Draft Version Presented at "Land Tenure and Forest Carbon Management" Workshop, Land Tenure Center, University of Wisconsin, Madison, October 21-22, 2011

Working Paper:

Changing forests and overlapping tenure in the Ecuadorian Amazon: implications for the future implementation of SocioBosque

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Abstract

In this paper, we explore the standard predictors of deforestation but also test whether the form of tenure, the identity of owner, affect land use change. We focus on the northern Ecuadorian Amazon, whose forests contain globally significant biological and cultural diversity, but also grow above significant oil reserves. As elsewhere in the Amazon, land in this area is subject to multiple designations with different rules concerning deforestation. We explicitly examine whether overlapping land claims affect deforestation. Recognizing that drivers of Amazonian deforestation can change abruptly with national-level political change (Alvarez and Naughton, 2003), we run our tests during two key time periods (1990-2000-2008) marked by different policies and land availability. A wealth of previous research in this region contributes to our understanding of land use change dynamics and the differences between the activities of different groups of actors (mainly indigenous groups vs. colonists). Our study adds to this knowledge base by (1) extending the time period of land use change analysis up to 2008, (2) addressing land tenure form directly across the entire region, and (3) focusing on the challenges and promise for SocioBosque as a forest conservation and climate mitigation tool. While our results point to a notable decrease in the rate of forest loss over the two time periods, we find variability across categories of tenure, and within overlapping forms of tenure, such as protected forests and protected areas with indigenous areas. Overall we conclude that tenure is complex; and that the effects on land use change are dynamic, even shifting significantly across more than one time period. We suggest that community-level incentive agreements, one of the mechanisms through which SocioBosque offers incentives, present a key opportunity to effect forest conservation, particularly for indigenous areas within this region.

Introduction

The forests of the Amazon basin play a significant role in the planetary carbon cycle (Phillips et al., 2009). Even though global deforestation decreased over the decade of 2000-2010, net annual forest loss in South America remained among the highest worldwide (FAO 2010). The severe drought events of 2005 and 2010 exacerbate the impacts of deforestation trends. More recently researchers suggest that the remaining intact forests in the Amazon are at risk of crossing the critical threshold from carbon sink to source, or net emitter (Lewis, Brando, Phillips, van der Heijden, & Daniel Nepstad, 2011).

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Increasing encroachment into the intact forests in the Amazon is a result of the dynamic frontier interplay of road expansion, resource extraction activities, and agricultural settlement. But the pattern and rate of deforestation are affected by more than the proximity of roads and rivers. Invisible, indirect factors such as land tenure and land policy are also important (Geist & Lambin 2002). Amazonian frontier forest is typically cleared more rapidly in areas where land ownership is uncertain and individuals clear forest to establish claim to the land and insure against the risk of expropriation or invasion (Fearnside, 2001). And despite pervasive problems of 'paper parks' and weak enforcement of indigenous reserves it appears that official land use designations affect forest clearing and fires(Nelson & Chomitz, 2011; D. Nepstad et al., 2006). Ultimately, if rural colonization policies, commercial resource extraction and road construction have determined the initial sweep of forest loss in these frontier regions, does the form of land ownership tell us something about how forests have continued to change?

Furthermore, land tenure has emerged as a critical, yet poorly understood, component of the most recent wave of incentive-based mechanisms that aim to conserve tropical forests and safeguard the ecosystem services and goods that they provide (e.g. carbon, biodiversity, and water)(Robinson, Holland, & Naughton-Treves, 2011). The highest profile of these incentive-oriented policies, REDD+ (Reducing Emissions from Deforestation and Degradation *plus* Conservation, Sustainable Forest Management and Enhancement of Carbon Stocks), was formally approved as part of the recent Cancun Agreements of the UNFCCC Conference of Parties (COP-16) (Robinson et al., 2011). Clear and secure tenure are essential for REDD+ and any related conservation incentive-based programs to be successful and equitable (Bruce et al. 2010). Yet there is a persistent lack of empirical knowledge on whether certain forms of land tenure are linked with slowed rates of deforestation. Such understanding, while often context-dependent, should help form the basis for the design, prioritization, and implementation of any conservation incentive program, especially when such programs have already become large components of national REDD+ strategies.

In this paper, we look to a northwest region of the Amazon and pose three questions:

1. Is there a significant variation in forest change across different forms of land tenure?
2. Are forest outcomes markedly different for areas where overlapping tenure forms exist?
3. How might the interplay between land tenure form and deforestation help inform improved implementation of a forest conservation incentive mechanism?

The adjacent provinces of Sucumbíos and Orellana, located within the northeastern boundary region of Ecuador (Fig 1), whose forests contain globally significant biological and cultural diversity, grow above globally significant oil reserves. As elsewhere in the

Amazon, land in this area is subject to multiple designations with different rules concerning deforestation. Thus we explicitly examine whether level of overlapping forms of tenure affect deforestation. We use a mixed effects linear model approach to regression to test forest change across different tenure categories and across two time periods. Recognizing that local drivers of Amazonian deforestation can change abruptly with national-level political change (Alvarez and Naughton, 2006), we run our tests during key time periods (1990-2000 and 2000-2008) marked by different policies and land availability. Previous research in the region confirmed that road construction is associated with rapid deforestation and has also revealed the significance of sociopolitical factors, especially indigenous versus colonist land use practices {REF}. Our study builds on this knowledge by (1) extending the time period of land use change analysis up to 2008 (2) addressing land tenure form directly across the entire region, and (3) focusing specifically on the challenges and promise for SocioBosque with respect to land tenure and future implementation of incentives in the region.

Figure 1. The study region spans the two northeastern Ecuadorian provinces of Sucumbios and Orellana.

We then discuss the implications of our analysis for Ecuador's national forest conservation incentive program, *SocioBosque*. The SocioBosque program comprises a main component of the national REDD+ strategy in development and since its start in 2008 the program has enrolled close to 8,800 km^2 to conserve natural ecosystems through incentive agreements with 73 communities and more than 1,115 individuals (MAE 2011b). One-fifth of the area currently enrolled in SocioBosque lies in our study region. Understanding land tenure characteristics, dynamics, and conflicts in this region is thus critical for meeting Ecuador's national program goals of conserving forests and alleviating poverty. More broadly, our results add to the growing body of research connecting forest change to governance.

Background

The sequence of settlement in northern Ecuadorian Amazon generally resembles that defined by Rudel (2007) in his meta-analysis of the changing agents of deforestation in the tropics: from state-driven deforestation through the land settlement programs and other related policies of the 1970s, to more enterprise-driven deforestation by the 1990s (Rudel, 2007). The discovery of oil in 1967 by the US Texaco-Gulf consortium effectively opened access to the northern Ecuadorian Amazon (West 2002), particularly since the government and private oil companies invested in rapid road-building and the construction of a trans-Andean pipeline to deliver petroleum from the region to the Pacific coast. Colonization was simultaneously spurred by Agrarian Reform and Colonization Law in 1964, as well as a change in the law in 1973 to encourage rural smallholder colonization in particular, resulting in rapid increase in human population (an increase in 30% during the 1990s), and dramatic rates of deforestation (-.65%/yr between 1986-1996) (R. E. Bilsborrow, Alisson F. Barbieri, & W. Pan, 2004; Sierra, 2000).

The 1990s was a decade of political and economic turmoil in Ecuador, marked by the entry and exit of five different presidents and inflation rates that frequently surpassed 50% (Beckerman, 2001). During this period, both oil development and land use policy were subject to abrupt shifts. In 1992, the Durán administration pulled Ecuador out of OPEC, (mainly due to disagreements over quotas), and immediately increased the country's oil production targets by more than 50%, prompting increased production pressure in the study region (West 2002). Further exploration in the early 1990s in the Amazon region resulted in a tripling of known petroleum reserves. In mid-1990s, the Government of Ecuador (GoE) signed contracts with foreign companies releasing the rights to lands that had previously been restricted from petroleum exploration, due to indigenous and environmental conflicts. Similarly, forest reserve boundaries were shifted and special zones distinguished in parks to accommodate oil drilling (Naughton-treves et al., 2006). The oil boom was associated with accelerated population growth: 5.6% and 4.7% (for Orellana and Sucumbíos, respectively), compared with 2.2% across Ecuador (INEC 2011). By 2001, roughly 215,500 people inhabited our study region.

During the thirty years between the discovery of oil in 1967 and the financial crisis in 1998, oil production from the Ecuadorian Amazon represented more than 50% of the country's exports and government revenue (through royalties). And yet, even as production increased substantially during the 1990s, earnings reached a peak, and then began to fall by the end of the decade (West 2002). National GDP had stagnated and the country entered a financial crisis (1998-99). The new millennium saw significant structural reforms in Ecuador, including the complete dollarization of the economy (Beckerman, 2001) . Between 2002 and 2006, the economy grew by, on average, 5.2%, bolstered by high oil prices, remittances, and an increase in non-traditional exports. Political instability continued, however, and three more presidents took office between 2000 and 2007. In January 2007, the current president, Rafael Correa, took office and was re-elected in an early election to hold office until 2013, with the possibility of a second term until 2017. Since 2008, the GoE has passed a new Constitution and made effective a new integrated national development plan (Plan Nacional para el Buen Vivir). It also launched a payment-based forest conservation incentive program (SocioBosque). Funding for forest parks and reserves grew as did campaigns to bolster indigenous land rights. The results from the most recent national census (taken in 2010), indicate that the rate of growth has slowed for Sucumbíos province (3.5%), but only slightly for Orellana (5.1%). The total population of the study reached approximately 312,870 inhabitants by 2010 (INEC 2011).

Beyond oil and settlement campaigns, previous research in this region indicates that the pattern and pace of forest loss have also been influenced by shifts in national forest conservation policy (Sierra 2000, Bilsborrow et al. 2004). Several studies have explored the relationship between demographic and migration trends with deforestation in this study region (Alisson F. Barbieri, R. E. Bilsborrow, & W. K. Pan, 2006; Carr, W. K. Y. Pan, & R. E. Bilsborrow, 2006). Studies point to the importance of local land tenure for forest conservation, both in terms of the form and security of tenure (Messina, Walsh, C. Mena, & Delamater, 2006). But this has yet to be tested directly.

Land tenure in Ecuador's forested regions

Land tenure in the Ecuadorian Amazon has followed a complex storyline since the time of Spanish colonization, intertwined with political and social change, as well as natural resource development. Shifting and contradictory land tenure and resource access rules complicate the story further. Beyond oil-spurred colonization, two agrarian reform laws (1963 and 1973) were instrumental in inducing a rapid influx of colonists to the area, primarily from communities in the Andes, and shaping their land use. These laws explicitly stated that only occupants who could prove that their land was under productive use would be eligible for provisional title and possible credit (Morales, M., Naughton-Treves, L., Suarez, 2010). Although these laws were changed in 1994, many settlers continue to associate forest clearing with improved security (Morales, M., Naughton-Treves, L., Suarez, 2010).

Rural lands in Ecuador presently fall under the jurisdiction of two agencies of the GoE: the Ministry of Agriculture (MAGAP) and the Ministry of the Environment (MAE). Lands administered by MAGAP were previously under the jurisdiction of the Agrarian Development Institute (INDA, from 1994-2010), and before that, under the Ecuadorian Institute for Agrarian Reform and Colonization (IERAC, from 1973-1994). When MAE was created in 1996, all lands within the forest patrimony and protected forests, which had previously been administered by the Institute for Forestry, Natural Areas and Wildlife (INEFAN), were handed over to MAE.

According to a study published in 2000 by the Food and Agriculture Organization (FAO), approximately 27% of lands administered by INDA (now by MAGAP), and 10% of MAE lands (in forest patrimony or protected forests) had yet to be titled, covering an overall area of close to 81,000 km^2 (FAO 2000). Admittedly, the majority of these lands are located in areas that are extremely remote, and experience a relatively low threat of deforestation, similar to portions of our study region (Morales, M., Naughton-Treves, L., Suarez, 2010). Furthermore, the process and cost of acquiring a title can be prohibitive to landholders, with one estimate placing the average cost for this region at $1500 USD per individual title (M. Morales, pers.comm., 2011).

Yet even lands with title suffer tenure insecurity due to the fact that there are conflicting or contested claims to the land. These conflict areas, even though technically titled, could represent an increased threat to forests because occupants are driven to convert the land in order to establish their claim. A study produced by ECOLEX/FAO in 2000 estimated that close to 30% of Ecuador's land area suffers from this situation of titled land under conflict (Morales, M., Naughton-Treves, L., Suarez, 2010).

According to Ecuador's Forestry Law (Ley Forestal 1981), forest extraction for commercial purposes is not permitted in the national system of protected areas. This extends to indigenous lands located within protected areas, although cutting of forest for subsistence use by indigenous groups in parks is permitted (Morales, M., Naughton-Treves, L., Suarez, 2010). Otherwise, for indigenous territories, land title is recognized as communal, and cannot be sold. Forest extraction for commercial gain in indigenous communal areas may be permitted if the community has a forest management plan approved by MAE. Communally held land cannot be legally sold. The oil industry, on the other hand, has been permitted to operate in national parks, reserves, and indigenous territories, by special exemption from the GoE. The recent Constitution of 2008 changed this to a prohibition of petroleum activities in protected areas, unless through petition by the President, and proven to be a case of national interest (Finer, Jenkins, Pimm, Keane, & Ross, 2008).

Protected forests, or *bosques protectores* , and the forest patrimony areas of the State, or *patrimonio forestal del Estado*, were both categories that were originally created as part of the Forestry Law from 1981, which was later revised in 1990. Protected forests can be privately-owned or publicly-held and fall under the jurisdiction of MAE. Forest patrimony areas are recognized as the property of the State (GoE), however they may be converted to private or communal ownership through a petition and adjudication process administered by MAE. Only once the lands have been adjudicated and transferred to private hands (either in forest patrimony areas or protected forests) is any forest extraction permitted. As such, it must be submitted as a plan and approved by MAE (Forestry Law, 1981).

Given these rules governing forest conservation and extraction across different tenure forms, we expect protected areas in the region to be the most effective form in slowing deforestation. Relatedly, we expect deforestation to be highest for those areas within privately held lands or those lands administered by the newly created sub-Secretariat of Lands within MAGAP. We predict that forest patrimony areas (PF) and protected forests (BP) would fall closer to the protected area end of the spectrum in terms of forest outcomes. Finally, as noted previously, we expect areas of overlap between indigenous community areas and forms of forest conservation (PA, PF, and BP) to exhibit higher rates of deforestation than those forms individually, since the overlap could represent a region of conflicting tenure regimes where tenure insecurity is thus increased.

Data and Methods

Study area

Our study area spans two provinces, Sucumbíos and Orellana, located in the northeastern Ecuadorian Amazon. The total area of this region is 39,763 km^2. We define five distinct forms of tenure across this study region: (1) protected areas (PAs), (2) forest patrimony areas (PF), (3) protected forests (BP), (4) indigenous community lands, and (5) lands held privately or as colonization areas adjudicated by the newly created sub-Secretariat of Lands within the Ministry of Agriculture, Livestock, and Fisheries (MAGAP) (Figure 2 and Table 1). More than half of the region is designated as indigenous lands (59.5% of study region), followed by private/MAGAP lands (21%), and protected areas (15%), according to the most recent figures.

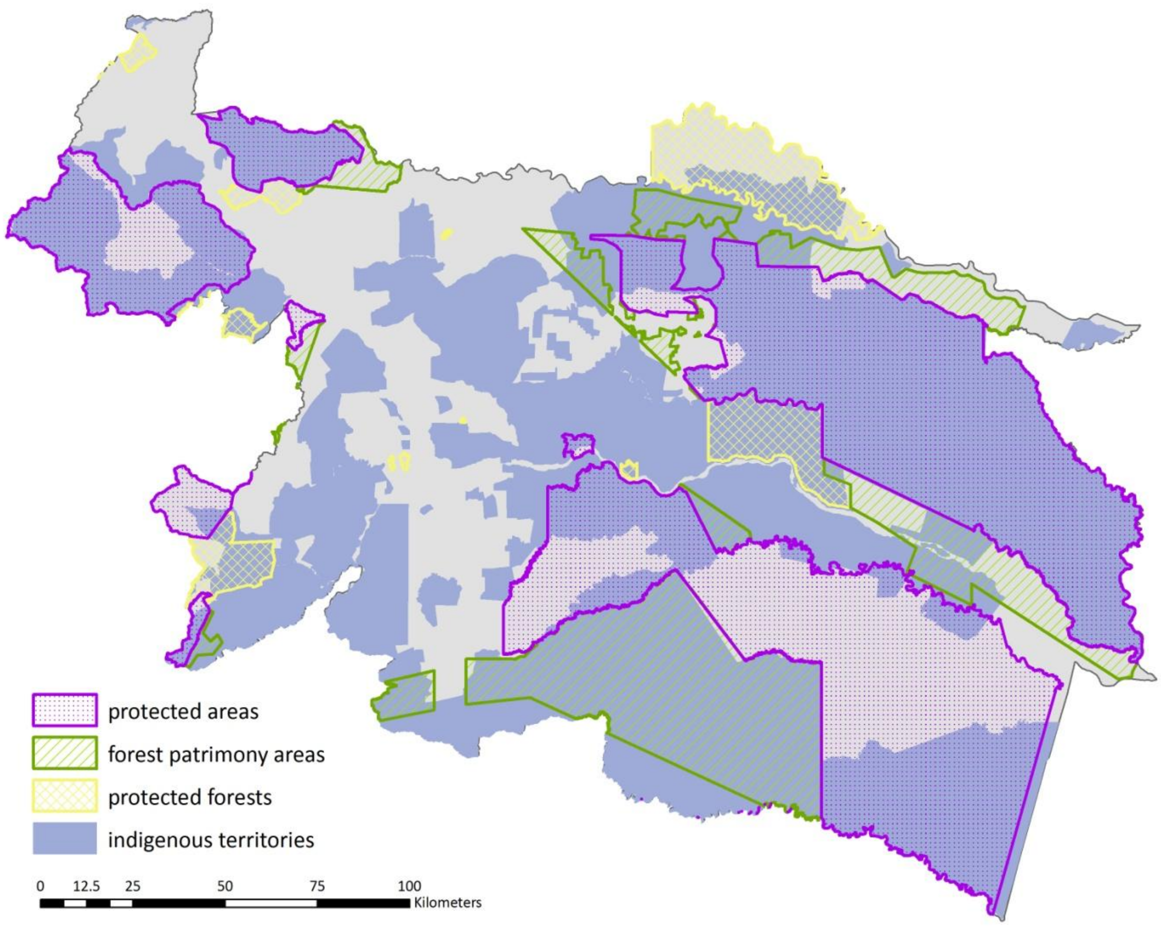

Figure 2. Location of study region and spatial distribution of main tenure categories. (note: all land in grey is considered private or held by MAGAP without title. Source: MAE 2010, Sierra & Maldonado 2009).

While all three forms of forest protection and management (protected areas, protected forests, and forest patrimony areas) have non-overlapping spatial boundaries, Figure 2 reveals a different reality for indigenous community areas in the region. The existence of this spatial overlap forces the question of whether it signals actual conflict over forest claims, which could then exacerbate deforestation, or if the overlap with forest protection areas represents decreased deforestation for those areas within the indigenous community territories. Thus we separate the three categories of spatial overlap from the other tenure forms and count them as additional categories for inclusion in this analysis: indigenous areas with (1) protected areas, (2) protected forests, and (3) forest patrimony areas. In comparison with indigenous lands where no overlap exists, we predict that these overlaps have a protective effect and result in reduced deforestation. Related to this, we expect the overlapping zones to be less effective at reducing deforestation than the areas of PAs, BP and PF with no overlap. This represents the set of overlapping claims to the land that we can map and interpret easily. It does not define the full set of conflicting claims over lands that exist within this region. There are several indications that other overlapping claims exist, particularly in indigenous territories, private lands, and lands previously held by the Agrarian Development Institute (INDA), and now by the sub-Secretariat of lands within the Ministry of Agriculture (MAGAP) under the new Agrarian Reform Law (2010) (Morales, M., Naughton-Treves, L., Suarez, 2010). Overall in our analysis, we expect these two forms of tenure (indigenous territories and mixed private/MAGAP lands) to have experienced higher rates of deforestation for both time periods than the other forms, all of which have more restrictions on forest extraction, or strict conservation goals (e.g. protected areas).

Table 1. Descriptive statistics for tenure categories within study region, separated according to those present in the first time period (T1), 1990-2000, and the second time period (T2), 2000-2008.

Tenure form (singular & overlapping)	**# areas**	**Total area in study region (km²)**	**Average size (Mean, km²)**	**% study region**	**Permitted forest use**
Private / MAGAP lands					forest extraction for commercial gain permitted where privately owned
T1	undefined	8564.46	n/a	21.5	
T2	undefined	8286.23	n/a	20.8	
Protected areas (PA)					strict conservation
T1	4	5717	1429.2	14.4	
T2	6	5995.2	999.2	15.1	
Forest patrimony areas (PF)					forest extraction permitted with plan only if privately owned
T1	7	1588.8	227	4	
T2	7	1588.8	227	4	
Protected forests (BP)					forest extraction permitted with plan only if privately owned
T1	7	272.8	39	0.7	
T2	7	272.8	39	0.7	
Indigenous community lands (non-overlapping)					forest extraction for commerical gain allowed with plan
T1	11	10215.8	928.7	25.7	
T2	10	9519.7	952	23.9	
PA overlap with Indigenous community lands					subsistence forest extraction permitted
T1	13	8375.6	644.3	21.1	
T2	15	9020.8	601.4	22.7	
PF overlap with Indigenous community lands					forest extraction permitted with plan (communal ownership)
T1	14	4261.4	304.4	10.7	
T2	14	4261.4	304.4	10.7	
BP overlap with indigenous community lands					forest extraction permitted with plan (communal ownership)
T1	3	804.9	268.3	2	
T2	5	858.8	171.8	2.2	

Data on land use change and deforestation

To determine the extent of land use change and the rate of deforestation in the region, we worked with a team from the Ecuadorian Ministry of the Environment (MAE) to acquire a portion of the recently released Historical Deforestation Map of Ecuador, which covers three reference years: 1990, 2000, and 2008. This land use change product was produced for the purpose of developing the national forest baseline and estimates for CO2 emissions from deforestation. Land use has been classified separately for each reference year, using the six Level 1 land use categories as defined by the Intergovernmental Panel on Climate Change (IPCC)(MAE, 2011). After image pre-processing, analysts used an unsupervised classification algorithm to perform the initial classification, and then proceeded to correct any thematically or spectrally-mixed pixel issues using visual and manual editing. The accuracy assessment for the final land use product resulted in an overall Kappa coefficient of 0.7 for the entire country (MAE, 2011).

Using the land use maps as our base, we masked out any cloud cover from all three reference years combined. All calculations related to forest cover and change followed the same methods used by Conservation International's forest change analysis protocol (Tabor, Burgess, Mbilinyi, Kashaigili, & Steininger, 2010). We then calculated the forest base for 1990 and 2000, along with observed deforestation for our two time periods of analysis: 1990-2000 and 2000-2008. We define observed deforestation as that which was known forest in the first date and visibly deforested by the second date. With our change calculations, we retained information on the resulting land use post-deforestation. Forest change estimates for the entire study region are included in Table 3.

Tenure form and other datasets

Map layers and associated datasets related to the different forms of land tenure in the study region were provided by MAE, Ecolex, and CI-Ecuador. These include the data for protected areas (PAs), protected forests (BP), and forest patrimony areas (FP), which is maintained by MAE. The final map of indigenous community areas for this region was derived from two sources (Ecolex 2009 for indigenous communities within the Cuyabeño Reserve; Sierra and Maldonaldo 2009 for the remainder of the study region). While not all of these areas are formally delimited yet according to law, these indigenous community areas reflect the most comprehensive and up-to-date map for the study region. All datasets related to regional resource extraction, transportation networks, and population centers were provided by MAE and published by various government entities.

To assess the relative influence of land tenure form with respect to forest change across the two time periods, we generated a grid consisting of 1-km^2 analysis units across the entire study region. We chose a unit size of 1-km^2 given that is captures variability from the land use change classification. It also represents 1-2 times the size of the average land settlement parcel for this region from the agrarian reform period (on average 50 hectares). From this grid, we selected only those units where no cloud was present in any of the land use change years (1990, 2000 or 2008), and where there was some baseline forest present as of 1990. This resulted in a total of 28,282 units of analysis. For each unit, we calculated the percent area in forest base as of Time 1 for each time period, as well as the percent of the forest base deforested by Time 2, (as defined in (Tabor et al., 2010)). Percent deforested served as our dependent variable for the regression analysis. For each unit, we calculated the values for a set of factors potentially driving deforestation, as informed by past research in this region. Specifically, we know that proximity to roads, markets, and oil production infrastructure have all been linked with higher deforestation in the decade of the 1990s (C. Mena et al. 2006). We incorporated two additional distance variables into this set, considering that mining concessions have expanded and intensified in the region in the most recent decade, and that navigable rivers in the region also serve as critical transportation networks for the movement of people and goods. For each of these five distance variables, we calculated a per pixel value of the distance of that pixel to the closest distance variable location (measured in kilometers). We also considered biophysical factors such as mean elevation (measured in meters above sea level) and soil fertility. We checked for correlations between the dependent and control variables, and kept all variables for inclusion in the regression model, given no correlation coefficient > 0.8.

Each analysis unit was assigned a binary value corresponding to its unique tenure category. We were able to account for the shifting spatial definitions of the tenure categories between the two time periods. For the first time period (1990-2000), only those protected areas and protected forests that were formally designated by 1990 were considered. All other areas were added to the set for the second time period (2000-2008). Since all forest patrimony areas in the region were designated in 1988, these were included for both analysis periods (Table 2).

Table 2. Descriptive statistics for dependent and control variables, separated according to each of the eight tenure categories.

Control variables (separated by tenure category)	Observations	Mean	Standard dev	Min	Max
Protected area (PA) non-overlap					
Percent forested, base year	8268	95.0	6.6	0	100
Percent deforested	8268	0.5	5.3	0	100
(log transformed variables)					
Distance to nearest road	8268	3.1	1.1	-11.5	4.0
Distance to nearest navigable river	8268	2.8	0.9	-9.2	3.9
Distance to nearest oil well	8268	2.3	1.1	-11.5	3.8
Distance to nearest populated center	8268	2.8	0.8	-6.9	3.9
Distance to nearest mining concession	8268	4.5	0.6	1.7	5.1
PA-INDIG (overlap)					

Percent forested, base year	10670	93.3	10.9	0	100
Percent deforested	10670	1.7	8.0	0	100
(log transformed variables)					
Distance to nearest road	10670	2.8	1.0	-11.5	4.0
Distance to nearest navigable river	10670	1.3	2.6	-9.2	3.8
Distance to nearest oil well	10670	2.4	0.9	-11.5	4.1
Distance to nearest populated center	10670	1.9	1.0	-6.9	3.3
Distance to nearest mining concession	10670	3.8	0.7	-1.1	4.9
Forest patrimony (PF) non-overlap					
Percent forested, base year	2100	90.7	17.5	0	100
Percent deforested	2100	5.7	17.1	0	100
(log transformed variables)					
Distance to nearest road	2100	1.2	3.3	-11.5	3.7
Distance to nearest navigable river	2100	1.0	2.5	-9.2	3.4
Distance to nearest oil well	2100	2.4	1.5	-11.5	3.7
Distance to nearest populated center	2100	0.9	1.5	-6.9	2.4
Distance to nearest mining concession	2100	3.7	1.0	1.2	5.0
PF-INDIG (overlap)					
Percent forested, base year	2698	93.6	9.2	8.2	100
Percent deforested	2698	2.5	9.4	0	92.3
(log transformed variables)					
Distance to nearest road	2698	2.5	2.6	-11.5	4.2
Distance to nearest navigable river	2698	2.6	1.5	-9.2	4.0
Distance to nearest oil well	2698	1.9	1.7	-11.5	3.4
Distance to nearest populated center	2698	1.6	1.4	-6.9	3.5
Distance to nearest mining concession	2698	3.6	0.9	0.3	4.7
Protected forest (BP) non-overlap					
Percent forested, base year	106	86.2	22.0	0	100
Percent deforested	106	8.7	19.4	0	96.9
(log transformed variables)					
Distance to nearest road	106	1.3	1.9	-11.5	2.1
Distance to nearest navigable river	106	2.3	0.6	1.2	3.3
Distance to nearest oil well	106	1.0	1.0	-3.3	2.1
Distance to nearest populated center	106	0.6	1.6	-6.9	1.9
Distance to nearest mining concession	106	0.4	2.7	-6.9	2.5
BP-INDIG (overlap)					
Percent forested, base year	792	89.6	18.7	0	100
Percent deforested	792	7.4	20.3	0	100
(log transformed variables)					
Distance to nearest road	792	1.3	2.2	-11.5	2.7
Distance to nearest navigable river	792	1.3	1.2	-9.2	3.6
Distance to nearest oil well	792	1.6	1.4	-11.5	2.8
Distance to nearest populated center	792	0.8	1.3	-6.9	2.3

Distance to nearest mining concession	792	3.3	1.0	-2.5	4.2
Indigenous community land (INDIG) non-overlap					
Percent forested, base year	10444	78.9	28.9	0	100
Percent deforested	10444	18.4	28.9	0	100
(log transformed variables)					
Distance to nearest road	10444	-1.0	5.0	-11.5	4.2
Distance to nearest navigable river	10444	1.6	1.6	-9.2	3.8
Distance to nearest oil well	10444	1.3	2.3	-11.5	3.9
Distance to nearest populated center	10444	0.0	2.2	-6.9	3.2
Distance to nearest mining concession	10444	2.4	1.4	-6.9	4.7
Private-MAGAP lands					
Percent forested, base year	21486	72.6	31.4	0	100
Percent deforested	21486	21.8	30.2	0	100
(log transformed variables)					
Distance to nearest road	21486	-1.4	5.3	-11.5	4.2
Distance to nearest navigable river	21486	0.3	3.8	-9.2	3.9
Distance to nearest oil well	21486	1.4	2.5	-11.5	4.1
Distance to nearest populated center	21486	-0.2	2.3	-6.9	3.5
Distance to nearest mining concession	21486	2.2	1.9	-6.9	5.1

We included both a time dummy and a canton, or municipality, dummy variable in the analysis to help capture the time-variant and spatially invariant unobservables, such as differences in population density, urbanization, migration and growth between provinces in the study region, as well as broader macro-level policy changes at the national level that might influence land use change in the region, such as shifts in oil prices. We know that past demographic trends, (mainly rapid population growth and migration patterns) have influenced land use change in the region (Alisson Flávio Barbieri, Carr, & R. E. Bilsborrow, 2009; Carr et al., 2006). We therefore include this canton dummy so as to account for any broader population change differences within the two provinces. The time dummy assumes a value of "1" for 1990-2000 and "0" for 2000-2008. We also use the time dummy variable to generate interaction terms of each of our control (distance) variables.

Calculations

We performed a one-way ANOVA on the dependent and control variables across the set of tenure categories to test if there is a significant difference in the means between categories. The ANOVA results indicate that yes, across the dependent and control variables, there is a significant difference in the mean values for different tenure categories. We performed a post-hoc Tukey HSD to this one-way ANOVA, and these results (Appendix I), indicate that the non-overlapping indigenous community lands and the private-MAGAP lands are homogeneous subsets for the following variables: percent deforested, distance to population center, and distance to road.

We used a hierarchical mixed model approach to regression analysis due to its flexibility in modeling clustered or dependent data, including data that is collected for the same units of analysis for more than one point in time. Our dependent variable is the percent of forest base area in Time 1 deforested by Time 2. Our effects for this model are defined as the eight tenure categories and the canton within which each unit is located. Using the time dummy variable, we also include interactions between the time period and each of the control variables, or covariates. We run our regression analyses using fixed effects, between effects, and random effects models, using model parameters available in both the SPSS® and Stata® statistical software packages. In this paper, we present the results of a mixed model where we set fixed effects at the canton level, and random effects for tenure category and our other covariates. Before exploring those results in more detail, we first review the background information and data used for linking the SocioBosque program with our present analysis.

SocioBosque background, data and methods

The SocioBosque, or Forest Partners, Program was formally launched as a national program in 2008, building from experiences gained through the conservation incentives project with the Gran Reserva Chachi (2005-2008). The two stated goals of the SocioBosque program are to conserve 36,000 km^2 of forest and other native ecosystems, and safeguard livelihoods and increase income for between 0.5-1.5 million people (de Koning et al., 2011). The SocioBosque program is administered by MAE. The total operating budget for the first two years was $8.5 million USD, with 70% being directed to payments, and 15% to monitoring costs (de Koning et al., 2011).

The incentive agreements are voluntary and consist of cash payments for each hectare of forest (or other native ecosystem) enrolled in the program. Incentive agreements can be made with individuals or with those holding communal title to the land, including indigenous groups and local community cooperatives. The incentive payments are scaled according to the number of hectares enrolled in each agreement: starting with $30/hectare/year for the first fifty hectares, scaling down to $20/ha/yr for the second fifty hectares, $10/ha/yr for hectares 100-500, and so on (a complete table of the payment structure is published in deKoning et al. 2011). To be eligible to become a beneficiary of SocioBosque, an individual or community group must have clear and uncontested title to the land. Initially, lands within protected areas were not eligible for SocioBosque payments. This rule has now been adjusted to accommodate for those living within protected areas that have proven title to the land from before the PA was created (de Koning et al., 2011). Each individual or community submits an investment plan for how the income will be used by the household or community group, and the duration of each agreement is twenty years.

SocioBosque has a spatial prioritization defined for implementation of the program, based on a criteria-based assessment of the following: deforestation threat, ecosystem service provision (carbon storage, water regulation, and habitat for biodiversity), and degree of poverty (based on an index of unsatisfied basic needs, as published by the GoE) (MAE 2008). Currently, the program is said to be prioritizing the brokering of incentive agreements in areas designated as priority #1 or 2, (see Figure 4 for locations of those priority areas in our study region). Through the Ministry of the Environment, we acquired the spatial layers defining these priority areas and used those definitions to assess specific deforestation trends as well as to describe the tenure landscape for each in the study region.

Results

Forest change across study region and tenure categories

During the first time period (1990-2000), 4,076 km^2 (12.1% of forest area) was deforested. This represents an annual deforestation rate of -1.3%, nearly double the national rate for the same time period (MAE, 2011). Both the extent and percent of deforestation decrease dramatically for the second time period (2000-2008), to 1,125 km^2 and 3.8%, respectively. The annual deforestation rate for this time period reduces to -0.5% for the entire study region, less than the -0.6% estimated for continental Ecuador (MAE, 2011).

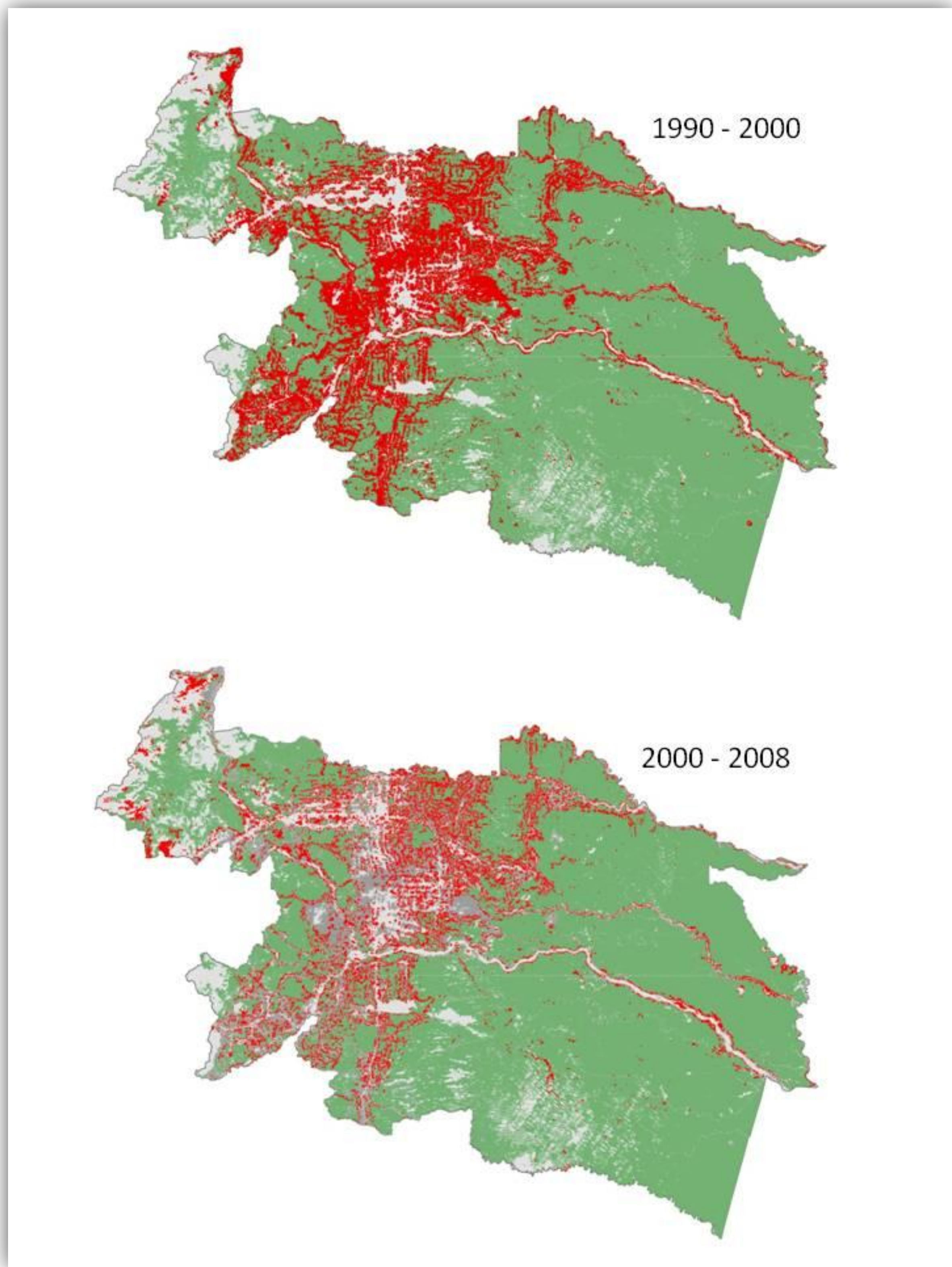

Figure 3. Observed deforestation in the study region (provinces of Sucumbios and Orellana) during the two time periods of analysis: 1990-2000 and 2000-2008.

Looking across the tenure categories, protected areas experienced the lowest percent and rate of deforestation across both time periods. And yet the fractional loss of forest (representing the annual rate of deforestation) remained level for forests in PAs, where it was reduced for all other categories by 2000-2008 (Table 3). As expected, the rate of deforestation remained highest for the mixed category of Private-MAGAP lands, but was reduced by more than half by 2008. Indigenous lands occupy the greatest proportion of the study region (64% of total area) and, overall, exhibited the highest volume of forest loss by area for the first time period.

Table 3. Deforestation calculations for 1990-2000 and 2000-2008, for the study region and eight categories of land tenure.

	Total area (km^2)	**Forest base (km^2)**	**De-forested (km^2)**	**% De-forested**	**Defor/yr**	**% Deforested to Agri-culture**	**Fractional loss of defor**
1990-2000							
Study region	**39,762.7**	**33,606.8**	**4,079.6**	**12.1**	**408.0**	**78.4**	**-1.3**
PA (no overlap)	5,717.0	5,381.5	49.4	0.9	4.9	50.2	-0.1
PA-INDIG (overlap)	8,375.6	7,477.5	134.1	1.8	13.4	20.2	-0.2
PF (no overlap)	1,588.8	1,472.8	88.4	6.0	8.8	69.1	-0.6
PF-INDIG (overlap)	4,261.4	3,564.9	136.6	3.8	13.7	47.1	-0.4
BP (no overlap)	272.8	164.8	31.4	19.0	3.1	62.6	-2.1
BP-INDIG (overlap)	804.9	738.5	89.1	12.1	8.9	63.4	-1.3
INDIG (no overlap)	10,215.8	8,549.8	1,858.4	21.7	185.8	81.1	-2.4
Private-MAGAP	8,564.5	6,278.4	1,693.7	27.0	169.4	85.0	-3.1
2000-2008							
Study region	**39,762.7**	**29,966.5**	**1,135.0**	**3.8**	**141.9**	**55.6**	**-0.5**
PA (no overlap)	5,995.2	5,088.6	25.0	0.5	3.1	54.1	-0.1
PA-INDIG (overlap)	9,020.8	7,883.0	120.1	1.5	15.0	9.4	-0.2
PF (no overlap)	1,588.8	1,392.2	38.5	2.8	4.8	49.2	-0.4
PF-INDIG (overlap)	4,261.4	3,476.3	52.4	1.5	6.5	46.7	-0.2
BP (no overlap)	272.8	140.1	9.9	7.1	1.2	22.2	-0.9
BP-INDIG (overlap)	858.8	695.0	18.2	2.6	2.3	51.5	-0.3
INDIG (no overlap)	9,519.7	6,307.4	411.5	6.5	51.4	65.2	-0.8
Private-MAGAP	8,286.2	4,616.4	460.2	10.0	57.5	61.5	-1.3

In the case of overlapping categories of tenure, where indigenous community areas overlapped with protected forests (BP) or forest patrimony areas (PF), the rate of deforestation was *less* than that which occurred in any of those tenure categories separately. This was true across both time periods. In essence, rather than creating an open access situation, apparently ambiguity in tenure is associated with slower clearing. While there was no change in the rate of deforestation for indigenous lands overlapping protected areas, there is a noticeable reduction in the amount of deforested land being converted to agriculture, for the PA-INDIG overlap, by 2000-2008. Of all the tenure categories, those lands in protected areas exhibited the most minimal change in forest trends across the two time periods.

Model results

We present here the results of two hierarchical mixed models, Models I (Table 4) and II (Table 5). Model I shows the results for the tenure categories across the entire time period (1990-2008). Model II shows the same model approach, but factors separately for each time period (1990-2000 and 2000-2008). We chose to include both models in this result set to demonstrate the dynamic effect of tenure on deforestation over time. According to the results of both models, as expected, the heaviest forest losses occurred in areas within private-MAGAP lands and during the first time period (1990-2000). Overall, we observe in these models a trend of increased deforestation for municipalities (cantones) within the province of Orellana, as compared with those in Sucumbíos.

Table 4. Model I: Hierarchical mixed model regression results for estimating effects of tenure on percent deforestation in study region.

Dependent variable: percent deforested	Model I Coefficients	Std. Err. (z)	P>|z|
Tenure category			
Protected area (PA)	-0.44	2.75	
Protected area – Indigenous overlap	-4.00	1.26	***
Forest patrimony area (PF)	-1.66	1.36	
Forest patrimony – Indigenous overlap	-3.68	1.56	**
Protected forest (BP)	-1.99	3.36	
Protected forest – Indigenous overlap	0.73	3.78	
Indigenous community areas (non-overlap)	-1.08	1.09	
Y-Intercept = ((tenure category is private-MAGAP lands) *and* (time period 2000-2008))	59.15 -27.75	4.33 0.74	*** ***

**p<0.05, ***p<0.01

All of the distance covariates in both Model I (Table 4) and Model II (Table 5) emerge as significant with the expected set of relationships with forest change, yet with coefficients that are slightly lower than those for significant tenure categories. For Model I, looking at the effects across the entire eighteen-year time period, we observe that two of the overlapping categories (protected areas with indigenous, and forest patrimony with indigenous), are significant factors in determining reduced deforestation overall. These results also show that, relative to private lands, protected areas actually have little extra effect over the entire study period, after controlling for the potential location effect and our distance covariates. All other land tenure categories in this Model I (Table 4) are not significantly different from private lands in their estimated effects on forest change across the entire time period.

Table 5. Model II: Hierarchical mixed model regression results for estimating effects of tenure on percent deforestation in study region, factoring in the effect of the time period.

Dependent variable: percent deforested	**Model II Coefficients**	**Std. Err. (z)**	**P>|z|**	**Time Period**
Tenure category				
Protected area (PA)	-1.76	2.71		1
	0.75	2.71		2
Protected area – Indigenous overlap	-6.13	1.28	***	1
	-2.08	1.27		2
Forest patrimony area (PF)	-5.56	1.40	***	1
	2.32	1.40	*	2
Forest patrimony – Indigenous overlap	-5.75	1.59	***	1
	-1.53	1.59		2
Protected forest (BP)	-2.61	3.68		1
	-1.33	3.68		2
Protected forest – Indigenous overlap	-0.31	3.79		1
	1.61	3.75		2
Indigenous community areas (non-overlap)	-0.69	1.13		1
	-1.61	1.13		2
Y-Intercept = ((tenure category is private-MAGAP lands) *and* (time period 2000-2008))	58.90 -27.25	4.38 0.75	*** ***	

*p<0.1, **p<0.05, ***p<0.01

By splitting the model into the two time periods, we observe some clear differences in the effect of tenure on deforestation when looking at the first versus the second time period. First, the protected area and indigenous overlap effect is large and strong (highly significant) in the first time period, but absent as an effect in Time Period 2. We see a similar effect for forest patrimony and indigenous overlap.

In Model II, forest patrimony areas (non-overlap) now hold important explanatory power as a tenure category. Perhaps more notably, this tenure form has the effect of less deforestation than private land in Time Period 1, whereas in Time Period 2, these same areas are less protective than private lands.

Overall, we observe with these models the significant effect that tenure form can have in slowing or accelerating forest loss (even when controlling for that classic driver of distance to roads – or the other covariates). In fact, with our current set of models, the tenure effects that are significant, exhibit coefficients of far greater magnitude than those distance covariates. Furthermore, the significance, direction, and magnitude of these effects stay the same even when controlling for the effects of location within a given municipality, which for us holds meaning in terms of population growth & migration trends, as well as local governance.

Related to this, the observed effect of higher forest losses if an area is located within the province of Orellana potentially speaks to the fact that Orellana's population continues to grow at a faster rate than that of Sucumbíos. Sucumbíos experienced the highest population growth in the country between 1974-1990 (Viña, Echavarria, & Rundquist, 2004). Orellana has effectively replaced Sucumbíos with the highest growth rate in the country since 1990. Orellana also has a much higher percentage of the population as well who self-identify as belonging to an indigenous group (31.8% vs. 13.4% in Sucumbíos, according to the most recent population census) (INEC, 2011). Within the province of Orellana, the highest percent increase in population between 2001 and 2010 occurred within the district of Orellana (73.3% increase), which is classified as 56% urban (highest percentage urban of any district in the study region). The most recent census results suggest, however, that it is not only the highly urban districts that are experiencing growth: the districts of Loreto (in Orellana) and Putumayo (in Sucumbíos) both increased by 57.2% and 64.9%, respectively. Putumayo is the district bordering Colombia, where there has been a more recent phenomenon of immigration (potentially due to the Colombian government's actions to address illegal drug cultivation and trafficking, M. Morales, pers comm).

We discuss the implications of these hierarchical mixed model results after first presenting the forest change outcomes across priority areas for the implementation of Ecuador's SocioBosque program in the study region.

SocioBosque, deforestation, and land tenure

The currently spatial definitions of the SocioBosque priority areas do not include existing protected areas, as these were not originally considered to be eligible for SocioBosque agreements. Thus protected areas are not included as a tenure category in Table 6, and their absence should be considered when interpreting the changes in forest cover for each priority area. Similar to the overall results for the study region, the overall amount and rate of deforestation declined between the two time periods, and for all priority areas. The deforestation rate for Priority area #2, however, reduced to lower than that of Priority area #1 by 2000-2008. Indigenous non-overlapping lands occupy the largest percentage area for both Priority areas #1 and 2, signaling a potential spatial synergy and opportunity to develop recommendations for more specific targeting of SocioBosque to specific forms of land tenure within this study region.

Table 6. Forest outcomes and tenure categories across the SocioBosque priority areas.

	Priority 1	Priority 2	Priority 3
Total area (km^2)	**8,651.7**	**11,701.3**	**4,223.2**
Forest base, 1990 (km^2)	7,237.7	9,607.3	3,208.6
Forest base, 2000 (km^2)	6,269.0	7,957.7	2,274.8
% deforested, 1990-2000	14.5	18.9	31.5
% deforested, 2000-2008	5.9	5.4	7.4
% area in tenure categories			
BP	2.3	0.5	0.4
BP-INDIG	3.4	3.8	2.8
PF	9	4.3	5.6
PF-INDIG	13.6	16.3	26.9
INDIG (no overlap)	38.3	41.9	29.8
Private-MAGAP	32.8	33.3	34.6

Across the study region, SocioBosque has brokered 195 individual agreements and 16 community agreements between December 2008 and May 2011, representing a total forest area of 1,804 km^2 (more than 90% of this area falls within the community agreements). According to our calculations of observed deforestation, the areas now under individual agreements with SocioBosque experienced 9.8% deforestation in 1990-2000, and 4% deforestation for 2000-2008. The community agreement areas registered 2.2% forest loss during 1990-2000, and 1.7% in 2000-2008. Thus deforestation has already slow considerably in this study region, particularly in the areas where individual contracts have been negotiated, even before the active implementation of SocioBosque (Figure 4).

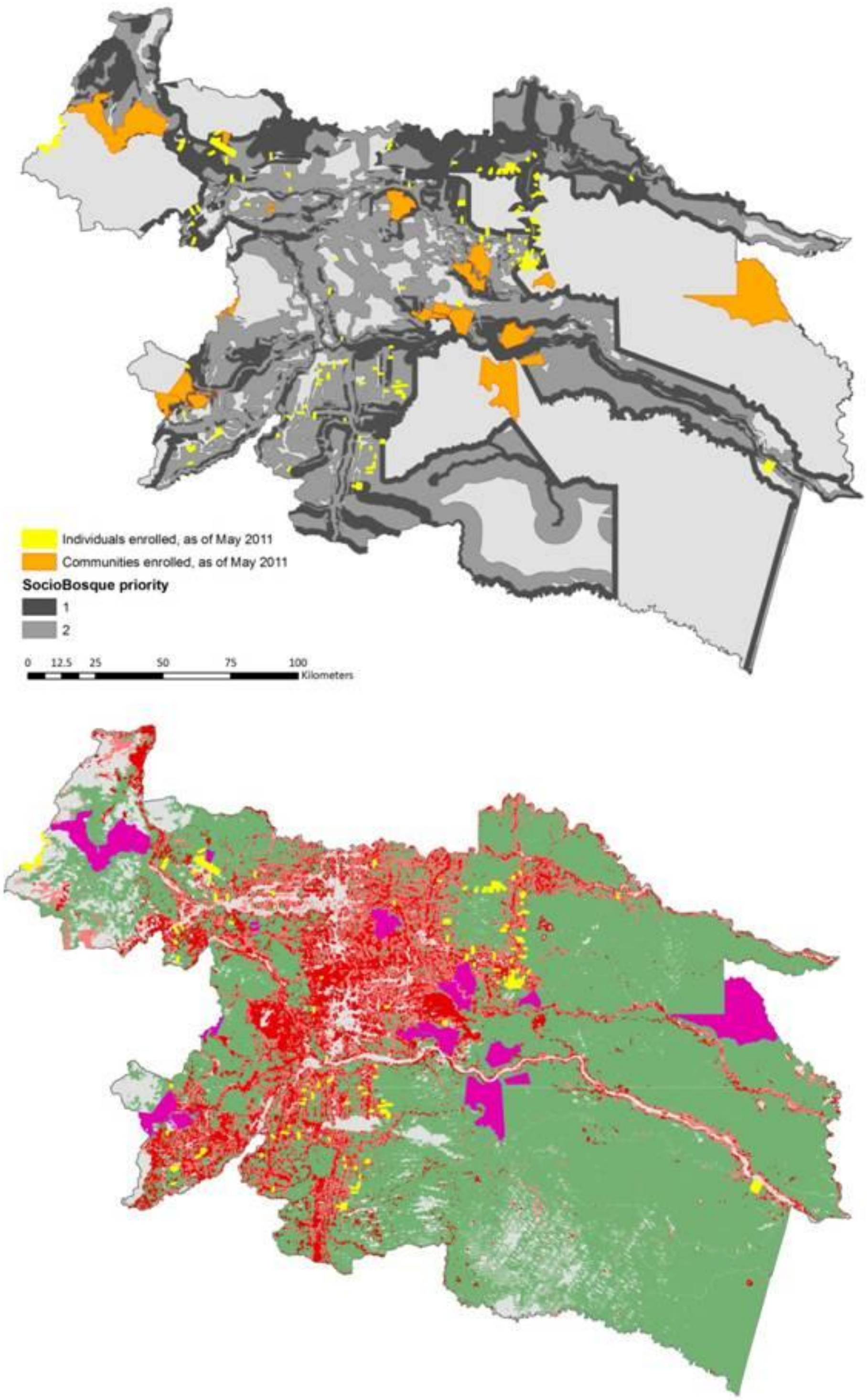

Figure 4. Spatial distribution of SocioBosque investments in the study region, as of May 2011. The map on top (a) shows the priority areas for investments, along with the agreement locations. The bottom map (b) shows those same investments & forest loss 90-00-08. In map (b) the community agreements are displayed in magenta, while the individual agreements appear as yellow.

Discussion and conclusion

The results of our hierarchical mixed effects model impel us to reject two of the hypotheses we originally made regarding the relationship between varying tenure forms and deforestation in this study region. First, counter to our expected outcomes, protected areas in this study region did not demonstrate a significant protective effect on forest change, when accounting for the effects of location and distance to those covariates included in our models. Second, the areas of overlapping forms, where we expected an increase in forest loss due to potential conflict over intended management of the forest, in fact tended to predict forest outcomes that were better than those experienced within protected areas.

Related to forest patrimony areas in this study region, the unique result of changing effect on deforestation between time periods points to a specific tenure form where further analysis could confirm the degree to which tenure conflict and insecurity is exacerbated in these areas in particular. We expect to explore this in depth for the forest patrimony area surrounding the head of the Cuyabeño Reserve, where accounts of land conflicts have been documented by several researchers and practitioners over the past two decades (C. Mena, a Barbieri, et al., 2006).

Most importantly, our results demonstrate that, not only is the form of tenure complex in its relationship with forest change, but the effect of tenure form can be dynamic. Our results regarding forest patrimony areas in particular demonstrate that such effects can even shift dramatically between time periods, pointing to the benefit of analyzing more than one time period, if at all possible.

From these overall results, we derive three key messages for practitioners and policymakers related to future actions towards implementing REDD+ and SocioBosque within this region. The first message is simply that the form of tenure matters when it comes to predicting the future pattern and extent of land use change in this region. Even when accounting for those documented drivers of deforestation in this region, (proximity to oil exploration, roads, and markets), the tenure regime plays a role in slowing forest loss. These observed trends over 18 years, during a time of transition from high deforestation to significantly slowed forest loss, along with the significant influence of tenure form, can help refine the spatial prioritization for SocioBosque, which currently considers only poverty levels as a socioeconomic and human population criteria for geographic priority setting. Defining the tenure landscape can improve SocioBosque's definition of areas under high deforestation threat, as well as pinpoint key opportunities for establishing connectivity within the landscape.

The second message is that we cannot assume that all indigenous areas exhibit similar outcomes in terms of forest change. The variation we observe between non-overlapping indigenous areas and those which overlap with protected areas, protected forests, and forest patrimony areas cautions against such an assumption. In fact these results match well with the research by Gray et al. (2007), who in this same study region observed a high degree of variability between indigenous communities with respect to agricultural activity and land use(Gray, R. E. Bilsborrow, Bremner, & Lu, 2007). We might have missed this variation in forest outcomes between overlapping and non-overlapping indigenous community areas had we not initially considered that these overlaps could signal increased conflict and tenure insecurity. And yet we find quite the opposite. While indigenous lands on their own trend more closely towards the expected higher deforestation for privately-held or MAGAP-administered lands, the existence of an overlap suggests an additive effect of improved forest protection. Because of this, we feel that indigenous community areas in this region represent a key opportunity for SocioBosque, and related REDD+ projects, that have not necessarily been fully explored.

Our third and final message relates to a broader challenge facing Ecuador as it continues to develop the SocioBosque program as a central piece of its national REDD+ strategy. The results from the forest change analysis point to the fact that deforestation has slowed drastically in this region, which has historically experienced among the highest rates nationally. This is a trend that has occurred even prior to the implementation of a single SocioBosque incentive. As SocioBosque moves forward, it will be important to closely monitor the impact of the incentives on forest outcomes over time, in order to prove the additionality of the mechanism, particularly for future accounting related to REDD+. The question of additionality is one that has recently been brought to the Costa Rican national PES program (Daniels, Bagstad, Esposito, Moulaert, & Rodriguez, 2010). With this research into the effect of tenure form on deforestation outcomes, we suggest that the SocioBosque program could improve the deforestation impact and avoid potential doubts regarding the additionality of the incentives if it considers targeting specific forms of tenure, including non-overlapping indigenous community areas, where historic deforestation rates are higher, but there is a demonstrated example of improved forest conservation when such forms intersect with a focused forest policy.

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Appendix I

One-way ANOVA and post-hoc Tukey HSD test results for tenure categories (8) compared means for percent forest, percent deforested (dependent), distance to roads, rivers, mines, oil wells, and population centers.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pctforest	Between Groups	5306919.381	7	758131.340	1309.051	.000
	Within Groups	32754158.071	56556	579.146		
	Total	38061077.452	56563			
pctdefor	Between Groups	5072043.879	7	724577.697	1345.385	.000
	Within Groups	30459103.716	56556	538.565		
	Total	35531147.595	56563			
lndistrd	Between Groups	222225.088	7	31746.441	1944.686	.000
	Within Groups	923260.579	56556	16.325		
	Total	1145485.667	56563			
lndistoil	Between Groups	12887.670	7	1841.096	472.710	.000
	Within Groups	220272.653	56556	3.895		
	Total	233160.323	56563			
lndistriv	Between Groups	44289.318	7	6327.045	819.404	.000
	Within Groups	436698.417	56556	7.722		
	Total	480987.736	56563			
lndistpob	Between Groups	74406.459	7	10629.494	3145.406	.000
	Within Groups	191123.706	56556	3.379		
	Total	265530.165	56563			
lndistmin	Between Groups	46259.054	7	6608.436	3408.992	.000
	Within Groups	109635.549	56556	1.939		
	Total	155894.603	56563			

pctforest

Tukey HSD[a,b]

tenureformmaster	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
8	21486	72.5897					
7	10444		78.8790				

5	106			86.2090			
6	792			89.6066	89.6066		
3	2100				90.6551	90.6551	
2	10670				93.3433	93.3433	93.3433
4	2698					93.6453	93.6453
1	8268						95.0262
Sig.		1.000	1.000	.160	.084	.306	.906

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

pctdefor

Tukey HSD[a,b]

tenureformmaster	N	Subset for alpha = 0.05 1	2	3	4
1	8268	.5217			
2	10670	1.6506			
4	2698	2.4954	2.4954		
3	2100		5.6535	5.6535	
6	792			7.4195	
5	106			8.7021	
7	10444				18.4400
8	21486				21.8314
Sig.		.775	.197	.237	.129

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

lndistrd

Tukey HSD[a,b]

tenureformmaster	N	Subset for alpha = 0.05 1	2	3
8	21486	-1.3518		

7	10444	-1.0087		
3	2100		1.1723	
6	792		1.3230	
5	106		1.3474	
4	2698			2.5495
2	10670			2.7700
1	8268			3.1248
Sig.		.776	.993	.152

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Indistoil

Tukey HSD[a,b]

		Subset for alpha = 0.05				
tenureformmaster	N	1	2	3	4	5
5	106	1.0103				
7	10444		1.3499			
8	21486		1.3820			
6	792		1.6389	1.6389		
4	2698			1.9439	1.9439	
1	8268				2.2593	2.2593
3	2100					2.4356
2	10670					2.4368
Sig.		1.000	.127	.087	.067	.720

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Indistriv

Tukey HSD[a,b]

		Subset for alpha = 0.05				
tenureformmaster	N	1	2	3	4	5

8	21486	.3204				
3	2100		.9503			
6	792		1.2547	1.2547		
2	10670		1.2686	1.2686		
7	10444			1.5672		
5	106				2.3057	
4	2698				2.5763	2.5763
1	8268					2.7905
Sig.		1.000	.414	.440	.630	.851

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Indistpob

Tukey HSD[a,b]

tenureformmaster	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
8	21486	-.1590					
7	10444	.0223					
5	106		.6141				
6	792		.7725	.7725			
3	2100			.9296			
4	2698				1.5610		
2	10670					1.9123	
1	8268						2.8160
Sig.		.615	.763	.770	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Indistmin

Tukey HSD[a,b]

tenureformmaster	N	Subset for alpha = 0.05

		1	2	3	4	5
5	106	.4084				
8	21486		2.2328			
7	10444		2.4094			
6	792			3.2667		
4	2698				3.6208	
3	2100				3.6747	
2	10670				3.8391	
1	8268					4.5465
Sig.		1.000	.279	1.000	.078	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 672.247.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.