

Colonization, clear-cutting, and cornfields: Rural migration and deforestation in The Sierra de Lacandón National Park, Petén, Guatemala

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Abstract

This paper uses household level data to examine the ecological and political factors and household characteristics associated with small farmer land use change and forest clearing between 1993 and 1998. The research site is a settlement frontier within a protected area in northern Guatemala. The great expanse of accessible, open land of the Sierra de Lacandón National Park (SLNP) has been a magnet for land-poor colonists from other rural areas in Guatemala. Colonists arrived following the construction of a road through the area in the early 1980s. Today farmers occupy lands up to 20 kilometers into the SLNP, a core zone of Guatemala's Maya Biosphere Reserve. There is an immediate concern for the continued expansion of the agricultural frontier further into the park. This paper considers the household and farm characteristics and the land use and land allocation decisions of 132 farmers in the SLNP to understand how these factors may contribute to forest clearing in the park. For the purpose of this research, farms are separated into two categories. The first group includes the 33% of farmers in the sample who cleared the most forest between 1993 and 1998 between and who farmed land in the SLNP in both years. The second group includes the 33% of farmers who cleared the least amount of forest during the same time period. The analysis finds significant variability in the amount of forest cleared in the sample. While the high deforestation group cleared an average of 13.6 hectares, or 49% of their forest during the time period, the low deforestation group on average experienced modest forest regrowth on their farms. This challenges the notion that frontier farming in the tropics is consistently and uniformly expansive. The key factor involved in forest clearing was farm size. The farms of greatest forest loss between the two time periods were more than twice as large as the farms in the lowest deforestation.

Introduction

The planet's forest cover has atrophied to approximately 25% of the globe's land surface (FAO, 1995). Until the completion of the westward agricultural expansion of North American pioneers in the late 19th century, deforestation was largely concentrated in the northern hemisphere. Today, the accelerated elimination of the globe's forest reserves is due solely to deforestation in the tropics.¹ If rates continue to accelerate as they did from 1984 to 1994 (at a 40% clip), the planet's tropical forests will vanish by 2050 (Houghton, 1994). The Latin American nations alone account for 57,800 km² per annum of forest clearing—double the rate of any other continent (World Bank, 1998).

There has been increasing attention focused on the environmental and socio-economic problems posed by tropical deforestation. In recent years, it has been estimated that 90% of species extinctions (an estimated 27,000 species annually according to Myers, 1993) have occurred in tropical forests, a biome that covers only 7% of the earth's terrestrial surface. The extermination of species irreparably damages the globe's biological gene pool, invaluable for the advancements of science, medicine, and food production (Smith and Schultes, 1993; Wilson, 1992).

The resource degradation unleashed by rapid deforestation has also led to chronic underdevelopment in rural areas of the humid tropics where primary resource extraction is necessary for subsistence (DasGupta, 1995; Stonich, 1989). Forest elimination spurs soil erosion and the sedimentation of waterways (Southgate and Whitaker, 1992), and soil impoverishment (Lal, 1996; Ehui and Hertel, 1992; Weischet and Caviedes, 1993)—diminishing small farmer capacities to maintain crop yields. The problem has global consequences as well; it threatens to exacerbate climate change at local (O'Brien, 1995; Fearnside, 1996) and global scales, where it has been estimated that between 25% and 30% of climate warming is caused by tropical deforestation (Adger and Brown, 1994).

Within Latin America, much attention has been focused on the ecological devastation of the Brazilian Amazon. Yet from 1990 to 1995, the rate of forest clearing in Central America outpaced Brazil's rate by almost six times (FAO, 1995). At 2% per annum, Guatemala is among the world's leaders in deforestation. Most of Guatemala's recent forest loss has occurred in the vast departamento (similar to a US state) of Petén. Much of the deforestation in Petén during the 1980s and 1990s has been concentrated in the Sierra de Lacandón National Park (SLNP). Colonization since the 1980s has expanded the agricultural frontier up to 20 kilometers into the second largest national park in Guatemala. If 1990's deforestation rates continue into the coming decades, the park's forest canopy may be extinguished by the time settler children become household heads in search of land for their families.

As alarm over tropical deforestation has grown in recent decades, the academic literature on frontier colonization in Latin America has expanded, mostly with cases from the Amazon (e.g., Hecht, 1990; Fearnside, 1987; Moran, 1982). Though a review of the literature imbues an appreciation of the variable political economic and physical contexts of settler environments, some important characteristics are shared. Frontier settlers tend to invest intensively in labor and extensively in their resource base relative to farmers in areas

¹ Among the nations of the temperate regions, only Finland and Japan (at approximately 0.2% annually) reported positive deforestation rates in the 1990's (World Bank, 1998). Conversely, all tropical nations deforest at a rate of 0.5% or greater annually.

of greater population density, for example in colonists' areas of origin. Given an environment of great land and scarce labor and capital resources, swidden or slash and burn agriculture is a logical way for settler farmers to maximize available resources (Pichón, 1997).

Though enabled by great land endowments, frontier farmers are often constrained by poor soils and erosive rains characteristic of tropical lowland environments, penurious market access, scant access to technology, and an unfavorable institutional environment in regards to land tenure, financial credit and technical assistance. Frontier farmers are thus placed in an environment in which destroying their own resource base through expansive farming—and, therefore, destroying the ecosystems of local tropical forests—is a reasonable choice for securing their household's wellbeing.

Yet there is much more to the story of deforestation in the humid tropics than the many factors that make expansive agriculture an attractive option for settler farmers. A focus on the popularly advertised immediate cause of forest clearing, slash and burn farming, ignores the migration process antecedent to land cover change in remote forest regions. Some of the same forces that foster an environment of expansive agriculture also impel families from longer settled rural regions to migrate to resource frontiers. Lack of technical assistance and capital to invest in more sustainable farming techniques, a dearth of off-farm employment opportunities, and high population growth, are some of the factors that create environments ripe for out-migration in rural areas throughout the developing world (Bilsborrow and Carr, 2000).

Most migration in the developing world is rural to urban or international, and the literature on these topics dwarfs the scant research on the much less understood process of rural to rural migration. Yet The World Bank estimates that migrant farmers account for more forest clearing in the tropics than all other human land uses combined (World Bank, 1991). So it is this minority of migrants that contribute to most of the forest clearing in the tropics.

Government policies have directly or indirectly sponsored population movements to frontier environments and the subsequent expansive land use of the colonists. Some of these policies include planned colonization, policies that favor export agriculture and urban consumers to the detriment of the small producer, and building roads through remote forest areas. Sometimes the absence of policies catalyzes the deforestation process, for example, the lack of investments in rural development, family planning policies that cause rapid population growth in rural areas, the absence of credit, technical assistance, appropriate agricultural technologies, and market access (see, e.g., Hecht, 1990; Jones, 1990; Pichon, 1996).

Roads are built for geopolitical and economic objectives. In some cases, road building through jungles has been spurred by the political motivation of controlling a nation's hinterlands, as was the case in the 1960s and 1970s in the Brazilian Amazon under military governments (Hecht, 1990). In other cases, economic interests are at the heart of such road construction as witnessed by the swift expansion of transportation routes into the biologically rich Ecuadorian Amazon in the 1970s and 1980s for the purpose of oil exploration (Pichón, 1992). In both Ecuador and Brazil, government sponsored colonization policies were later reversed in the 1990s as farms failed, and international concern grew for the pace of Amazonian deforestation.

In many ways, the shrinking of the Central American lowland forests reflect the story of Amazonian deforestation. For example, geopolitical and economic motives initiated the colonization of the vast Petén region—the heart of Latin America’s largest tropical forest north of the Amazon—for colonization in the 1950s. Geopolitically, the bordering Mexican states were much more developed and populated than Petén and concern over Mexican hegemony extending into the region influenced government-sponsored colonization of the area (Schwartz, 1995). Economically, the Guatemalan government, like Brazilian generals in the 1960s and 1970s, wished to harness the vast untapped resources of almost half the nation’s territory. But by the 1980s, spontaneous migration had outpaced planned colonization and governments were beginning to voice concern over the rapid destruction of their dwindling tropical forests. With the aid of international donors, a network of protected areas emerged throughout Latin America. But in both Central and South America, government sponsored colonization had unleashed a much larger flood of colonists from more population dense areas to the forest hinterlands.

Based on surveys at the farm level collected in the PNSL, this paper seeks to understand the impact of this colonization on forest clearing based on the land use of settler farmers. Socioeconomic and family composition and characteristics, as well as the policy environment are examined. The analysis finds that while the high deforestation group cleared an average of almost 14 hectares between 1993 and 1998, the low deforestation group on average experienced modest forest regrowth. This challenges the notion that colonist farmers will continually farm extensively given abundant land resources. This also offers a case study in small farmer colonization and land cover change in an area other than the Amazon, the site of a disproportionate number of studies on the topic. The SLNP is also important because it is a region of eminent ecological importance and a site of rapid forest loss.

Historical Antecedents to the Colonization of the SLNP

By the 1970s, decades of plantation expansion, coupled with chronic rural population growth, conspired to marginalize subsistent farmers on ever-dwindling, increasingly barren plots of land throughout rural Guatemala. According to the last agricultural survey (1979 – lamentably!), the amount of cultivable land per capita plummeted from 1.71 hectares to .79 hectares from 1950 to 1979, by which time most farmers were working less than 1.4 hectares (Valenzuela de Pisano, 1996). This land inequity, combined with complex demographic, economic, and political dynamics unique to each region have strained families’ capacities to maintain subsistence living standards. According to the World Bank, 90% of farms accounted for only 16% of total farm area while 2% of landowners controlled 65% of the land (World Bank, 1995). Most fertile areas are managed for export agriculture and that most peasants are forced to support their families on 1.4 hectares or less.

Aggravating feudal land concentrations and pauperesque economic opportunities, the highest rural total fertility rate in Central America (6.1 births per woman according to the Guatemalan National Statistics Institute, 1996) has accelerated the geometric contraction of farm plots. Stupp and Bilsborrow (1989, 1995), for example, concluded from their study on fertility and land use in highland communities, that population growth has unchained a destructive cycle of forest clearing, soil degradation, land fragmentation, rural out-migration, and continued deforestation. Many have migrated to the departamento that offers the richest prospects for rural families in search of farmland, Petén.

Widely deforested by Maya agriculturists from 1500 BC to AD 900, the Petén was

virtually depopulated by AD 900 (West 1964). Spanish colonizers and early republican governments largely ignored the sparsely inhabited territory, and the forest's original growth returned. Called the "inhospitable immensity" by naturalist novelist Virgilio Macal (1950), colonial and republican governments wrestled with land pressures for several hundred years without considering incursion into 40% of its national territory.

In 1959 the Economic Development and Promotion Company (FYDEP in Spanish) was commissioned to integrate the vast natural riches of the departamento into the national economy. Until 1959 only 71 farms were registered in Petén, occupying only 1% of its territory (Clark, 1996). Since the 1960s, Petén's population has exploded from a few isolated chicle extractors to a teeming population of approximately 600,000 farmers and labourers (INEGE, 1998). Based on fertility data, it is safe to assume that at least 6% of Petén's 9% annual population growth (since the mid 1960s) has been from in-migration.

In 1971 the government promulgated el Decreto #38-71, "El Uso, Tenencia, y Adjudicación de la Tierra de Petén" which granted lands of up to 675 hectares (with a minimum of 45 hectares) for the development of livestock ranching. However, a major impediment to colonization still needed to be overcome if Petén were to become the meat butcher and breadbasket of Guatemala; Petén would need to be connected to the national economy by roads. By 1971 the majority of FYDEP's budget was spent on road construction. The first road linking the central zone of Petén to Guatemala City was completed in 1970. In that year, corn and beans were sent for the first time to the capital's markets. A mere five years later, Petén led all of Guatemala's 22 departamentos in the production of beans and corn (Schwartz, 1995). By 1980 the two principle roads to the SLNP—the roads (rutas) to Bethel and el Naranjo—met the Petén's capital at Flores, opening the valve to a massive in-migration that would presage dramatic land cover change during the subsequent two decades.

In order to cope with the enormous influx of colonists, the National Institute for Agrarian Transformation (INTA in Spanish) replaced FYDEP in 1990. INTA inherited FYDEP's torpid bureaucracy; 75% of the land title requests were frozen in a morass of paperwork and many landowners from the FYDEP era enjoyed immense, often illegal land claims.² Today, in response to government inattentiveness to peasant concerns, an unofficial land market recognizes the sale of mejoras (improvements) and títulos de propiedad (property titles) notarized by lawyers in complete disregard to INTA regulations. In most Petenero communities, land tenure security is a function of internal codices tacitly understood among community members. Most current unoccupied land is located in protected areas. In the search for land, subsistent farmer colonists have no choice then but to continue colonizing these areas. Since the 1980s, virtually all of the in-migrants to Petén have been land poor corn farmers. They have been the agents of dramatic landscape change. From the 1960s to the mid 1990s, half the Petén's forests were eliminated (Aguayo, 1987; World Bank 1995). At the recent rate of 40,000 hectares cleared per annum, the departamento's last forests will be erased in fewer than thirty years (World Bank, 1995).

With heightened preoccupation among donor countries of the western world that Guatemala would exterminate its forests within a generation, in 1989 the Maya Biosphere Reserve (MBR) was established (Decreto #5-90) with an area of 2, 113 km², occupying almost 60% of Petén and 20% of national territory. The heart of La Selva Maya, (the largest

² Many had put, for example, the names of relatives or false names on ownership documents to double or even triple their land titles (Clark, 1996).

tropical forest in Central America), the Maya Biosphere Reserve serves as a pan-continental biological bridge, a cardinal repository of global biodiversity, and a cache of hundreds of archeological sites, including Tikal, the magnificent ancient Mayan city state. Reserve boundaries were drawn in apparent disregard to the chaotic matrix of private property, invaded lands, and cooperatives scribbled about the landscape. Park inhabitants were not granted permanence, nor was a relocation negotiated. On the contrary, inconsistent and lax national laws and the inertia of the FYDEP era bureaucracy has stagnated conservation and development efforts to provide sufficient land outside of the reserve to the voluminous arrivals of landless families.

Originally under government sponsorship, and now spontaneously, colonization has been haphazard, planning minimal, and land distribution inappropriate to reconciling successful agricultural production with forest conservation. Furthermore, most farmers have been relatively ignorant to management practices appropriate for tropical lowland conditions markedly different from their traditional piedmont and highland environments. Unfortunately for the migrants, roads were not built to coincide with areas of high soil fertility. The World Bank (1995) estimates that only 17.6% of the Petén is suitable for continuous farming. Thus, corn cultivation leads to plummeting yields after two to three years of harvests, prompting migrants to clear more forest. Land tenure insecurity is ubiquitous in and around the Reserve and the great majority of smallholders occupy plots acquired illegally through invasion and forest clearing. The uncertainty of legal land title encourages migrants to deforest land in order to demonstrate occupancy. Plot insecurity also encourages farmers to exploit forest resources for short term profits rather than investing in the future of insecure plots (Clark, 1995).

The Research Site: The Sierra de Lacandón National Park

The Sierra de Lacandón National Park (SLNP) is a core zone (area of strict conservation) within the MBR. The second largest national park in Guatemala, the SLNP boasts the richest biodiversity in the MBR and is the sole biological corridor linking the MBR and the Montes Azules Biosphere Reserve – the largest protected lowland tropical forest in Mexico (TNC, 1997). Despite its biological importance and its designation as a core conservation zone, the SLNP suffers some of the highest rates of population growth and agricultural expansion in Petén.

While ineffectually protecting the park's natural resources through underfunded government agencies, the government has facilitated further settlement in the park by paving much of the major access road to the park. Little attention has been provided the farmers in the form of technical assistance, credit, or market strategies to promote sustainable agricultural management. Currently the Guatemalan government in collaboration with USAID and other European donor agencies have invested in sustainable farming practices in the buffer zones of the Maya Biosphere Reserve to relieve human pressures on the park. But data is scant on farm level decisions for resource use, hampering policy efforts to temper the environmental impacts of local farmers.

The buffer zone areas, however, are areas that have already been significantly altered by human intervention and stand little chance of reverting to forest. It is the core zones that are being most altered from their original state. Thus, while buffer zones receive attention and aid from conservation and development agencies, efforts to mitigate environmental impacts within the core zones of protected areas like the SLNP are minimal, even if it

promotes conservation. Settlements within protected areas are not legally recognized and are therefore ineligible for government aid of any sort.

The most marginalized of frontier farmers are those that have settled within the core zone of the SLNP. These farmers have a limited set of options available to them. They are constrained by unfavorable market conditions, lack of technology and training in alternative farm management strategies. The SLNP farmer counts on little labor and technology and great land endowments. Within this general context, how he manages his resources will depend on the balance between minimizing risk in securing food for his household and maximizing surplus produced for market. This balance will be constrained by his labor capacity, his land quality and availability and security of ownership, and his land use and production costs (See, e.g., Pichón, 1996)

Sample Selection and Fieldwork

The core zone of the SLNP was the study site for a survey conducted in 1998 (Carr, 1999). With the exception cooperative farmers in two communities and a cluster of farmers with private land in one community, the farmers with agricultural fields in the 28 communities within the park are squatters that followed newly opened roads to settle the vast public lands of the reserve. The original sample of 279 households represents approximately 10% of the households in the 28 communities that farm in the park. Based on interviews with local leaders in each of the 28 communities, 9 were chosen to represent the ethnic and geographic distribution of the park. Some communities are comprised almost entirely of indigenous Maya farmers, especially Q'eqchi. Most communities are located along the two major roads that access the park but some, more recently established villages, have emerged along paths deeper within the park.

Separate questionnaires were administered to the household heads and their partners. The interviewing team comprised eight forestry students from the Centro Universitario de Petén and a Q'eqchi Maya interpreter (approximately 13% of the sample is Q'eqchi). Information on migration, fertility, and land use was collected for four time periods: the last year in the last place of residence before migrating to the SLNP, 1993, 1998, and 2008 (speculative). Qualitative questions followed each of the major sections of the survey to assess farmer's perceptions and attitudes about the colonization process, farmer perceptions on farming the forest, the park, and the future of their children. Surveys took an average of one hour to complete.

The fieldwork was physically demanding on the research team. We hiked upwards of 10 kilometers daily through mountainous jungle during the hot season. Forest fires had burned much of the forest in the region and farmer's crops immediately prior to field research. Transportation through sinuous mountain passes was hampered by scores of burned and fallen trees. Food reserves were low in the surveyed communities. Nonetheless, we were graciously offered the little food available, usually tortillas and cornmeal mush. Still, all of the interviewers completed the fieldwork and all but one farmer accepted being interviewed.

Description of the sample:

Most of the settlers arrived in the Park after 1988. The area experienced the greatest influx of colonists during the last years of the 1980s and the first half of the 1990s. Colonists came from diverse rural regions of Guatemala. The southeast region of the country,

particularly Izabal, is the most represented area of origin. Most had lived in other areas besides their village of birth, many residing in southern Peten or Izabal before migrating to the SLNP. Most of the farmers in the sample reported that they had no land before migrating. And of those that had land, the average plot size was less than 2 hectares. Most men had begun primary school only to leave after a year or two. None had education beyond primary school. These education levels are below the national average where almost half the population has finished primary school (INE, 1999).

There is very high fertility and migrant retention. Virtually all the farmers reported that they intend to remain on their farm though almost the same number expect that their children will migrate and live elsewhere when they are adults. This implies children of the farmers in the SLNP may seek land elsewhere, adding to population pressures on other remaining forests of the Petén.

The typical farm size is 45 hectares, or one *caballería* though landholdings tend to be larger further from the earlier settled areas close to roads. As mentioned above, with the exception of three cooperatives with land in the park, and one cluster of private landowners, most of the farmers in the SLNP are squatters. The communities range in size from 45 to 250 households. Very few have inherited land and almost all “grabbed” unoccupied land. Many purchased their plots from speculators at marginal fees. Some more recent arrivals are renting land close to the road from earlier arrivals. Most communities are located from 100 to 200 kilometers from the capital of Petén, Flores. Corn is grown by virtually all farmers for subsistence and for sale. Corn is purchased by intermediaries who transport the grains to large wholesalers in Guatemala City.

The Physical Geography of the SLNP and Farmer Management

According to the National Geographical Institute, most of the SLNP is classified as lands inappropriate for agriculture (1986). These are shallow, rocky, karstic soils that tend to drain poorly. Only the alluvial soils along the banks of the Usumacinta River and the Yaxchilán stream in the southwest corner of the park are considered amenable to agricultural cultivation. Rainfall is seasonal, with heavy downpours frequent from June to October, followed by an extended dry season. Consistent with the frontier conditions of land abundance, little money is invested in purchased soil amendments. Few farmers complained of poor soils though many recognized that soils were becoming degraded after several years of harvests. Still, most farmers had a significant endowment of forest left to burn to fertilize future harvests. Approximately half of the farmers use herbicides to control the insidious *chispa* weed, and velvet bean (*Macuna Pruriens*) has been adopted in recent years to enhance soil fertility. Macuna is a legume that fixes nitrogen in the soil and has been known to double corn harvests. In the SLNP it is intercropped with corn on the field used for the second year's harvest.

The swidden or slash and burn system of farming is uniformly practiced. Farmers clear a few hectares for corn production. This plot is cropped for two to three years and abandoned. More forest is cleared for the introduction of a second cornfield. After two or three years the farmer may continue to clear more forest or return to the original field left fallow. Farmers plant two corn harvests each year. The first planting begins in May and June (depending on the timing of rainfall). The second planting is in October and November. The second harvest of corn is poorer than the first. However, lower yield is compensated by higher prices commanded during the second harvest in April and May. In March, the land is

prepared by the felling of the largest trees. In April and May, fallow land and recently cleared land is prepared by burning weeds, bushes and small trees. Few farmers grow significant amounts of crops other than corn and fewer possess cattle. Nonetheless, almost all the farmers desire to own cattle one day. Most farmers have little or no contact with agricultural extension agencies and even fewer claim to have received credit from lending institutions.

Results: Land Use Patterns, Farm Characteristics, and Land Clearing in the SLNP

In this section I examine how political and ecological factors and farm household characteristics and land use may help explain land-clearing in the SLNP between 1993 and 1998. Farm households have been separated into two groups: high and low land clearing between 1993 and 1998 (Figure 1). Each group includes 66 farm households representing the group (top 33%) that cleared the most hectares and the group that cleared the fewest hectares (lowest 33%). The middle 33% of the sample is excluded for this analysis. Further, since forest clearing between 1993 and 1998 is considered an outcome variable, the sample for this analysis excludes 82 households that arrived after 1993. The factors examined include the natural resource base (soil quality, presence of sterile or unusable land, and topography), household characteristics (household size, education of head of household, and duration on the farm), policy factors (land tenure, and contact with NGOs or GOs), farmer land allocation (number of hectares in corn, frijol, other crops, pasture, and fallow land), and farmer land management (use of soil amendments such as velvet bean, pesticides, herbicides, and fertilizers). Farmer land use may be affected by household and farm characteristics and by the policy environment. These factors, in turn, will influence the amount of forest cleared on the farm between 1993 and 1998.

Land Use

The analysis finds significant variability in the amount of forest cleared in the sample. While the high deforestation group cleared an average of 13.6 hectares, or 49% of their forest during the time period, the low deforestation group on average experienced modest forest regrowth on their farms. The land allocation tables and pie charts illustrate land use changes that contributed to forest clearing. For the high deforestation group, the amount of land in corn ballooned from 3.4 hectares in 1993 to 6.7 hectares in 1998 while fallow land nearly tripled from 4.9 to 12.3 hectares (Table 5). Conversely, farmers in the low deforestation group reduced the amount of corn cropped by an average of 1 hectare while fallow land remained almost constant. Evidently much of the second group is employing a swidden that incorporates more than one field.

The most striking difference between the groups is the overall farm size. High deforestation farms are almost twice as large as small deforestation farms. Further, even in 1998 the forest cover on high deforestation farms was more than double the forestland on low deforestation farms. It is axiomatic that farms with greater endowments of forest naturally may have more potential forest clearing. However, with an average of 14.9 hectares of land in forest remaining in 1998, there was still plenty of forest for low deforestation farmers to clear. Yet they did not. This finding is consistent with Shriar (1999) who found that farmers in the buffer zone of the Maya Biosphere Reserve commonly retained up to 15 hectares of primary forest on their farm plots. Perhaps there is a threshold in the amount of forest a farmer will clear. Maintaining a certain amount of forest on the farm

is crucial. Wood can be used or sold for fuel or for timber. A farmer can always count on a good two years of crops if he farms on recently cleared and burned land. A farmer may wish to retain a few years worth of good harvests in his forest bank account as well as enough forest to supply wood for the long-term sustainability of the household. Forestland can also be an insurance in the wellbeing of household children. With such a great number of children per household, land availability for the next generation of Lacandonians must be a real concern for families in the area.

These incentives to conserve forest are not as strong for farmers with large forest endowments. The high deforestation farms had a lower production per hectare than low deforestation farms, further evidence for their need to crop more land. It is interesting to note the quite similar total corn production for the two groups despite their significant difference in hectares in corn (273.9 for the high group and 235.8 for the low group) (Table 6).

With almost double the land in fallow as in corn, high deforestation farmers are evidently managing a more extensive swidden than low deforestation farmers with a virtual 1 to 1 crop/fallow ratio. One reason for the more expansive swidden may be the intent to plant pasture for cattle. Livestock holdings ballooned among the high deforestation farmers from 8% to 38% in five years. Conversely, among the low deforestation farmers only 9% had cattle in 1998.

Most farmers in the sample reported a desire to convert most of their land to pasture within the next several years. Those with greater land availability are in a better position to convert the ranching dream to reality. With greater land endowments, the first group is able to introduce or expand pastureland and still maintain a sustainable swidden for their corn production. With fewer than 40 hectares it may be difficult to sustain more than a few heads of cattle and still have enough land for subsistence agricultural production. Therefore, if they intend to convert much of their plot to pasture, which would require a more intensive use of the land remaining in crops, in order to compensate for the loss of agricultural soils through pasture expansion, the high deforestation group may ironically be intensifying their crop production through velvet bean and herbicide use despite an apparent abundance of fallow and forest. In sum, the high deforestation group may be attempting to intensify agricultural production in order to extensify livestock holdings.

Farm Management

In terms of farm management, the high deforestation group had nearly twice the number of users of velvet bean than the low deforestation group. Planting corn in *aboneras* can double second harvest yields at a time when farmers can command higher selling prices because of lower supply of corn on the market.

Almost a third of the farmers in the high deforestation group are located in remote communities (compared to 15% in the low deforestation group) characterized by great land availability and high transportation costs to bring products to market. Higher transportation costs, coupled with increased land availability, encourage farm expansion. These farmers claim that they need to compensate for higher transportation costs by raising production. As one farmer reported in a remote community. “With such high costs to transport crops to the road and with prices so low, we have to expand our milpas in order to keep up with falling production.”

Few farmers use purchased fertilizers—fewer than 10% of the low deforestation farmers and fewer than 5% of the high deforestation farmers. There was very minimal variability in

cropping density with an average of slightly under 2 meters of distance between stocks and rows in both groups. This cropping patterns is much less dense than in the colonist's origin areas where they tended to plant at 1 meter distance between stocks and rows. Pesticides are used by only 4 farmers in the sample. However, weeds such as *chispa* are quite invasive in the area and are a constant nuisance to farmers. Thus, almost half of all farmers apply herbicides.

Household Characteristics

All but four (97%) of the household heads farm as their primary source of employment (Table 3). Household sizes are uniformly large, 6.8 for the low deforestation group and 7.3 for the high deforestation group. This is particularly large considering that colonist families tend to be younger than families in longer settled regions; young people migrate more readily than the elderly. Guatemala has the highest rural fertility rate in Latin America, yet average family size at the national level for rural areas is only 5.64. Even the average family size for rural Petén (5.98) is well below the figure in the SLNP (INE, 1999).

The ratio of consumers to producers is high among both groups. The ratio is defined as the number of males over 11 relative to all members of the household. The difference is negligible between the two groups: 4.1 for the high deforestation group and 4.6 for the low deforestation group. This is surprising since it appears that the high deforestation group required more labor to crop more land and to plant more labor intensive velvet bean than the low deforestation group (see Table 4). Thus population density a la Boserup does not appear to be a factor involved with agricultural intensification among farmers in the SLNP.

Most farmers in the sample work over fifty hours a week on their milpa. Men usually rise between 4 and 5 AM and work until late afternoon, Monday through Saturday. The farmers in the high deforestation group work on average slightly more hours than farmers in the low deforestation group, which may help explain the surprising find that that the high deforestation group had a lower producer to consumer ratio than the low deforestation group. However, the difference is not statistically significant.

Most heads of household either never entered primary school or completed just a few years before dropping out. The education level of the heads of household is therefore lower than the national average in each of the two groups. In rural areas of Guatemala almost half of household heads interviewed by the National Institute for Statistics (INE) in 1998 had completed primary school (INE, 1999). Yet the literatures on the migration determinants agree that migrants tend to be higher educated than their cohorts in sending areas. This may suggest a selection of lower migration to rural areas as opposed to migration to cities and international destinations.

Some researchers have discussed how indigenous farmers place religious importance on forest and farm conservation and, as subsistence farmers, are more likely to diversify crops with perennials and vegetable gardens. These factors would tend to reduce farm pressures on the forest (Wilson, 1995; Atran, 1993). This may be true in traditional Maya areas in the western highlands. However, in the SLNP, it appears that indigenous farmers may be more extensive farmers than their Ladino neighbors. The high deforestation group had a significantly greatest proportion of indigenous farmers (32%) than the low deforestation group (16%).

In terms of duration on the farm, if farms evolve through a similar process of land use over time than we would expect that farms settled earlier would be further along in the farm

evolution. Specifically, farms that have been settled for a longer amount of time might slow forest clearing since longer duration on the farm means that there is a greater probability that the swidden rotation has been completed. Conversely, deforestation will always be high in the first years of farm settlement when a farmer is clearing his first cropland. This theory is not supported by the data presented here. The two clusters of farms shared similar average duration of settlement. Similarly, it is expected that farms further from principle roads would be more recently settled than those farms closer to roads, and therefore would have higher rates of forest clearing in recent years. However the mean distance to a principle road between the high and low deforestation groups is insignificantly greater among farms of high deforestation (6.0 kilometers) than among those of low deforestation (5.6). Of course if the 82 farms settled after 1993 were included in the analysis, it is likely that different results would obtain.

Political Factors

In terms of the political environment, it is curious that the farmers who deforested the most were the ones with the greatest proportion who had contact with NGO or GO extension agents (Table 3). The difference is significant at the .15 level. This is not a sanguine result for NGOs working in the area. Most claim that the contact was minimal, that they had discussed their land use briefly with an extension agent without receiving direct assistance of aid. There are mixed reactions to government and non-government institutions in the area among locals. Several agencies work under the Mayarema project to conserve the Maya Biosphere Reserve. Some of them such as The Nature Conservancy (TNC) and The National Council on Protected Areas of Guatemala (CONAP) focus almost exclusively on park conservation. Other groups such as CARE and PROFRUTA are concerned almost exclusively with providing land tenure to farmers and offering technical assistance in farming techniques, usually to farmers in the buffer zone adjacent to the park. Farmers sometimes distrust the motives of field workers whom they claim wish to restrict their production, or worse, to relocate them outside of the park. Many expressed dispassionate resignation that regardless of the intentions of NGOs and GOs, farmers would inevitably cut down the forest to farm corn.

The number of farmers who rent their land is more than three times greater among low deforesters than high deforesters (Table 3). The number is still a minority of low deforesters, but it suggests that renters simply have less land to deforest as they tend to work parcels just large enough to crop for one or two years. A significantly greater number of the low deforestation farmers are squatters (70%) compared to the high deforestation group (47%). This is counterintuitive since it is expected that secure land tenure will promote land-saving farming practices.

Nevertheless, renters are included in the squatter group and they tend to rent a few hectares of land in order to grow corn and usually crop on former fallow land rather than cutting new forest. Also, the low deforestation group has much less land than the high deforestation group and farmers with land tenure uniformly have at least 45 hectares, much more than the average for the low deforestation group (27 has.). It is the land availability more than the tenure situation itself that may promote greater forest clearing. Indeed, in 1998 the *proportion* of land in forest is quite similar between the high deforestation group (49%) and the low deforestation group (44%).

Ecological Factors

Most farmers reported having slightly more mediocre and poor soil than very good soil though there was some variation, particularly between the medium and low deforestation groups (Table 2).

Of the farmers that cleared the least forest between 1993 and 1998, 43% reported having excellent soil on their plots, compared to 36% for the low deforestation farmers. However the difference between these two groups was statistically insignificant.

In terms of topography, most of the plots in the sample are situated on at least partially hilly terrain. The two groups reported almost exactly the same percentage of farms with hilly terrain with 65% for the high deforestation group and 67% for the low deforestation group.

Taking the three ecological measures into account, soil quality, presence of slopes, and unusable land, we would expect that farms of lower soil quality or of high erosion potential would compensate for these conditions with intensification measures or by increasing cropland to maintain production. Yet without clear evidence of poorer ecological conditions on the farm, it appears that the high deforestation group did both. (Table 4). And, as observed in Table 5, the area in corn and fallow increased most dramatically for the high deforestation farmers. That an increase in cropland may have been necessary to compensate for inadequate production levels is suggested by the fact that the corn production per hectare was significantly lower in 1998 for the high deforestation farmers than for low deforestation group (Table 6).

Conclusion

Land use and allocation differences between high and low deforestation farms cannot be explained by population alone. In the context of the SLNP, low household population density is often associated with greater land endowments amenable to livestock. This has had the interesting affect of producing spatial intensification on farms of lower population density. Livestock means that fallows are converted to pasture, shortening fallow times for crops and demanding increased spatial intensification for the production of subsistence grains. This could presage a development of the agricultural frontier in the SLNP similar to other frontier in Latin America—initial forest clearing for subsistence production followed by the introduction of cattle.

Over three-quarters of agricultural land in Latin America is in pasture. Deforestation in Latin America has an ever-changing cast but the narrative has remained largely unchanged (FAO 1995). Pasture often follows staple grain production along colonist frontiers. It is an ideal environment for it given the great land abundance and scarce labor as well as the desire to “improve” lands through forest clearing in order to increase land values. On most tropical soils, after 2 to 3 years, agricultural productivity declines and farmers clear more land. Instead of letting land go fallow they often plant pasture seed in previously cropped fields (see, e.g. Hecht, 1983 and 1990 and Nations, 1993 for examples from South and Central America). The potential for increased deforestation is greatly heightened with the introduction of cattle. In a semi-subsistence production environment, land will still be needed for staple grains, adding to land cleared for pasture. Further, Hecht (1983) found for example that 80% of pastureland in Amazon had been abandoned, suggesting the short viability of many pasture grasses in the tropics and the need for farmers to expand

agricultural land further into forested areas. Thus, the impact on forest clearing of livestock can be exponentially greater than the impact of corn production.

If farm size appears to explain some of the difference in land use, particularly the adoption of cattle, and therefore deforestation, it is crucial to understand how farmers came to occupy so much land. The answer lies in migration origin areas. The conservation of tropical forests and the sustainable production of frontier farmers may be moot as long as pressures in migrant origin areas compel men and women to migrate to forest frontiers.

This paper examined the relationship between some household characteristics, and political and ecological factors on land use and land clearing change between 1993 and 1998 among settler farmers in the SLNP. This group of settlers shares many characteristics. They have all settled the region within the past fifteen years. Most came from other rural environments where land was scarce. Family sizes are larger than average for rural Guatemala. They have also inherited a fairly uniform climate and soil environment. However, these pressures represent only a fraction of the deforestation in the region. Almost all of the deforestation to date in the SLNP has been from colonist agriculture. Population density is certainly a factor then, but so is the incentives to raise livestock....

What is different about these farmers? The data presented here indicate that land availability is the most striking difference between the farmers who deforested the most and those who cleared the least forest. Households among the top 33% of the sample in land cleared between 1993 and 1998 cleared an average of 13.6 hectares while the low deforestation group on average experienced modest forest regrowth between 1993 and 1998. There is some evidence that larger farms may compensate for lower production per hectare and higher transportation costs (more of the high deforestation farms were located in remote communities) by increasing cropland, maintaining a multi-field swidden, and employing velvet bean and herbicides. Conversely, the fact that the low deforestation group has more renters than the other two groups may explain the small farm size. Renters tend to crop fewer hectares than owners and to fell fallow land rather than forest since they tend to rent a plot for only for a year or two of harvests before renting elsewhere. It therefore makes little sense for a renter to cut land since he does not need to be concerned about degrading his cropland's soil.

It may seem aphoristic that farmers with more land cleared more forest. However, with an average of 14.9 hectares in forest, the low deforestation farmers still have ample land to convert to agriculture. A key difference between the high and the low deforestation group is the relative level of spatial intensification; on average it appears that the low deforestation group employs a two-field rather than a multiple-field swidden rotation characteristic of the high deforestation group. If past trends are any indicator, many of the high deforestation farmers may be hoping to take advantage of their superior land availability to sow pasture grass to introduce or expand current livestock holdings. Livestock holdings ballooned among the high deforestation farmers from 8% to 38% in five years. Conversely, among the low deforestation farmers only 9% had cattle in 1998. Since they are also rapidly expanding their cropland and have more expansive swiddens it may seem counterintuitive that significantly more of the high deforestation farmers are employing velvet bean than the low deforestation farmers. However, if the high deforestation farmers intend to increase the amount of land in pasture as they have in recent years, they may need to intensify their agricultural production in order to compensate for the loss of agricultural soils through

pasture expansion. In sum, the high deforestation group may be attempting to intensify agricultural production in order to extensify livestock holdings.

Finally, if farm size appears to explain deforestation, it is crucial to understand how farmers came to occupy so much land. The answer lies in migration origin areas. The conservation of tropical forests and the sustainable production of frontier farmers may be moot as long as pressures in migrant origin areas compel men and women to migrate to forest frontiers. Policy thus must address how to improve living conditions in rural areas throughout the developing world, but also how to improve land use strategies in frontier environments. Tropical deforestation at colonist frontiers is ultimately driven by the decision of men and women from rural areas to migrate to move to remote rural areas. Tropical forests are a repository of untapped resources for poor rural dwellers who are confronted with inadequate standards of living from a host of pressures in their environment: population growth, the expansion of large agricultural holdings for export, and marginal development initiatives.

Increasingly, protected areas harbor the only undeveloped land available to migrating farmers (e.g., Herlihy 1990; Wells and Brandon, 1992). And the in-migration of land-poor peasants represents the foremost population pressure on protected area forests (e.g., McNeely and Ness, 1996; Thoresen and Brechin, 1995; and Harmon, 1994). Understanding the land use of colonists on the frontier is a first step to improving efforts to conserve tropical forests, particularly those deemed to have natural qualities worthy of a biosphere reserve or national park. It is also crucial to understanding ways in which colonist farmers' standards of living may be improved. Increasing production per unit not only can protect forests but can also lower farmer labor inputs while improving profit margins. Technical assistance may allow farmers to grow more profitable crops that are less land extensive than the basic grains that many colonist farmers rely heavily upon in frontier environments. Providing education provides skills and opens opportunities for other employment. Providing health care enables families the choice of how many children they want, which can reduce pressures on the family budget and pressures on the land for future generations.

In terms of future migration, if a farm plot can scarcely sustain a household under current conditions, it is even less likely to be able to support the families of the next cohort of adults. Because children in remote colonization frontiers are at a distinct educational disadvantage to children in urban areas or in longer settled rural areas, these children will be limited in their employment opportunities. If there is insufficient land on his father's plot or on other land in the community and few off-farm employment opportunities, a young adult will very likely decide to migrate. Since those who grew up in a remote frontier are at an educational disadvantage relative to other migrants, second generation migrants may be more likely to settle another resource frontier than migrants from other rural areas. Thus, the issue of farm sustainability is pertinent in the immediate sense of reducing deforestation and for improving farmer output. But it is also germane to the issue of farm and ecosystem sustainability in other regions since there appears to be a high possibility for second generation out-migration among frontier households. Future research will need to examine the forces operating at migration origin areas that cause small farmers to settle a remote forest frontier and the potential for second generation out-migration to forest frontiers. Their decision to migrate is a prerequisite to land cover change throughout the tropics.

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Figure 1. High and Low deforestation groups: 1993 & 1998

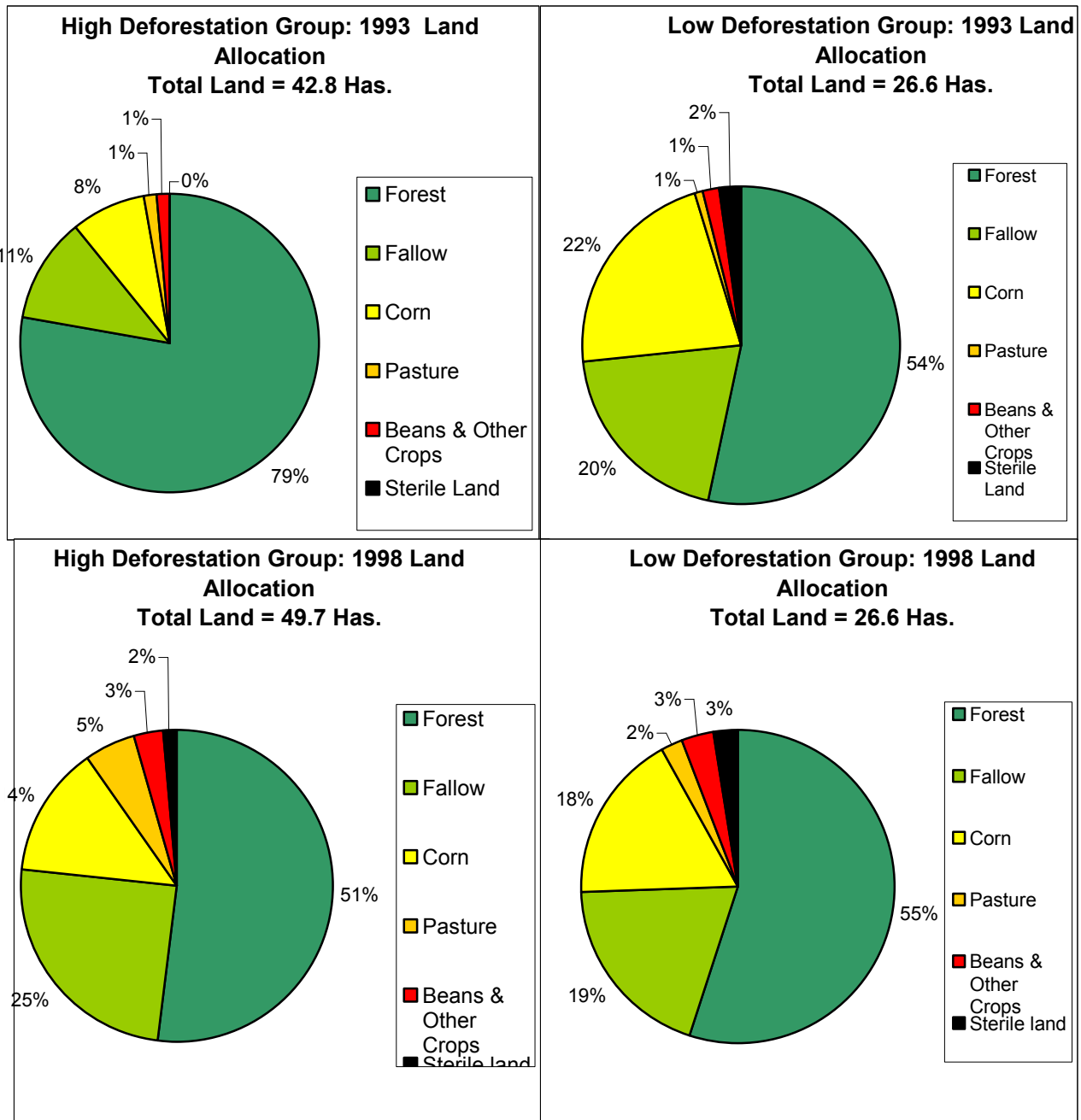


Table 1: 1993-1998 Forest Cover Change

	High Deforestation	Low Deforestation	Probability (T)
1993-1998 Total No. of Has. Deforested	13.6	-1.3	0.00
1998 Percent of Land Cleared	49%	44%	0.00
1993-1998 Percent Change in Percent of Deforestation: 1993-1998	61%	-7%	0.00
	41%	-9%	0.00
	n=66	n=66	

Table 2: 1998 Farm Topography and Soils

	High Deforestation	Low Deforestation	Significance (Chi)
Very Fertile Soils	43%	36%	0.65
Mediocre or Poor Soils	57%	64%	0.57
Hilly or Partially Hilly Terrain	65%	67%	0.35
	n=66	n=66	

Table 3: 1998 Household Characteristics and Political Factors

	High Deforestation Percentage or Mean	Low Deforestation Percentage or Mean	Significance
Native Language Spanish	68%	84%	0.99 (Chi)
Farms as Primary Job	97%	97%	.32 (Chi)
Household Size	7.3	6.8	.33 (T)
Squatters	31	46	.99 (Chi)
Avg. Number of Years Schooling	2	1.8	.49 (T)
Hours Worked per Week	49.1	42.9	.49 (T)
Contact with GO or NGO	32	24	.84 (Chi)
Duration on the Farm	10.7	11.5	.37 (T)
Rents Land from Someone	8	19	.96 (Chi)
Number from a Remote Community	27%	15%	.99 (Chi)
	n=66	n=66	

Table 4: 1998 Farm Management

	High Deforestation Mean No. of Has.	Low Deforestation Mean No. of Has.	Significance
Years Land is Cropped	2.1	2.1	.70 (T)
Space Between Rows and Stalks	1.8	1.7	.65 (T)
	Number of users	Number of users	
Velvet Bean	35	20	0.99 (Chi)
Velvet Bean 1993	16	10	0.84 (Chi)
Fertilizers	3	6	0.65 (Chi)
Pesticides	3	1	0.83 (Chi)
Herbicides	35	32	0.49 (Chi)]
	n=66	n=66	

Table 5: Land Allocation 1993 and 1998

<i>Farm Land Allocation 1998</i>	High Deforestation		Low Deforestation		Significance
	No. of affirmative	Mean No. of Has.	No. of affirmative	Mean No. of	
Pasture	25	2.5	6	0.6	0.01
Sterile land	11	0.8	8	0.7	0.92
Fallow	62	12.3	33	5.2	0
Corn	65	6.7	63	4.7	0.02
Beans and Other Crops	33	1.5	26	0.6	0.28
Forest	61	25.9	38	14.9	0
Total Land Cleared	66	23.8	63	11.5	0
Total Land	66	49.7	63	26.6	0
Percentage of Farm Cleared		49%		44%	0
<i>Farm Land Allocation 1993</i>	No. of affirmative	Mean No. of Has.	No. of affirmative	Mean No. of	St. Dev.
Pasture	5	0.6	2	0.2	0.19
Corn	51	3.4	61	5.9	0.01
Fallow	30	4.9	29	5.4	0.7
Sterile land	0	0	6	0.6	0.07
Forest	48	33.3	38	14.2	0
Beans and Other Crops	22	0.6	15	0.5	0.6
Land Cleared in 1993	54	9.6	61	12.9	0.09
Total Land	57	42.8	61	26.6	0
Percentage of Farm Cleared	40	20%	56	47%	0
	n=66		n=66		

Table 6: 1998 Corn Production

	High Deforestation	Low Deforestation	Significance (T)
	Mean No. of Has.	Mean No. of Has.	
Corn Production per ha. 1st Harvest	31.8	39.2	0.1
Total Corn Production	273.9	235.8	0.9
	n=66	n=66	