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LETTER

The impact of paying for forest conservation on perceived tenure security in Ecuador

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Abstract

We study the impact of Ecuador's national forest conservation incentives program on reported land conflicts. Data come from a survey of >900 households located within 49 indigenous and Afro-Ecuadorian communities holding communal conservation contracts. We use quasi-experimental methods to test for relationships between program participation and changes in land conflicts. Respondents reported that the program reduced land conflicts when households resided in communities with *de facto* communal tenure arrangements (vs. *de facto* semiprivate arrangements). We find no evidence that the conservation incentive program increased land conflicts. These results counter concerns that conservation payments undermine land tenure security; in some cases perceived tenure security is improved.

KEYWORDS

impact evaluation, land conflicts, land tenure, payment for ecosystem services, quasi-experimental, Socio Bosque

1 | INTRODUCTION

The conservation community is increasingly attendant to the relationship(s) between tenure security and the success of conservation interventions (Robinson et al., 2018). With the rise of payment for ecosystem services (PES) programs in the Global South, the focus has shifted to the connections and feedbacks between these programs and tenure security (Davis & Goldman, 2017; Naughton-Treves & Wendland, 2014). Some warn that PES programs may undermine local rights and weaken tenure security (Sandbrook et al, 2010; Phelps, Webb, & Agrawal, 2010; Sikor et al., 2010), while others suggest PES programs may increase participants' perceived tenure security (Bremer, Farley, & Lopez-Carr, 2014a; Jones et al., 2017). There are few impact evaluations testing whether participation in PES programs changes perceived tenure security. One exception is a comparative study that estimated the effect of tenure clarification projects that were part of the PES intervention on perceived tenure security (Sunderlin et al., 2018).

In this paper we provide national-level evidence on the impact of a payment-based forest conservation program on perceived tenure security. Tenure security is often conceptualized as the "assurances" of landholders that their land tenure will be upheld by society (Arnot, Luckert, & Boxall, 2011; Sjaastad & Bromley, 2000; van Gelder, 2010), with conflict being one factor influencing tenure security (Robinson et al., 2018). We study the relationship between participation in Ecuador's Socio Bosque program and reported land conflicts by households living in indigenous and Afro-Ecuadorian communities holding communal conservation contracts. Launched in 2008, Socio Bosque has enrolled 16,000 km^2 of

land, the majority (14,500 km^2) held in community contracts (N = 196). Many of these contracts are with indigenous or Afro-Ecuadorian communities who own the largest share of native forest in Ecuador and who struggle with land incursions and uncertain access rules (Morales, Naughton-Treves, & Suárez, 2010). Socio Bosque aims to: protect biodiversity and ecosystem services, improve socio-economic conditions, and improve natural resource governance (de Koning et al., 2011). Relative to research on forest outcomes, empirical studies of the socioeconomic or institutional outcomes of Socio Bosque are few: previous studies have focused on equity and livelihood concerns but not explicitly on tenure security (Bremer, Farley, Lopez-Carr, & Romero, 2014b; Hayes, Murtinho, & Wolff, 2015; Krause & Loft, 2013; Nogüés & Moretta, 2017; Yanez, 2016).

2 | THEORY OF CHANGE LINKING SOCIO BOSQUE TO TENURE SECURITY

The Socio Bosque program prioritizes areas based on deforestation threat, ecosystem service potential, and poverty rates (de Koning et al., 2011). To enroll in Socio Bosque, communities must possess *de jure* communal land titles. Ecuadorian communities customarily designate a portion of their forested land for conservation, and these are the areas that communities typically enroll in Socio Bosque contracts (in full or some portion). Participating communities voluntarily enter contracts with the government to conserve enrolled land for 20 years. Socio Bosque dictates that communities use incentive payments for community development projects. Additionally, some of the money is to be used to adequately demarcate and protect enrolled land against hunting and deforestation (MAE, 2014). This includes placing signage around the enrolled property and in some cases hiring community guards to monitor boundaries (Bremer et al., 2014a; Hayes, Murtinho, & Wolff, 2017).

We predict Socio Bosque enrollment could strengthen tenure security by reducing land conflicts (Figure 1). Mechanisms may include demarcating and monitoring property boundaries (per program requirements), greater confidence in government backing of tenure claims due to participation in the program (Bremer et al., 2014a; Jones et al., 2017), and clarification of community land tenure rules within enrolled communities (Hayes et al., 2015; Hayes et al., 2017). Alternatively, Socio Bosque could heighten land conflicts and reduce security if demarcation leads to contested claims about boundary placement (Corbera, Estrada, May, Navarro, & Pacheco, 2011). It is also possible that Socio Bosque has no effect on land conflicts, which would at least demonstrate that PES has not undermined tenure security. Land conflicts can occur with internal or external actors, and different mechanisms may affect these types of conflicts differentially. For example, internal clarification of community land tenure rules is more likely to reduce internal conflicts whereas heightened perceptions of government backing is more likely to reduce conflicts with external actors.

We also expect the effect of PES participation on changes in tenure security to be moderated by variation in customary access rules. Beyond *de jure* communal land tenure designations in Ecuador there is important variation and complexity in the *de facto* land tenure (Bennett & Sierra, 2014; Bremner & Lu, 2006; Grey, Bilsborrow, Bremner, & Lu, 2008). Some communities allow individual households temporary use of common pool resources, but permanent rights lie with the larger community. Other communities divide a portion of common land into tracts managed by individual households, and although none holds a legal individual land title, each household maintains its rights regardless of land use. In addition to institutional conditions moderating the impact of Socio Bosque on tenure security, biophysical (e.g., forest cover, land size) and socioeconomic (e.g., population size, community type) context could also influence program impacts (Sills & Jones, 2018).

3 | METHODS

3.1 | Survey

Our sample includes 49 indigenous and Afro-Ecuadorian communities in Ecuador's Amazonian and Northern regions; 25 that are enrolled in Socio Bosque (Figure 2). Treatment communities were randomly selected; date of enrollment varied between 2008 and 2013 (S1). Control communities were selected based on similarities in observable socioeconomic and biophysical characteristics with treatment communities (Arriagada, Cotacachi, Schiling, & Morrison, 2018). A community-level survey was conducted with leaders and then households were randomly selected. Surveys were conducted in early 2017. The sample used in this paper was 932 households; however sample size varies for some analyses.

Our dependent variable is self-reported information on boundary disputes and land invasions. Retrospective questions were used to gather information on land conflicts before and after Socio Bosque was implemented (S2). Specifically, we asked individual households: "Before 2008 (and 'After 2008 and until today'), were there any disputes or disagreements with anyone over the ownership of land?" Respondents replied either yes or no. Respondents were then asked about the disputants involved, allowing us to distinguish conflicts with internal actors—within family or community—and external actors—other individuals, communities, private industry, or government agencies.

Since there were not baseline data, we used recall data about land conflicts. To reduce potential bias, the survey team

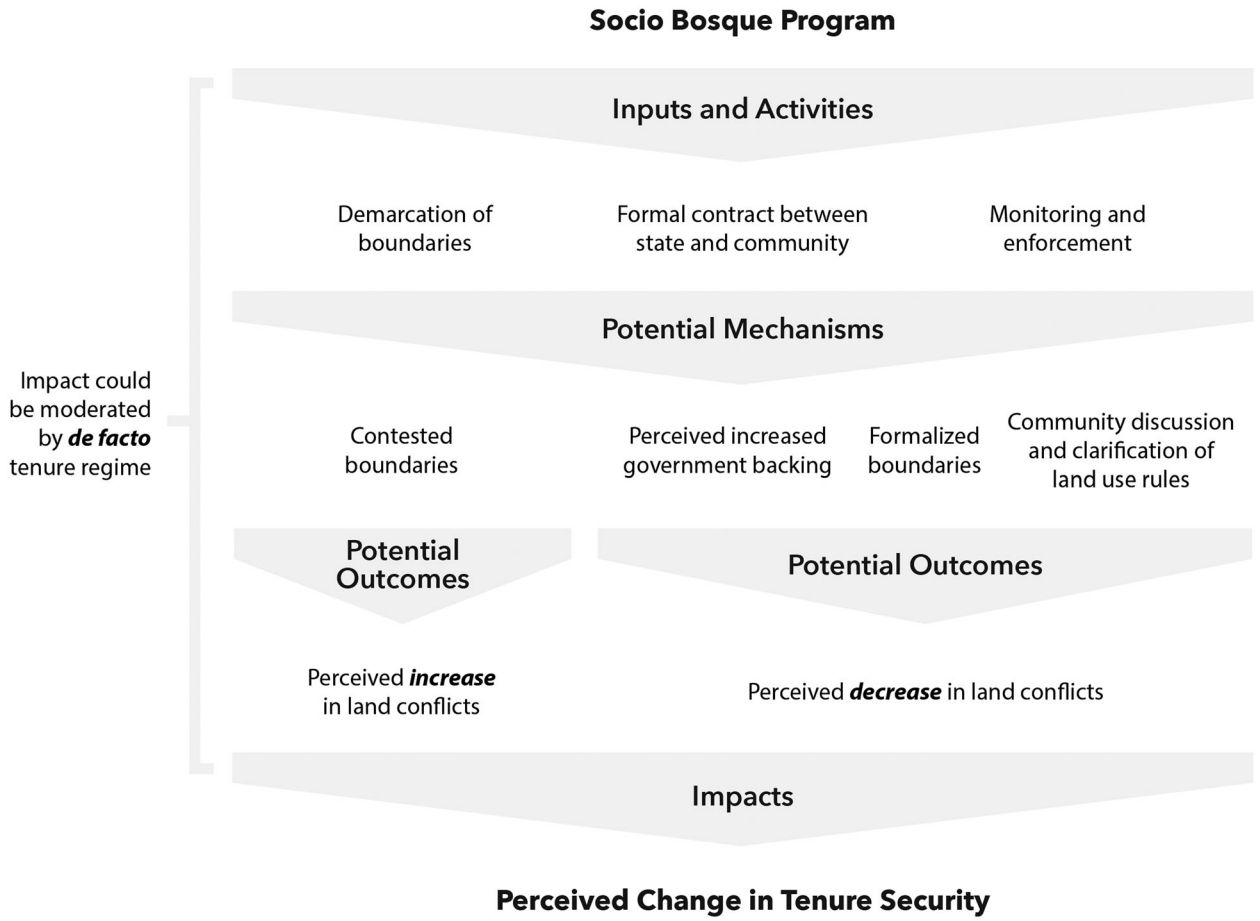

FIGURE 1 Theory of change linking Socio Bosque to changes in tenure security

established a time reference based on historical events (e.g., creation of the new Constitution of the Republic in 2008 as well as specific events identified by the community leaders) and we asked about presence of any conflict (i.e., yes/no response) versus specific numbers of conflicts (Schaeffer & Presser, 2003). We did not ask households specifically about tenure security on lands enrolled in Socio Bosque, as these lands would have been off limits if under contract and there would not be comparable areas to ask about in control communities. Instead, each household reported on total area of land they had access to or could use, including any semiprivate parcels, communal use lands, and leased or borrowed lands. Our assumption was that the inputs and activities, and potential mechanisms, induced by participating in Socio Bosque (Figure 1) would affect tenure security beyond the boundaries of enrolled lands. Information on the type of land the household had access to (e.g., semiprivate parcels) was used to construct dummy variables for access to *de facto* communal use and *de facto* semiprivate land parcels.

To control for other factors affecting the occurrence of land conflicts, we selected independent variables from the household survey expected to be correlated with reported land conflicts and enrollment in Socio Bosque (Bremer et al., 2014a; Hayes et al., 2015; Jones et al., 2017). These included: household family size, slope, total area of land the household had access to in 2008 and 2016, whether the land they had access to had forest on it, distance to the nearest market town and nearest paved road, and whether a household identified as being indigenous (versus Afro-Ecuadorian or other). We also used variables on total community population size and land area (in ha) set aside for communal use in 2008 and 2016 from the community leaders' survey to control for factors that might influence the communal decision to enroll in Socio Bosque and prevalence of land conflicts.

3.2 | Identification strategy

To estimate the average treatment effect for the treated we combined propensity score matching (PSM) with difference-in-differences (DID) to control for observable and time-invariant nonobservable bias (Imbens & Wooldridge, 2009). First, we estimated a propensity score for each household and then used 1-to-1 PSM without replacement to find the most similar control observation. All household and community variables listed above were included in the matching equation, along with regional (Coast, Andes, Amazon) dummy

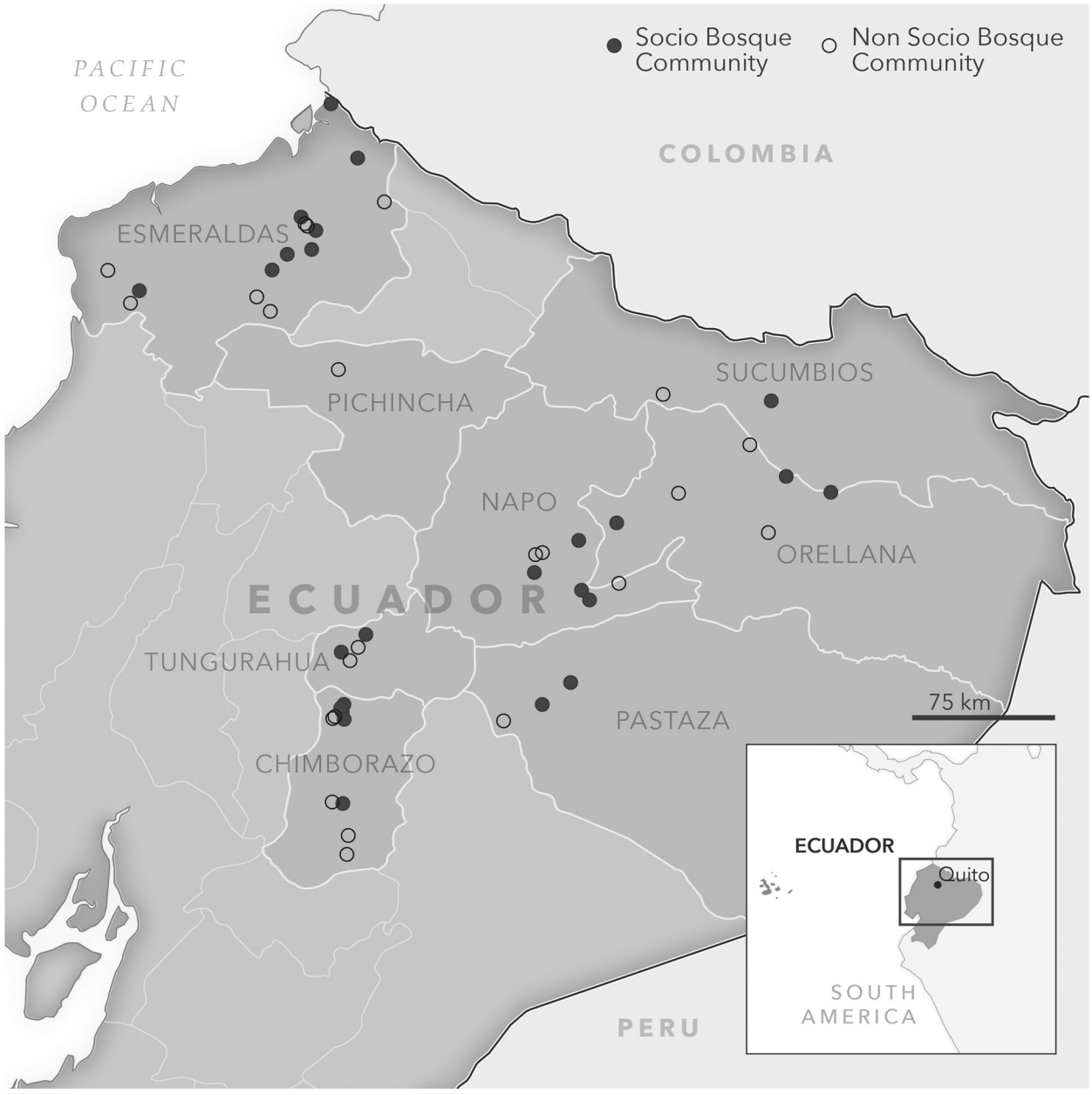

FIGURE 2 Map of study area with community locations

variables. We used a caliper to trim the sample to the best set of matches (Guo & Fraser, 2010). We checked covariate balance before and after PSM.

We used our trimmed sample of households in the following fixed effects panel regression:

$$Y_{it} = \beta_1 SocioBosque_{it} + \beta_2 X_{it} + \beta_3 Year_t + \beta_4 Region_i * Year_t + \mu_i + \varepsilon_{it}, \quad (1)$$

where i represents the household and t time. Y_{it} is self-reported land conflicts recorded as a "1″ if there was a land conflict reported in that year and "0″ otherwise. We controlled for household (μ_i) and year (β_3) fixed effects, and also included regional fixed effects interacted with year fixed effects (β_4) to account for time-varying characteristics at the regional level (e.g., economic prices) that might influence tenure security. β_1 is the variable of interest. Household covariates that are time-invariant are controlled for by the household fixed effects; X_{it} includes the total area of land the household had access to, community population, and total area of communal use land. In Equation (1), ε_{it} is estimated with cluster robust standard errors at the communal level to account for the clustered assignment of treatment and to control for spatial and temporal correlation (Abadie, Athey, Imbens, & Wooldridge, 2017).

We estimated Equation (1) as a linear fixed effects panel regression model. We used a linear probability model over

TABLE 1 Community and household summary statistics for 46 communities[a]

Variable	All households	Socio Bosque households	Non-Socio Bosque households
Report land conflict before 2008 (0/1)	0.21*0.40*	0.26*0.44*	0.15*0.35*
Report land conflict after 2008 (0/1)	0.12*0.33*	0.15*0.36*	0.08*0.27*
Community population in 2008	594.54*869.60*	437.27*199.73*	773.38*1129.91*
Communal use lands in 2008 (ha)	1444.142*073.10*	2016.662*412.68*	793.03*1312.16*
Household family size	5.44*2.62*	5.78*2.81*	5.06*2.32*
Total area of land household had access to in 2008 (ha)	14.94*26.47*	16.52*27.22*	13.14*25.50*
Household had forest on their land in 2008 (0/1)	0.61*0.49*	0.63*0.48*	0.59*0.50*
Slope (degrees)	2.26*6.44*	2.44*7.66*	2.07*4.69*
Distance to market town (hours)	1.12*1.13*	1.06*1.07*	1.18*1.19*
Distance to paved road (hours)	0.97*1.48*	1.10*1.71*	0.83*1.16*
Indigenous (1/0)	0.84*0.37*	0.93*0.24*	0.72*0.45*
De facto communal land tenure	0.58*0.49*	0.71*0.43*	0.38*0.49*
De facto semiprivate land tenure	0.45*0.50*	0.30*0.46*	0.63*0.48*
N	*872*	*464*	*408*

[a]Three communities (60 households) dropped due to missing community-level variables used in matching equation.

Note: Mean values reported with standard deviations in italics.

a nonlinear (binary) model because household fixed effects cannot be easily included in nonlinear binary-choice models (Wooldridge, 2010). Linear fixed effects models have been shown to give almost identical marginal effects at the mean of the data as nonlinear models with similar identifying assumptions (Angrist & Pischke, 2009; Wooldridge, 2010).

Equation (1) was estimated with Y_{it} representing all land conflicts and then separate regression models were estimated for the sub-set of land conflicts with external versus internal actors. As a robustness check we also estimated Equation (1) excluding X_{it} variables in case there is endogeneity between the dependent and independent variables. To test whether the *de facto* tenure regime moderated the impact of Socio Bosque on reported land conflicts we added an interaction term between *de facto* tenure regime and Socio Bosque participation (β_1) in Equation (1). We also tested whether the following noninstitutional variables moderated Y_{it} : (1) community population size; (2) size of communal use land; (3) community type; and (4) presence of forest. Data on community variables were missing for three communities—and 60 households within these communities. We present results omitting these three communities but including community-level variables and results with all 49 communities, but excluding community-level variables.

4 | RESULTS

Overall, reported land conflicts decreased by 9% over time in our sample (Tables 1 and S1). Reported land conflicts by households residing in Socio Bosque-enrolled communities decreased by around 11% while in non-Socio Bosque communities, decreases were closer to 7%. Community leaders enrolled in Socio Bosque reported smaller total population sizes and more communal use land than those not enrolled. Households within Socio Bosque-enrolled communities reported larger household sizes and more access to land than non-Socio Bosque households. About 60% of all households reported forest on the land they had access to. Households reported being located on average one hour from the nearest market town or paved road. More than 80% of respondents self-identified as indigenous. Seventy percent of households within communities enrolled in Socio Bosque reported that they had access to *de facto* communal use parcels, whereas non-Socio Bosque households were more likely to report access to *de facto* semiprivate parcels of land (63%).

While most covariates were statistically different between Socio Bosque and non-Socio Bosque households before matching, PSM considerably improved observable covariate balance as illustrated by differences in means and normalized differences in means (Table 2). Covariate balance across community-level variables was not achieved when community-level variables were excluded from the matching equation (Table S2).

Estimating Equation (1) using the full sample, households participating in Socio Bosque were no more likely to report a change in land conflicts than nonparticipant households (Table 3). The same is true when Equation (1) was estimated separately for conflicts with external versus internal actors. The effect of Socio Bosque participation on reported changes in land conflicts did vary by *de facto* land tenure: households with access to *de facto* communal use land and enrolled in Socio Bosque were more likely to report a decrease in land

TABLE 2 Covariate balance before and after matching using 46 communities[a]

Variable	Difference in means[b] before matching (with community variables)	Difference in means[b] after matching(with community variables)	Standardized differences in means[c] after propensity score matching(with community variables)
Community population in 2008	5.45**	−0.54	0.04
Communal use lands in 2008 (ha)	−9.42**	−1.58	0.13
Household size	−4.11**	0.24	0.02
Total area of land household had access to in 2008 (ha)	−1.89*	−0.69	0.06
Household had forest on their land in 2008 (0/1)	−1.16	1.01	0.09
Slope (degrees)	−0.87	−0.49	0.04
Distance to market town (hours)	1.52	−0.21	0.02
Distance to paved road (hours)	−2.68**	1.03	0.08
Indigenous (1/0)	−8.89**	−0.41	0.03
N	*872*	*588*	*588*

*$p \leq .05$; **$p \leq .01$.

Note: To reduce differences at the household and community level we included the following variables in the matching equation: household size, total area of land household had access to in 2008, whether this land had forest on it, slope, distance to market town and paved road, whether household was indigenous, community population size in 2008, total communal use lands in 2008, and regional dummy variables. All variables were included in the matching equation.

[a]Three communities (60 households) dropped due to missing community-level variables used in matching equation.

[b]*T*-values from two-sample *t*-tests with unequal variances for differences between Socio Bosque and Non-Socio Bosque households.

[c]Standardized differences in means normalize the difference based on sample size. A value > .25 is considered large enough to bias parametric regression analysis (Imbens & Wooldridge, 2009).

TABLE 3 Impact of Socio Bosque on reported changes in land conflicts using 46 communities[a]

	All conflicts	Conflicts with external actors	Conflicts with internal actors	*De facto* access to communal use land	*De facto* access to semiprivate land
All households	−0.050	−0.030	−0.017	−0.095&	0.070
	0.046	*0.028*	*0.030*	*0.057*	*0.061*
N	*1,176*	*1,176*	*1,176*	*1,176*	*1,176*
Omitting households that rented or borrowed land[b]	−0.043	−0.017	−0.023	−0.103&	0.047
	0.046	*0.029*	*0.028*	*0.056*	*0.060*
N	*1,152*	*1,152*	*1,152*	*1,152*	*1,152*
Omitting households that reported access to both semiprivate and communal use lands[c]	−0.047	−0.026	−0.023	−0.128*	0.067
	0.046	*0.029*	*0.029*	*0.057*	*0.067*
N	*1,128*	*1,128*	*1,128*	*1,128*	*1,128*
Omitting households that rented or borrowed land and that reported access to both semiprivate and communal use lands[d]	−0.054	−0.028	−0.025	−0.135*	0.065
	0.047	*0.028*	*0.030*	*0.061*	*0.063*
N	*1,112*	*1,112*	*1,112*	*1,112*	*1,112*

*$p \leq .05$; **$p \leq .01$; &$p \leq .10$.

Note: Linear fixed effects panel regression estimated with program dummy variable, total area of land household had access to in 2008 and 2016, community population size in 2008 and 2016, total area of communal use land in 2008 and 2016, household fixed effects, year fixed effects, and region-year fixed effects. Standard errors were clustered at the community level. After matching, 294 treatment observations and 294 control observations were retained under "all households." Minimum detectable effect size is between 0.07 and 0.11 depending on power level (60–90%) using sample size of 600 (2 groups). Marginal effects reported with standard errors in italics.

[a]Three communities (60 households) dropped due to missing community-level variables used in matching equation.

[b]Drops 22 households that reported only having access to rented or borrowed land, since these households may have different tenure security.

[c]Drops 44 households that reported access to both semiprivate and communal use lands, since these may represent measurement error since it was often just one household per community that reported this dual type of access.

[d]Drops 22 households that reported only having access to rented or borrowed land and the 44 households that reported access to both semiprivate and communal use lands.

TABLE 4 Impact of Socio Bosque on reported changes in land conflicts using 46 communities[a] and no control variables

	All conflicts	Conflicts with external actors	Conflicts with internal actors	*De facto* access to communal use land	*De facto* access to semiprivate land
All households	−0.062	−0.034	−0.028	−0.108*	0.011
	0.045	*0.027*	*0.029*	*0.051*	*0.061*
N	*1,176*	*1,176*	*1,176*	*1,176*	*1,176*
Omitting households that rented or borrowed land	−0.055	−0.024	−0.031	−0.113*	0.049
	0.046	*0.029*	*0.027*	*0.052*	*0.060*
N	*1,152*	*1,152*	*1,152*	*1,152*	*1,152*
Omitting households that reported access to both semiprivate and communal use lands	−0.050	−0.025	−0.032	−0.125*	0.070
	0.046	0.028	*0.029*	*0.054*	*0.067*
N	*1,128*	*1,128*	*1,128*	*1,128*	*1,128*
Omitting households that rented or borrowed land and that reported access to both semiprivate and communal use lands	−0.062	−0.030	−0.036	−0.136*	0.067
	0.046	*0.028*	*0.029*	*0.056*	*0.063*
N	*1,112*	*1,112*	*1,112*	*1,112*	*1,112*

*$p \leq .05$; **$p \leq .01$; &$p \leq .10$.

Note: Linear fixed effects panel regression estimated with program dummy variable, household fixed effects, year fixed effects, and region-year fixed effects, No control variables included. Standard errors were clustered at the community level. After matching, 294 treatment observations and 294 control observations were retained under "all households." Minimum detectable effect size is between 0.07 and 0.11 depending on power level (60–90%) using sample size of 600 (2 groups). Marginal effects reported with standard errors in italics

[a]Three communities (60 households) dropped due to missing community-level variables used in matching equation.

[b]Drops 22 households that reported only having access to rented or borrowed land, since these households may have different tenure security.

[c]Drops 44 households that reported access to both semiprivate and communal use lands, since these may represent measurement error since it was often just one household per community that reported this dual type of access.

[d]Drops 22 households that reported only having access to rented or borrowed land and the 44 households that reported access to both semiprivate and communal use lands.

conflicts of around 0.10%-points. There was no statistically significant difference in reported land conflicts for households with *de facto* semiprivate parcels due to Socio Bosque. Treatment effect results were similar using all 49 communities (Table S3) and when no control variables were included in Equation (1) (Table 4). Controlling for year of PES enrollment does not change these results (S1). The only consistently statistically significant noninstitutional moderating factor was communal land size (Table S4): Socio Bosque reduced land conflicts when communal use lands were above the median value but not when they were below the median value.

5 | DISCUSSION

During our study, Afro-Ecuadorians and indigenous peoples enjoyed significant gains in their collective land rights in Ecuador thanks partly to the new 2008 Constitution (Becker, 2011). Even within the context of these national-level changes, we found evidence that Socio Bosque participation led to reductions in reported land conflicts for some households, indicating a strengthened sense of some aspects of land tenure security. Just as importantly, we found no evidence that Socio Bosque participation led to reported increases in land conflicts. In many cases we found no effect of the program on land conflicts, which is also a positive result for tenure security as it indicates that participation in the program did not exacerbate land conflicts. Similarly, Sunderlin et al. (2018) find no effect of PES on tenure security in three countries but a positive and negative effect in one country respectively. Thus, the influence of PES on tenure security is context dependent.

We found a moderating effect of community *de facto* land tenure regimes on the impact of Socio Bosque on reported land conflicts: households within Socio Bosque-enrolled communities that had access to communal use land were more likely to report a decrease in land conflicts than households with access to communal use lands but not enrolled in Socio Bosque. The moderating effect that informal institutional arrangements can have on tenure security and conservation outcomes has been hypothesized in the literature (Robinson et al., 2018), but rarely tested (Sills & Jones, 2018). Semiprivate parcels are likely to be already demarcated within communities in Ecuador and associated with exclusionary rights, whereas *de facto* communal use lands are generally unlikely to be demarcated and therefore harder to defend against other actors (Bennett & Sierra, 2014; Bremner & Lu, 2006; Grey et al., 2008).

Turning to potential mechanisms that would explain these decreases in land conflicts, we cannot rule out any of

the potential positive mechanisms in Figure 1. Boundary demarcation and monitoring and enforcement are Socio Bosque contract requirements. Socio Bosque participation could lead to decreases in land conflicts by formalizing boundaries and increasing surveillance for illegal activities. Leaders in our community surveys reported that they conducted monitoring activities in 24 of the 25 Socio Bosque communities. Another possible mechanism is the heightened perception of government engagement. The Socio Bosque program promised participants government mediation in conflicts on enrolled lands. Evidence that participants pay heed to these promises comes from field studies in Ecuador (Bremer et al., 2014a; Jones et al., 2017), and in other PES programs (Arriagada, Sills, Pattanayak, & Ferraro, 2009). It is possible that these assurances allowed community leaders to ward off other actors with possible government mediation, and/or such actors would desist given the potential for government intervention. Finally, internal clarification of land tenure rules has been documented in Socio Bosque communities (Hayes et al., 2017), and participation in the program could discourage community members from violating their own rules.

These results should not be interpreted as causal since we do not have random assignment of the PES program; however, within Ecuador, communities were randomly selected and are representative of the majority of community forest conservation contracts. Our results should be applied with caution to other payment programs, since the effect of conservation payments on land conflicts will vary due to differences in land tenure arrangements and PES contract design. Furthermore, we only measure one aspect of tenure security, and participation in Socio Bosque could have simultaneously affected other aspects of tenure security.

Despite these caveats, this study presents one of the first large-N assessments utilizing quasi-experimental methods to evaluate the counterfactual impact of a conservation payment program on reported changes in land conflicts. Our results are important globally for the conservation community, as they provide rigorous evidence that it is possible to compensate communities for forest protection without exacerbating land conflicts, and that these programs can even strengthen perceived tenure security. Improving tenure security outcomes should have positive impacts on other dimensions of human well-being and sustainable development, both important targets in the Socio Bosque program and PES interventions more widely (Blundo-Canto et al., 2018; Liu & Kontoleon, 2018).

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We thank the Interamerican Development Bank for funding this survey. The data used in this analysis are available by request. Survey questions were reviewed by IADB and deemed to provide minimal risk to human subjects. This manuscript has been greatly improved by two anonymous reviewers.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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