review, Snilsveit et al. (2019) extended the sample to 11 studies in eight countries, with a slightly higher average effect size than Samii et al. (2015), but a large variation across cases. Their conclusions remained pessimistic:

> Despite the hundreds of millions of dollars dedicated to PES programmes over the last decades. . .we are unable to determine with any certainty if these are worthwhile investments. [O]ur review suggest reasons to be cautious about investing in the implementation of PES programmes. . .we do not know whether PES programmes do in fact achieve desired environmental. . .outcomes.

Paul Ferraro (2011, p. 1134), who played a key role in theoretical PES development at the turn of the millennium, concluded in a *Conservation Biology* editorial that "greater use of PES is unwarranted unless new or expanded systems are designed explicitly to measure PES's environmental and social effects and to explore competing notions of effective contract design." He also believed that the limited rigorous evidence may still contain upward (confirmation) biases: The methodologically most solid study (Alix-Garcia et al. 2015 on Mexico's PES) finds very low forest impact, yet high poverty alleviation effect, thus reconfirming a familiar trade-off (Ferraro 2018). However, as we argue below, the evidence base for other conservation interventions is similarly thin.

6.2. A Fresh Comparative Look

In **Figure 4*a***, we summarize results for PES impact evaluations, as found in a new systematic literature review of multiple conservation instruments (Börner et al. 2020). We show normalized effect sizes, using Cohen's *d* as an indicator,[11] and rank our 19 studies from 8 countries accordingly. The

[11]Unfortunately, to replicate the effect size indicators used in Samii et al. (2014) and Snilsveit et al. (2019), we would have needed (but lacked) background data about several studies, which would have limited our sample more.

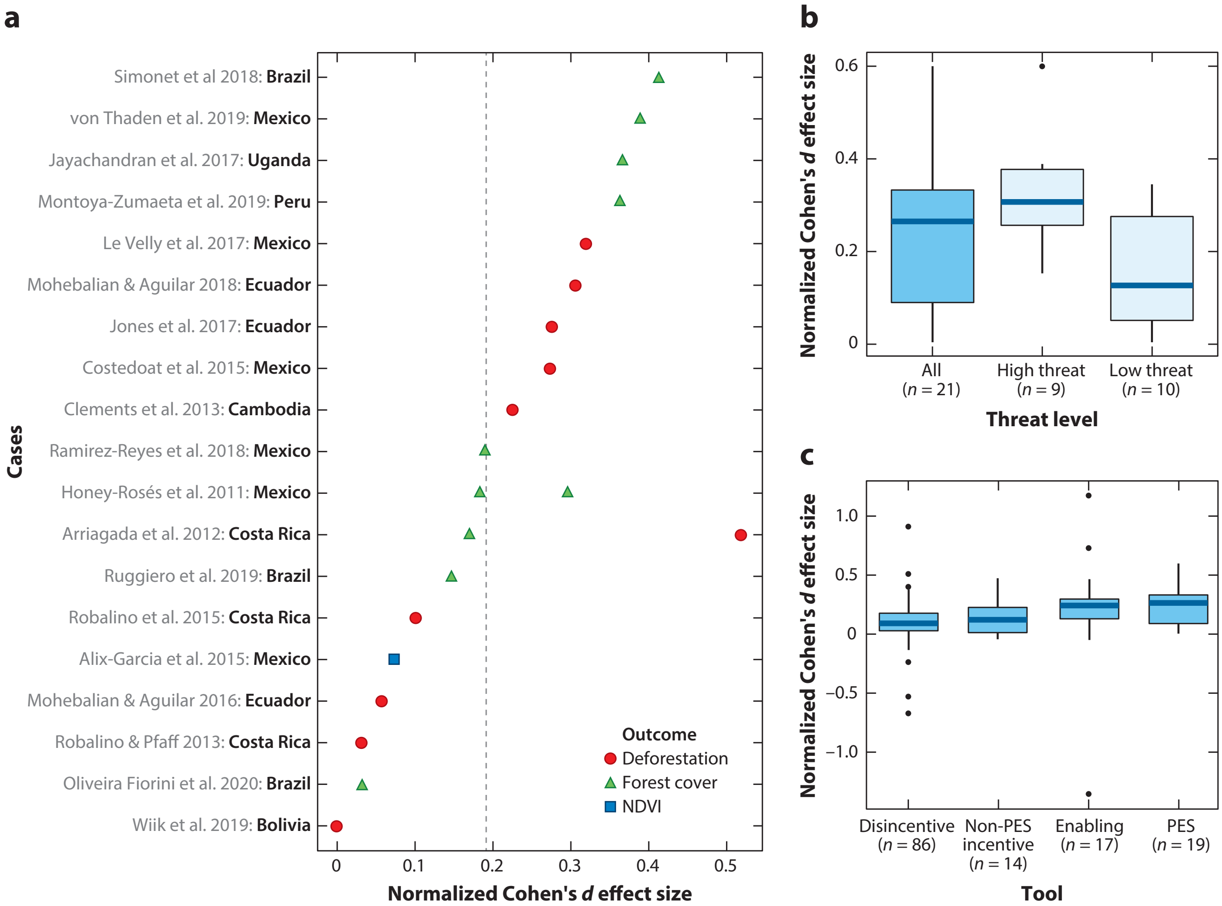

Figure 4

Payments for environmental services (PES)-evaluated impacts on forests. (*a*) PES cases (dashed line indicates sample average value), (*b*) threat level (high versus low deforestation), and (*c*) PES vis-à-vis other tools. Abbreviation: NDVI, normalized difference vegetation index.

first impression is that of large variation between countries and programs, but also within programs. Although all three estimates for the Costa Rican PSA are unsurprisingly located below the overall average (vertical line), the four estimates for the Mexican PSA rank from the fifth-lowest (Alix-Garcia et al. 2015) to the second-highest (von Thaden et al. 2019) estimate in the sample. Similarly, the three estimates for Ecuador's Socio Bosque Program vary greatly, even though two of them are by the same analysts (Mohebalian & Aguilar 2016, 2018).

In decomposing this variability, the forest indicators used—forest cover, deforestation, and normalized difference vegetation index (NDVI)—can also cause differences. Different methodologies for impact assessment can yield systematically different averages and standard deviations (Börner et al. 2020). Finally, we should remember that national and regional estimates are mixed together here, where some regions will face higher threats than others. For instance, Alix-Garcia et al. (2015) found impacts of Mexico's PES program to be insignificant at a national level but significant in selected high-threat areas. The fact that threat levels can make a large difference is indicated in **Figure 4*b***, comparing the results according to a source-based classification of high- versus low-threat scenarios:[12] If there is large deforestation pressure, a PES program has an enemy to work against, so it also becomes easier to obtain high forest impacts. In spite of the small sample, it is noteworthy that slightly more are low-threat ($n = 10$) than high-threat ($n = 9$) scenarios. Arguably, this illustrates that administrative site selection has been problematic: to date, the low-hanging fruits of low-pressure scenarios often seem to have been preferred for PES implementation.

Finally, taking advantage of data from Börner et al. (2020) on other conservation tools, we would like to place the statements in the beginning of this section into perspective: If there is shockingly little evidence about PES impacts, and the little available is troublingly disappointing, what is the outlook for other conservation tools? In **Figure 4*c***, following Börner & Vosti (2013) we grouped instruments into PES, other non-PES incentives (e.g., certification, ICDP), disincentives (protected areas), and enabling measures (e.g., decentralization, land reform).

As we can initially see from the observation count, the 19 impact evaluations for the single-instrument PES rank second behind protected areas (Börner et al. 2020) and higher than the umbrella categories other incentives and enabling measures, respectively. Looking at effect sizes, PES actually have the highest average among the four groups. The differences are obviously quite small, samples are small, and distributions are skewed, but for what it is worth, at least we observe that statistically (using both ANOVA and the one-sided t-test), PES average impacts are significantly higher than those of disincentives, i.e., protected areas. Surely, this beauty contest of conservation impact evaluations is still not a pretty sight, as Ferraro & Pattanayak (2006) had already warned us, but for now PES might just aspire to be crowned as the least ugly of the listed candidates.

7. CONCLUSIONS AND DISCUSSION

In this review of PES, we attempted to use a theory of change to make explicit the intervention's logic, to explain how inputs, design, and contexts could become compatible with successful environmental results and, conversely, to identify the alleged PES killer assumptions: What things most frequently go wrong with PES?

Ferraro (2018) and James & Sills (2019) have all recently elaborated similar lists with perceived weaknesses of PES, identifying seven combined critical factors, which we discuss here for a comparative angle on our findings, starting with the ones we also highlight.[13]

1. Adverse self-selection of participants: This may indeed be the biggest problem faced by PES. It is easy to get an "anyway" participation bias that inflates "hot air," especially perhaps when addressing a creeping, spatially mobile problem such as deforestation. However, this is not a problem for PES alone, as other voluntary conservation tools (REDD+, certification, etc.) face the same dilemma. Effective targeting vis-à-vis predicted threats, ES density, and possibly cost levels are potential remedies.
2. Poor administrative targeting: We agree with Ferraro (2018) that public PES schemes, in particular, are often born with strong nonenvironmental political economy motives (e.g., Rosa da Conceição et al. 2015) and tend to have multiple goals with overloaded objective functions (Alix-Garcia & Wolff 2014). One problem is that many PES programs, just like protected areas, have been disproportionally located in high-and-far places featuring low-pressure scenarios. To some extent, this may represent an understandable choice for first-generation PES implementers looking for local proof of concept. However, by now,

[12] We excluded here ambiguous/nonclassified cases.

[13] We made slight adjustments in their terminologies to fit with ours.

it seems an imperative for policy makers and PES implementers to increasingly move beyond the low-hanging fruits. Yet, that requires that available ES funding suffices to pay for the higher landholder costs of ES provision in high-threat areas (cf. point 1). Many PES proponents may realize that scenarios of intermediate threats and opportunity costs (e.g., with moderate returns to converted land uses) are where PES can be most cost-efficient (Wunder 2005).

3. Noncompliance: A PES scheme without contract compliance is like a car without wheels: Without its bare essentials, it will go nowhere. It is a major worry that so many PES schemes never seem to use sanctions. Trying to receive PES while not complying (moral hazard) can in many cases be a rational strategy, thus undoubtedly reducing additionality, as we can see in various remote-sensing assessments. Again, though, similar compliance problems are reported in the literature for other incentive-based conditional tools (REDD+, certification), as well as regulatory ones (protected areas, land-use regulations).
4. Leakage: Perhaps this is not a factor that scores high on our list. For the things that PES can realistically buy out (itinerant agriculture, low-yield cash crops, extensive pastures), leakage rates are probably not very high. There is one exception: on-farm leakage implied by only enrolling portions of properties could depress additionality significantly, e.g., in community contracts, if pressures can be moved in principle to other parts of the land. Writing contracts to cover the entire farm area may remedy this problem.
5. Credit/rebound effects: Does new PES wealth unleash credit access and new environmental pressures from PES recipients? Generally not, we believe, since typically the income gains from PES are just insufficient to power up this effect. Obviously, there are exceptions where poor PES recipients have seen large increases in income and where these effects might in principle play out.
6. Motivation crowding: This is an analytically complex issue, but increasing empirical work seems to show us that it is seldom a very relevant problem for PES implementation: In the market-penetrated setting where PES is normally applied, people usually feel environmentally motivated from receiving payments. Cases of crowding in seem just as likely as crowding out. But, being aware of contexts and PES design issues cannot hurt.
7. Paying for (perhaps wrong) proxies, not ES delivery: We believe paying for ES delivery is often not possible (e.g., for watershed services, the most dynamic PES field today). And considering where it is, ES buyers may be better positioned than ES providers to assume the ES provision risks when nature is not well-behaved, i.e., when ES delivery fluctuates over time due to external factors.

In summary, we agree with Ferraro (2018) and James & Sills (2019) on three of their critical PES implementation issues: adverse self-selection, poor administrative targeting (at multiple scales), and noncompliance. Jointly, they may also explain quite well why we are not seeing larger PES environmental impacts on average. However, a meaningful performance assessment needs to be comparative: Are other environmental conservation tools free of the described problems? Do they achieve better scores on our impact assessment scales? If not, should we then just stop investing at all in conservation?

With respect to past performance and pending potentials, another weighty shortcoming refers to all the PES schemes that could have emerged, but never did: What preconditional factors can lead to PES termination in its incipient stages? In an increasingly full world of humans occupying ecosystems with their growing ecological footprints, with deepening conflicts and complex externalities, the potential for PES-type negotiated solutions will arguably only go up in the future. The question is: Why have more PES programs not emerged until now?

We believe two major restrictions to PES establishment may be at play. First, land-tenure insecurity, especially in tropical forest frontiers, continues to jeopardize PES-type solutions there, because land stewards have no effective right to exclude third parties, and thus the ability to act as effective ES providers. Second, the limited willingness/organizational capacity to pay for the ES they need restricts many potentials for PES initiatives: Humans tend to free-ride and often wait for the state to step in on their behalf to pay for positive externalities. Despite the rugged record of government-led PES schemes in terms of design and implementation errors, their ability to organize collective payments at scale and to intelligently bundle them into complex policy mixes may be important future arguments in their favor.

DISCLOSURE STATEMENT

S.P. has been involved in helping to design, implement, and evaluate numerous PES programs. The other authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

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