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

Short Title: Conservation payments and land conflict

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Abstract

We study the impact of Ecuador's national forest conservation incentives program on perceived land tenure conflicts. Data come from a survey of 861 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 perceived changes in land conflicts. Respondents reported that the program reduced land conflicts with external actors when households resided in communities with *de facto* communal tenure arrangements (vs. *de facto* semi-private tenure arrangements). We find no evidence that the conservation payment program increased perceptions of land conflicts. These results counter concerns that conservation payments undermine local rights and land tenure security; in some cases perceived tenure security is improved.

Introduction

The conservation community is increasingly attendant to the relationship(s) between tenure security and the success of conservation interventions (Robinson et al. 2014; Robinson et al. 2018). With the rise of payments for ecosystem services (PES) in the Global South, the focus has shifted to the connections and feedbacks between tenure security and payment-based conservation programs (Naughton-Treves and Wendland 2014; Davis and Goldman 2017). Some warn that PES programs may undermine local rights and weaken tenure security (Sikor et al. 2010; Phelps et al. 2010; Sandbrook et al. 2010), while others suggest increased perceptions of tenure security by participants as a result of payment-based conservation programs (Bremer et al. 2014a; Jones et al. 2017). There are few impact evaluations testing whether participation in conservation payment programs decrease or increase tenure security (but see Sunderlin et al. 2018).

This study provides national-level evidence on the impact of a payment-based forest conservation program on tenure security. We study the relationship of Ecuador's forest conservation-payment program, Socio Bosque, on perceptions of land conflicts experienced 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). 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 (but see Krause and Loft 2013; Bremer et al. 2014b; Hayes et al. 2015; Yanez 2016; Nogüés and Moretta 2017).

Theory of Change Linking Socio Bosque to Tenure Security

To enroll in Socio Bosque, communities must possess *de jure* communal land titles (de Koning et al. 2011). Many Ecuadorian communities 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 enter voluntary contracts with the government to conserve a portion of their forested land for 20 years. The contract stipulates that any land enrolled in the program must be demarcated and protected by the community against hunting or deforestation (MAE 2012).

We predict Socio Bosque enrollment could strengthen tenure security by reducing land conflicts (see Fig. 1 for our theory of change). Mechanisms include: formalized property boundaries, 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 et al. 2011). Moreover, land conflicts between community members or with external actors would be affected differentially. For example, if Socio Bosque leads to internal clarification of community land tenure rules, internal conflicts may be reduced. If the program heightens perceptions of government backing in the mediation of community-level claims, this may reduce external actors' motivations to encroach on communal land.

Beyond *de jure* communal land tenure designations in Ecuador there is important variation and complexity in the *de facto* access rules (Bremner and Lu 2006; Grey et al. 2008; Bennett and Sierra 2014), which may moderate the effect of Socio Bosque on changes in tenure security. 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. These *de facto* access rules might moderate the impact of Socio Bosque on land conflicts because households with *de facto* semi-private tenure arrangements are more likely to hold exclusionary rights and to have already demarcated their lands, while in *de facto* communal systems, land claims are more fluid and excluding others is more difficult (Bremner and Lu 2006; Grey et al. 2008).

Methods

Data

Our sample includes 49 indigenous and Afro-Ecuadorian communities in Ecuador's Amazonian and Northern regions; 25 that are enrolled in Socio Bosque (Fig. 2). Treatment communities all held contracts with Socio Bosque since 2008. Control communities were selected to match socioeconomic and biophysical characteristics of treatment communities (Arriagada et al. 2018). After a community-level survey with leaders, households were randomly selected and surveyed within these 49 communities. The final household sample size used in this analysis is 861 households: 453 in treatment communities and 408 in control communities.

The dependent variable in our analysis is self-reported information on boundary disputes and land invasions. Tenure security is often conceptualized as the 'assurances' or 'perceptions' of land managers (Sjaastad and Bromley 2000; van Gelder 2010; Arnot et al. 2011), and our dependent variable follows this line of thinking. Retrospective questions were used to gather information on land conflicts before and after Socio Bosque was implemented (see S1). Specifically, we asked individual households: "Before 2008, were there any disputes, conflicts, or disagreements with anyone over this property?" and "After 2008 and until today, have there been any disputes, conflicts, or disagreements over this property?". From these questions we created

two dependent variables: "decreased perception of land conflict" and "increased perception of land conflict". A household that reported a conflict before 2008 but not after was labeled as "decreased perception of land conflict", where "1" represents a decrease and "0" otherwise. A household free of conflict before 2008 but reporting one after was considered "increased perception of land conflict", where "1" represents an increase and "0" otherwise.

Survey questions about the disputants involved allowed us to distinguish conflicts with internal actors—within family or community—and external actors—other individuals, communities, private industry, or government agencies. Each household reported on total area of land they have access to, including semi-private parcels, communal use lands, and leased or borrowed land. This information was used to construct dummy variables for access to *de facto* communal use and *de facto* semi-private land parcels.

To control for other factors affecting perceptions of land conflicts, we selected independent variables from the household survey expected to be correlated with presence of land conflicts and enrollment in Socio Bosque (Bremer et al. 2014a; Hayes et al. 2015; Jones et al. 2017). Household family size and total area of accessible land (in ha) were recorded for 2008. Household distance to the nearest market town and paved road were recorded in hours of travel time. We recorded whether a household identified as being indigenous or not. We also used variables on total community population size and land area (in ha) set aside for communal use 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.

Data Analysis

We used quasi-experimental methods to estimate the impact of Socio Bosque on the perception of land conflicts (see S2). First, we used nearest neighbor matching with bias

adjustment and robust standard errors to estimate the average treatment effect on the treated (Abadie and Imbens 2006). We matched using the observable covariates listed above and with and without exact matching on region (Amazon, Andes, Coast). We checked covariate balance before and after matching using differences in means and standardized differences in means tests (Imbens and Wooldridge 2009). Second, we estimated the impact of Socio Bosque on the perception of land conflicts using difference-in-difference (DID) methods. DID controls for time-invariant unobservables that can bias observable causal estimates (Imbens and Wooldridge 2009); we implemented DID using fixed effects panel regression. Third, we combined propensity score matching (PSM) with DID to control for observable and time-invariant non-observable bias; trimming the sample to the best set of matches based on the propensity score (Guo and Fraser 2010) before employing fixed effects panel regression (Imbens and Wooldridge 2009). We present results using cluster robust standard errors at the household and community level (Abadie et al. 2017).

For all three empirical methods the full set of households was first used to test whether Socio Bosque increased or decreased perceived land conflicts. We then tested hypotheses laid out in Fig. 1. First, we tested for differences in the impact of Socio Bosque on conflicts with external versus internal actors. To do this we separated our sample by type of actor and estimated separate treatment effects for these two sub-samples. The second hypothesis we tested was whether the *de facto* tenure regime moderated the impact of Socio Bosque on perceived land conflicts. We used sub-sample analysis, separating out *de facto* communal use lands and *de facto* semi-private lands, and additionally, we estimated this effect through adding an interaction term between *de facto* tenure regime and Socio Bosque participation in fixed effects regression. Sub-sample analysis

relaxes the assumption that the structural form is the same for all samples while interaction effects impose the same structural form for each subgroup (Sills and Jones 2018).

Results

Community leaders enrolled in Socio Bosque reported smaller total population sizes and more communal use land than those not enrolled (Table 1). Households within Socio Bosque-enrolled communities reported an average of 6 persons per household and access to 19 ha of land. About 90% of Socio Bosque households surveyed self-identified as indigenous. Non-Socio Bosque households reported smaller family sizes (5 persons) and access to less total land (14 ha); they were less likely to self-identify as indigenous (66%). On average, all households surveyed were about one hour from the nearest road and nearest market town. Seventy percent of households within communities enrolled in Socio Bosque reported that they have access to *de facto* communal use (30% had access to semi-private parcels), whereas non-Socio Bosque households were more likely to report access to *de facto* semi-private parcels of land (67%) versus *de facto* communal use (33%).

About 20% of households in our sample reported having a land conflict before 2008; of these 176 households that reported land conflicts, 59% were with external actors and 41% with internal actors. About 12% of households reported having a land conflict after 2008. When separated out by decreases and increases before and after 2008, 14% of households perceived a decrease in land conflicts and 5% perceived an increase (Table 2). Households residing in a Socio Bosque-enrolled community were more likely to report a decrease in conflicts after 2008 than non-Socio Bosque households. Differences in reported decreases were only statistically significant for disputes with external actors and disputes on *de facto* communal lands. The number of households

reporting increases in land conflicts over time was not statistically different between Socio Bosque and non-Socio Bosque households.

Nearest neighbor matching and PSM improved observable covariate balance across Socio Bosque and non-Socio Bosque households as illustrated by differences in means and normalized differences in means (Table 1 and Table S1). Using all three quasi-experimental estimation methods, households in Socio Bosque were more likely to report a significant decrease in land conflicts compared to non-participant households. The average treatment effect using the full sample of households varies between 0.09-0.1% points with nearest neighbor matching (Table 3) and 0.07-0.09% points with fixed effects panel regression (Table 4).

There was a significant and positive effect of Socio Bosque on perceived decreases in land conflicts with external actors; the treatment effect varies between 0.06-0.08% points (Table 3 and 4). Socio Bosque participation did not have a significant effect on decreasing land disputes with internal actors. The effect of Socio Bosque participation on decreasing land conflicts for households with *de facto* communal use land was statistically significant and 0.14% points using nearest neighbor matching (Table 3). Using PSM plus fixed effects panel regression the treatment effect was 0.14% points using an interaction term and 0.18% points using sub-sample analysis. There was no statistically significant decrease in reported land conflicts for households with *de facto* semi-private parcels due to Socio Bosque.

We found no statistically significant effects of participation in Socio Bosque on perceived increases in land conflicts (Table S2 and S3). This is true for the full sample of households and all sub-sample analyses.

Discussion

During our study, Afro-Ecuadorians and indigenous peoples enjoyed significant gains in their collective land rights in Ecuador thanks partly to changes written into the new 2008 Constitution (Becker 2011). Even within the context of these national-level changes, we found evidence that Socio Bosque participation led to perceived reductions in land conflicts, indicating a strengthened sense of at least some aspects of land tenure security. Specifically, we found that the conservation payment program led to a reduced perception of land disputes with external actors.

Based on these results, it does not appear that the Socio Bosque program has led to contested boundaries in our study area since we do not find any statistically significant increases in perceived land conflicts (Fig. 1). It is also unlikely that community clarification and discussion of land tenure rules around forest management led to the reduced perceptions of land conflicts, since these discussions would have likely impacted internal land conflicts as well. The two mechanisms that would most plausibly be influencing perceived decreases in land conflict with external actors are: 1) more secure boundaries due to demarcation of community boundaries or monitoring and enforcement activities, and 2) heightened perceptions of possible government mediation of land conflicts.

Boundary demarcation and monitoring and enforcement are Socio Bosque contract requirements. These efforts could lead to decreases in land conflicts with external actors by formalizing boundaries and increasing surveillance for illegal activities. While these activities may not always be implemented in practice, leaders in our community surveys self-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 government mediation in land conflicts for enrolled communities (and individual

contracts). Further evidence that communities (and individuals) 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 et al. 2009). Whether or not these promises would be upheld, it is possible that the assurances allowed community leaders to threaten external actors with possible government mediation, and/or external actors would be less keen to spark disputes with communities enrolled in Socio Bosque given the potential for government intervention.

We also found a moderating effect of community *de facto* land tenure regimes on the impact of Socio Bosque on the perception of land conflicts: households that had access to *de facto* communal use land were more likely to report a decreased perception of land conflicts due to participation in the program. 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 and Jones 2018). Semi-private parcels are typically already demarcated within communities in Ecuador and associated with exclusionary rights, whereas *de facto* communal use lands are generally not demarcated and therefore harder to defend against external actors.

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 formal and informal land tenure arrangements and PES contract design. There are also potential limitations of our data in terms of measurement bias, since there may be reluctance to report some types of land conflicts, and recall bias, since we asked households retrospectively about land conflicts. Furthermore, we only measure one aspect of tenure security in this study, 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 perceived changes in land conflicts. The increase in perceived tenure security outcomes should have positive impacts on 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 and Kontoleon 2018). 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 perceptions of land tenure security.

Acknowledgements and Data

We thank the Interamerican Development Bank for funding this survey. The data used in this analysis will be available on figshare.com once the manuscript is published. Survey questions were reviewed by IADB deemed to provide minimal risk to human subjects.

Figure Legends

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

Fig 2. Map of study area with community locations

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

- S1. Household survey questions on land conflict.

- S2. Additional details on data analysis.
- Table S1. Covariate balance before and after matching using full sample of households.
- Table S2. Impact of Socio Bosque on perceived increases in land conflicts using nearest neighbor matching.
- Table S3. Impact of Socio Bosque on perceived increases in land conflicts using fixed effects panel regression.

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Table 1. Community and household summary statistics[a].

Variable	All households	Socio Bosque households	Non-Socio Bosque households	Difference in means[b] before matching	Difference in means[b] after matching
Community population	600.98 *840.34*	431.74 *196.66*	788.88 *1,175.56*	6.06**	1.45
Communal use lands (ha)	1,591.78 *2,256.88*	1,922.64 *2,412.73*	1,216.15 *2,003.63*	-4.54**	-0.80
Household family size	5.42 *2.63*	5.79 *2.85*	4.99 *2.30*	-4.53**	-1.79
Total area of land household had access to (ha)	16.45 *27.39*	18.79 *28.59*	13.85 *25.77*	-2.63**	-1.24
Distance to market town (hours)	1.09 *1.08*	1.00 *0.91*	1.19 *1.26*	2.66*	0.10
Distance to road (hours)	0.96 *1.44*	1.05 *1.66*	0.86 *1.16*	-2.16*	0.76
Indigenous (1/0)	0.78 *0.41*	0.90 *0.31*	0.66 *0.47*	-8.52**	0.16
N	*861*	*453*	*408*	*861*	*520*

**p≤0.05, **p≤0.01*

[a] Mean values with standard deviations in italics.

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

Table 2. Summary of perceived decreases and increases in land conflicts[a].

	All households	Socio Bosque households	Non-Socio Bosque households	Difference in means[b] before matching	Difference in means[b] after matching
Decrease in land conflicts					
All disputes	13.5% *34.2%*	16.7% *37.4%*	10.0% *30.1%*	-2.89**	-2.06*
N	*861*	453	408	*861*	*516*
Disputes with external actors	8.4% *27.7%*	11.1% *31.4%*	5.3% *22.3%*	-2.93**	-1.81
N	*787*	*413*	*374*	*787*	*473*
Disputes with internal actors	6.7% 25.0%	7.9% *27.0%*	5.5% *22.9%*	-1.29	-1.33
N	*759*	380	379	*759*	*466*
Disputes on *de facto* communal lands	16.0% *36.7%*	18.8% *39.1%*	9.6% *29.5%*	-2.45*	-2.81**
N	*456*	*320*	*136*	*456*	*234*
Disputes on *de facto* private lands	10.9% *31.2%*	12.0% *32.7%*	10.3% *30.4%*	-0.53	0.75
N	*405*	*272*	*133*	*405*	*282*
Increase in land conflicts					
All disputes	4.6% *21.1%*	5.5% *22.9%*	3.7% *18.8%*	-1.28	-0.22
N	*861*	*453*	*408*	*861*	*516*
Disputes with external actors	5.1% *22.0%*	6.1% *23.9%*	4.0% *19.6%*	-1.30	-0.31
N	*787*	*413*	*374*	*787*	*473*
Disputes with internal actors	5.3% *22.4%*	6.6% *24.8%*	4.0% *19.5%*	-1.62	-0.40
N	*759*	*380*	*379*	*759*	*466*
Disputes on de facto communal lands	5.0% *21.9%*	5.9% *23.7%*	2.9% *17.0%*	-1.34	0.34
N	*456*	*320*	*136*	*456*	*234*
Disputes on de facto private lands	4.2% *20.1%*	4.5% *20.8%*	4.0% *19.7%*	-0.22	-0.85
N	*405*	*272*	*133*	*405*	*282*

**p≤0.05, **p≤0.01*

[a] Mean values with standard deviations in italics.

[b] Z-scores from two-sample Wilcoxon rank-sum tests for differences between Socio Bosque and Non-Socio Bosque households.

410

411

Table 3. Impact of Socio Bosque on perceived decreases in land conflicts using nearest neighbor matching.

	Full sample	*De facto* access to communal use land (sub-sample analysis)	*De facto* access to semi-private land (sub-sample analysis)	External actor conflicts (sub-sample analysis)	Internal actor conflicts (sub-sample analysis)
	Nearest neighbor matching-covariates only[a]				
Mahalanobis metric	0.097** *0.035*	0.150** *0.033*	-0.030 *0.052*	0.076** *0.027*	0.033 *0.026*
Inverse metric	0.099** *0.035*	0.152** *0.031*	0.058 *0.062*	0.082** *0.028*	0.042 *0.026*
	Nearest neighbor matching-covariates & exact match on region[b]				
Mahalanobis metric	0.094** *0.032*	0.143** *0.034*	-0.010 *0.064*	0.063* *0.026*	0.022 *0.026*
Inverse metric	0.090** *0.031*	0.144** *0.032*	-0.007 *0.058*	0.069** *0.025*	0.026 *0.026*
N	*789*	*450*	*339*	*718*	*696*

**p≤0.05, **p≤0.01*

[a] *Matching results based on nearest neighbor matching with regression bias-adjustment and robust standard errors (in italics). Covariates included in the match and bias-adjustment: household size, total area of land, distance to market town, distance to road, indigenous, community population size, and size of communal use lands.*

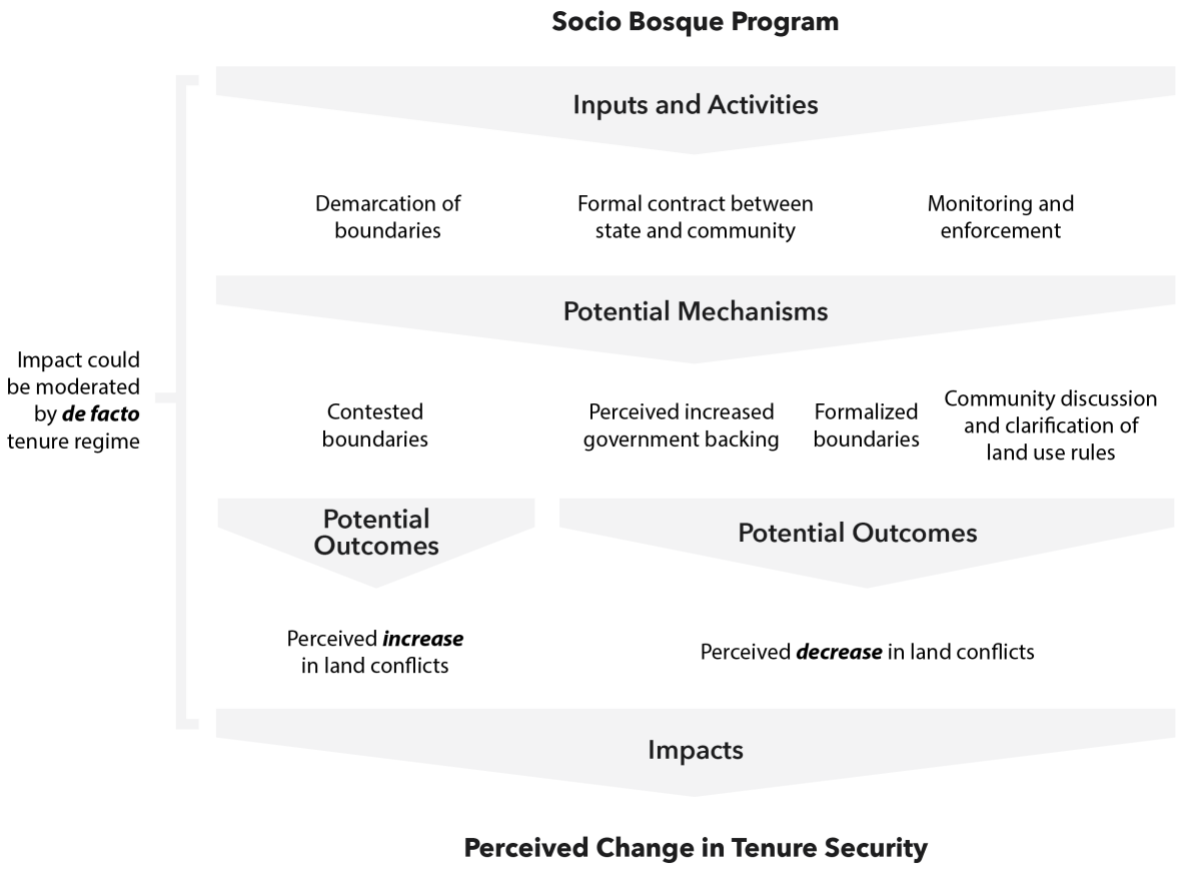
[b] *Includes same covariates as above plus exact match on region (i.e., Amazon, Andes, Coast).*

Table 4. Impact of Socio Bosque on perceived decreases in land conflicts using fixed effects panel regression.

	Full sample	***De facto* access to communal use land (sub-sample analysis)**	***De facto* access to semi-private land (sub-sample analysis)**	***De facto* access to communal use land (interaction term)**	***De facto* access to semi-private land (interaction term)**	**External actor conflicts (sub-sample analysis)**	**Internal actor conflicts (sub-sample analysis)**
Fixed effects panel regression							
Clustering on household	0.067** *0.023*	0.092** *0.033*	0.017 *0.041*	0.087** *0.026*	0.020 *0.032*	0.058** *0.019*	0.024 *0.018*
Clustering on community	0.067* *0.033*	0.092 *0.049*	0.017 *0.033*	0.087* *0.039*	0.020 *0.039*	0.058* *0.027*	0.024 *0.021*
N	*1,722*	*912*	*810*	*1,722*	*1,772*	*1,574*	*1,518*
PSM[a] + Fixed effects panel regression							
Clustering on household	0.085** *0.030*	0.175** *0.044*	-0.022 *0.036*	0.139** *0.038*	-0.007 *0.035*	0.071** *0.026*	0.033 *0.027*
Clustering on community	0.085* *0.042*	0.175* *0.066*	-0.022 *0.038*	0.139** *0.054*	-0.007 *0.034*	0.071* *0.034*	0.032 *0.024*
N	*1,040*	*482*	*558*	*1,040*	*1,040*	*950*	*930*

**p≤0.05, **p≤0.01*

[a] *Propensity scores estimated using the following covariates: household size, total area of land, distance to market town, distance to road, indigenous, community population size, size of communal use lands, and region. One-to-one nearest match calculated using a caliper and without replacement. Observations that were not matched were dropped from sample, and the 'trimmed' sample was used to estimate fixed effects panel regression.*



444
445 **Fig 1. Theory of change linking Socio Bosque to changes in tenure security**

446

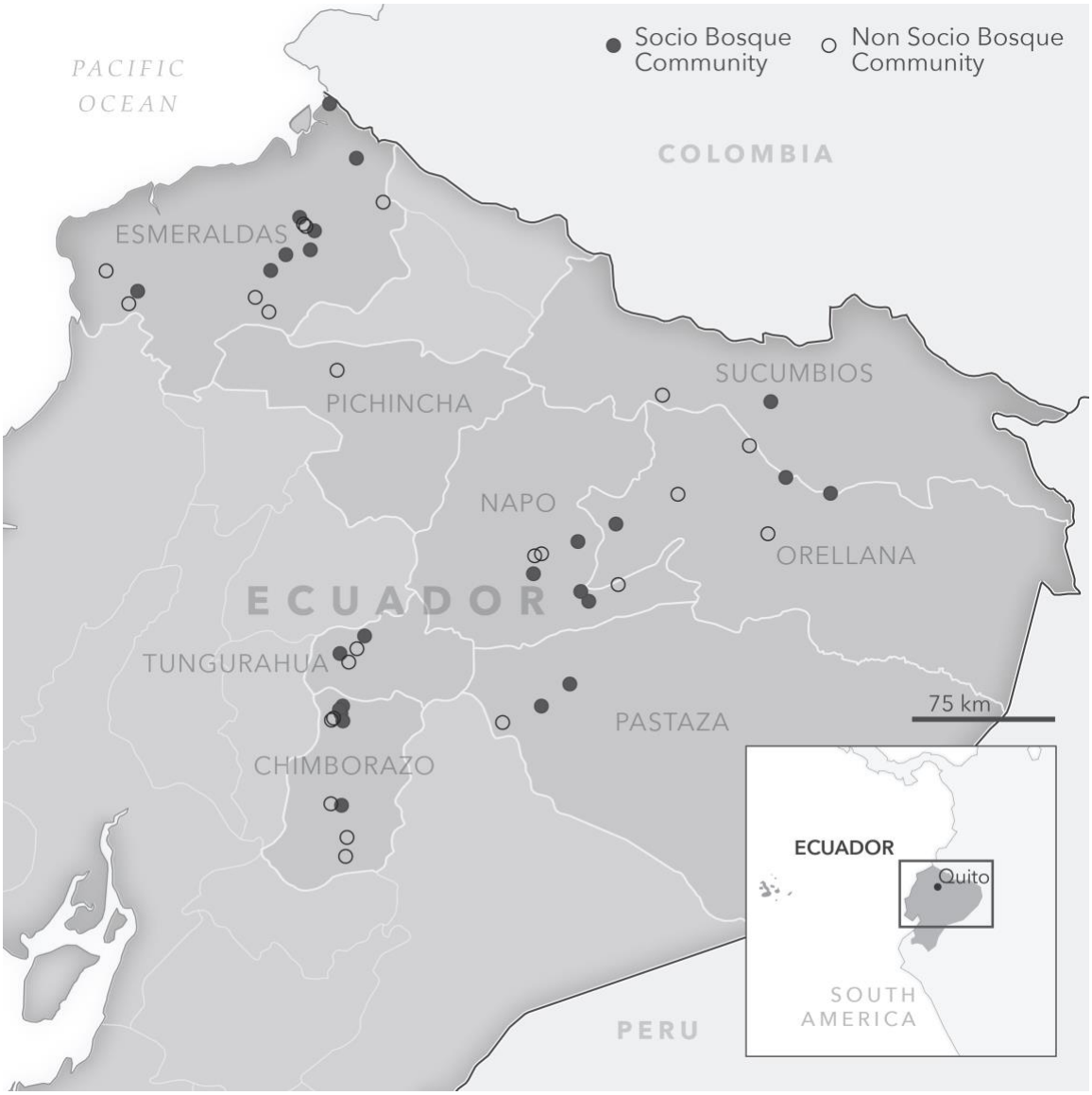


Fig 2. Map of study area with community locations