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What happens when the money runs out? Forest outcomes and equity concerns following Ecuador's suspension of conservation payments



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ABSTRACT

Payments for Ecosystem Services (PES) are now a prominent policy instrument for conserving tropical forests. PES are voluntary, direct, and contractual: an ES buyer pays an ES steward for adopting conservation practices for a fixed term. A defining feature of PES is its 'quid pro quo' conditionality, e.g. stewards are paid only if they deliver contracted conservation outcomes. Most studies on PES effectiveness focus on the *steward's* compliance with contract conditions. By contrast, the *buyer's* compliance has received scant attention despite the fact that PES programs across the globe have delayed payments, suspended re-enrollment, or shut down altogether. 'Use-restricting' PES depend on the continued flow of funding to pay for conservation; however, institutional, political, and economic factors can disrupt or terminate PES funding. What happens when the PES money unexpectedly runs out? Do stewards continue to conserve or revert to their former practices? We use mixed methods to study equity concerns and forest outcomes of an unexpected, two-year interruption in conservation payments to 63 private landowners residing in Ecuador's Amazon and enrolled in the Socio Bosque program, compared to similar landowners who did not enroll. Using quasi-experimental methods, we found that during the payment suspension period enrolled properties did not maintain their conservation outcomes where deforestation pressures were high (e.g. close to roads). Where deforestation pressures were low, enrolled properties continued to conserve more, on average, than similar properties not enrolled. Findings from 40 interviews and 26 focus groups conducted before, during, and after the payment suspension exposed profound landowner uncertainty regarding their contract rights. Poor official communication and imbalanced PES contract terms reinforced power inequalities between the state and rural ES stewards. Our work highlights the need to plan for financial volatility and to protect participants' rights in PES contract design.

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1. Introduction

Payments for Ecosystem Services (PES) are now a prominent policy instrument used to protect or enhance the provision of environmental services, particularly in Latin America (Ezzine-De-Blas, Wunder, Ruiz-Pérez, & Del Pilar Moreno-Sanchez, 2016). PES are voluntary, direct, and contract-based: an ecosystem service (ES) buyer (often the government) directly incentivizes or rewards an ES steward (usually a landowner) for adopting conservation practices for a fixed term (Wunder, 2005). While there has been exten-

sive debate on how to define PES, many scholars agree that a defining feature is 'quid pro quo' conditionality—e.g. ES stewards are paid only if they comply with their contracted conservation obligations (Wunder, 2015). Most studies on the effectiveness of PES focus on forest outcomes (Börner et al., 2017; Calvet-Mir, Corbera, Martin, Fisher, & Gross-Camp, 2015; Snilstveit et al., 2019), or the *steward's* compliance with contracts (Ezzine-De-Blas et al., 2016; Honey-Rosés, López-García, Rendón-Salinas, Peralta-Higuera, & Galindo-Leal, 2009; Wunder et al., 2018). By contrast, the *buyer's* compliance is not addressed despite the fact that PES programs across the globe have delayed payments, suspended re-enrollment, or shut down altogether.

Incentive programs often end and contracts are not renewed when institutional priorities shift and/or funding becomes insufficient (Dayer, Lutter, Sesser, Hickey, & Gardali, 2018; Jayachandran,

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De Laat, Audy, Pagiola, & Sedano Santamaria, 2018). Worse, PES may falter mid-contract if funds for payments suddenly dry up. For example, in Mexico, a watershed PES program in Veracruz, *Programa de Servicios Ambientales de la Cuenca del Río Pixquiuc*, delayed payments to landowners during 2010–2011 (Muñoz, 2012). In 2017, budget cuts reduced funds for Mexico's national PES program, CONAFOR, by > US\$34 million, and the enrolled area fell from 600,000 ha to <170,000 ha (Jayachandran et al., 2018). In Brazil, a 12% budget cut to the Ministry of the Environment resulted in the dismantling of the *Bolsa Verde* program in 2018 (Angelo, 2018; Guerra, 2018). The *Suruí Forest Carbon Project*, launched in 2009 in Brazil as the first indigenous-led PES financed through the sale of carbon offsets, was suspended in 2018 when large gold deposits were discovered in the Paiter-Suruí territory (Bebbington, Verdum, Gamboa, & Bebbington, 2018; Zwick, 2019). *Proambiente*, another Brazilian federal program launched in 2003, stopped conservation payments after only six months due to financial issues (G. Simonet, personal communication, Oct 9, 2018). With more than 550 active PES programs contracting with individuals and communities across the globe (Salzman, Bennett, Carroll, Goldstein, & Jenkins, 2018), PES participants' responses to these unexpected events deserve attention. What happens when PES money unexpectedly runs out mid-contract? Do PES participants revert to their former practices or continue to conserve? And what are the equity implications of suspended payments for PES program participants, who suddenly stop receiving payments despite their compliance with contractual obligations?

Despite the rapid growth of PES literature (Börner et al., 2017), research on post-PES outcomes in the tropics is lacking. Some scholars have begun to test for the permanence of conservation outcomes in the few PES projects that have reached their planned cessation (Calle, 2020; Jayachandran et al., 2018; Pagiola et al., 2016, 2020). No research to our knowledge has been published on the effects of an *un-planned* interruption in payments on individuals' conservation behavior. This is problematic for several reasons. First, by design, PES that limit stewards' use of natural resources depend on the continued flow of funding to ensure the permanence of conservation gains. Any instability in payments could lead to a reversal of induced land changes. Second, in the tropics, most large PES programs are financed by governments, often with funding from multilateral or bilateral donors, with the state playing the role of PES buyer (Ezzine-De-Blas et al., 2016). Implementing government agencies are subject to a variety of political and economic pressures from competing constituencies and government factions that can result in institutional and economic instability (Engel, Pagiola, & Wunder, 2008; Karsenty & Ongolo, 2012). Additionally, most such agencies have limited funding horizons for conservation (da Conceição, Börner, & Wunder, 2018). These institutional, political, and economic factors may put national PES funding at risk. Third, external sources of PES funding may decline when international pledges and promises fail to materialize. Last, many PES programs in the tropics aim to simultaneously achieve environmental conservation and poverty reduction goals and thus target enrollment of poor landowners in their programs (Grieg-Gran, Porras, & Wunder, 2005). Such participants are unlikely to have the legal resources to protect their rights in the event of non-payment. Reversing (or threatening to reverse) their contracted conservation activity may be their only instrument of leverage or recourse.

Here we study the deforestation outcomes and stewards' experiences of an unexpected, two-year interruption in PES payments in Ecuador. We take a mixed methods approach and draw from our multi-year engagement with local communities involved in a national PES program at our study site. To quantify the impact of the payment suspension on forest cover, we analyze remotely sensed forest change data using a matched sample of enrolled

and non-enrolled properties and a linear fixed effects panel regression. We then connect this analysis with qualitative fieldwork before, during, and after the suspension in payments to yield insights on official policy and public communication during the suspension, and how the lapse in payments affected landowners' land use decisions and their attitudes toward the implementing agency. We conducted focus groups with landowners at our study site before and during the payment suspension. We then used our quantitative analysis to guide the selection of communities as focus group sites after the payment suspension, aiming to include those that experienced an increased rate of deforestation during the suspension relative to the prior period with payment (2011–2014), and those with deforestation rates that remained unchanged or similar to the prior period. We also interviewed staff of the implementing PES agency and other environmental groups.

2. Issues of PES additionality, permanence, and equity

Concerns about the aftermath of PES projects have accompanied PES scholarship since its inception. Scholars have posited that the continuation of payment-induced conservation should not be expected once payments stop (Engel et al., 2008; Swart, 2003), and that the persistence of such behavior in the absence of payments may reveal 'wasted' or poorly targeted conservation investments (Ferraro & Pattanayak, 2006; Pattanayak, Wunder, & Ferraro, 2010). Achieving additionality is considered the gold standard for PES: payments ought to induce behavior change that would not have occurred without the financial incentive (Tacconi, 2012; Wunder, 2005). Permanence, on the other hand, is the ability of PES-induced land use changes to persist over the long-term after payments end (Calle, 2020; Pagiola et al., 2016, 2020; Wunder, 2008). Additionality and the possibility of permanence are expected to work in different ways for 'asset-building' and 'use-restricting' PES. Asset-building PES pay landowners to establish or restore an ES by adopting environmentally-beneficial practices that are also profitable, e.g. silvopastoral practices (Calle, 2020; Pagiola et al., 2016, 2020; Wunder, 2005). These programs typically achieve additionality through short-term payments that help landowners overcome the initial economic obstacles to implementing the desired practice, e.g. tree planting. For asset-building PES, continuous payments may not be required to deliver long-term conservation outcomes (Calle, 2020). By contrast, use-restricting PES use financial incentives to achieve additionality by paying landowners for restricting their use of a resource, e.g. protecting forests. Use-restricting schemes typically rely on long contract periods (e.g. 10+ years) to ensure landowners sustain PES-induced conservation behaviors over the long term (Wunder, 2005). These two features—restricting resource use and requiring lengthier term contract commitments—makes the permanence of 'use-restricting' PES conservation gains more dependent on the continued flow of funding (Engel et al., 2008).

Thus far, scholars interested in the persistence of PES-induced conservation practices after payments reach their contracted endpoint have largely relied on PES participants' stated behavioral intentions rather than actual participant behavior (Dayer et al., 2018; Swann & Richards, 2016). The majority of these studies have focused on conservation incentive programs based in the United States—e.g. riparian buffer vegetation, agriculture conservation practices, etc.—especially the Conservation Reserve Program. Reported persistence intention rates vary widely, ranging from 31 to 85%, and are shaped by context and conservation practice (Dayer et al., 2018). Drawing on insights from these studies in non-tropical contexts and study results on home energy use and public health, Dayer et al. (2018) identify various pathways by which PES participants could be expected to continue conservation

practices after payments end. Participants are more likely to continue the behavior if they perceive the program to be a success; or they enroll for reasons other than financial gain; or they have sufficient financial resources to overcome opportunity costs associated with the conservation behavior. Post-payment persistence is also theorized to be more likely when the conservation practice is simple and becomes habitual and easier to perform over time. Conversely, others have argued that for use-restricting PES, persistence of behavioral changes cannot be expected to continue without payments, given the underlying logic that payments are supposed to compensate ES stewards for foregoing environmentally-damaging practices (Engel et al., 2008). For example, forest conservation PES participants facing high deforestation pressure would be expected to revert back to their pre-PES land use practices once payments end. Any continuance of PES-induced practices after payments have ceased may indicate a PES program's lack of additionality (Ferraro & Pattanayak, 2006).

Only recently in the tropics have some PES projects reached their scheduled end, providing opportunities to empirically study the permanence of PES-induced conservation outcomes post-program completion (Calle, 2020; Jayachandran et al., 2018; Pagiola et al., 2016, 2020). In Nicaragua and Colombia, the *Regional Integrated Silvopastoral Ecosystem Management Project* used short-term payments from 2003 to 2007 to induce landholders in two cattle ranching landscapes to adopt silvopastoral practices on degraded pastures (Calle, 2020; Pagiola et al., 2016, 2020). In both countries, four years after the PES program's completion, landholders maintained the environmentally beneficial land use changes they adopted while under the program, but did not expand these post-payments (Pagiola et al., 2016, 2020). Eight years after payments ceased, Colombian participants still maintained more tree cover compared to the baseline (Calle, 2020). These findings suggest that asset-building PES programs that provide an early financial boost to support income-generating activities, such as agroforestry, can trigger conservation behaviors that persist after payments end.

The sole study to date of the post-program permanence of a use-restricting PES looked at post-program deforestation rates in both control and treatment villages in western Uganda. Implemented as a randomized control trial of PES, the two-year Ugandan forest conservation PES program randomly assigned eligible participants to measure the causal impacts of the program on tree cover. During the program's payment period, PES reduced tree loss by half in the treatment group compared to the control group (Jayachandran et al., 2017). Three years after payments ended, program graduates had resumed deforestation, though at a slower rate than control households (Jayachandran et al., 2018). This result aligns with the expectation that use-restricting PES involve offsetting the opportunity costs of conservation, and thus sustaining these behaviors should be financially difficult for landowners without payments. Another possibility is that payments are necessary only in certain periods (e.g. during surges of deforestation) and that persistence post-payment is not evidence of 'wasted' conservation investment. Put simply, we need more assessment of outcomes associated with PES after payments have ended.

Analyzing post-PES impacts is especially important when PES participants have faced *unanticipated* interruptions or cessation in payments mid-contract. Suspended payments can have equity implications for participants. Scholarship on PES and equity distinguishes between three dimensions: the distribution of costs, risks, and benefits (distributive equity); participation in decision-making (procedural equity); and distribution of access, capabilities, and power (contextual equity) (Corbera, Brown, & Adger, 2007; McDermott, Mahanty, & Schreckenber, 2013; Pascual et al., 2014). Here we focus on contextual and distributive equity. Socio-political and economic disparities such as power dynamics,

economic resources, and transparency of information, can affect participants' ability to lobby for fair distribution of burdens (McDermott et al., 2013; Pascual et al., 2014). In contexts where the ES buyer is more powerful than the seller—such as when a government acts as the PES implementing agency and rural landowners as recipients—a PES contract may inequitably distribute the burden of a contract violation: participants are penalized when they fail to meet their contracted conservation requirements but no such penalization occurs when the state does not fulfill its payment obligations on time. Powerful ES buyers can poorly communicate and/or monopolize access to critical information regarding funding sources and constraints and thus limit participants' ability to assess risks related to their land use choices. Power relationships and access to information shape actors' ability to benefit from PES (McDermott et al., 2013). Given the global prevalence of PES, understanding the potential impact of funding volatility is key to designing use-restricting PES programs that are both effective for conservation and equitable for ES stewards.

3. PES in Ecuador amid financial turbulence

Launched in 2008, Ecuador's national government-run Socio Bosque (SB) program aims to reduce deforestation and alleviate poverty (de Koning et al., 2011). Designed as a contract-based reward¹ for conservation and administered by the Ministry of the Environment (MAE), SB pays landowners who voluntarily commit to conserve forests on their properties for 20 years (MAE, 2012). To date, SB has enrolled >1.6 million hectares of land through 2681 contracts, including ~175,000 beneficiaries and spanning ~15.4% of Ecuador's territory (MAE, n.d.; SB (Socio Bosque) (Socio Bosque), 2019). Approximately 84% of total enrolled land consists of tropical moist forest (MAE, n.d.).

To participate, landowners must have formal title to their land. Participants select which parts of their land to enroll, and the 20-year contract is renewable upon completion (MAE, 2012). Participants are paid a yearly incentive in two installments, in May and October. The incentive amount is scaled based on the area they enroll. Participating private landowners receive US\$30/ha/year for the first 50 ha of enrolled land, US\$20/ha/year for 51–100 enrolled hectares, etc. (MAE, 2012). Payments are conditional on landowners protecting their enrolled land from logging, clearing, burning, non-subsistence hunting, agriculture, grazing, the introduction of non-native species, or any activity that might adversely affect biodiverse forest. Monitoring of contract compliance is conducted by the Quito-based SB central office via remote sensing, with follow-up field visits of sites flagged during the remotely-sensed analysis. The rigor and consistency of such monitoring, however, has also proven vulnerable to fluctuations in program funding (interview with MAE official, 2017). Each time a participating landowner is found in violation of the contract, they lose one payment. If the violation is caused by a third party, the landowner must report it within five days or be subject to the same loss of payment. The SB contract follows a 'three strikes and you're out' principle: if a landowner accumulates three consecutive violations, SB terminates the contract, and the landowner is required to pay

¹ Ecuador's SB leaders do not identify the program as a PES initiative given that it does not establish a price or pay for a specific environmental service. Rather, SB provides a financial incentive to landowners who voluntarily commit to conserving an area of land that generates an environmental service. In the PES literature, it is now generally accepted that the environmental services targeted by PES are rarely well-defined, and PES compliance and conditionality are typically based on resource management proxies—such as forest conservation—rather than environmental services proper (Wunder, 2015). For this reason, and to contribute to the broader PES literature, in this paper we refer to the SB program as a PES project. Others have referred to SB as a "direct payments for conservation program" (de Koning et al., 2011), or a "forest conservation incentive" (Jones et al., 2017).

back a percentage of the payments received since the start of the contract. Termination within the first five years requires the participant to repay 100% of payments received; termination within years 6–10 requires 75% payback, and so forth (MAE, 2012). Participants may voluntarily exit the contract but are subject to the same penalty and payback rules. However, the contract does not address participants' rights in the event of noncompliance, i.e. nonpayment, by the implementing agency. In fact, the contract states that MAE can end the contract at will (MAE, 2012; Section 9.4).

The average annual program costs for SB range between US \$11–12.5 million, with 95% of funds going directly to pay participants (Gordillo, Elsasser, & Günter, 2019; Lascano, 2015). Over US\$50 million have been invested in SB, largely financed through direct national budget allocations (~50–75%) and supplemented by international institutions (primarily from KfW, Germany's state-owned development bank) and private donors (Lascano, 2015; Ortiz, 2017). To increase international and private-sector funding, Ecuador has also included SB in its national REDD+ (Reduced Emissions from Deforestation and Forest Degradation) Action Plan² (Cuenca, Robalino, Arriagada, & Echeverría, 2018; Lascano, 2015; MAE, 2016).

In 2015, after a sudden collapse in global crude oil prices that took place in the fourth quarter of 2014 (U.S. Energy Information Administration, 2015), Ecuador plunged into a deep economic recession. Ecuador's growth rate, largely dependent on primary exports—especially crude petroleum—, declined from 3.8% in 2014 to 0.1% in 2015, and –1.2% in 2016 (The World Bank, n.d.). The fiscal crisis worsened in 2016 when a 7.8 magnitude earthquake struck the Ecuadorian coast. Emergency assistance and reconstruction costs topped US\$3 billion (International Monetary Fund, 2016). Amidst this financial crisis, the flow of conservation funds from Germany to Ecuador stopped due to diplomatic tensions between the two countries³, and Ecuador's National Environment Fund (FAN)—the non-profit institution responsible for investing and managing the country's conservation funds from international donors—closed and went through a re-structuring process (Ortiz, 2017). These events undermined SB's ability to pay participants. For some SB participants, the May 2015 payment arrived a few months late. By October 2015, SB officially suspended payments to all program participants and closed new enrollments. Most SB participants were without payment for two years, from Oct. 2015–2017. Even so, during this payment suspension period, SB continued its satellite monitoring to detect contract violation through deforestation and conducted informal and formal field inspections of some enrolled sites (interview with SB official, 2017).

Here, we assess the impacts to forests and to SB participants' perceptions of the program when payments stop. We expect the lapse in payments to reduce SB's protective effect on enrolled forests and thus increase deforestation on participating properties. Potential pathways include landowners' need to find other sources of income, reduced trust in SB and its ability to restart payments, and deforestation as a strategic tool to pressure SB to resume payments. A lack of information and deep uncertainty regarding contract obligations or payment resumption could also lead landowners to deforest. Alternatively, the lapse in payments may leave forests unaffected if participating landowners are not moti-

vated by money, or the duration of the suspension is short enough for participants to wait, or if SB's official communications give participants confidence that payment resumption will occur within an acceptable amount of time. We suspect these pathways are moderated by the relative remoteness of participating properties. Landowners with properties located closer to deforestation pressures are more likely to deforest than landowners with more remote properties (Jones et al., 2017).

4. Methods

4.1. Study area

Our study looks at private landowners with properties located around the Cuyabeno Fauna Production Reserve in Sucumbíos province in Ecuador's northeastern Amazon (see Fig. 1). Established in 1979, the Cuyabeno Reserve is one of Ecuador's largest and most important protected areas, with a total of ~600,000 ha (Mena et al., 2006). The Reserve and its adjacent lands contain lowland tropical forest (<300 masl) with interspersed areas of *terra firme*, interconnected lakes, and seasonally flooded wetland areas (Mena et al., 2006). Although it holds 'extraordinary' biodiversity (Valencia, Balslev, & Paz Y Miño, 1994), Cuyabeno's soil fertility has been described as 'poor' relative to other Amazonian sites in Ecuador (Guevara et al., 2017).

Here, we focus on landowners residing in a mixed-use buffer zone of protected forest located at the western boundary of the Reserve and classified as Patrimony Forest—a public land category that allows limited forest use (Holland et al., 2017; Mena et al., 2006). In 2009, landholders within Patrimony Forest were given the right to obtain legal titles to their land, but titles are issued with restrictions: 70% of a property's naturally forested area must be conserved; MAE must approve the sale of all properties; and these may never be subdivided (MAE, 2007) (see Holland et al., 2017). However, conservation rules in Patrimony Forest have generally been poorly communicated and erratically enforced, with the exception of the title restrictions pertaining to MAE approval for sale and no subdivision of properties. These particular restrictions are legally enforced; though, in practice, informal land subdivision occurs. More generally, enforcement of rules for forest use in the broader area has been inconsistent (Holland et al., 2017; Messina, Walsh, Mena, & Delamater, 2006).

Deforestation in the region was historically driven by an interplay of road expansion, petroleum extraction, agriculture, and national land settlement policies (Holland et al., 2014; Messina et al., 2006). The region's remoteness buffered the area from development until the 1970s, when the discovery of oil and its subsequent production rapidly expanded the road network and accessibility. National land settlement policies incentivized migrants fleeing drought and land shortages elsewhere to settle in the region, claim land, and put it to "productive use" (Acosta, 2001; Larrea, Larrea, & Bravo, 2009). Colonists, as the migrants were called, formed 'pre-cooperative' community settlements, informal organizations whose purpose was to legitimize land claims locally and facilitate collective decision-making around land allocation (Eberhart, 1998; Holland et al., 2017). Individuals within pre-cooperative communities manage their respective landholdings privately, with the majority of landholders (74.9%) in our study area holding legal titles. We studied 22 of these pre-cooperatives and 513 titled properties within them.

The mean annual deforestation rate for parcels around the Cuyabeno Reserve rose from an annual mean of 0.66% in 2001–2009 (before colonists in Patrimony Forest received titles to their lands), to 0.86% in 2010–2014 (post-titling) (see Holland et al., 2017). Deforestation rates on site were higher

² In 2019, Ecuador became the second country (following Brazil) to receive a REDD + results-based payment (totaling US\$18.5 million) from the United Nations Development Program's Green Climate Fund for having successfully reduced greenhouse gas emissions from deforestation in 2014 (United Nations Development Programme, 2019).

³ Ecuador temporarily halted its environmental cooperation agreements with Germany in December 2014 after German lawmakers attempted to visit Yasuní National Park—a site receiving German conservation funding—to observe oil operations and meet environmental groups opposing the oil extraction ("Ecuador halts environment deals with Germany over rainforest visits," 2014).

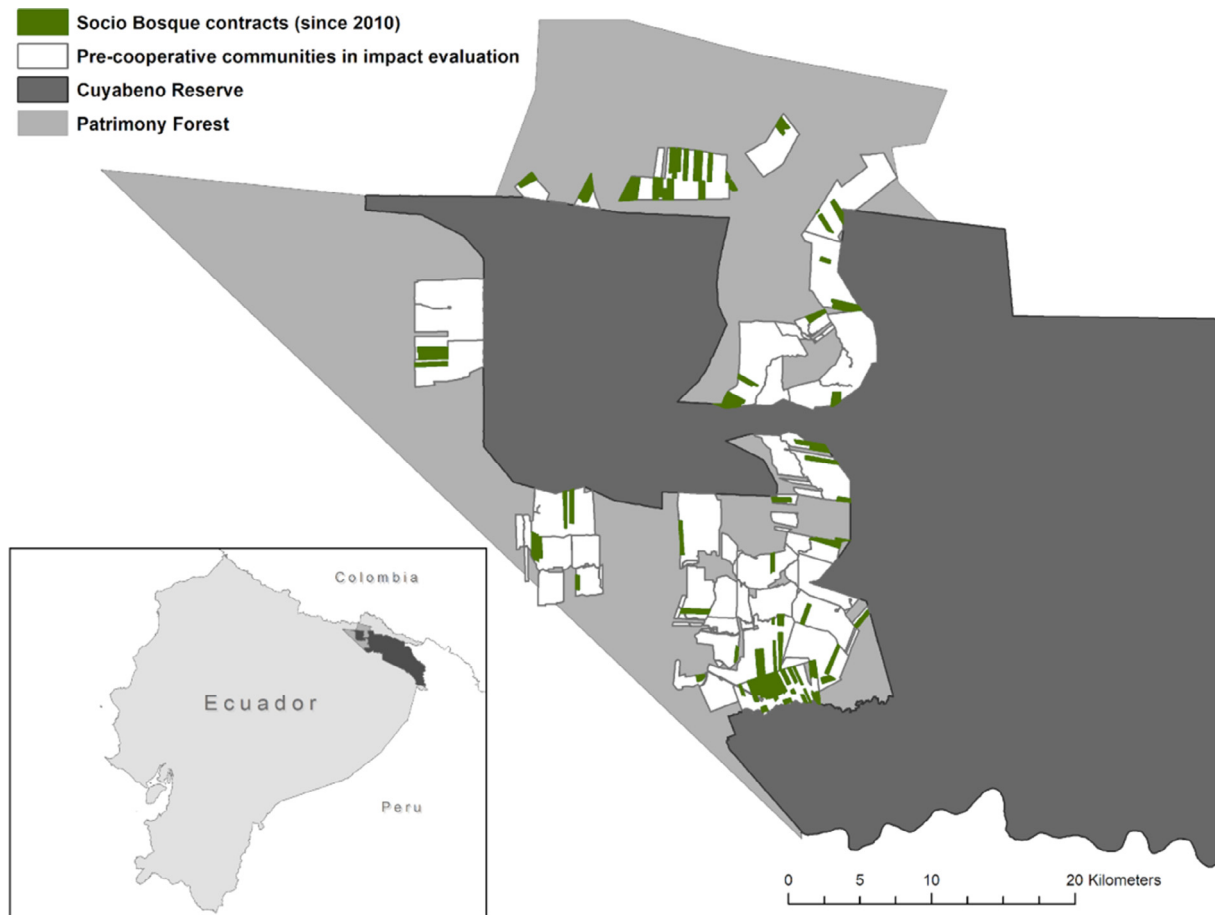


Fig. 1. Study area.

than the average for the Sucumbíos province ($\sim 0.3\%$) and for the neighboring Cuyabeno Reserve (just above 0%) (Holland et al., 2017).

Agricultural production on site is small-scale and comprised of a mix of subsistence farming, livestock, and some cash cropping (Holland et al., 2017; Jones et al., 2017; Messina et al., 2006). Local landowners hold an average of 44 ha (range 10–347 ha) (Holland et al., 2017). Most households do not have off-farm employment (Jones et al., 2017). Agriculture productivity is limited by low soil fertility and poor drainage. However, communities are working to increase the agricultural productivity of their lands (GAD Sucumbíos, 2019). Between 2014 and 2016, five of the 22 pre-cooperatives in our study undertook drainage projects, jointly financed by the Sucumbíos Provincial Government and Ecuador's National Water Secretariat (SENAGUA).

Within the site, 63 landowners from our 22 pre-cooperatives enrolled land in SB between 2009 and 2010, representing $\sim 7\%$ of titled properties in the Patrimony Forest. SB participants contracted an average of 49 ha, or 77% of their properties. They received an average annual payment of US\$1470 (range US\$510–2970) (Jones et al., 2017), which is equal to $\sim 50\%$ of the estimated average annual income (US\$3200) for colonists in this region (Mejia, Pacheco, Muzo, & Torres, 2015). Prior research on site revealed that between 2011 and 2013, SB participation reduced the mean annual deforestation by 0.4–0.5%-points on enrolled land, representing as much as a 70% relative reduction in deforestation that can be attributed to SB (Jones et al., 2017).

4.2. Quasi-experimental approach

To study the effects of the payment suspension, we used quasi-experimental methods—specifically matching combined with fixed effects panel regression analysis—to estimate the average treatment effect of SB on forest cover for 63 landowners enrolled in SB in the study site. Annual tree cover loss for each property was estimated using Hansen's Global Forest Change product for 2004–2017 (Hansen et al., 2013), which analyzes spatial data at a spatial resolution of 30 m per Landsat pixel. We used annual measures of tree cover from 2004 until 2017, similar to Jones et al. (2017). Because the property was our unit of analysis, pixel-level forest change was analyzed and summarized for property boundaries.

To identify a valid control group for the 63 properties enrolled in SB, we used 'matching': we constructed a counterfactual group based on observable variables thought to influence both receiving the treatment (SB participation) and the outcome of interest (deforestation). This helps control for selection bias in who participates in the PES program. Thus, we first restricted eligible control units to the 22 pre-cooperative communities where the 63 SB-enrolled properties were located, which left 450 titled properties not enrolled in SB. Second, we used propensity score matching (PSM) to pair enrolled to non-enrolled properties (Guo & Fraser, 2010). Enrolled properties were matched to non-enrolled properties with the closest propensity score using one-to-one matching without replacement. To improve the quality of matches, we used

a caliper equal to 0.25 the standard deviation of the estimated propensity score (Rubin, 2006).

Based on previous research on SB and deforestation at our site, we matched on the following spatial variables proven to be correlated with deforestation trends and with the decision to enroll in SB: baseline deforestation rates, property size, and distance to roads, population centers, navigable rivers, oil wells and the reserve boundary (Jones et al., 2017). We defined baseline deforestation rates as 2004–2006 and include a robustness check with baseline deforestation rates as 2005–2007 (Appendix II). While matching on observable covariates faces the challenge of including the full set of variables needed to ensure “good” matches (Peikes, Moreno, & Orzol, 2008; Shadish, 2013), clear documentation of the decision process in conducting matching and multiple reliability checks can improve confidence in using matching methods to construct a control group (Lampach & Morawetz, 2016). Admittedly, we do not include household-level variables that might influence participation in SB, but to build confidence in our matched sample, we check overlap in the propensity scores and covariate balance before and after matching using t-tests and normalized differences in means. We find good overlap (Appendix I), and matching substantially improved the similarity of observable variables between the two groups (Table 1). Additionally, we estimate average treatment effects on the full sample (without matching) using the panel regression method described below and find similar results (Appendix II).

With the matched sample of enrolled and non-enrolled properties, we estimated the impact of SB on deforestation using linear fixed effects panel regression. This method is more robust than using matching alone, as it uses the temporal dynamics of the data (observing the two groups before and after SB) along with cross-sectional variation in who received the program to construct the counterfactual outcomes (Imbens & Wooldridge, 2009; Jones & Lewis, 2015). Previous research has shown that combining matching with fixed effects panel regression can mimic results from experimental designs (Ferraro & Miranda, 2017). The fixed effects regression controls for any time-invariant omitted property and household characteristics, since the same landowner had user rights to these properties before and after SB started. We also included year fixed effects to control for variations over time that affected all observations (e.g., national oil prices). The years of data used in the PSM equation to define baseline deforestation (e.g., 2004–2006) were not included in the fixed effects estimation. We accounted for serial and spatial correlation in the standard errors by estimating cluster robust standard errors, clustering on the pre-cooperative community (Cameron & Trivedi, 2005).

We calculated the impact of SB on forest loss for three time periods: the full duration of SB (2011–2017); during payment (2011 to 2014); and during payment suspension (2015–2017). In addition to estimating the average program effects, we looked at variation in SB impacts (i.e. heterogeneity effects) due to three variables expected to be correlated with known deforestation pressures. First, based on previous research on site (Holland et al., 2017; Jones et al., 2017; Messina et al., 2006), we expect that proximity to oil wells and roads increases deforestation pressure, so we introduced an interaction term between SB enrollment and distance variables individually to look at heterogeneity in impacts of SB. Second, our fieldwork focus group interviews revealed that some pre-cooperatives in our study undertook drainage projects between 2014 and 2016. We expect these communities experience increased forest loss; thus, we incorporated these findings into our evaluation: we used an interaction term between SB enrollment and presence of a drainage project (0/1) in the regression. We apply this heterogeneous treatment effect analysis to test how the degree of deforestation pressure influences the average treatment effect of SB participation. This can help us understand where

and why SB worked during payment suspension in addition to whether it worked or not.

4.3. Semi-structured interviews and focus groups

This study also draws on fieldwork data collected via in-depth semi-structured interviews and focus groups from 2015 to 2019. Some of our findings from fieldwork in 2015 have been published elsewhere (Jones et al., 2017). Our multi-year engagement with stakeholders—both local communities and SB and MAE authorities—allowed us to learn about the underlying social relationships and motivations that shape perceptions of SB and forest outcomes. Specifically, between 2015 and 2019, we conducted 40 in-depth semi-structured interviews with SB and MAE staff at national and provincial offices, and with staff of environmental non-governmental organizations (NGOs) in our study region. Interviews included general questions on deforestation trends and SB’s incentive-based intervention at our site, as well as specific questions about how the payment suspension was officially handled and communicated.

Additionally, during three different fieldwork sessions between 2015 and 2018, we conducted 26 focus groups to learn how participating and nonparticipating landowners perceived the SB program and the payment suspension. Though focus groups are not designed to generate data representative of the general population, they effectively elicit multiple reactions to a question at once (Cyr, 2014) and can thus help reveal the “range of experiences and perspectives” (Morgan, 1996). Moreover, the conversational nature of the focus group method allows participants to react to each other’s responses and thus expands the realm of possible ideas and opinions about the phenomenon under consideration (Cyr, 2014). Though the group dynamic of focus groups can stifle the expression of individual opinions, it can also encourage rather than repress disclosure of perceptions and attitudes towards sensitive issues (Jordan et al., 2007). Last, because we were asking about sensitive topics such as participants’ land use decisions during the payment suspension and their attitudes towards conservation authorities, we chose to use focus groups to give participants a sense of security from being in a group setting, as people can feel more comfortable sharing opinions and experiences if they perceive themselves to be in safe spaces with others like themselves (Browne-Nuñez, Treves, MacFarland, Voyles, & Turng, 2015; Jordan et al., 2007; Kamberelis & Dimitriadis, 2011). Importantly, we asked focus group participants to speak generally about their perceptions of deforestation, experiences, and attitudes in their communities and never specifically about their own land use behavior in order to protect them from possible penalties and to encourage their engagement in the discussion.

To select sites for our initial focus groups in 2015 and 2017, we stratified the pre-cooperative communities included in our impact evaluation by the number of landowners enrolled in SB, proximity to the Cuyabeno Reserve boundary, and relative accessibility. For our 2018 focus groups, we used the results from our forest change analysis to guide the selection of focus groups sites from among the pre-cooperatives included in our impact evaluation, targeting those that experienced an increased rate of deforestation relative to the prior period of 2011–2014, and those with deforestation rates unchanged or similar to the prior period. Thus, across all focus groups, we reached 15 of the 22 pre-cooperatives included in the impact evaluation. Fifty-one of the 63 landowners enrolled in SB in our site reside in the 15 pre-cooperatives interviewed. We conducted focus groups with three of the 15 pre-cooperatives at all three fieldwork periods: June 2015 (pre-payment suspension), June 2017 (mid-suspension), and November 2018 (post-suspension) (n = 9 focus groups). The remaining focus

Table 1

Property summary statistics and covariate balance. Mean values reported with standard deviations in italics.

Variable	All properties	Properties enrolled in SB	Properties not enrolled in SB	Difference in means ^a before matching	Difference in means ^a after matching	Standardized differences in means ^b after propensity score matching
Property (km ²)	0.49 <i>0.26</i>	0.64 <i>0.24</i>	0.46 <i>0.26</i>	-5.36***	1.25	0.24
Distance to urban area (km)	3.99 <i>3.08</i>	4.81 <i>3.36</i>	3.88 <i>3.03</i>	-2.10**	0.15	0.02
Distance to road (km)	2.06 <i>2.73</i>	4.12 <i>4.22</i>	1.77 <i>2.32</i>	-4.34***	-0.123	0.23
Distance to river (km)	8.21 <i>3.29</i>	8.43 <i>2.91</i>	8.18 <i>3.34</i>	-0.62	-1.10	0.21
Distance to oil well (km)	2.76 <i>2.58</i>	3.90 <i>3.19</i>	2.61 <i>2.44</i>	-3.10***	-0.78	0.15
Distance to reserve boundary (km)	1.71 <i>1.71</i>	1.36 <i>1.51</i>	1.76 <i>1.73</i>	1.93*	0.35	0.06
N	512	63	449	512	112	112

* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.^a T-values from two-sample t-tests with unequal variances for differences between properties enrolled in SB and properties not enrolled in SB.^b Standardized differences in means normalize the difference based on sample size. A value >0.25 is considered large enough to bias parametric regression analysis (Imbens & Wooldridge, 2009).

group sessions ($n = 17$) took place either in 2015 only ($n = 4$), in 2015 and 2018 ($n = 10$), or in 2018 only ($n = 3$) (Appendix III).

To arrange the focus group interviews at each site, we used the pre-cooperative structure, inviting all pre-cooperative members to the focus group via a formal invitation letter delivered to the pre-cooperative acting president. We created a semi-structured questionnaire to guide the focus groups discussions and updated this tool with additional questions for each subsequent period as the payment suspension evolved (Appendix IV). We asked focus group participants questions about perceived deforestation pressures; their relationship with and attitudes toward conservation authorities and SB officials, in particular; how those enrolled in SB experienced the payment suspension; and how it affected their land use decisions. We also asked all focus group participants about their knowledge of SB contract rules; their motivations to participate or not in SB; the frequency and nature of interactions with conservation authorities and SB personnel; and their perceptions of SB's fairness. A fluent Spanish speaker from our research team facilitated each group interview. Focus groups lasted between one and three hours, and attendance averaged 12 persons (range 2–23).

5. Results

5.1. Impact evaluation of changes in deforestation

Deforestation on both enrolled and non-enrolled properties increased between 2015 and 2017, suggesting that factors other than the payment suspension affected deforestation during this period (Fig. 2). Mean annual deforestation rates across the study region were <1% for 2001–2016 (range 0.3–0.8%) and jumped to 1.8% in 2017 (Fig. 2). The mean annual forest loss rate on SB-enrolled lands between 2011 and 2014 (prior to the 2015 payment suspension) was 0.15%. During the 2015–2017 payment suspension period, the mean annual deforestation rate nearly tripled, reaching 0.43%. On non-enrolled lands, the mean annual forest loss rate between 2011 and 2014 was 0.67%; during the payment suspension period, it rose to 1.06%.

The trends in deforestation rates in Fig. 2, however, do not account for differences in properties enrolled and not enrolled in SB. Enrolled properties are, on average, larger than those not enrolled; located farther from towns, roads, and oil wells; and closer to the boundary of the Cuyabeno Reserve (Table 1). After PSM, no statistical differences remained between enrolled and non-enrolled properties, showing that covariate balance was achieved and that with matching we were able to find a comparable control

group (Table 1). The annual trends in deforestation for matched SB-enrolled and not-enrolled properties are more similar in 2004–2011 than for the full sample, but differences remain between 2011 and 2017 (Fig. 3).

Using the matched sample in linear fixed effects panel regression, the overall impact of participation in SB (2011–2017) is to reduce deforestation by about 0.5%-points (Table 2), similar to Jones et al. (2017). When we split our sample of SB-enrolled properties into the period with payment (2011–2014) and without payment (2015–2017), we find that on average, SB-enrolled properties maintain lower deforestation rates than not-enrolled control properties during the payment suspension period, but the statistical significance level weakens to the 90% level using a 2005–2007 baseline (Appendix II) and 2004–2006 baseline (Table 2). When we used fixed effects panel regression on the full sample without matching (Appendix II), we also find either weak statistical significance (90% level) or no statistically significant effect of the program in 2015–2017 (during payment suspension).

Looking at heterogeneity effects of the SB program during payment suspension, we find that SB participation during the payment suspension period was not effective at blocking deforestation in pre-cooperatives that undertook drainage projects between 2014 and 2016 (Table 3). SB-enrolled properties in pre-cooperatives without drainage projects maintained lower rates of deforestation than similar unenrolled properties (significant at the 90% level) using baseline deforestation rates of 2004–2006 (Table 3) and 2005–2007 (Appendix II). Similar results were found using the full sample without matching (Appendix II).

We also find variation in SB impacts during payment suspension by distance to oil wells and roads: SB participation in properties closer to oil wells or roads had no effect on reducing deforestation in 2015–2017, whereas SB participation was effective at preventing deforestation on enrolled properties farther from roads and oil wells even when participants were not being paid (Fig. 4). For comparison, in 2011–2014 when SB participants were receiving payments, SB was found to be effective at blocking deforestation pressures at all distances to oil wells and roads, indicating that it was effective at conserving forest regardless of deforestation pressure when payments were being received (Fig. 5).

5.2. Semi-structured interviews: administrators' experiences

SB administrators told us that during the payment suspension period, SB drastically reduced its operations: between 2015 and 2017, the program cut its staff from >50 employees to <10 and

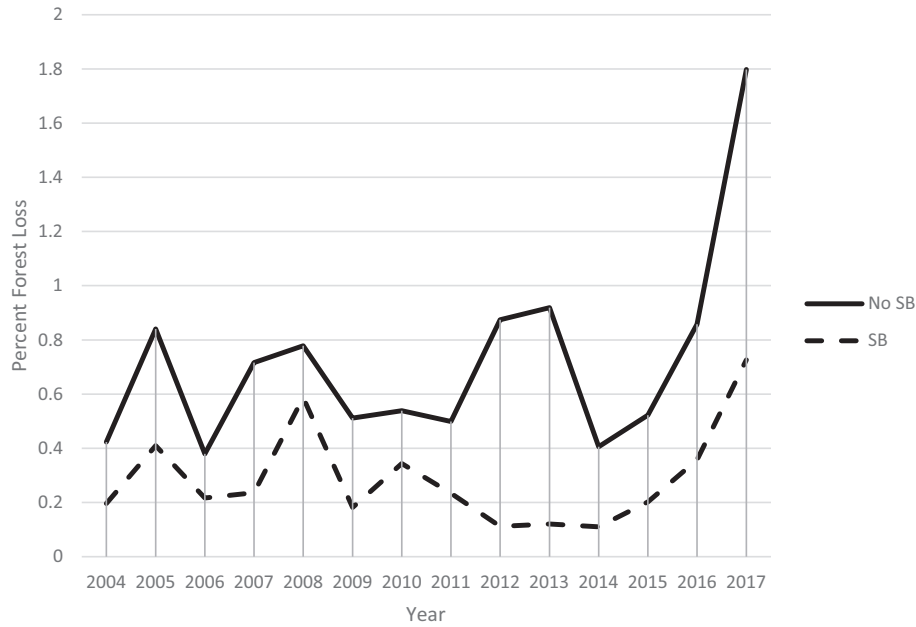


Fig. 2. Deforestation trends in SB-enrolled (SB) and non-enrolled (No SB) properties for the full sample of properties (n = 512).

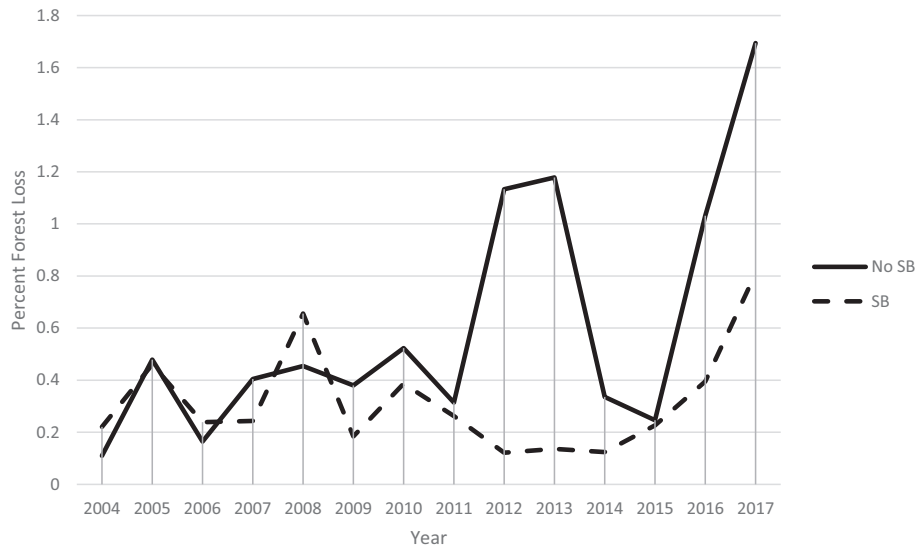


Fig. 3. Deforestation trends in SB-enrolled (SB) and non-enrolled (No SB) properties for the matched sample of properties (n = 112).

Table 2
Marginal effect of SB participation on forest cover change (%-point) using fixed effects panel regression with the matched sample of properties.

	2011–2017 (full SB program period)	2011–2014 (during payment)	2015–2017 (during payment suspension)
2004–2006 baseline		–0.48**	–0.51**
	–0.45	0.19	0.19
	0.26		
N	1232	1232	1232

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01

Table 3
Marginal effect of SB participation on forest cover change (%-point) during payment suspension (2015–2017) split by communities that had a drainage project and those that did not using 2004–2006 baseline. Average treatment effect of the treated presented using matching to trim the sample and fixed effects panel regression to estimate the treatment effects.

	2015–2017 (without drainage project)	2015–2017 (with drainage project)
2004–2006 baseline	–0.56*	–0.19
	0.33	0.29
N	1232	1232

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01.

experienced significant leadership turnover, with three different directors presiding over the program over three years. In 2016 SB shut down its national call center, cut all funding for its field-

based staff, and devolved the majority of its contract management and field-based operations to provincial MAE offices. Provincial MAE forest technicians were tasked with managing all SB contracts

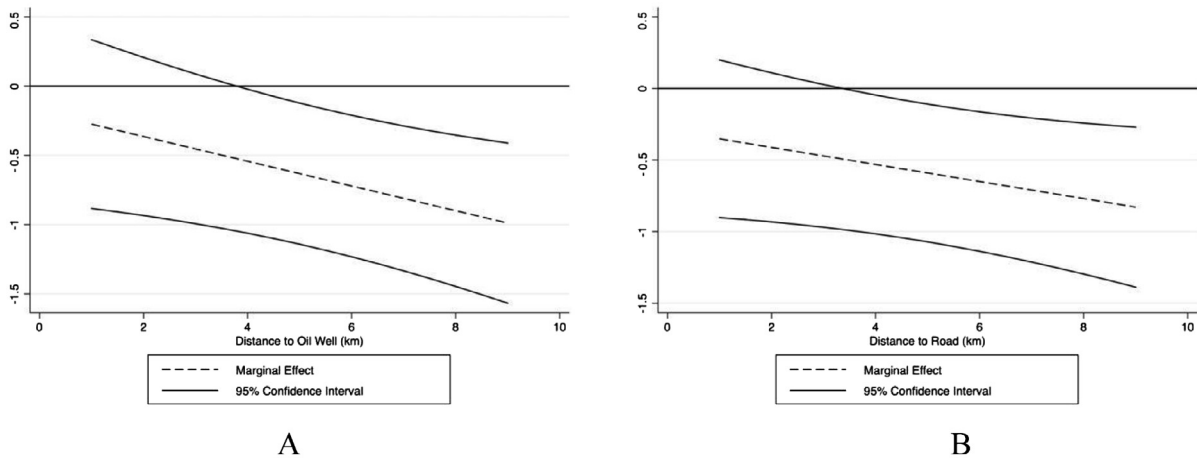


Fig. 4. Average treatment effect of SB participation on deforestation in 2015–2017 (during payment suspension) by distance to oil well (A) and road (B). Where the confidence interval crosses zero indicates insignificant treatment effects. These are properties located closer to oil wells and roads and thus higher deforestation pressures.

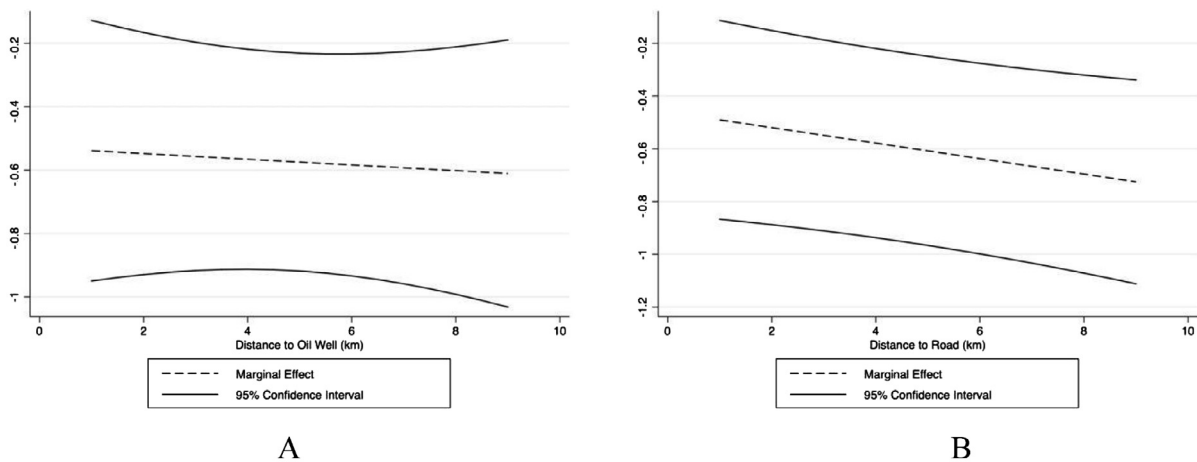


Fig. 5. Average treatment effect of SB participation on deforestation in 2011–2014 (during payment) by distance to oil well (A) and road (B). The treatment effects are statistically significant at all distances from oil wells and roads.

in their respective provinces—performing field inspections, attending to participants’ complaints and payment questions, and tracking all contract activity—in addition to their extant province-wide forestry enforcement duties. In MAE’s Sucumbíos provincial office, this meant that the four forest technicians on staff had to manage 205 SB contracts, across ~129,900 ha of forestland (SB, 2019). In interviews, officials at SB’s central office in Quito framed the restructuring as a decentralization measure designed to empower regional environmental authorities, however the devolution of responsibilities did not come with any additional funding for provincial MAE staff. In interviews, provincial MAE forest technicians reported feeling unable to keep up with the added workload.

Provincial MAE officials also indicated that they did not receive sufficient, accurate, or timely information from the SB central office about the payment suspension nor about future funding of the program. This uncertainty made it difficult for provincial MAE technicians to respond to angry SB participants who traveled to provincial MAE offices to demand payment. The central messaging passed on from the SB central office to provincial MAE officials was that the payment suspension was due to the economic crisis and the subsequent earthquake, which required funds to be diverted to provide relief on the coast. However, there was less clarity about when payments would resume or about the future of the program. As one provincial MAE official complained, ‘There hasn’t been an

official pronouncement [by the SB central office about when payments will be made]. The people [at the SB central office] don’t answer their phones. Here [in the local office] we have a few different telephone numbers and we tell [SB participants who come to inquire] to call these numbers in Quito to find out directly from [the SB central office personnel] whatever they tell them [...] We even lend them our landline to make the call’.

In late March 2017, one and a half years after payments were officially suspended, SB attempted to catch up with back-payments, issuing the payment owed in October 2015 to some enrolled participants (~800) (interview with SB official, 2017). Subsequent ‘catch up’ payments slowly trickled in, with 92% of contracts paid in full through 2017 by June 2018 (interview with SB official, 2018). According to SB, some participants (3%) received only partial back payment in June 2018 due to incomplete paperwork (e.g. sworn affidavits) required by their contracts; others experienced conservation area losses (3% of contracts) or were under analysis due to “organizational issues” (2% of contracts) (MAE, 2020). Some of these “organizational issues” were likely related to amendments made to contracts to reduce the extent of enrolled area due to mapping errors (interview with SB official, 2018).

In interviews we also observed that provincial MAE staff had insufficient knowledge about SB contract terms. One provincial

MAE official explained that when SB participants came with complaints about the lack of payments, he would console them by telling them that he had heard that after three consecutive non-payments by SB, the contract would be declared void. However, in an interview at the SB central office, the program's lead lawyer stated that participants were legally required to continue conserving even though they were not being paid. A closer analysis of the contract in consultation with external lawyers confirmed that the contract does not provide program participants with a penalty-free exit or redress in the event of the state's nonpayment. Nevertheless, confusion over these specific contract terms was prevalent during the payment suspension period among provincial MAE technicians and among SB participants in our focus groups, as shown below.

5.3. Focus groups: landowners' experiences

Across all 26 focus groups and periods (i.e. before, during, and after payment suspension), pre-cooperative members stressed three themes that provide important framing context for interpreting their more heterogeneous responses to other payment suspension-specific question prompts. Thus, we present the themes before delving into specific responses pertaining to focus groups from each period. First, both SB participants and non-participants alike repeatedly voiced a shared perception of the strictness of the SB program. Though SB participants in the focus groups reported varying levels of actual field inspections and informal site visits (ranging from none to twice a year), most respondents perceived that SB strictly enforced its conservation contracts. For example, one focus group participant asserted that 'one can't even take a single stick on Socio Bosque land'.

Second, landowners in our focus groups at all three time periods voiced a general lack of trust in the government. In particular, many non-enrolled landowners expressed a misinformed but persistent rumor that linked SB to land expropriation: they reported choosing not to participate in SB out of fear that the state would rescind their title should they violate the contract by logging on enrolled land, or that enrolled land would revert to the government at the end of the 20-year contract. Additionally, landowners repeatedly expressed mistrust of government agents, in particular MAE authorities. Decades of local environmental degradation due to oil contamination by national and foreign petroleum companies left focus group participants skeptical of MAE officials following official rules. As one focus group participant commented: 'There is no support from the Ministry of the Environment for us farmers. When a poor farmer like me needs to cut down a few trees in order to survive, [Ministry authorities] are quick to come down with a sanction. But if I were a petroleum company, or an oil palm company, they would look the other way'.

Last, SB participants across all focus groups persistently expressed that it was the *reliability* of the SB payment, versus the amount, that was most important to them and a key motivation for their participation in the program. Whereas agriculture income could be volatile, they counted on the SB payment twice a year to better weather unpredicted hardship.

Turning to our period-specific focus groups, in our June 2015 focus groups (n = 12) many SB participants complained about a missed payment and referred to it as a 'delay'. No one knew why the delay had occurred, and all reported not receiving any formal communication about its cause or when the payment could be expected. Even so, most consistently expressed overall satisfaction with SB. In addition to the reliability of the payments, SB participants liked that the SB financial incentive served as an economic support for their stewardship of their forests. As one participant exclaimed, 'Before [SB] who gave us any money at all [for our stewardship]? Nobody! [SB] helps us to conserve [our land]'. In two

focus groups, however, non-enrolled participants pointed to the delayed payment to illustrate one of the reasons they had chosen not to enroll: they did not trust the government and did not expect that the program would comply with its rules. In these 2015 focus groups, we also learned that some SB participants enrolled lands that were often flooded or remote. As one participant explained, enrolled properties in her community 'signed up for the program because they are on the bad, swampy land'. Landowners are exempted from paying property taxes on land enrolled in SB, and participants expressed that this was an added economic benefit of enrolling land unsuitable for agriculture. However, when asked, some SB participants said that if SB were to end, they would have to put more of their lands to crop cultivation.

The three focus groups in 2017 occurred after SB had missed four payments. In these meetings, SB participants expressed anger regarding the payment suspension and considerable confusion about their contract rights and obligations. Many thought that after SB missed three consecutive payments, participants could terminate the contract and be relieved of their conservation obligations. In one pre-cooperative, SB participants reported not having copies of their contracts. In all three pre-cooperatives, SB participants reported receiving no formal communication about when payments would resume. The few who made trips to the provincial capital to inquire about their contract rights received conflicting information from provincial MAE technicians, some of whom purportedly told them they were contractually obligated to continue conserving, others advising them to withdraw from the contract due to lack of payment. SB participants indicated understanding the likely causes of payment suspension (i.e. the economic crisis and a major earthquake) and some even expressed that the delay in payment was a necessary (but temporary) hardship to help earthquake victims. However, they also described feeling "ping-ponged" back and forth between reassurances that payment was 'around the corner' and explanations that cited incomplete paperwork as the cause of missed payments. Some focus group participants compared the stalled payments to other 'piecemeal' projects funded by the government in the region. In the words of one participant, 'This is no different from the way it has always been here. [The government] builds the road only as far as the money goes. They run [land] titling campaigns until the money runs out. This [SB program] is the same'. In one of the three pre-cooperatives, SB participants in our focus group directly threatened to deforest enrolled land if SB did not pay immediately.

In the final round of focus groups in 2018 (n = 11), we first asked pre-cooperative members—both SB participants and non-participants—about their perceptions on why deforestation in their pre-cooperative community had increased or stayed the same between 2015 and 2017. Where tree cover had stayed the same, pre-cooperative members reported not noticing any changes in their land use activities. In pre-cooperatives where deforestation was perceived to have increased, various reasons were given. Here focus group participants reported expanding their cropped areas to secure income to meet the needs of their growing families (e.g. school fees for children now of school age), and to make up for low soil fertility or poor agricultural sales associated with the economic crisis. With families expanding, some encountered land shortages on areas already cleared and thus extended the area for cultivation. As one member exclaimed, 'As our children grow, they need land to cultivate. We've had to extend the agricultural frontier [on our lands]'. Focus group participants in these communities described increasing their production of short-cycle crops with quicker to-harvest times, such as rice, maize, plantain, and yuca. A few pointed to a couple of land sales made to petroleum companies.

Four pre-cooperative communities in the 2018 focus groups reported undertaking drainage projects to improve the agricultural

productivity of their lands, something they had long planned to do (we later learned of a fifth pre-cooperative, not interviewed, that also had completed a drainage project). Focus group participants reported that the drainage projects and the new publicly owned farm machinery, purchased jointly by the Prefecture and the Parish Assembly, had vastly sped up the cultivation process in the pre-cooperatives already planting in their newly drained fields. As one focus group participant described, 'The land here used to be very marshy, and that's why people couldn't work it. But now that it has been drained, the soil is compact, and the machines can go out into the fields. You can rent the machines at no cost [...] Now we are able to work our fields more quickly'. The goal, one pre-cooperative president reported, was for each community member to have five hectares of land drained for new cultivation. Additionally, in two pre-cooperatives, focus group participants said that the drainage projects were opportune because some men in their communities had returned to farming after petroleum companies laid off workers due to the drop in oil prices.

There were mixed reports about whether the drainage projects conflicted with SB-enrolled land. In two communities, focus group participants complained that the drainage projects had raised tensions among community members because SB participants did not want the drainage canal to cut across their enrolled lands. In the other two communities interviewed where drainage projects had taken place, focus group participants reported that the drainage canals had been designed so as to not interfere with SB-enrolled land.

By 2018, most, though not all, SB participants in our focus groups had received their outstanding payments. When asked to reflect on their experience of the suspension in payments, opinions were mixed. Some SB participants reported that they did not deforest because they were scared of possible legal consequences, while others said that they kept hoping that payments would resume shortly. Other SB participants expressed a 'willingness to wait' given that the suspension had been caused by a country-wide economic crisis and a subsequent earthquake. Still others expressed continued anger, mistrust of SB's commitment to continuous payments, and skepticism about the program's future.

Both SB participants and nonparticipants in the 2018 focus groups reported feeling that SB contracts were not fair. One SB participant rebuked that '[SB] expects us to comply and be punctual with our yearly paperwork or else our payment can be suspended, yet they aren't punctual themselves [with payments] and don't suffer any consequences because of it'. Even so, when asked, many focus group participants not enrolled in SB expressed that they might be interested in enrolling if enrollment re-opened. More generally, focus group participants thought that the SB contract could be improved in three ways: increasing the incentive amount; decreasing the term from 20 to 10 years; and incorporating safeguards to protect participants from possible SB noncompliance, especially non-payment.

Discussion and conclusion

This paper and previous evaluation conducted by our research team (Jones et al., 2017) found that SB participation at our site reduced the mean annual rate of tree loss by 0.4–0.5%-points on enrolled lands between 2011 and 2014. Here, we find that during the payment suspension period (2015–2017), deforestation drivers in the region increased forest loss on both enrolled and not-enrolled properties. On average SB-enrolled landowners continued to deforest at a lower rate than similar landowners not enrolled even while not receiving payments (average treatment effect of 0.5%-points although not statistically significant when matching is not used to trim the sample; Appendix II). However, SB partici-

pants on properties located closer to roads or oil wells, or at community drainage project sites, did not protect forest any more than similar unenrolled properties during this payment suspension period. Our findings are similar to the Uganda study that found conservation behavior stopped when payments ended (Jayachandran et al., 2018). Without payments, SB stopped having a protective effect on forests in enrolled properties facing deforestation pressures. Farther away from deforestation pressures and in pre-cooperatives that did not undertake drainage projects, it is likely that enrolled properties are located in areas that are seasonally flooded and less suited to productive agriculture. These characteristics reduce overall deforestation risk and possibly explain why enrolled properties in these locations maintained, on average, slightly lower deforestation rates than properties not enrolled (average treatment effect of 0.6%-points).

Caution is warranted when interpreting these findings. While we show that the PES program failed to reduce deforestation during payment suspension near known pressures at our site, the form and characteristics of land tenure, as well as the biophysical characteristics of our site—namely the title restrictions associated with properties in Patrimony Forest and the low agricultural potential of the land—limit the generalizability of our results. Evaluation of SB during the payment suspension period in other regions of the country, and across different tenure forms (individual and community contracts), would improve our assessment of the impact of the payment suspension on deforestation. Notably, the forest loss data product we used does not detect selective logging, which some observers fear is common in the area. Last, the forest loss product captures yearly deforestation totals per property whereas the payment suspension start and end dates varied slightly for participants. While this difference in temporal scales opens the possibility of differences existing within the group of SB participants in terms of their land use behavior—e.g. through anticipatory or lagged effects of the payment suspension—, the significant average treatment effects we find remain the same across groups, even when these differences within the group of SB participants may have occurred temporarily.

Despite these caveats, our findings directly contribute empirical evidence to inform debates on the permanence of PES-induced changes (Börner et al., 2017; Calle, 2020; Engel et al., 2008; Jayachandran et al., 2018; Pagiola et al., 2016, 2020). Moreover, to our knowledge, it is the first evaluation of the impacts of a temporary suspension of conservation payments. Our results suggest that conservation behaviors do not persist in use-restricting PES when payments stop (even temporarily) when ES stewards are faced with deforestation pressures. However much desirable from a conservation perspective, persistence cannot be assumed to follow post-PES investment, and conservation gains from PES may be lost altogether if current PES funding is not sustained over the long-term, or at least until deforestation pressures subside. This is a significant and global research gap that deserves attention because PES projects are unlikely to be funded in perpetuity, and economic and political factors can suddenly place funding for PES projects underway at risk, not just in the tropics, but also in high-income countries, as evidenced by the recent de-funding of environmental programs and policy reversals lead by the current U.S. administration. Indeed, given the likely economic fallout of COVID-19, global funds for conservation may sharply diminish. The effects of this crisis will surely leave their mark on funding for PES projects worldwide, possibly forcing tens of thousands of participating communities and individuals to contend with the realities of suspended payments or terminated projects.

Our study also reveals the challenge of assessing PES additionality and associated explanations for persistent conservation behavior. At our site, as elsewhere, deforestation pressures and landowner attitudes demonstrate spatiotemporal heterogeneity.

The boggy nature of much of the enrolled land apparently discouraged forest clearing, but with new drainage projects, agriculture may become more viable and opportunity costs may rise (thus increasing the potential for additionality). Moreover, though in our study area and period it was drainage projects that constituted a new deforestation pressure, PES projects are usually carried out alongside other policy interventions. Policy mix interactions are an important but understudied field of research that can provide crucial insights on how environmental protection is affected when PES interact with other policies on the ground (Ezzine-De-Blas, Dutilly, Lara-Pulido, Le Velly, & Guevara-Sanginés, 2016; Izquierdo-Tort, 2020; Lambin et al., 2014; Robalino, Sandoval, Barton, Chacon, & Pfaff, 2015). Further, the growth in family sizes is re-shaping land needs at our site and potentially adding further pressure to deforest. These changes offer a counterpoint to the scenario posited by Dayer et al. (2018) that when conservation is easy and becomes habitual, it will continue. It also provides insightful nuance for PES programs that incorporate risk-weighted eligibility criteria: designing PES enrollment to spatially target areas with high ES-density, high land productivity, or other high threat factors can be a moving target that requires continuous updating and adaptive management (Sims et al., 2014; Wunder et al., 2018).

Dayer et al. also predicted that a generally positive view of a PES program's goals and structure increases the likelihood of conservation persistence. In our case study, SB's institutional recognition of landowner stewardship and the program's previous reliability likely improved participants' willingness to wait for delayed payments. Trust in SB quickly dropped, however, as payments stalled and access to information became limited. Beyond Dayer et al. but relevant in tropical countries facing economic crises, the reason for the delay mattered (earthquake and oil price crash). Other reasons for stalled or cancelled payments might affect participants' views differently, e.g. a new political regime that dismantles conservation initiatives (Brazil, U.S.).

Our focus group discussions and interviews revealed the considerable uncertainty experienced by SB participants during the payment suspension and the importance of trust in the implementing agency. Many participating ES stewards were ill-informed about their contract rights, an issue that mainly surfaced in light of the ES buyer's nonpayment. PES participants' confusion over contract details has been documented elsewhere (Fisher, 2012; Shapiro-Garza, 2013; Tacconi, Mahanty, & Suich, 2013). Moreover, SB participants received little and conflicting official information about if and when payments would resume. SB's restructuring and downsizing further compounded participants' uncertainty. Generally, as the payment suspension dragged on, participants grew angrier and more dissatisfied with the program, some even threatening to reverse their conservation behavior unless they received payment. In the context of landowners' history of mistrust of the government, and of conservation authorities in particular, SB's payment suspension further reinforced local negative perceptions of MAE. Once payments resumed, landowners' perceptions of SB improved as did their perceptions of their experience of the payment suspension, some even expressing having had a willingness to wait for payment and not deforest. However, the specific context of the economic crisis that drove the payment suspension, i.e. its national character and the widely publicized disastrous effects of the earthquake, may have played a role in landowners' improved perceptions of the program and the suspension experience. Likewise, the fact that the suspension only lasted two years and most participants were ultimately repaid likely improved post-suspension attitudes toward the program. Because focus groups are non-random, our findings regarding participants' perceptions of the suspension period should not be extrapolated to other individuals or communities; however, many of the opinions

expressed in our study echo those reported in Ecuador's popular press (Ortiz, 2017).

Ultimately, our focus group and interview findings revealed an often-overlooked issue in PES design, namely that SB contracts did not give participants the right to a penalty-free exit from their contracts in the event of nonpayment by the state. These findings support calls to incorporate equity criteria in PES design (Calvet-Mir et al., 2015; Corbera, Kosoy, & Martínez Tuna, 2007; Pascual et al., 2014). Scholarship on PES and equity has primarily focused on inequalities in access to PES, reduced access to resources, tenure insecurity, and distribution of economic outcomes or benefits (Corbera et al., 2007; Grieg-Gran et al., 2005; Pascual et al., 2014; Wunder, 2008). Additional focus is needed on the role that PES contract terms and access to information play in reinforcing existing power inequalities between powerful ES buyers and vulnerable ES stewards. PES contracts need provisions that protect participants from possible breaches by ES buyers, particularly for programs with long contract lengths that require landowners to forego other more profitable land uses for decades. PES programs that undermine social equity through unequal contract terms, payment delays, and lack of transparent communication may create negative feedbacks (e.g. compromised trust, rekindled conflicts, etc.) that compromise ecological outcomes (Pascual et al., 2014). Ultimately, contracts that do not protect ES stewards from defaults in payment ask stewards to carry an unreasonably heavier burden of risk. To ensure persistence and equity in forest conservation incentives, PES programs should be designed to be financially sustainable over the long term, and they should include social safeguards that can shelter participating landowners from unfair power relations in contracts with the state.

CRediT authorship contribution statement

Nicolle Etchart: Conceptualization, Methodology, Investigation, Writing - original draft. **José Luis Freire:** Conceptualization, Investigation. **Margaret B. Holland:** Conceptualization, Methodology, Investigation, Writing - review & editing. **Kelly W. Jones:** Conceptualization, Methodology, Investigation, Writing - original draft. **Lisa Naughton-Treves:** Conceptualization, Methodology, Investigation, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix I. Propensity score overlap

The graph below (Fig. A.1) shows that the range of propensity scores estimated for treatment and control observations have suf-

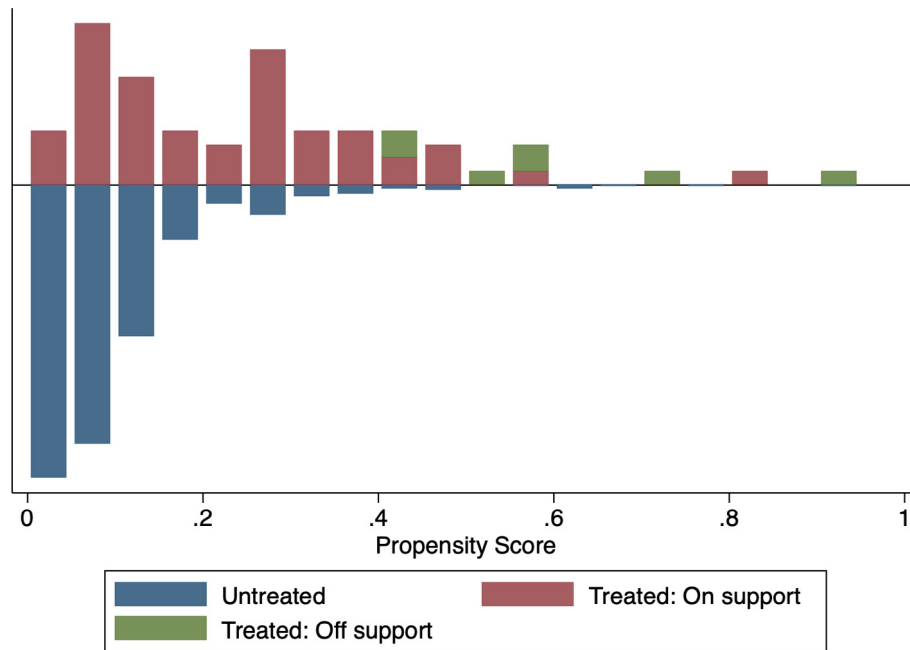


Fig. A1. Common support graph of propensity score matching.

ficient overlap. Most treated observations were “on support”, which means that matches were found.

Appendix II. Robustness checks

We conducted several additional analyses to check the robustness of our main results. First, we matched treatment to control observations using 2005–2007 average baseline deforestation versus 2004–2006 to test for sensitivity to the years of baseline data. These results are presented in Table A.1 for the average treatment effect and Table A.2 for the heterogeneity effects test based on presence of a drainage project in the community. These results are similar to what is found when we used 2004–2006 as the baseline years.

Second, we estimated the average treatment effect and the influence of drainage projects on deforestation using the full sample. In this analysis we do not use matching to trim the sample first, but only use fixed effects panel regression to construct the counterfactual group and estimate the treatment effects. These results are presented in Table A.3 for the average treatment effect and Table A.4 for the heterogeneity effects test based on presence of a drainage project in the community. These results are similar to what is found when we used matching first to trim the sample and combined that with fixed effects panel regression.

Table A1

Marginal effect of SB participation on forest cover change (%-point) for 2005–2007 baseline. Average treatment effect of the treated presented using matching to trim the sample and fixed effects panel regression to estimate the treatment effects.

	2011–2017 (all years of SB program)	2011–2014 (during payment)	2015–2017 (during payment suspension)
2005–2007 baseline	–0.45*	–0.47***	–0.49***
	0.22	0.15	0.15
N	1120	1140	1120

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01.

Table A2

Marginal effect of SB participation on forest cover change (%-point) during payment suspension (2015–2017) split by communities that had a drainage project and those that did not, using 2005–2007 baseline. Average treatment effect of the treated presented using matching to trim the sample and fixed effects panel regression to estimate the treatment effects.

	2015–2017 (without drainage project)	2015–2017 (with drainage project)
2005–2007 baseline	–0.56*	–0.15
	0.15	0.23
N	1120	1120

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01.

Table A3

Marginal effect of SB participation on forest cover change (%-point) using linear fixed effects panel regression without matching (full sample).

	2011–2017	2011–2014	2015–2017
2007–2010 as baseline	–0.27**	–0.23*	–0.33
	0.12	0.12	0.20
N	5632	5632	5632
2008–2010 as baseline	–0.33**	–0.29**	–0.39*
	0.13	0.13	0.21
N	5120	5120	5120

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01.

Table A4

Marginal effect of SB participation on forest cover change (%-point) split by communities that had a drainage project and using linear fixed effects panel regression without matching (full sample).

	2015–2017 (without drainage project)	2015–2017 (with drainage project)
2007–2010 as baseline	–0.44*	–0.05
	0.22	0.21
N	5632	5632
2008–2010 as baseline	–0.52**	–0.06
	0.22	0.22
N	5120	5120

*p ≤ 0.1, **p ≤ 0.05, ***p ≤ 0.01.

Table A5
Characteristics of pre-cooperative communities in impact evaluation.

Pre-cooperative community	Avg % Deforestation 2011–2014	Avg % Deforestation 2015–2017	Had drainage project	Participated in 2015 focus groups	Participated in 2017 focus groups	Participated in 2018 focus groups
1	1.09%	1.28%	–	Y	–	Y
2	0.45%	1.48%	Y	Y	Y	Y
3	0.92%	0.52%	–	Y	–	–
4	0.37%	1.31%	Y	Y	–	Y
5	0.62%	1.91%	Y	Y	–	Y
6	0.07%	0.36%	–	Y	–	Y
7	0.08%	0.04%	–	Y	Y	Y
8	0.65%	0.60%	–	Y	–	Y
9	0.43%	0.33%	–	Y	–	–
10	0.28%	0.21%	–	Y	–	–
11	0.12%	1.20%	–	Y	Y	Y
12	0.77%	0.51%	–	Y	–	–
13	0.67%	2.04%	Y	–	–	Y
14	1.13%	0.50%	–	–	–	Y
15	0.66%	1.19%	–	–	–	Y
16	0.27%	0.42%	–	–	–	–
17	0.71%	0.02%	–	–	–	–
18	0.95%	1.10%	–	–	–	–
19	0.58%	0.18%	–	–	–	–
20	1.33%	0.79%	–	–	–	–
21	0.17%	0.96%	–	–	–	–
22	0.17%	1.29%	Y	–	–	–

Appendix III. Pre-cooperative communities in our impact evaluation

Table A.5.

Appendix IV. Focus group semi-structured questionnaire

Questions about community members' perceptions on changes in forest cover and wildlife:

- In the time you have lived here, have you seen changes in the type or quantity of forests and/or in the wildlife present here?
- What has changed? Why?
- When the community first established itself here, did community members use the forest or wildlife for any purposes? If so, how?
- And now? How have community members' use of the forest and/or wildlife changed? Why?
- In your opinion, has deforestation in this area increased, stayed the same, or decreased?
 - If it's increased, what do you think are the causes?
 - If it hasn't increased, how do you think the community has been able to avoid having to cut down the forest?
- [specific to 2018 focus groups] Prior to coming here, our research team did a remote sensing analysis of the changes in forest cover in the Cuyabeno area, and the results of the analysis suggest that the rate of deforestation has increased/decreased (*facilitator note: select one based on community and corresponding analysis results*) in the land area corresponding to this community. We want to check and validate these findings with you.
 - Do you agree with these findings?
 - If so, why do you think there has been an increase/decrease/no change in deforestation?
 - If not, why do you think these findings may not be correct?
- Do community members have interest in conserving the forest?

Questions on possible drivers of forest change in the community:

- Ten years ago, how did community members typically use their lands?
 - What portion of your lands used to consist of crops?
 - Which crops did you use to plant?
 - What portion of your lands used to consist of forest?
- How about in the present day? How do community members typically use their lands now?
 - What portion of your land consists of crops?
 - Which crops do you plant?
 - What portion of your lands consist of forest?
- How did the economic crisis affect community members here? How did it make itself felt?
- Did the economic crisis affect the price of crops?
- What options did community members consider to shelter themselves from the economic effects of the crisis?
- Did any community members sell or consider selling any land?
- Did any community members sell timber?
- Currently, what are the most profitable crops?
- Which crops have stopped being profitable or productive?

Questions on land/resource use restrictions related to having titled property inside/outside of Patrimony Forest and near or in the Cuyabeno Reserve

- Do community members know exactly where the boundaries of the Reserve are located?
- Do community members know exactly where the boundaries of the Patrimony Forest areas are located?
- As landowners, what kinds of access and use rights do you have in the forested areas on your farms?
- Are there any restrictions on your use of these forested areas?
- How do you feel about these restrictions? Are there too many? Too few? A reasonable amount? Why?
- Which of these restrictions are the hardest for community members to comply with? Which bring the most amount of complications?

7. In your opinion, why do you think people sometimes break some of these restriction rules?

Questions about landholders' past and current relationship with Ministry of the Environment (MAE) staff

1. Since your arrival in this community, have you had any kind of contact or relationship with:
 - a. The Cuyabeno Reserve park guards and staff?
 - b. Officers from the provincial office of MAE (forest technical officers, etc.)?
2. Who have you had more contact with: the Reserve staff, the forest technical officers from MAE, or other staff from MAE?
3. What have been the reasons for these moments of contact (interactions) or for these relationships?
4. Have these interactions or relationships changed in the past 10 years? If so, why?
5. How would you describe community members' relationship with Provincial MAE officials: positive/negative/neutral, and why? How about with Reserve staff?
6. Have any community members experienced any conflicts with either the Reserve park guards or staff or with officers from the MAE?
7. Can you describe any positive experiences with either the Reserve park guards or staff or with officers from MAE?
8. How have Reserve park guards or MAE officers helped or supported you?
9. In contrast, what has been more complicated about your interactions or relationship with either the Reserve park guards or staff or officers from MAE?
10. In general, how satisfied are you with the way the Reserve park guards or staff and the officers from MAE manage the forest resources here?
11. Do you trust that they are working with the community's best interests in mind?

Questions on community members' experiences with or perceptions of Socio Bosque

For non-enrolled focus group participants

For those of you who chose not to participate in the Socio Bosque program:

1. Why did you decide not to participate?
2. [*specific to 2018 focus groups*] If the program were to re-open their enrollment, would you be interested in participating? Why or why not?

For SB-enrolled focus group participants

For those of you who participate in the program:

1. How many families in this community participate in the Socio Bosque program?
2. Why did you decide to participate?
3. Approximately what percentage of your farm have you enrolled in the program?
4. From your perspective, what has been more important: the amount of the conservation incentive payment or the reliability of the payments, that is, knowing you can count on the payment on specific dates?
5. From your perspective, does participation in SB cause landowners to change the way they use their land?
6. From your perspective, does participation in SB influence the decisions landowners make about the rest of their land? If so, how?

7. How do you use the funds you receive from Socio Bosque? Can you give us some examples?
8. How is monitoring, vigilance, and enforcement carried out on SB-enrolled area(s)?
 - a. Do Socio Bosque technicians carry out inspections? If so, how often?
 - b. Has anyone in the focus group ever received a visit from a Socio Bosque or MAE technician who came to carry out an inspection of enrolled land?
 - c. If so, how was the inspection performed? Were you given any prior notice? Did the inspection result in a modification of the contract?
 - d. Does the enrolled landowner play a role in the vigilance, monitoring or enforcement of enrolled areas?
 - e. Has anyone ever filed an SB-related complaint to SB or MAE?
 - f. If so, how are complaints handled?
9. Generally speaking, in your opinion what have been the benefits or positive aspects of participating in the Socio Bosque program?
10. Likewise, what have been the difficulties or negative aspects of participating in the Socio Bosque program?
11. Has the frequency of your contact or the character of your relationship with MAE changed since your enrollment and participation in the Socio Bosque program? (e.g. increased/decreased? Improved/declined?)
12. Has the frequency of your contact or the character of your relationship with Reserve park guards changed since your enrollment and participation in the Socio Bosque program?
13. Do you feel like your participation in the Socio Bosque program has increased or decreased your trust in MAE staff?

For all focus group participants, enrolled and non-enrolled in SB

1. Do you see the Socio Bosque program as part of the MAE, or as its own independent program?
2. Is there a difference between the two?
3. Did you always perceive them this way (same as MAE/distinct from MAE) from the inception of the SB program or did your perception change at some point after SB program was established?
4. Generally speaking, what are the benefits or positive aspects of the Socio Bosque program?
5. Likewise, what have been the difficulties or negative aspects of the Socio Bosque program?
6. In your opinion, does the Socio Bosque program increase, decrease, or have no effect on conflicts within the community?
7. Do you feel that the Socio Bosque program is fair? Why or why not?
8. In your opinion, has the program changed the way enrolled and non-enrolled community members think about their use of the forest, or about conservation in general? Or is the program more a reflection of or recognition of the way they have already been thinking about their use of the forest and/or conservation in general?
9. How could the program be improved?

Questions on SB-enrolled focus group participants' experiences of the suspension in payments (specific to 2017 and 2018 focus groups)

1. How long were you without payment?
2. When the payment suspension started, what did you think was the cause?
3. How did you find out about the payment suspension?

4. Did Socio Bosque inform the community or SB participants that payments had officially been suspended? Or did you have to obtain this information for yourself?
5. How did you go about obtaining information on the payment suspension?
6. Who did you ask?
7. Can you describe how your experience was in trying to obtain the information?
8. What was Socio Bosque's official response? What information did they offer, and who offered it?
9. What did you think about this response/information?
10. Has the government caught up with their back payments now?
11. If so, how long did they take to catch up?
12. If not, which payments are you still missing?
13. Do you feel that this payment suspension experience changed your relationship with the Provincial MAE or with SB?
14. Did it increase or decrease your trust in the MAE? Why?
15. Did it increase or decrease your trust in SB? Why?
16. Do you trust that MAE has your interests and wellbeing in mind?
17. Do you trust that SB has your interests and wellbeing in mind?

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