

Examining the Proximate and Underlying Causes of Tropical Deforestation: Migration and Land Use in the Sierra de Lacandón National Park, Guatemala¹

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Abstract

In explaining variability in tropical deforestation, scholars have focused almost exclusively on *in situ* (or “on-farm”) resource use, while population scholars have largely ignored rural-to-rural migration. The way in which household responses to the human and physical environment in one place may affect land cover change in another place has been inadequately explored. This paper investigates the primary proximate and underlying causes of deforestation in the humid tropics with a case study from Guatemala. To investigate the first cause of this phenomenon, farmer land use, I collected data from community leaders in twenty-eight communities and from 279 settler farmers and 221 women in nine communities in the Sierra de Lacandón Park (SLNP). To address the second cause of deforestation in the SLNP, migration, I conducted interviews with community leaders in twenty-eight communities of SLNP settler origin. Results from the SLNP revealed several factors positively related to forest clearing at the farm level including family size, secure land title, duration on the farm, agricultural intensification, ethnicity, and farm size. Results from areas of origin of migrants to the SLNP suggest that larger families, Q’eqchí Maya, landless households, families with small or environmentally degraded plots, households with poor access to labor and produce markets, the least educated, and the exceptionally poor run the greatest risk for migration to the frontier. Evidently, attention to both migration origin and destination areas enhances options for policy interventions aimed at sustainable rural development and forest conservation. \

Introduction

The primary cause of deforestation worldwide has been agricultural expansion, mostly from small farm families migrating to forest frontiers² in the humid tropics (Houghton, 1994; Myers, 1994; Geist and Lambdin, 2001). Yet in studying tropical deforestation, scholars have focused almost exclusively on *in situ* resource use and degradation, without considering why farmers are there in the first place; at the same time virtually all research on migration in the developing world has focused on rural-urban and international migration, which is only peripherally related to deforestation. The research presented here is the first to explicitly link the *proximate cause* of deforestation in the humid tropics—land use by migrant colonists—to its *underlying cause*—the factors that lead to migration to the frontier. To do so I draw upon two linked data sets: (1) survey data from households and communities in a core conservation zone of Guatemala’s Maya Biosphere Reserve (MBR), the Sierra de Lacandón National Park (SLNP) (Map 1); and (2) data from community leaders in MBR migrant areas of origin (Map 2).

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² I refer to an agricultural frontier as a region that has undergone rapid population growth and land appropriation, and where the “geographical boundary between ‘directly productive’ and ‘usury-mercantile’ capital...[that]...lasts as long as landed property does not consolidate (Almeida 1992).” The frontier is not a fixed place but rather “a brief transitional process” (Almeida 1992).

Significance

The long history of forest conversion to agriculture represents the most expansive footprint of human habitation on the earth's surface (Myers, 1991; Parsons, 1994). The planet's intact forests have dwindled to one-fifth of their original cover (World Resources Institute, 2002). During recent decades deforestation has accelerated and is now almost totally concentrated in the most biodiverse forests on earth. If rates continue as during the last decade, most biologically rich forests on the planet will be erased within fifty years (FAO, 2001).

This trend has several human and environmental consequences. The diminution of the planet's gene pool threatens future advances in science, medicine, and food production (Smith and Schultes, 1990; Wilson, 1992). Forest elimination has also led to soil erosion and increased sedimentation of waterways (Southgate and Whitaker, 1992), hydrological and nutrient cycle perturbation (Fearnside and Barbosa, 1998), and soil impoverishment (Weischet and Caviedes, 1993; Lal, 1996). Tropical deforestation has global consequences as well, threatening to exacerbate climate change at local (O'Brien, 1995; Fearnside, 1996) and global levels (Adger and Brown 1994).

Within Latin America, much attention has focused on the ecological devastation of the Amazon, yet no major world region has lost a greater percentage of its forest cover than Central America in recent decades³ (FAO 2001). Only seven countries worldwide contain as much forest as Guatemala (over 28,000 km.²) and at the same time experienced a greater rate of deforestation during the 1990s (1.7% per annum) (FAO 2001). Most of the forest clearing in Guatemala in recent years has been concentrated in the Maya Biosphere Reserve (MBR), particularly in one of its core conservation zones, the Sierra de Lacandón National Park (SLNP).

Migration and deforestation in the tropics

Proximate cause of deforestation on the agricultural frontier: Small farmer land use

The proximate causes of deforestation in the humid tropics vary significantly across and within countries, but it is generally agreed that migrant farmers are the primary *direct* agents (Myers, 1991; Geist and Lambdin, 2001; United Nations, 2001).⁴ Factors found associated with variation in small farmer rates of forest clearing include market access and duration of residence on the farm (Sierra 2000; Cortina Villar et al. 2001); land tenure security (Southgate et al., 1990; Moran, Brondizio et al. 1994); soil quality and topography (Hecht, S., 1985; Moran et al., 1994); household demographic composition (McCracken, Siqueira et al. 2002; Walker, Perz et al. 2002; Pan, Walsh et al. 2004); and educational achievement (e.g., Moran 1984; Godoy, Groff et al. 1998). Others have noted the effects of fiscal and political structures, the expansion of export agriculture, cattle ranching, land speculation, and agricultural output prices (Stonich, 1993; Walker et al., 2000). Despite some agreement on general trends, place-based effects have yielded quite different results in different places (Carr 2002a). And despite the widespread obeisance to political ecology theory and recognition of the importance of context and spatial scale, the literature on frontier land use/cover change (LUCC) largely ignores the effects of contextual factors at the community and sub-regional level.

Underlying causes of deforestation in agricultural frontiers in the tropics: Out-migration from areas of origin

The most conspicuous shortcoming of current LUCC research is the failure to systematically examine the antecedents to frontier deforestation. Given the dominant roles of migrant colonists in land clearing, this means understanding the decisions of farm families to leave origin areas to migrate to the frontier. Yet of the work on internal migration in developing countries, almost all is on *rural-urban* migration, most based upon survey data obtained only in destination areas (Bilsborrow 2001). In effect, rural-rural migrants have been largely ignored in the migration and development literatures, even though they are the key migrants in

³ From 1966 to 1994, 43% of the region's forests were felled (Carr and Bilsborrow 2001).

⁴ Estimates of the share of global deforestation attributed to shifting cultivators range from 45% (UNEP 1992) and 60% (World Bank 1991; Myers 1992) to 79% (Amelung and Diehl 1992).

population-environment relationships. Thus, two critical questions remain unanswered: 1), who migrates from rural areas of origin; and 2), among these, who chooses the agricultural frontier as their destination?

Regarding factors leading to out-migration from rural communities in general, Wood, (1982), Bilborrow (1987), Massey (1990), Findley and Li (1999), Lee, (1985), and others argue for a structural approach considering a range of economic and non-economic factors embodied in perceived “place utility” (Wolpert, 1965; Bible and Brown, 1981; Brown and Sierra, 1994).

With respect to migration to the agricultural frontier, a variety of hypotheses have been posited in the land use and political ecology literatures focusing on macro-level economic and political factors, with little in the way of analyses at local scales, where decision-makers actually operate (Stonich, 1989; Barbier, 2000). Explanations of migration have also failed to highlight that the conditions sufficient for out-migration do not necessarily lead to migration, much less to the frontier. Indeed, the vast majority of people in rural places do *not* move, and of those who do, most *do not* choose the frontier as their destination. Therefore, examining the modest population that out-migrates and why they choose to migrate to the frontier is essential to understand the primary cause of tropical deforestation.

The research sites

Destination area: The Sierra de Lacandón National Park

Widely deforested by Maya agriculturists from 1500 BC to AD 900, the vast northern *departamento* of Petén (Map 1) was virtually depopulated by AD 900 (West 1964; Turner II, Clark et al. 1990). Spanish colonizers and early republican governments largely ignored the sparsely inhabited territory, and old growth forests returned to cover the region (Schwartz 1990). By the late 1960s, mounting population and land pressures, civil unrest, and a national policy to stimulate export agriculture led to a rapid colonization of the region. Since the 1960s, the population of Petén has risen from a few *chicle* extractors to 600,000 (Instituto Nacional de Estadística 1999), and is projected to pass one million by 2020 (Grandia 2000). Concomitantly, from the 1960s to the mid-1990s, half of Petén's forests were eliminated (Valenzuela 1996); a process documented by a number of scholars (e.g., Jones 1990; Colchester 1991; Schwartz 1995; Sader, Reining et al. 1997; Grunberg, J. ed. 2000). At the recent rate of 40,000 hectares cleared per annum, the *departamento's* last forests would be erased by 2015.

With heightened concern over the region's ecological conversion, in 1989 UNESCO working jointly with a host of institutes from donor nations established the Maya Biosphere Reserve (MBR). Occupying nearly 60% of Petén and 20% of national territory, the MBR forms the heart of the *Selva Maya* (the largest lowland tropical forest in Central America). The MBR also serves as a pan-continental biological bridge, a cardinal repository of biodiversity and archeological sites, including Tikal, the remains of the magnificent ancient Mayan city (The Nature Conservancy 1997).

Established in 1990 as one of four *core* zones (area of strict conservation) within the MBR, the Sierra de Lacandón National Park (SLNP), is the second largest national park in Guatemala (Map 1). With the maximum relief and greatest rainfall in the MBR, the SLNP has the highest biodiversity in the *Selva Maya* (The Nature Conservancy 1997). Despite its biological richness and its designation as a core conservation zone, the SLNP suffers from some of the highest population growth and agricultural expansion in Petén. More than 10% of its forest canopy has been eliminated since 1990, during which time most of the park's 3,000 families settled in the area (Carr 1999; Sader, Martinez et al. 2000) (Map 2). As in the rest of Petén, the proximate cause of the deforestation has been agricultural expansion by swidden corn farmers (Figure 1). A prerequisite to deforestation in the park was the decision of these farm families to migrate from their origin communities to the frontier.

Areas of origin of migrants to the SLNP

Highly unequal resource distribution—resulting in a lack of land and alternative employment opportunities for small farm families—is a common denominator of areas of high out-migration in rural Guatemala and elsewhere throughout the developing world. Cultivable land per capita in the country fell from 1.7 to 0.8 hectares between 1950 and 1979. During this time over 150,000 new sub-subsistence farms were created under 1.5 acres (SEGEPLAN 1987). Compounding problems of skewed land distribution,

political violence displaced hundreds of thousands of peasants during the 1980s (Aguayo, Christensen et al. 1987; Morrison and May 1989). Further, the extreme concentration of landholdings and underemployment, combined with the highest rural fertility rate in Central America,⁵ led to fragmentation of farm plots and rural poverty, stimulating out-migration (Bilsborrow and Stupp 1997). Despite these processes, most rural Guatemalans have remained in their origin areas, while most of those who migrate go to the US or to Guatemala City rather than to the frontier. Little is known about the minority that has migrated to the frontier, let alone why they choose such a destination.

Data Collection and Analysis

The SLNP

In 1998 and 1999 I conducted the first statistically representative survey on population and frontier land use in Guatemala. Community leaders were interviewed in each of the 28 communities within and adjacent to the SLNP.⁶ Surveys with household heads then were collected from a stratified random sample of 279 households and 221 spouses in a subset of 9 of the 28 SLNP communities⁷ (Map 3). Both household and community-level instruments featured structured and open-ended questions relating to household and farm characteristics, frontier colonization, and land use. Following a descriptive (e.g., means, standard deviations) and qualitative analysis (examining emerging themes from open-ended interview questions), I estimated one and two-level hierarchical multivariate regression models to investigate farm-level deforestation in the SLNP.⁸ The latter is the first application of such a model to frontier land use in Central America. Multi-level models are preferable as they statistically test the influence of geographical factors (e.g., community and regional influences) not measured by single-level models.

Dependent variables included forest, crops, pasture, fallow, cleared land, and percent cleared. The latter two variables are featured in the analysis presented here. For simplicity, I illustrate the structure of the model for only an intercept term, one household-level independent variable (X_{ij}), and one community-level variable (W_j); an extension to more explanatory variables is straightforward. The estimation models for one and two levels take the form (Bryk and Raudenbush 1992; Goldstein 1995):

$$\begin{aligned} \text{Level 1: } Y_{ij} &= \beta_{0j} + \beta_{1j}X_{ij} + r_{ij} & \text{Level 2: } \beta_{0j} &= \gamma_{00} + \gamma_{01}W_j + u_{0j} \\ & & & \beta_{1j} &= \gamma_{10} + \gamma_{11}W_j + u_{1j} \end{aligned}$$

where Y represents the outcomes of interest (e.g., forest cleared), β and γ represent the level-1 (household) and -2 (community) unknown parameters⁹, W is a level-2 (community-level) variable which affects intercepts and slopes for each community, and r and u are random error terms for the household

⁵ 6.1 births per woman, according to the Guatemalan National Institute of Statistics (Instituto Nacional de Estadística 1999).

⁶ Interviews were conducted with community officials, such as town council members, mayors, and health promoters, and were supplemented by conversations with key informants, such as storeowners and farmers. Questionnaires were developed from instruments used previously in Guatemala (Corzo-Márquez and Obando 2000), Ecuador (Pichón and Bilsborrow 1999), and Mexico (Klepeis and Turner II 2001). Although not presented here due to space constraints, data collected from community leaders in the 28 SLNP villages match closely data reported in 7A below from household surveys in eight randomly selected SLNP communities selected for household surveys, suggesting a sample that is representative of the SLNP region.

⁷The household sample represents an estimated 10% of all the *fincas* or farms in the SLNP

⁸ Bootstrapping, whereby the estimation of sample variability is estimated through the observation of frequent iterations, was implemented to correct for bias from violations of minimum second-level (community) sample size (Van der Leeden, Busing et al. 1997).

⁹ γ_{00} and γ_{10} are household level effects and γ_{01} and γ_{11} are community-level effects,

and community levels respectively. Subscript *i* indexes individual households; subscript *j* indexes communities.¹⁰

SLNP Migrant origin areas

Subsequent to the Petén fieldwork, in 1999 and 2000 I completed a survey in areas of migrant origin to the SLNP.¹¹ I interviewed community and municipal leaders and other key informants in 28 communities in 16 *municipios* of highest out-migration to the SLNP (Map 4). *Municipios* were selected from 1993 Guatemala census data and were corroborated as key regions of out-migration to the SLNP by my SLNP household and community surveys. Questionnaires featured structured and open-ended questions on in-and out-migration, perceived reasons for migration and primary destinations, and perceived determinants of frontier migration.

Results

A. Factors Associated with the Proximate Cause of Deforestation in the SLNP: Small Farmer Land Use

Deforestation in the SLNP has resulted mainly from swidden corn farming and pasture expansion. The mean farm size is 34 hectares, with five hectares dedicated to maize, seven to fallow land and a fraction to other land uses (Figure 2). The majority of the farms' land cover remains in forest, suggesting the great potential for further forest clearing on settler parcels. Land allocations, and thus deforestation, vary from farm to farm as a result of different household characteristics. Table 1 shows the means or percentages of variables hypothesized to be related to forest clearing on the farm, their expected associations with forest clearing, and the observed directions of association. The independent variables explained more than 50% of the variation in forest clearing in the single-level multiple regression (R^2 of .54). Improvement of model fit was significant at the .01 level in the second-level model, which adds the influence of community-level factors. I will now discuss the relation between demographic, political-economic, socio-economic, and ecological factors and forest clearing in the SLNP.

Demographic factors

Despite the young average age of women (28 years old), family size remains large at 6.5 members per household. Even when community-level effects and important variables such as size of farm and duration of settlement were controlled in the models, larger families cleared more forest than did smaller families. Larger households likely stimulated greater demand for crops, both for household consumption and for sale to market (Caldwell and Caldwell 1987; Pichón 1997).

Political-economic factors

Communities located within the park remain unrecognized by the national government. Thus, informal political arrangements have emerged, and community leaders suggest that NGOs (non-government organizations) have more impact on local people and their land use than do GOs (government organizations). Yet, raising questions as to the effectiveness of local NGOs, fewer than half the

¹⁰ The main assumptions required for estimating this model, detailed by Bryk and Raudenbush (1992), are that the household (*r*) and community level (*u*) error terms are uncorrelated, and are both independent and normally distributed.

¹¹ Using data from the latest (1993) population census, I defined migrants as persons living in the *municipio* of La Libertad, the *municipio* (similar to a US county) in which the SLNP is situated (occupying most of the *municipio*'s territory) at the time of the census who had ever lived in another *municipio*. Most migrants to the *municipio* of La Libertad during the decade prior to the census migrated to the SLNP.

respondents claimed to have had any contact with a conservation or development worker, and there was no significant difference in forest clearing among these farmers.

Fewer than a third of the farmers reported legal claim to their farm; these farms were located in the MBR's "buffer zone" adjacent to the SLNP. A large literature supports the belief that tenure security may temper farmer impacts on the forest (Southgate, Sanders et al. 1990; Schneider 1993; Mahar and Schneider 1994). Yet farmers with legal title had more land in crops and pasture and less land in forest. Farmers with legal claim to the farm were much more likely to have availed themselves of credit which enables the purchase of cattle and farm machinery (Carr 2002). Nevertheless, farmers with secure land access through agro-forestry cooperatives cleared less than half the amount of forest than non-cooperative farmers. In addition to leaving a significantly smaller ecological footprint on the reserve's forests, these farmers earned several times more revenues per hectare through sustainable forestry harvesting and diversified crops than did squatter farmers specializing in maize cultivation and cattle ranching.

Socio-economic factors

Slightly more than half of the household heads, and fewer than half the women in the sample, had completed even one year in primary school. More educated household heads maintained more of their farm in forest. Literate farmers may be more aware of or sympathetic to conservation initiatives, or the means to intensify production, despite the fact that education can also stimulate consumption and the motivation and ability to increase production (Moran 1983; Pichón 1997; Godoy, Groff et al. 1998; Pichón and Bilsborrow 1999). That this effect was diminished when adding community-level effects points to the importance of community variation in educational access.

Maya farmers (23% of the sample) cleared more land than Ladinos (mixed Spanish and indigenous descent). However, as Ladinos and non-Q'eqchí Maya are more likely to adopt cattle it is anticipated that they will soon surpass the Q'eqchí (15% of the sample) as the more expansive farmers (Carr In Press). This supports the importance of examining differences in land use among indigenous groups rather than conflating them into one category (Atran 1999).

Having access to land to farm in the previous residence is associated with greater levels of extensification (opposite of intensification), suggesting the importance of land use experience prior to migration (e.g., Almeida 1992). It is likely that many of the farmers with land in their previous residence learned their land management strategies from tilling the soils of former frontier regions in Petén and other remote regions.

Approximately half the household heads worked off the farm (usually on a neighboring farm in a labor exchange during labor-intensive periods of the agricultural calendar), which decreased labor availability and, thus, deforestation on the farm, supporting previous research in the Amazon (Pichón 1997; Bilsborrow and Pan 2001).

Farm and farming characteristics

Corroborating previous research in frontier environments (Murphy and colleagues, 1997; Rudel, 1993) farm size emerged as by far the strongest predictor of forest cleared on the farm. Farmers cleared two more hectares for each additional ten hectares of land. Some of the effect of land size appear to be due to land consolidation by new cattle ranchers, a process documented throughout Latin America (Hecht 1983; Walker, Moran et al. 2000). Farms with cattle are approximately 50% larger than farms without cattle, and as observed in Figure 3, the quarter of the farmers in the sample with pasture have cleared much more forest on their farms.¹²

The longer a farm had been settled, the greater percentage of the farm was cleared through the accumulation of fallow land from crop rotations and from pasture expansion. Those arriving during the first wave of colonization in the 1980s and early 1990s enjoyed squatters' rights to land on or near the road.

¹² Land in pasture and whether or not a farm has pasture are highly significant variables in the cleared land and percent of farm cleared models but are excluded due to concerns of endogeneity.

Subsequent colonists either claimed land farther into the park, or they purchased or rented land close to the road. Therefore, as expected, greater distance from the road was associated with less forest cleared.

Much has been made of the role of agricultural intensification (enhancing yields per unit labor per unit land) in attenuating tropical deforestation (Netting et al., 1993; Zimmerer, 1993; Turner II and Ali, 1996; Shriar, 2000). Yet contrary to theory, SLNP farmers who cropped the nitrogen-fixing legume, velvet bean (Latin *mucuna pruriens*), or applied herbicides cleared more land than traditional “extensive farmers”. Indeed, agricultural intensification has been most evident among farmers who also have cattle who may be intensifying crop production to free up land for pasture expansion (Carr 2002).

Ecological factors

Soil quality and topography did not significantly influence farmer land use. Most farms are amply covered in forest, which serves as a ready stock of nutrients for future harvests. Still, a marginal association was found in which farmers with very good soil cleared a smaller percentage of their land than those with poor or mediocre soil, suggesting a possible trend in the future of accelerated deforestation to compensate for the decreased yields that may result from soil degradation over time.

Most of the variation in farm-level forest clearing was explained by the factors discussed above. However, when examining underlying causes of forest clearing, it is evident that a perfect correlation exists between migration to the frontier and forest clearing for agricultural expansion. Thus, an immediate prerequisite to frontier deforestation is the decision of farm households to migrate to the SLNP from origin areas. Roughly 80% of SLNP colonists cited some aspect of land (e.g., access, ownership, or quality) as their primary motive for migrating (Carr, 1999). But how did land poverty arise in different places, and why did a small minority choose to leave friends and family and move to a disease-infested remote agricultural frontier with scant government funding for schools and health care? The second part of this paper addresses these questions.

B. Factors associated with the Primary Underlying Cause of Deforestation in the SLNP: Rural-frontier Migration

Table 2 describes permanent out-migration patterns from origin communities. Approximately 10% of the adults had permanently out-migrated during the previous ten years. Peak out-migration coincided with the period of greatest in-migration to the SLNP: the height of the civil war in the 1980s and 1990s. Even in this sample weighted towards areas of high out-migration to the SLNP, as many migrated to Guatemala City as to Petén. Approximately 70% of all permanent out-migrants chose one of these two destinations, with the remainder migrating to the US and other internal destinations.

Demographic factors

Table 3 shows the means of a host of factors related to migration to the frontier as indicated by a plus or minus sign. Community leaders opined that more children increased the likelihood of out-migration by family members to increase household resource access and security. Further, frontier migrants were more likely to come from large families, particularly from remote rural areas where contraception availability is poor and dependence on the land is great.

Political-economic factors

Approximately 70% of individuals had no access to farmland, even as renters, and those landless individuals were more likely to migrate to the frontier, particularly in the absence of alternative employment or the skills to compete for non-agricultural jobs. Market access was not a problem in origin communities, unlike on the frontier, but few farmers had sufficient land to produce a surplus for market. Improved access to markets, and thus the potential for income improvement, appeared to favor migrant retention or out-migration to destinations other than the frontier. Conversely, remote locations appeared to favor frontier migration.

One-third of the communities reported civil war violence as a factor in fostering out-migration in the 1980s and early 1990s. For the most part, violence was not the sole factor motivating migration, but rather was a precipitating trigger following years of population growth, land consolidation, and environmental degradation. However, as reported in northern Quiché and Huehuetenango (e.g. Menchu and Burgos-Debray 1984; Castaneda 1998), violence was sufficient in itself for out-migration in some regions, particularly among communities in Fray Bartolomé de las Casas, Alta Verapaz,

Socio-economic factors

The ethnic distribution of origin communities was similar to that of the SLNP; Mayans comprised roughly 30% of the population and the Q'eqch'í were the majority indigenous group. As in the SLNP, the Q'eqch'í tended to live in remote enclaves and were much more likely to choose the frontier as a destination than were other indigenous groups and Ladinos.

Consistent with national trends, approximately three-quarters of the men and slightly fewer women in the origin areas were literate, and most school-age children attended school. Frontier migrants were usually less educated than non-frontier migrants, while migrants to the US and Guatemala City were generally more educated than non-migrants.

Infrastructure, as measured by electricity and modern home construction materials, was far superior in origin areas to the frontier. Similarly, non-agricultural employment options were much more abundant than in the SLNP although they still lagged behind the national average. A quarter of the household heads in origin areas work primarily in non-agricultural jobs for an average of \$3 US dollars daily. To the extent that the above conditions worsened, the probability of frontier migration increased. While informants opined that frontier migrants were almost uniformly of low socio-economic status, higher socio-economic standing was considered a necessary condition to finance a move to the US.

Ecological factors

Unlike the SLNP where over half of the farm's land cover remains in forest, in origin communities virtually all farmers dedicate all the land on their small plots to growing maize. As a result of constant cropping, soil degradation was a major out-migration push. Thus, the vast majority of farmers in all regions employed some intensification method to combat decreased yields, including herbicides, pesticides, and fertilizers. Along river valleys, especially where small farms were situated in marginal locations, flooding and associated soil erosion were also important out-migration factors.

Why place matters

A common denominator among frontier migrants was insufficient access to resources, including land and other forms of capital, due to skewed land concentration, rapid population growth, and both chronic and sudden land degradation. However, the nature and determinants of resource scarcity are largely place-specific. Examples from three *municipios* illustrate this point.

Out-migration from the *municipio* of Morales followed on the heels of land consolidation by large banana plantations and cattle ranchers, the marginalization of rural households on the poorest lands, and subsequent environmental degradation. Like other banana-producing areas in Izabal, the large *departamento* on Guatemala's Caribbean coast, Morales' population and export-producing economy swelled during the middle decades of the 20th century, initially drawing rural laborers from across the country. But plantation expansion increasingly pushed colonist small farmers off the land, leaving plantation labor as one of the few viable subsistence options. Though population growth has been a factor in the fragmentation of farm plots, plantation expansion has left virtually no productive lands for small farm families. Ultimately, dramatic flooding events devastated small family farms and spurred widespread out-migration.

Conversely, Nueva Concepción (*departamento* of Escuintla), located on the fertile volcanic plains of the Pacific Coast, has experienced no land consolidation in recent decades. In 1954, the *municipio* was formed from a government-appropriated banana plantation. Settler families were awarded 28-hectare parcels, precipitating a massive influx of colonists, many hailing from the east (e.g., Izabal, Zacapa,

Jalapa). Since land redistribution in 1954 to the time of the survey, the typical household land holding in Nueva Concepción had been reduced from 28 to 2-4 hectares resulting principally from two generations of large families. Given the complexity of human-land relations in rural Latin America, it is extremely rare to isolate fertility as the overwhelming direct cause of farm fragmentation and, thus, out-migration. And the rapidity and magnitude of farm splintering in Nueva Concepción is even more dramatic considering the mitigating effect of significant out-migration to the US and to the SLNP during recent decades.

Lastly, in Fray Bartolomé de las Casas, (*departamento* of Alta Verapaz), government-sponsored development of the Franja Transversal del Norte region, brought an influx of Q'eqch'í from western Alta Verapaz in the 1950s through the 1970s. Initially, colonists claimed large farms of 20 or more hectares. By the late 1970s, population growth and land consolidation had transformed the *municipio* from a colonization front to a colonization font. During the 1980s civil war violence terrorized many communities which, aggravated by soil degradation rendering many farms scarcely adequate for subsistence, spurred pockets of extremely high and rapid out-migration. The above conditions prompted large migration streams to southern Petén in the 1970s and 1980s, where the emergence of similar circumstances in turn gave rise to the colonization of the SLNP in the 1980s and 1990s.

Conclusion

I examined land use/cover change (LUCC) in one place as a result of (local) proximate and (distal) antecedent processes. Most of the deforestation in Latin America occurs at the hands of colonist farmers. Yet in explaining forest clearing, land use researchers have focused our attention on farmer land management where they are, not why they got there. Conversely, the great majority of research on migration in Latin America relates to rural-urban or trans-national migration and is therefore only peripherally relevant to deforestation. Novel methodological approaches presented in this research represent a first step in researching the two inter-linked processes jointly.

Studying both migration and land use tells us something about not just the internal frontier, where farmers already are, but why they settled there in the first place, which gets at the real threat for future deforestation, the vast external forest frontier yet to be colonized. Examining the problem this way clarifies the progressively wider contexts of political-ecological forces that may spur both phenomena to loop inexorably in cyclical iterations. Land use is not an ultimate denouement, nor is migration. Households will make decisions over and over again, changing their land use, migrating, seeking off-farm employment, etc. This has implications for recent modeling efforts, which may boast a high degree of accuracy given current conditions. But if origin conditions not currently factored into models, change so will frontier landscapes.

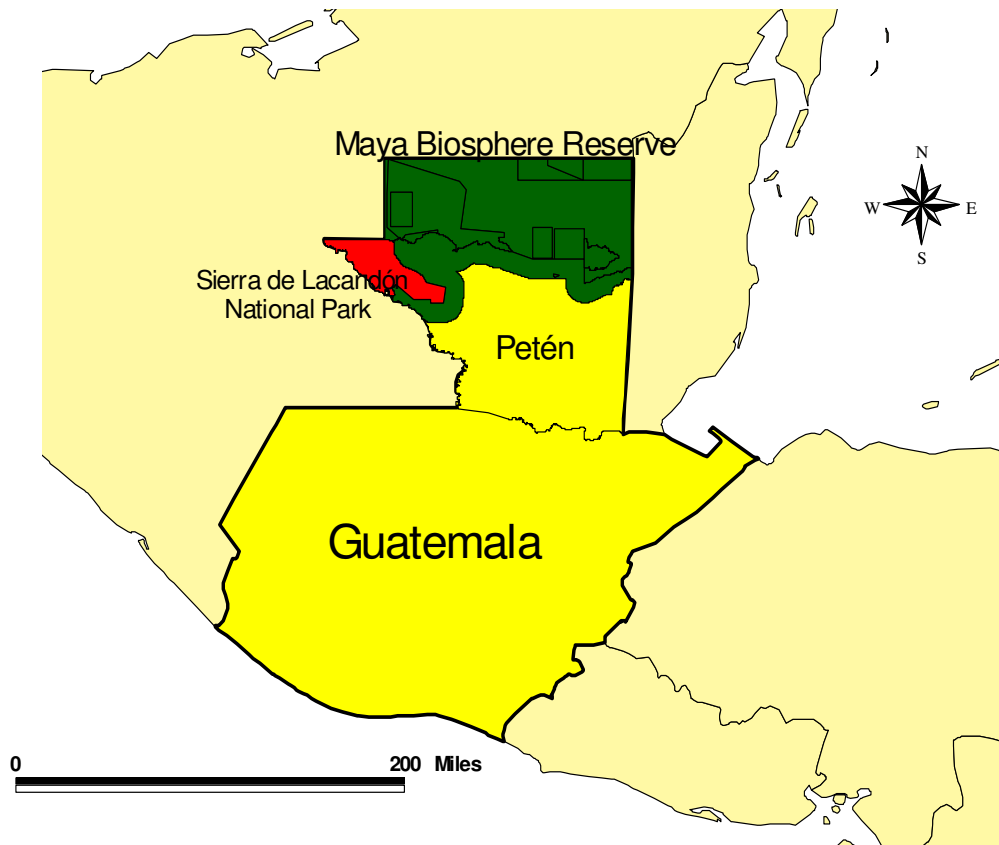
Results indicate that many of the same factors help explain out-migration to the frontier, and land use once there. It is the relative strength of the variables that changes in each place. For example, land scarcity is the primary reason colonists site for migrating, while land abundance was the primary reason for migrating to the SLNP; it was also the key predictor of deforestation following settlement. But the causes of land scarcity vary from place to place, suggesting that policy prescriptions need to be place sensitive.

It is noteworthy that the data from origin and destination regions agree that the very small population most at risk for frontier migration, and therefore deforestation, is the poorest, most marginalized, least educated, largest households. However, it is the relatively “well-off” among the rather uniformly poor agricultural colonists on the frontier—those who have the greatest land access and relative land security—who clear the most forest. If this is true in other countries, investments in rural development could usefully target agricultural intensification, livestock replacement alternatives, education, health care, and the generation of alternative employment in areas of frontier migration destination *and* origin. Such efforts represent a moral imperative of immediate concern for human development. This study suggests that such an approach may also serve to minimize farmer impacts on the forest in agricultural frontiers and, more fundamentally, to stanch a prerequisite to frontier deforestation, rural-frontier migration.

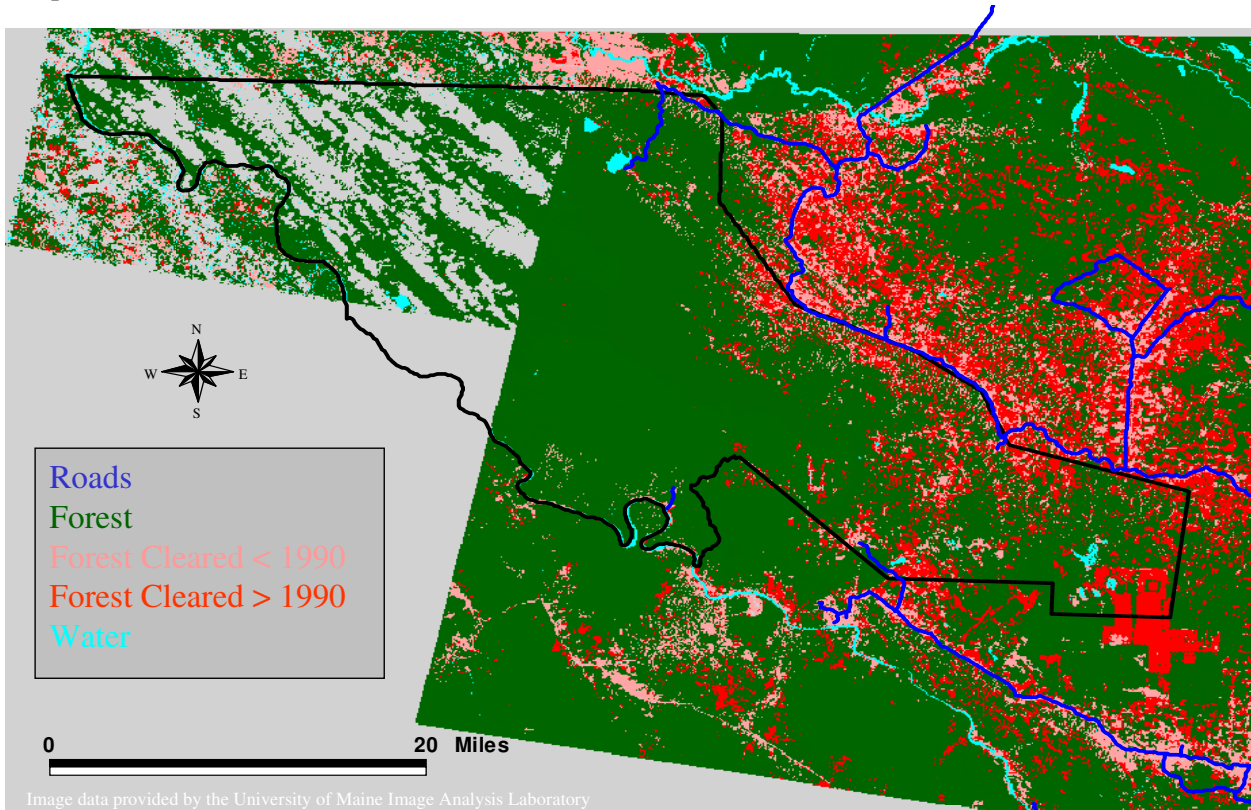
Figure 1. Maya ruins exposed on recently cleared land in the SLNP.



Map 1. The Sierra de Lacandón National Park, Petén, Guatemala



Map 2. Deforestation in the SLNP

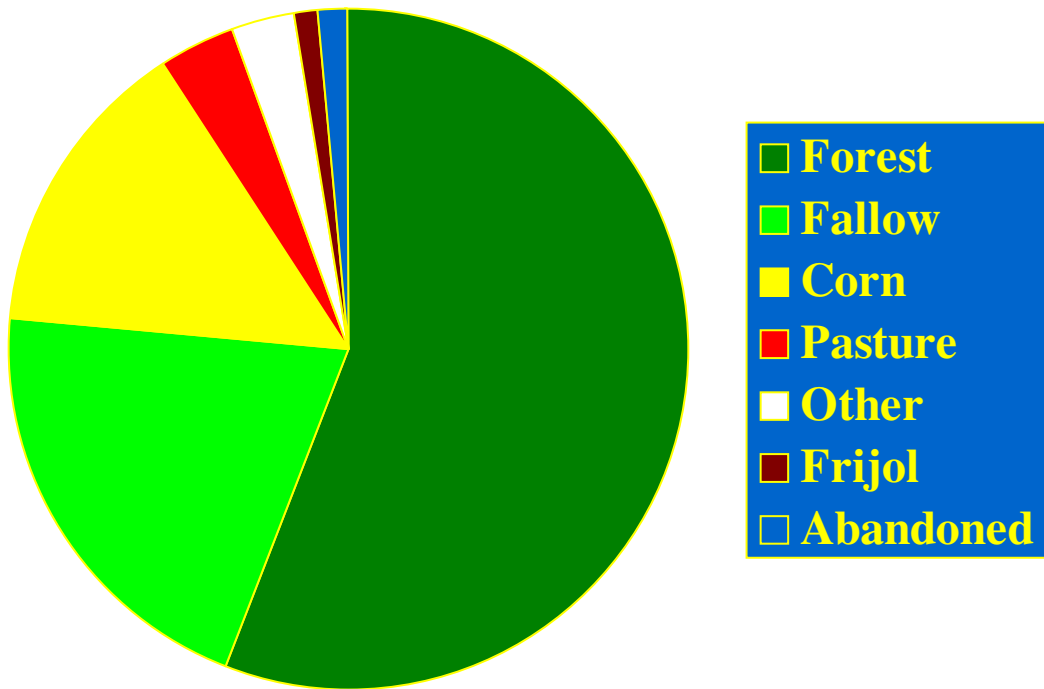


Map 4. Departments of Guatemala and Municipios of Migration Origin to the SLNP.



Fuente: <http://www.inguat.net/redtp/map/indexe.html>

Figure 2



Mean Farm Size = 34 Hectares

Figure 3.

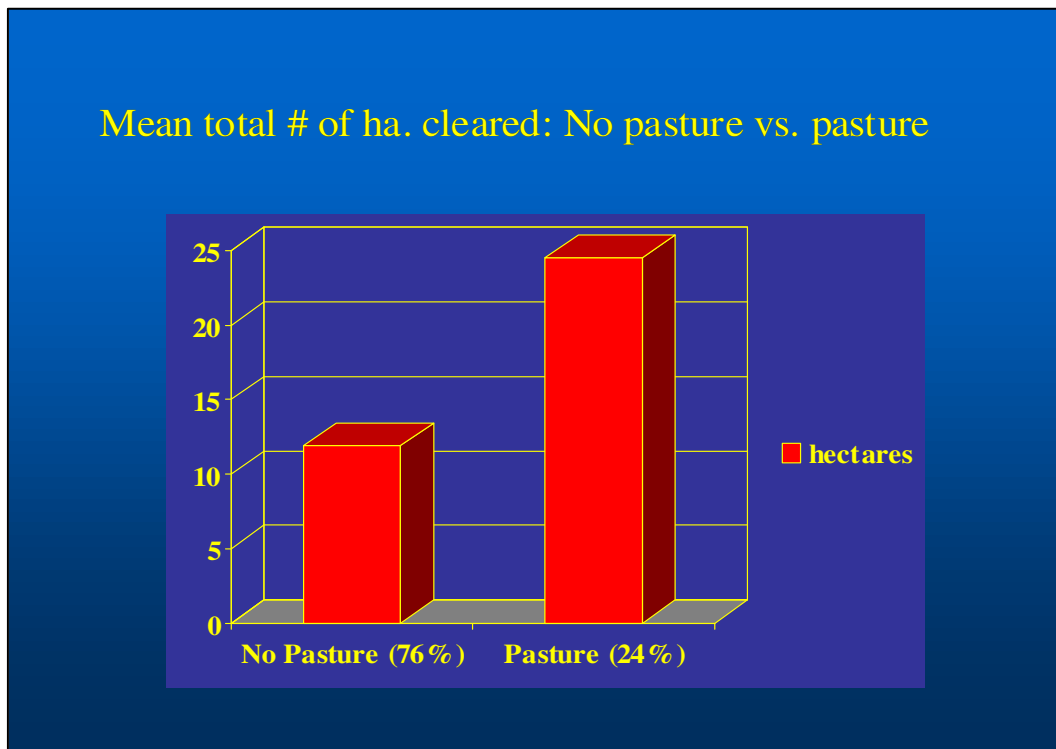


Table 1. Two-level Multivariate regression of Farm-level Deforestation

<u>Predictors</u>		<u>Cleared Land</u>		
	<u>Mean/%</u>	<u>Level 1</u>	<u>Level 2</u>	
		Expected	$\hat{\beta}$	$\hat{\beta}$
1. Demographics factors				
Household size	6.5	+	0.5 **	0.3 **
2. Political-economic factors				
Contact with an NGO/GO	41%	?	-1.0	
No land title	69%	?	-3.2 **	-7.4 ***
Cooperative	2 of 8	-		-11.3 ***
3. Socioeconomic Factors				
<i>Household socio-economic characteristics</i>				
Maya(a)	23%	?	2.9 **	3.4 ***
Ever attended schol(b)	57%	?	-2.7 **	
Land in previous residence(c)	32%	+	0.2 **	
Off-farm labor(d)	43%	-	-4.5 ***	-3.0 ***
Rents Land ¹	23%	-	-3.3	
<i>Farm and Farming Characteristics</i>				
Size of total holdings	34.8 ha.	+	0.2 ***	0.3 ***
Distance to road	5.9 km.	-	-0.4 ***	-0.5 ***
Duration on the Farm ²	9.2 years	+	1.3	
Additional agricultural fields	17%	+	4.3 ***	4.5
Velvet Bean and/or herbicides(e)	51%	-	2.9 ***	1.4 **
4. Ecological factors				
Farm has predominantly fertile soil ³	40%	-	-2.0	
Farm is predominantly on flat land	55%	+	-1.6	
Adjusted R2			0.54	
Log likelihood ratio test[^]			30.4 ***	

P values: *** < or = .01, ** < or = .05

[^]Significance test of difference between 1 and 2-level models (based on model 1 parameters).

a) 0 = Ladino, 1 = Indigenous.

b) 0 = never attended school, 1 = has attended school (in reference to the household head).

c) 0 = no access to land in previous residence, 1 = some access to land in previous residence.

d) 0 = no participation in off-farm labor during previous 12 months, 1 = some participation

e) 0=no usage, 1=crops velvet bean or applies herbicides,

¹Significant at the .05 level in a single-level model for percent of farm cleared

²Significant at the .05 level in a single-level model for percent of farm cleared

Table 2. Permanent Migration

Permanent Migration		
Percent of adults permanently out-migrating from 1989 to 1999		Approximate Mean
Men		10%
Women		10%
Principal Destinations	Primary employment	
Guatemala City	Factory or service worker	35%
Peten	Acquire land for farming	35%
USA	Factory, service, or agricultural worker	10%
Other	Plantation laborer	10%
Principal pushes/pulls		
Work		35%
Land		30%
Improve living standard/education		20%
Natural disasters/Env. Degradation		10%
Remittances	From migrants to the following places:	Proportion sending
	USA	Almost all
	Guatemala City	Some
	Peten	None

Source: Interviews with community leaders in 28 communities of migrant origin throughout rural Guatemala.

Table 3. Factors Associated with Frontier Migration from SLNP Migrant Origin Areas

	<u>Mean*</u>	<u>Frontier Migration</u>
<u>Demographic Factors</u>		
Family Size	5.5	+
Married at time of migration	50%	+
<u>Political-economic Factors</u>		
Landless	70%	+
Farm Size	1.75	-
Receive Credit	10%	-
Price of a one manzana plot (.7 ha)	Q15,000	-
Market access	2.6 km.	-
Communities that suffered violence	36%	+
<u>Household SES Characteristics</u>		
<u>Ethnicity</u>		
Ladino	60%	-
Other	40%	+
<u>Literacy</u>		
Men	70%	-
Women	60%	-
Children in primary school	75%	-
<u>Infrastructure</u>		
Metal Roofs	68%	-
Earth floors	68%	+
Communities with Electricity	79%	-
<u>Work</u>		
Percent in Non-agricultural Employment	20%	-
Daily Salary	20Q	-
<u>Ecological characteristics</u>		
Communities in which an average farmer has forestland	15%	+
<u>Percent of communities in which the average farmer employs the following:</u>		
Pesticides	90%	-
Fertilizers	90%	-
Herbicides	90%	-
Velvet Bean	65%	NA
Employs one of the above	100%	-
<u>Percent listing the following as the principal problems with farming:</u>		
Insufficient land	25%	+
Too much rain	20%	+
Pests	18%	+
Lack of land tenure	14%	+
Communities in which the soil has degraded since 1989	90%	+

Source: Interviews with community leaders in 28 communities of SLNP migrant origin throughout rural Guatemala

*Estimated according to the responses of community leaders on each topic.

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