Journal of International and Global Studies

Volume 1 | Number 1 Article 3

11-1-2009

Population, Rural Development, and Land Use Among Settler Households in an Agricultural Frontier in Guatemala's Maya Biosphere Reserve

David Carr Ph.D.
University of California, Santa Barbara, carr@geog.ucsb.edu

Population, Rural Development, and Land Use Among Settler Households in an Agricultural Frontier in Guatemala's Maya Biosphere Reserve

David Carr Ph.D.
University of California, Santa Barbara
carr@geog.ucsb.edu

Abstract

Guatemala was among the world's leaders in deforestation during the 1990s at a rate of 2% per annum. Much of Guatemala's recent forest loss has occurred in the emerging agricultural frontiers of the Maya Biosphere Reserve (MBR), the heart of the largest contiguous tropical forest in Central America—*La Selva Maya*. This paper presents data from 241 heads of households and 219 partners of household heads from a geographically stratified sample of eight (of 28) communities in the Sierra de Lacandón National Park (SLNP), the most ecologically biodiverse region in *La Selva Maya* and a core conservation zone of the MBR. Settler households are examined relative to a host of factors relating land use and land cover change. Specifically, demographic trends, political and socio-economic development, and ecological factors are described in this first detailed statistically-representative sample probing human population and environment interactions in an emerging agricultural frontier in Central America.

Introduction

Achieving a balance between human welfare and environmental integrity is a sustainable development conundrum worldwide. In order to meet food demand over time, the world is faced with important trade-offs relative to rural development and forest conservation. Increasing agricultural output on dwindling available lands suitable for cultivation while limiting this expansion in critical forest ecosystems is of central importance in a world of over 6 billion and growing.

The success with which food production versus forest conservation is achieved has manifold human and environmental consequences. As the majority of the best agricultural land has been in production for decades and even millennia, deforestation increasingly occurs on impoverished soils (Carr, Barbieri et al., 2006). Agricultural frontier[1] are among the most sociologically and ecologically dynamic landscapes on the earth. These are places where human demographic and socio-economic processes and environmental change interact in dramatic fashion. Most deforestation on the planet has occurred along agricultural frontiers during recent decades (Achard, Gallego, et al., 2002; Houghton, 1994; Myers 1994). This is especially true in Latin America (Rudel & Roper 1996; Carr & Bilsborrow, 2001).

Political, economic, demographic, and ecological factors all impact forest conversion on the frontier (Geist and Lambdin 2001; Turner II, Geoghegan et al. 2001). Researching household demographic, socio-economic characteristics, and land management strategies is therefore of dual importance. First, farmers in remote, economically and environmentally impoverished regions are among the planet's most destitute inhabitants (Leonard et al., 1989; Barbier, 2004), countenancing difficult market access and a dearth of potable water, schools, and health care (Carr 2006; Murphy et al., 1997). Second, relative to ecological concerns, deforestation has led to soil degradation (Ehui and Hertel 1992; Lal 1996) —ultimately reducing agricultural yields. Problems associated with forest conversion in tropical agricultural frontiers are not limited to the frontier; the phenomenon has global consequences as well. The elimination of tropical forests threatens scientific advances in medicine and food security with the diminution of genetic stores of diversity (Smith & Schultes, 1990). Forest conversion to agriculture, particularly pasture, has also been linked to global climate change (Fearnside, 2004).

Perhaps no place else on earth are the competing demands between humans and forests more volatile than in Central America (Carr, Barbieri et al 2006). Central America has destroyed a great percentage of its forests, most of it ultimately for livestock production, than any major world region during recent decades. While agricultural land expansion and food output exceeded population growth during recent decades, most agricultural expansion has been concentrated on lands that are only marginally adequate for cultivation but that are often, nonetheless, rich in ecological diversity. Meanwhile, virtually all food production increases have come from capital-intensive farms yoked largely for foreign export. Further, capital-intensive farming has pushed many thousands of small farm families to marginally cultivatable lands in forest frontiers rich in biodiversity (Carr, Barbieri et al., 2006).

This paper examines several key factors relating to demography, political-economic development, land use, and forest conversion at the household level in the

Sierra de Lacandón National Park (SLNP), the most ecologically biodiverse region in *La Selva Maya* and a core conservation zone of the Maya Biosphere Reserve (MBR). What is the relationship between farm families' demographic, political, social, economic, and ecological characteristics, food production patterns and subsequent impacts on the SLNP's "protected" forests? The survey represents the first detailed statistically-representative sample probing human population and environmental interactions in an emerging agricultural frontier in Central America. The following section introduces the study site. The field research methods are then described, followed by descriptive results of household land use and demographic, social, economic, political, and ecological characteristics of the households and their farms. The paper concludes with a summary of the results and implications for future research and for policy.

The Study Site: The Sierra de Lacandón National Park

The vast northern *departamento* of Petén (Map 1) was virtually depopulated by A.D. 900, as it was widely deforested by Maya agriculturists from 1500 B.C. to A.D. 900 (West 1964; Turner II, et al. 2002). 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 handful of itinerant rubber tappers to over 600,000 mostly rural inhabitants (Instituto Nacional de Estadistica [INE] 1999) and is projected to exceed 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 ha cleared per annum, the departamento's last forests will be erased by 2015.

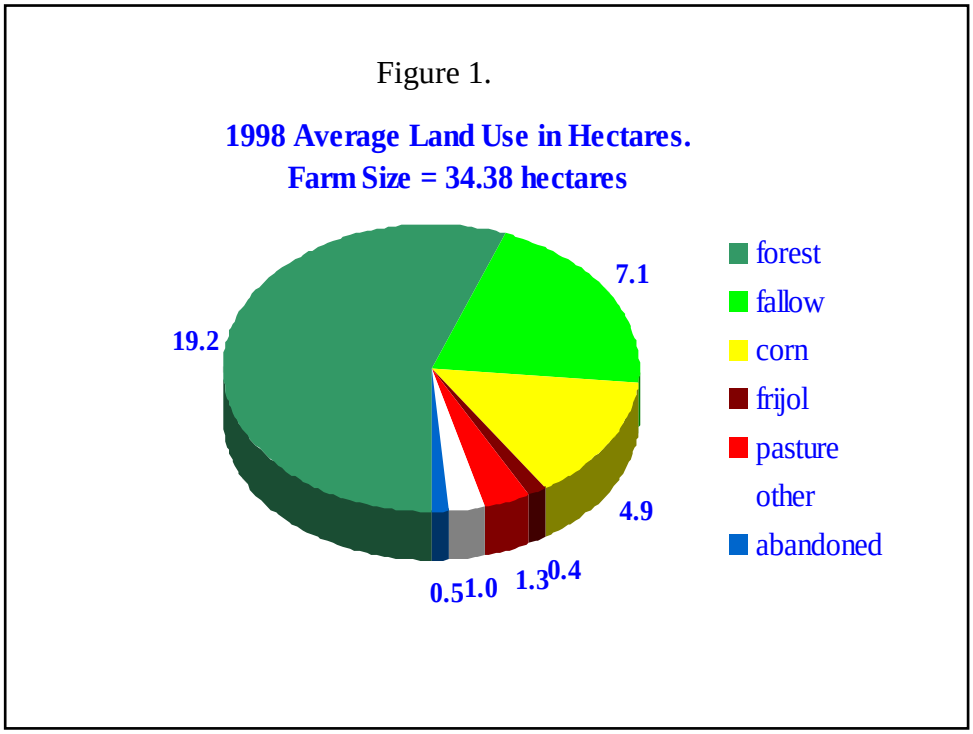
Map 1. The SLNP, RBM, and Petén, Guatemala

With heightened concern about the region's ecological conversion, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), working jointly with a host of institutes from donor nations, established the MBR in 1989. The MBR forms the heart of the Selva Maya (the largest lowland tropical forest in Central America) and comprises 60% of the *departamento* of Petén. The MBR also serves as a pan-continental biological bridge, a cardinal repository of biodiversity and archeological sites, including the remains of the magnificent ancient Mayan city, Tikal (The Nature Conservancy [TNC] 1997). The Nature Conservancy and Conservation International and Guatemalan conservation institutions Defensores de la Naturaleza and the Consejo Nacional de Areas Protegidas (CONAP) all work in the region with the goal of conserving the SLNP's remaining forest. However, these organizations are hampered by government reticence to enforce conservation policy given the contentious land history of Guatemala and the resulting protracted civil war that lasted into the mid 1990s.

The SLNP dates from 1990 as a core conservation zone within the MBR. It is Guatemala's second largest national park and the sole biological corridor linking the MBR and the Montes Azules Biosphere Reserve—the largest protected humid lowland tropical forest in Mexico—and with the maximum relief and greatest rainfall in the MBR,

the SLNP has the highest biodiversity in the Selva Maya (TNC 1997). Despite its biological importance and its designation as a core conservation zone, the SLNP suffers from some of the fastest population growth and largest 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 2008a; Sader Martinez et al., 2000) (Map 2). As in the rest of Petén, the proximate cause of the deforestation has been agricultural extensification by swidden corn farmers (Figure 1). All land use in the park is used for agricultural purposes except for small plots used for home construction. Settlers acquired farms through land invasion and squatting following the construction of a road by oil interests in the early 1980s (Schwartz, 1990). There is modest non-timber extraction and some hunting. Forest timber extraction occurs in cooperatives to the south and north of the park. A prerequisite to deforestation in the park was the decision of these farm families to migrate from their origin communities to the frontier.

Figure 1.



The most marginalized of frontier farmers are those that have settled within the core zone of the SLNP. These farmers have few options available to them. They are constrained by unfavorable market conditions, as well as lack of technology and training in alternative farm management strategies. The SLNP farmer relies on great land endowments and a small amount of labor and technology. Within this general context, how resources are managed will depend on the balance between minimizing risk in securing food for the household and maximizing surplus produced for market. This balance will be constrained by labor capacity, land quality and availability, security of ownership, land use, and production costs.

Sample design and data

Because of its rich biological diversity coupled with the rapidity of population growth and forest clearing since the 1980s, the SLNP is an appropriate study site for conducting research on small farmer colonization and tropical deforestation. Such a study contrasts with the vast majority of land use and land cover change (LUCC) research, which is either conducted at a macro-scale, on which complex causal processes operating at the local scale are concealed by data aggregation, or at a micro-scale, on which true frontier research is rare and is commonly a misnomer for post-frontier environments. The data presented here are from a survey collected by the author in the SLNP in 1998 and supplemented with qualitative research conducted from 1997 to 2000. A detailed description of the survey is beyond the scope of this paper (see Carr, 2003), but several aspects are worth mentioning. First, a two-stage probability sample of approximately 10% (279 households in 8 of the 28 communities that farm in the park) of the SLNP settler population was achieved. Sample stage one was the random selection of communities; stage two was the random selection of households within selected communities by choosing a random fraction of houses equivalent to approximately 25-45 households per community. The farmers with agricultural fields within the park, with the exception of cooperative farmers in two communities and a cluster of farmers with private land in one community, were squatters that followed newly opened roads to settle the vast public lands of the reserve. Separate questionnaires were administered to the household heads and their partners. For the purpose of this analysis, the sample was reduced to 241 heads of household by excluding a community of returned refugees, an anomaly in the park.

The survey collected information on variables selected from literature reviews and from surveys in the Ecuadorian Amazon (e.g., Bilsborrow and Pan 2001) and the Mexican Yucatán (Turner II et al, 2004). Building on these and other previous studies, the survey was crafted in content and expression to fit the cultural mores of the SLNP region. Assistance in this effort came from several sources, most important among them were (a) Norman Schwartz of the Pro-Petén-Conservation International (Corzo-Márquez and Obando 2000), (b) Jorge Grunberg, formerly of the CARE (Macz and Grunberg 1999), (c) Edgar Calderón Rudy Herrera and Edgar Calderón of The Nature Conservancy (The Nature Conservancy 1997), and (d) members of the Guatemalan agro-forestry aid institute, Centro Maya. Lastly, variables were derived from additions and modifications of earlier instruments with the help of my Peténero interview team and from many long discussions with community leaders in the SLNP.

Eight forestry students from the Centro Universitario de Petén and a Q'eqchi Maya interpreter (approximately 13% of the sample is Q'eqchi) comprised the Peténero interview team. Before implementing the survey, the author lived among the communities for several months conducting informal interviews and making observations in order to improve questionnaire content and design and to gain the trust of local households to ensure data fidelity.

The fieldwork was more successful than planned. Hard work and patience were necessary, as well as a good bit of luck. The socio-political climate at the time augured poorly for successful data collection. Farmers were wary of government-backed attempts to relocate them off parkland. Indeed, the very organization that supported this study,

The Nature Conservancy, was spearheading negotiations with community leaders to relocate several communities from the core zone of the park. Farmers prepared to fight The Nature Conservancy for their land, as some stated "over our dead bodies." Vigilante justice in the SLNP has filled the lacuna left by the virtual absence of a government-sponsored police force.

The natural conditions were also less than propitious for carrying out fieldwork. A drought stoked severe forest fires in the SLNP region during the spring of 1998. Flames engulfed significant portions of the park's lower forest canopy and destroyed farmers' crops. A thick haze of smoke completely absorbed the tropical sun's rays during all but the last month of fieldwork and trees felled from forest fires obstructed our advance on several occasions.

In some communities, a large portion of the harvest was burned to ashes, and locals were surviving on carefully measured rations of maize in the form of tortillas and *atol* (maize gruel). I enjoyed a thrice-daily meal consisting only of corn tortillas and corn mush for weeks several weeks at a time. Rare exceptions to the maize monotony included the delicacy of cooked *tepescuintle* (a large jungle rat), and the occasional (perhaps once a week) serving of chile, squash, or lemon grass to accompany the meal. Still, all of the interviewees completed the fieldwork and only one person, of the more than 500 total interviewed, declined participation in the survey.

Based on collected data from surveys at the farm level in the SLNP, this paper seeks to understand the impact of colonization on forest clearing based on the land use of settler farmers. The next section examines descriptive results on household farm land use, followed by a discussion of family composition and demographic structure and socioeconomic, political, and ecological background characteristics.

Results

Land Use

Most farmers cultivated 4–8 ha of maize—which was sometimes supplemented by frijól (*Phaseolus vulgaris*) or pepitoria (*Cucurbita. pepo*)—and had approximately the same amount of land in fallow land (Figure 1). One-quarter of the households (all non-renters and many with some degree of legal claim to their farm) owned some cattle, usually only a few head. Because settlement occurred in recent years, most farms, except the small plots of renters, had yet to complete their crop rotations, to adopt or increase land in pasture, or to develop their farms in other ways to fully realize household needs and aspirations. Therefore, on most farms—typically 25–45 ha in size—substantial tracts of forestland remained.

Since SLNP farmers, as is typical in a frontier environment, enjoy land abundance and suffer labor and capital scarcity, shifting agriculture is a desirable strategy. Farmers cultivate maize (*Zea mays*) according to household subsistence needs but also work long hours to produce surpluses for sale to earn cash to buy household goods such as cooking oil, coffee, salt, sugar, and soap. Maize is the sole crop grown by many farmers. A minority rotate maize seasonally with frijol. After two years, a second agricultural plot is usually established on recently cleared land.

FIGURE 2. CLEARING A *MILPA* FROM THE FOREST, FAMERS DISCOVER MAYA RUINS

After a period of at least two years, and usually four or more, is preferred before returning to the initial plot. This "bush fallow" rotation is very common in the Maya Biosphere Reserve (Schwartz, 1995; Corzo-Márquez & Obando, 2000; Fagan, 2000; Grunberg. J. Ed., 2000) and the buffer zone areas of the reserve (Shriar, 2000) and is consistent with the short-fallow farming system centered predominantly on subsistence maize found throughout the Maya forests during the initial years of colonization; such practices were present, for example, in the Mexican Yucatán (Ewell & Merril-Sands, 1987; Humphries, 1993; Klepeis et al., 2004; Faust & Bilsborrow, 1999) and other sparsely populated areas of Guatemala (Orellana & Castro, 1983; McCreery, 1994; Valenzuela, 1996).

Nevertheless, since the fieldwork was conducted in 1998, the principle road running adjacent to the SLNP has been paved, with plans to build a road that will connect the region to markets in Mexico. This has enabled improved connections with the departmental capital, Flores, which in turn is now better connected with Belize and Guatemala City due to recent road improvements. With improved transportation links connecting the region to domestic markets as well as to those in Mexico and Belize, the expansive maize-dominated farming system could become more diverse, intensive, and market oriented, as has happened with the shift to chile among neighboring Mexican farmers (Keys, 2005). Such a process is well-documented in other regions of Guatemala and Latin America in general. For example, in the Sierra de las Minas National Park in Guatemala, migrant Q'eqchí farmers maintained a traditional bush fallow maize system but also adopted more intensive cardamom production as a cash crop following shrinking land availability and increasing international market demands for the crop (Castellon, 1996). Similarly, in the Ecuadorian Oriente, Pichón (1997) describes more market-

oriented farmers with large areas in perennials (e.g., coffee) once subsistence became secure following several years of successful production of crops for home consumption.

Despite substantial potential for further agricultural extensification (i.e., farms still have substantial amounts of forest remaining), two intensification techniques are employed by nearly half the farmers in the sampled communities: the cropping of velvet bean and the use of herbicides. The use of velvet bean (*Mucuna pruriens*) as a green manure is being rapidly adopted. Velvet bean is a nitrogen-fixing legume grown in the *milpa* that can nearly double maize yields during the second harvest, at which time farmers can fetch double the revenues from their yield (Mausolff & Ferber, 1995; Shriar, 2000). Mucuna plots or *aboneras* (these are separate from the plots used for the *primera*) are planted with maize shortly after planting the *primera*. Nitrogen is fixed in the soil over time by these legumes such that the soil is enriched for the development of the *segunda* harvest. This cycle is repeated yearly on the same *milpa*, thus reducing the need to clear more forest. Secondly, herbicides are sometimes sprayed (by approximately half the farmers), particularly on plots that have been farmed more than once.

As in other parts of Latin America, it is the dream of many farmers to become cattle ranchers whose cattle is used to occupy land with no further economical benefit or is consumed by elites (DeWalt, 1985; Carr, 2004). Yet cattle require capital beyond the means of many farmers, and therefore only "wealthier" farmers can convert this dream to reality. Cattle are also typically held as an insurance to be sold locally in times of need. Cattle ranching is extensive, and pastures are usually managed without rotations on existing fallow land but rather through further forest clearing.

I have discussed the principle land uses and land management strategies of farmers in the SLNP frontier. Agricultural production represents the means to survival and the dreams of household improvement in the years to come. Household farm land use is also the primary driver of deforestation in the SLNP, just as it is in other frontiers throughout the Maya forest and the Latin American tropics. Demographic, political-economic, socio-economic, and ecological factors are hypothesized to relate to land use and forest conversion on these frontier farms. The following section is a first exploration of some of these factors.

Demographic Characteristics

Demographic dynamics on the frontier are intimately related to land use and forest conversion patterns (Carr et al, 2006). Life cycle effects are of particular importance to land use on the frontier. Forest conversion is usually high following settlement with young families clearing forest for subsistence production (Pichón 1997). Some years later, children increasingly add to the household labor supply, and perennials and/or livestock tend to diversify farm holdings while older children may out-migrate to establish new farms or search for employment elsewhere (Barbieri and Carr 2005). Whether lifecycle development on the farm increases or decreases forest conversion will depend on the relative emphasis placed on each land use and on family food and capital demands (Carr, Suter, et al 2006; Perz 2001; McCracken, Siqueira et al. 2002; Walker, Perz et al., 2002). In the SLNP, most families remain in the early stage of the life cycle, and their first deforestation pulse is evident in the relatively small amount of land in maize and fallow relative to forest (Figure 1).

Most population growth in agricultural frontiers is due to in-migration (Carr 2009). However, fertility is particularly high in remote rural regions and has been correlated with more expansive land use (Carr, Pan et al 2006; Sutherland et al., 2004; Pichón, 1997; Rosero-Bixby & Palloni, 1998). In Petén, the total fertility rate remained at 6.8 births per woman in the most recent Demographic and Health Survey (Sutherland et al., 2004). Unlike most other studies from more developed agricultural frontiers, descriptive results from the survey underscore the homogeneity of land use and socio-economic and ecological characteristics of the region and its settlers. Such uniformity belies the diversity of settler origins. The southeast region of the country, particularly Izabal, is the most represented area of migrant origin (Table 1). Most settlers had lived in areas other than their village of birth, many residing in southern Petén (39%) or Izabal before migrating to the SLNP (Carr, 2008b). Most of the settlers arrived in the park after 1988, mostly from diverse rural regions of Guatemala. The average residence duration on the farm was nine years. Some farmers arrived as early as the late 1960s and early 1970s, usually as rubber tappers (Schwartz, 1990). Prior to 1987, only a handful of farmers had established settlement in the area. Migration began in earnest following the completion of a road from Flores (the departmental capital in the center of Petén) to El Naranjo (to the west on the Mexican border) in the mid-1980s with a large wave of colonists arriving between 1987 and 1993. This period coincides with waves of intense violence in rural areas of Guatemala. Although few colonists cited the war as the primary reason for migration, many mentioned that it served as a catalyst, if not a direct cause, for land and wage-deprived rural households to migrate to the SLNP.

Table 1. Demographic Characteristics

Migration and Migrant Characteristics	**N**		**Mean**	**Median**	**Standard Deviation**	
Duration in current residence (years)	241		9.2	8.0	5.9	
		Peten	**Southeast**	**Verapaces**	**Highlands**	**Pacific Littoral**
Region of origin	241	9%	48%	10%	9%	24%
Previous Residence (other than origin)	241	39%	12%	2%	0%	5%
		Acquire more land	**Acquire better land**	**To own land**	**Family**	**Other**
Reason for Migration	241	68%	8%	5%	9%	10%
		Wished to remain	**Wished to migrate**			
Intention to Remain in Origin	241	71%	29%			

Household Demographics	**N**	**Mean**	**Median**	**Standard Deviation**
Household Size (years)	241	6.5	6.0	3.1
Age of Household head (years)	241	40.0	39.0	13.5
Age of partner (years)	229	34.4	33.0	12.2
Household Population Density (a)	241	8.6	8.0	57.3
Sex ratio(b)	241	1.2	1.0	1.1
Adult Sex Ratio(c)	239	1.3	1.0	0.6
Child Dependency*(d)	241	1.6	0.8	0.9

a) Household Population Density is the number of members of a household relative to one caballeria of land (45 ha.). This is the size of the plurality of farms.

b) Sex Ratio equals all males/all females.

c) Adult Sex Ratio is the same as Sex Ratio but for people 18 or older.

d) Child Dependency Ratio equals Children <12 / Adults > 12.

All but a few of the households were nuclear. (DHS, 1998). The mean household size of 6.5 persons per household was higher than the national mean (5.3), the national rural mean (5.6), and Petén's average of 5.7 (INE, 1999). Given the young age that was found for the household heads and their partners (40 and 34, respectively), the large number of children suggests that fertility was notably higher than in other rural regions of Guatemala—the nation with the highest rural fertility in Latin America While most men and women claimed to want fewer children, less than one-quarter of all households was using contraception of any form. Given the apparently high fertility rate and the large number of young women in the area, natural population growth, even with unusually high mortality, likely exceeded 3% annually, and the young population portends continued high growth into the near future. At almost nine persons per caballería (45 ha), the household population density (measured as household members per caballería of land occupied by the household) exceeded what local farmers would consider the region's carrying capacity. A caballería is commonly and ubiquitously cited as the standard amount of land that is needed to support a family over time with minimal technical inputs (Carr, 2006). The male-dominated adult sex ratio in the SLNP (129 men per 100 women) was similar to other frontier regions and is explained by the fact that men often settle frontier regions first and are followed by their spouses and young children after secure settlement has been established (Martine, 1981). There were approximately one and one half children under 12 years of age relative to adults twelve years or older in the average household. This is a proxy measure for the consumer to producer ratio for the household and suggests a surplus of producers to consumers.[2]

Political-economic Characteristics

Table 2 describes political-economic characteristics of the sample households. Nearly 70% of the households were homesteaders squatting illegally on park land or were renting land. Nevertheless, these farmers were generally recognized to enjoy full access rights to their farmland within their respective communities (if not always externally as witnessed by continued land invasion attempts) (Carr, 2006). Almost a third of the farmers reported having some legal claim to their farm (approximately half of which had legal claim through membership in an agricultural cooperative). A large body of literature debates the role of land tenure in influencing farmer land-use decisions, with most investigators agreeing that secure land title impels farmers to manage resources more sustainably (Southgate, et al., 1990; Barbier, 2004). However, in the SLNP, farmers were usually only in the preliminary stages of legally claiming their land. Specifically, farmers had typically already applied for land ownership to the National Institute for Agrarian Transformation (INTA) or possessed documents showing measurement of the plot (usually performed by a private surveying agency, as INTA was overwhelmed with requests for farm measurements), a required step in the legalization process (Carr and Barbieri, 2006). Only farms adjacent to the road (on the southeast side) or, most recently, in the southern portion of the park that had been rezoned as a "multiple use zone" may credibly make a claim to legal title.

Table 2. Political-economic Characteristics	N	Percent affirmative	Mean Farm Size (ha.)	Standard Deviation
Squatter	241	69%	29.9	20.9
Some Legal Claim to the Farm	241	31%	45.5	23.5
Received Credit - previous 12 Months	241	5%		
Contact with NGO or GO - previous 12 Months	241	41%		
Knowledge of the Park's Existence	241	66%		
		Good	**Bad**	**No opinion**
Opinion of SLNP	241	68%	18%	16%

agency, usually for developing cattle activities. However, many households had also incurred debt from credit loans provided by middlemen who stored or transported crops. Middlemen lent money to farmers for help in hiring labor for cutting trees, planting, or harvesting, in exchange for a portion of their crop or for a low price at harvest time.

Consistent with reports from community leaders, fewer than half the survey respondents claimed to have had contact with a conservation or development agent. Astoundingly, and consistent with reports from community leaders, a full third of the respondents claimed to have never heard of the park. Virtually all agreed that conservation efforts should not be developed to the detriment of farming "their" land.

Socio-economic Characteristics

Several recent studies from agricultural frontiers in South America point to the importance of household-level socio-economic and individual characteristics relating to land use, forest conversion, and economic development (Pan et al, 2004; Brondizio, et al, 2002). Three-quarters of the sample were Ladinos (Table 3), about 13% were Q'eqchí Maya, and the remaining belonged to various other Maya groups. Although some authors argue that the Q'eqchí Maya are more expansive in their swidden rotation and less crop diverse than other indigenous groups and Ladinos, and thus more destructive of the tropical forests in the region (e.g., Atran, 1999), the two groups appear to have had similar impacts on the park's forests at the farm level (Carr, 2004). Almost half the sample was Catholic; the other half was divided fairly evenly between Evangelicals and Agnostics (non-believers). Most households remained poor following settlement in the region. The average household had little more than a room, a palm leaf roof, walls of sticks, and dirt floors. In a measure of some basic assets (e.g., radio, automobile, chainsaw, horse/burro, automobile), the average number of assets per family was one; usually a radio was the sole item owned. Only a few local commercial "middlemen" owned a truck. Typically, one or two (at most) possessed a chainsaw per community. Horses and burros were owned by only a small fraction of households, a strong indication of the extreme shortage of capital among the households since, for the majority, these beasts of burden represented the only source of transportation (besides the farmer's own backs) to haul maize to middlemen on the road. Another source of income, in addition to selling maize or renting out chainsaws or animals, was working on neighboring farms for a modest daily wage. Almost half of the household heads worked as a wage laborer at least once during the year previous to data collection, usually during times of great labor

demand, such as harvest season. A further socio-economic indication that the sample was at a clear disadvantage relative to other regions in the country was educational achievement. None of the surveyed had an education beyond primary school. These education levels were below the national average, as almost half the population had finished primary school (INE, 1999). One-third of school-age children attended classes, but attendance was usually quite irregular.

Table 3. Ethnicity and Religion	**N**	**Ladino**	**Q'eqchi**	**Other Maya**		
Ethnicity	241	76%	13%	10%		
		Catholic	**Evangelical**	**Agnostic**	**Other**	
Religion	241	42%	24%	28%	5%	
Household SES Characteristics	**N**	**Percentage affirmative**	**Mean**	**Median**	**Maximum**	**Minimum**
Assets	241	100%	1.2	1.0	4.0	0.0
House Conditions	241	100%	6.0	5.0	12.0	3.0
Participation in off-farm labor	241	43%	43%			
Education	**N**	**Percent of total**				
Household head began primary school	241	57%				
Household head finished primary school	241	11%				
School-aged children in primary school	241	32%				
Size of total farm holdings according to farm status (in ha.)		**Percentage affirmative**	**Mean ha.**	**Median ha.**	**Maximum ha.**	**Minimum ha.**
Size of total holdings (ha.)		100%	34.8	42.3	135.2	0.7
Renter		7%	41.8	41.6	67.6	19.7
Rentee		23%	12.1	2.8	90.1	0.7
Percent inheriting farm		7%	28.7	30.3	60.6	2.8
Has additional agricultural fields		17%	32.5	33.8	90.1	1.4
Farm Distance to Road (in km.)			**Mean km.**	**Median km.**	**Maximum km**	**Minimum km.**
Farm Distance to Road (km.)			5.9	4.0	20.0	0.0

Early arrivals to the region typically claimed squatter farms of one caballería in size, though some earlier arrivals claimed two or more additional caballerías for friends and family. By 1998, the average farm size had shrunk to several hectares smaller than a caballería. As children become adults and further colonists seek land, farm fragmentation is likely to increase dramatically in the coming years, a pattern consistent with the evolution of frontier development observed in the Amazon and elsewhere in Latin America (Moran 1985; Pan, Walsh et al. 2004). It is notable that many more farmers in the sample rented land (42%) compared to those that rented it out to others (13%), suggesting that some of the larger farms had multiple renters farming portions of their

farm. Nearly one-fifth of the farmers in the sample worked on more than one farm parcel. The mean distance of farm plots to a road was 6 km, but most had farms within 5 km of the road. Those arriving during the first wave of colonization in the 1980s and early 1990s enjoyed squatters' rights to land closer to the road. Subsequent colonists either claimed land further into the park, or they purchased or rented land closer to the road.

Ecological Characteristics

An understudied aspect of frontier societies and land use is the role of ecological endowments and environmental change in shaping land use and land cover outcomes. However, compelling evidence exists of soil degradation fanning further forest conversion in South American frontiers (e.g., Hecht and Cockburn, 1989). In the SLNP, farm plots generally shared flat to slightly hilly slopes. Only a quarter of the informants complained that they endured poor soils; 40% opined that their soil was highly fertile, and the remainder (35%) claimed to have average soils (Table 4). Virtually all farmers in the sample claimed that compared to migrant origin areas, the recently farmed soils of the SLNP were a significant improvement over the soils of their origin areas, which they frequently described as "burned" or "very poor." Slightly less than half of the farmers reported having hilly land on their farm. This is notable, considering that the SLNP region is characterized by jagged karstic terrain and is another indicator of the relatively low population density that makes cropping on steep slopes unnecessary (Figure 3). Nevertheless, in interior communities confined between the valleys of the sharp ridges of the Lacandón mountain chains, such as Poza Azul and Nueva Jerusalén II, agricultural expansion on hillsides is becoming more common and is expected to increase over time and is associated with acceleration in erosion rates. A caveat to these findings is that these measurements were provided by farmer responses rather than direct measurement.

Table 4. Farm Soil and Topography	**N**	**Percent affirmative**
Very fertile	241	40%
Average soil	241	35%
Poor soil	241	24%
Hilly topography	241	45%
Flat topography	241	55%

FIGURE 3: JAGGED TERRAIN ON STEEP SLOPES IN SLNP

Conclusion

This paper presented data on farm-level land use as well as demographic, socio-economic, political-economic, and ecological characteristics of households and their farms in the Sierra de Lacandón National Park, Guatemala. The sample is the first detailed survey of human population and environment interactions in an emerging agricultural frontier in Central America. Land use was extensive, suggesting low levels of agricultural technology, an abundance of available land, and a scarcity of labor. Households were large, indicating a lack of health and family planning services. Education levels were well below the national rural average, auguring poorly for alternative employment opportunities for settlers and for widening the career horizons of

settler children. Development aid for conservation and development was scarcely apparent. Lastly, ecological conditions, while generally favorable, appear to be worsening with farm fragmentation and farmland expansion to more marginal lands.

Future research will need to explore how these variables interact at multiple scales relative to land use/land cover change and other socio-economic and demographic outcomes. There is an urgent need for such research to influence policy aimed at improving settler household wellbeing and ameliorating farming impacts on the precious ecosystems of the Maya Forest. A follow up visit in the spring of 2009 indicated that over the 10 year time period since this research was conducted, dramatic deforestation has occurred, with much of the land converted to pasture. The SLNP frontier is effectively closed unless new roads are built to provide access to the interior of the park; currently the frontier is several kilometers from the main road. Follow up surveys in the region will help document changes over time of potential benefit to both conservation and development communities. Such research promises to improve our understanding of human-environment interactions in tropical frontier environments, where much of the world's forests have been converted to agriculture by some of the world's most economically marginalized people.

Acknowledgements

This research was conducted thanks to the generous support of the following sources: National Aeronautics and Space Administration, the National Institutes of Health, the National Science Foundation, Latané Center for the Human Sciences, the Mellon Foundation Social Science Research Council, Association of American Geographers, and the University of North Carolina Institute of Latin American Studies, Department of Biostatistics, Carolina Population Center, and Royster Society of Fellows.

[1] Agricultural frontier is defined here borrowing from Almeida's (1992) definition as an area that "experienced rapid increase in population and land appropriation…[and the] geographical boundary between 'directly productive' and 'usury-mercantile' capital…[that]…lasts as long as landed property does not consolidate."

[2] The traditional Child Dependency Ratio employs the formula (Children<15 / Adults 15-64). However, since most adults in the sample commence farm work at age 12, I have adjusted this measure to the more faithfully capture the concept of child dependency.

References

Achard, F., J. Gallego, T. Richards, J. P. Malingreau, H. D. Eva, H. J. Stibig and P. Mayaux (2002). "Determination of deforestation rates of the world's humid tropical forests." *Science* 297(5583): 999-1002.

Almeida, A. (1992). *The Colonization of the Amazon*. Austin, University of Texas Press.

Atran, S., Medin, D., Ross, N., Lynch, E., Coley, J. Ucan Ek', E. & Vapnarsky, V. (1999). "Folkecology and commons management in the Maya Lowlands." *Proceedings of the National Academy of Sciences U.S.A.* 96: 7598-7603.

Barbier, E. B. (2004). "Agricultural Expansion, Resource Booms and Growth in Latin America: Implications for Long-run Economic Development." *World Development 32*(1), 137-157.

Barbieri, A. and D.L. Carr (2005). Gender-specific Out-Migration, Deforestation and Urbanization in the Ecuadorian Amazon. *Global and Planetary Change*. *47*(2-4), 99-110.

Bilsborrow, R. E. and W. Pan. 2001. Population Change, Land Use, and the Environment in the Ecuadorian Amazon. XXIV IUSSP General Conference, Salvador, Brazil.

Brondizio, E., S. McCracken, E. Moran, A. Siqueira, D. Nelson and C. Rodriguez-Pedraza (2002). The Colonist Footprint: Toward a conceptual framework of land use and deforestation trajectories among small farmers in the Amazonian Frontier. *Deforestation and land use in the Amazon*. C. H. Wood and R. Porro. Gainesville, FL, University Press of Florida.

Carr, D. L. (2003). Migración rural-rural y deforestación en Guatemala: Método de Entrevistas. 10 *Tiempos de América: Revista de Historia, Cultura y Territorio.* Centro de Investigaciones de América Latina (CIAL), Universitat Jaume I. Pp. 19-27.

Carr, D. L. (2004). "A comparison of Ladino and Q'eqchi Maya land use and land clearing in the Sierra de Lacandón National Park, Petén, Guatemala." *Agriculture and Human Values* 21: 67-76.

Carr, D. L. (2004). Proximate population factors and deforestation in tropical agricultural frontiers. *Population and Environment*. *25*(6), 585-612.

Carr, D. L. (2006). A tale of two roads: Population, poverty, and politics on the Guatemalan frontier. *Geoforum*. *37*(1), 94-103.

Carr, D.L., L. Suter, A. Barbieri, (2006). Population links to Deforestation. *Population and Environment*. 27(1), 89 – 113.

Carr, D.L. and A. Barbieri (2006). Población, tenencia territorial, uso del suelo, y deforestación en el Parque Nacional Sierra de Lacandón. *Journal of Latin American Geography*. *5*(1), 97-112.

Carr, D. L. W. K. Pan and R.E. Bilsborrow (2006). Declining Fertility on the Frontier: The Ecuadorian Amazon. *Population and Environment*. *28*(1), 17–39.

Carr, D.L, A. Barbieri, W. Pan, H. Iravani, (2006). Agricultural land use and limits to deforestation in Central America. Chapter 6 in *Agriculture and Climate Beyond 2015: A new perspective on future land use patterns*. Eds. Floor Brouwer and Bruce McCarl. Dordrecht, The Netherlands: Springer. p. 98-107

Carr, D. L. (2008a). Farm households and land use in a core conservation zone of the Maya Biosphere Reserve, Guatemala. *Human Ecology. 36*(2), p. 231-248.

Carr, D. L. (2008b). Migration to the Maya Biosphere Reserve, Guatemala: Why place matters. *Human Organization. 67*(1), 37-48.

Carr, D. L. (2009). Migration and Tropical Deforestation: Why Population Matters. *Progress in Human Geography*. *33*(9), 355-378.

Castellon, M. (1996). *Dynamics of Deforestation: Q'eqchí-Maya Colonists in Guatemala's Sierra de Las Minas*, 1964-1995. Ph.D. Dissertation. Department of Geography. Madison, University of Wisconsin**:** 292.

Colchester, M. 1991. Guatemala: The clamour for land and the fate of the forests. *The Ecologist 21*(4), 177-185.

Corzo-Márquez, A. R. and O. R. Obando. 2000. El Problema Agrario, el desarrollo económico y la conservación en la encrucijada. Una lectura socioeconómica al Parque Nacional Laguna del Tigre. In *Nuevas Perspectivas de Desarrollo Sostenible en Petén*. Ed. J. Grunberg, Guatemala City, FLACSO.

De Walt, B. 1985. Microcosmic and macrocosmic processes of agrarian change in Southern Honduras: The cattle are eating the forest. In *Micro and Macro Levels of Analysis in Anthropology: Issues in Theory and Research,* eds. B. DeWalt & P. Pelto. Boulder, Colorado: Westview Press.DHS. 1998. Guatemalan Demographic and Health Survey. Guatemala City, UN.

Ehui, S. K. and T. Hertel (1992). "Testing the Impact of Deforestation on Aggregate Agricultural Productivity." *Agriculture, Ecosystems & Environment* 38.

Ewell, P. T. and D. Merril-Sands (1987). Milpa in Yucatán: A long-fallow maize system and its alternatives in the Maya peasant economy. *The nature of farming systems and views of their change*. B. Turner II and S. B. Brush. New York, The Gilford Press.

Fagan, C. (2000). *Cultural and Economic Constraints to Farming in a Core-Zone Community of the Maya Biosphere Reserve, Guatemala*. Masters Thesis, Nicholas School of the Environment. Durham, NC, Duke University.

Faust, B. and R. Bilsborrow (1999). Maya Culture, Population and the Environment in the Yucatán Peninsula. *Population, Development and the Environment in the Yucatán Peninsula*. W. Lutz, W. Sanderson and L. Prieto. Laxenburg, Austria, International Institute for Applied Systems Analysis**:** 29-64.

Fearnside, P. L., WF (2004). "Tropical Deforestation and Greenhouse-Gas Emissions." *Ecological Applications 14*(4), 982-986.

Geoghegan, J., S. Cortina Villar, P. Klepeis, P. Macario Mendoza, Y. Ogneva-Himmelberger, R. Roy Cowdhury, B. L. Turner II and C. Vance. (2001). "Modeling tropical deforestation in the southern Yucatán peninsular region: Comparing survey and satellite data." *Agroecosystems and Environment* 85(1-3): 25-46.

Grandia, L. 2000. Cuántas personas quiera Ud. que vivan en Petén? In *Nuevas Perspectivas de Desarrollo Sostenible en Petén*. Ed. J. Grunberg, Guatemala City, Facultad Latinoamericana de Ciencias Sociales (FLACSO)**:** 137-151.

Hecht, S. and A. Cockburn (1989). *The Fate of the Forest*. New York, Harper Collins.

Houghton, R. A. (1994). "Land-Use Change and Tropical Forests." *BioScience* May, 44: 305-31.

Humphries, S. (1993). "The Intensification of Traditional Agriculture among Yucatec Maya Farmers: Facing up to the Dilemma of Livelihood Sustainability." *Human Ecology 21*(1), 87-102.

Grunberg. J. ed. 2000. *Nuevas Perspectivas de Desarrollo Sostenible en Petén*. Guatemala City, Facultad Latinoamericana de Ciencias Sociales (FLACSO).

Instituto Nacional de Estadistica (INE). 1999. *Encuesta Nacional de Ingresos y Gastos*. Guatemala.

Jones, J. R. 1990. *Colonization and Environment: Land Settlement Projects in Central America*. Tokyo, United Nations University Press.

Keys, E. (2005). "Exploring market based development: market intermediaries and farmers in Calakmul, Mexico." *Geographical Review* 95: 24-46.

Klepeis, P. and B. L. Turner II. 2001. Integrated land history and global change science: The example of the Southern Yucatán Peninsular Region project. *Land Use Policy 18*(1), 27-39.

Lal, R. (1996). "Deforestation and Land-use Effects on Soil Degradation and Rehabilitation in Western Nigeria." *Land Degradation and Development* 7(2).

Leonard, H. J., M. Yudelman, J. D. Stryker, J. Browder, A. J. De Boer, T. Campbell and A. Jolly (1989). *Environment and the poor: development strategies for a common agenda*. New Brunswick, Transaction Books.

Macz, N. and J. Grunberg. 1999. *Manual de Comunidades de Petén*. Guatemala City, Guatemala, CARE Guatemala and Magna Terra Editores.

Martine, G. 1981. *Contemporary settlement of frontier and empty lands: demographic aspects and environmental*. Proceedings and selected papers of the 19th General Conference of the International Union for the Scientific Study of Population, Manila, sponsored by the International Union for the Scientific Study of Population. Liege, Belgium, IUSSP.

Mausolff, C. and S. Ferber (1995). "An economic analysis of ecological agricultural technologies among peasant farmers in Honduras." *Ecological Economics* 12: 237-248.

Mc Creery, D. (1994). *Rural Guatemala*. Palo Alto, California, Stanford University Press.

Mc Cracken, S., E. Brondizio, D. Nelson, E. Moran, A. Siquiera and C. Rodriquez-Pedraza (1999). "Remote Sensing and GIS at Farm Property Level: Demography and Deforestation in the Brazilian Amazon." *Photogrammetric Engineering & Remote Sensing 65*(11), 1311-1320.

Moran, E. 1985. An Assessment of a decade of colonization in the Amazon Basin. In *Change in the Amazon Basin. Volume II: The Frontier after a Decade of Colonization*. Ed. J. Hemming, Cambridge, Cambridge University Press.

Murphy, L., Richard E. Bilsborrow, and Francico J. Pichón (1997). "Poverty and Prosperity among Migrant Settlers in the Amazon Rainforest Frontier of Ecuador." *Journal of Development Studies 34*(2), 35-66.

Orellana, R. A. G. and M. A. P. Castro (1983). *Algunos Rasgos de la Realidad Agraria en Guatemala*. Guatemala City, Instituto de Investigaciones Económicas y

sociales and la Facultad de Ciencias Económicas de la Universidad de San Carlos de Guatemala.

Pan, W. K., S. J. Walsh, R. E. Bilsborrow, B. Frizzelle, C. Erlien and F. Baquero (2004). Farm-level models of spatial patterns of land use and land cover dynamics in the Ecuadorian Amazon. *Agriculture, Ecosystems & Environment* 101: 117-134.

Perz, S. G. (2001). "Household demographic factors as life cycle determinants of land use in the Amazon." *Population Research and Policy Review 20*(3), 159-186.

Rosero-Bixby, L. and A. Palloni (1998). "Population and deforestation in Costa Rica." *Population and Environment 20*(2), 149-78.

Sader, S. A., E. B. Martinez, D. E. Irwin and H. T. Yax. 2000. Estimación de la deforestación en la Reserva de la Biosfera Maya, 1997-1999. In *Nuevas Perspectivas de Desarrollo Sostenible en Petén*. Ed. Guatemala, Guatemala, Facultad Latinoamericana de Ciencias Sociales (FLACSO)**:** 321-324.

Sader, S. A., C. Reining, T. Sever and C. Soza. 1997. Human Migration and agricultural expansion: an impending threat to the Maya Biosphere Reserve. *Journal of Forestry . 95*(12), 27-32.

Shriar, A. J. (2000). "Agricultural intensity and its measurement in frontier regions." *Agroforestry Systems 49*(3), 301-318.

Schwartz, N. 1990. *Forest Society: A Social History of Petén, Guatemala*. Philadelphia, Univ. Pennsylvania Press.

Schwartz, N. 1995. Colonization, Development and Deforestation in Petén, Northern Guatemala. In *The Social Causes of Deforestation in Latin America*. Ed. M. Painter and W. H. Durham, Ann Arbor, MI, University of Michigan Press**:** 101-130.

Smith, N. and R. E. Schultes (1990). "Deforestation and shrinking crop gene-pools in Amazonia." *Environmental Conservation 17*(3).

Southgate, D. D. (1998). *Tropical forest conservation : an economic assessment of the alternatives in Latin America*. New York, Oxford University Press.

Sutherland, E, D.L. Carr, and S. Curtis (2004). Fertility and the environment in a natural resource dependent economy: Evidence from Petén, Guatemala. *Población y Salud en Mesoamérica*. *2*(1), 1-12.

The Nature Conservancy (TNC). 1997. Estado del Parque Nacional Sierra de Lacandón. Flores, Guatemala, The Nature Conservancy (TNC).

Turner II, B., W. Clark, R. Kates, J. Richards, J. Mathews and W. Meyer, Eds. 1990. *The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years*. Cambridge New York Port Chester Melbourne & Sydney, Cambridge University Press with Clark University.

Turner II, B. L., P. Klepeis and L. Schneider (2002). Three millennia in the southern Yucatan peninsular region: implications for occupancy, use, and 'carrying capacity'. *The Lowland Maya Area: Three Millennia at the Human-Wildland Interface*. A. Gómez-Pompa, M. Allen, S. Fedick and J. Jimenez-Osornio. New York, Haworth Press**:** 361-387.

Turner II, B. L., D. Foster and J. Geoghegan (eds.) (2004). *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatan: Final Frontiers*. Oxford, Clarendon Press.

Valenzuela, I. 1996. *Agricultura y Bosque en Guatemala*. Guatemala City, UNRISD, WWF, Universidad Rafael Landivar.

Walker, R., S. Perz, M. Caldas and L. G. Teixeira Silva (2002). "Land use and land cover change in forest frontiers: The role of household life cycles." *International Regional Science Review 25*(2), 169-199.

West, R. C. 1964. *Handbook of Middle American Indians: v. 1 Natural Environment and Early Cultures*. Austin, University of Texas Press.