Land parcel fragmentation in the agricultural frontier: Sierra del Lacandón National Park, Guatemala

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Introduction

Map 1: Guatemala

Deforestation is decried for the loss of the habitats and ecosystem services that results from the reduction in forested areas (Foley, DeFries et al. 2005). Humans have long been implicated in causing forest conversion, with agency ascribed to a variety of sources. The immediate *in situ* agents of forest clearing, be it a subsistence agriculturalist or highly capitalized industrial farming enterprises, are local, immediate actors affecting land cover change, a complex and multi-scalar process. Geist and Lambin (2001) conceptualized deforestation as divided amongst proximate causes (more immediate both spatially and temporally) and underlying circumstances (more removed across the same two dimensions) (Geist and Lambin 2001). In the frontier forests of the tropics deforestation is of particular concern because of high biodiversity and ecosystem services contained in these areas, the elimination of which may have dramatic effects across a wide range of physical systems (e.g. local to global climate change) as well as social systems (e.g. elimination of a natural resource base for productive use). In these frontier environments migrant farmers seeking cultivable plots are often viewed as the primary proximate agents of deforestation (Rudel and Roper 1996; Carr 2005). Although population growth is positively associated with agricultural expansion in Latin America (Carr, Barbieri et al. 2006) the scale of analysis at which the phenomena is examined can conceal or be revelatory of the mechanism by which population increase does (or does not) lead to deforestation. Population growth alone does not necessarily lead to increased deforestation, for the interaction of these populations with their environment is mediated by technology, markets, physical and structural constraints, and agricultural policies, among other influences. Examinations from the national-level in many Latin American countries typically show that overall rural populations have declined while, counter-intuitively, deforestation has persisted and even in some instances accelerated (Carr, Lopez et al. 2009). Much of this deforestation, however, is taking place in the regions' frontier areas, the destination of only a small subset of migrants, often the poorest and most marginal (Carr 2008).

While global processes enable and constrain local agents, this study takes a household and a land parcel perspective, employing a multiphasic model for a household level analysis of *in situ* land effects. As Pan and others (Pan, Carr et al. 2007) point out, the rational for focusing conservation research on the level of the land user comes from the experience gained demonstrating that the most effective method for identifying the least uncertain policy leverage points comes from research conducted at the level of the land user.

This paper proposes to make use of a unique set of panel data in order to examine the maturation of the agricultural frontier. Changes in population number and composition will be examined, as will the important process, from both a social and ecological perspective, by which agricultural lands change hands as the frontier develops. This paper is a human-environment case study of frontier farmers in the Sierra del Lacandón National Park (SLNP), in the northernmost *departamento* (similar to a state) of Petén in Guatemala. This is an area where the agricultural frontier has expanded progressively into dwindling tropical rainforest. In-migration of small-scale agriculturalists and cropping done by the same are the direct agents of deforestation in this area of high biodiversity. My case study serves as a follow-up and expansion upon the land use/cover change (LUCC) case study conducted by Carr in1998 in eight frontier communities of the SLNP (Carr 2005). This research is the only in a Central American case study employing a panel survey in the agricultural frontier (instances of which are rare).Examination of the changes in land management that take place in an agricultural area as mounting population pressure limits the possibilities for both new, would-be colonists and the offspring of already established colonists to encounter sufficient agricultural lands.

In the intervening 10 year period since Carr's study and the one I am here proposing, the frontier has effectively become closed (i.e., without potential for further expansion in the immediate area). Most communities abut one another, while those communities which do find themselves surrounded by potentially fellable forests are not permitted to expand their footprint further by the co-administrators of the protected area, the non-governmental organization (NGO) *Fundación de la Defensores de la Naturaleza* (hereinto referred to as *Defensores*) and the Guatemalan Council of Protected Areas (CONAP, *Consejo Nacional de Areas Protegidas* in Spanish). Population, however, has continued to grow, both from natural increase and continuing in-migration. Where will these new households settle, and how will their presence impact land cover in the area? More specifically: given mounting population pressure on the finite resource of cultivable land, what will be the succession of land "ownership" between 1998 and 2008; what changes in land cover will we witness in comparison to the baseline year of 1998; what do these land covers say about the intensity of land use by farming populations (i.e. do they show an increase in the intensity of land use and thus exhibit a Boserupian-type response to population pressure); and how do the possible alternative responses to population pressure combine with contextual factors to influence land use outcomes. This paper will focus in particular on the question regarding the succession of land ownership in the area while conducting a parallel exploration of related themes which figure prominently in multiphasic response theory (de Sherbinin, Carr et al. 2007).

Bilsborrow's "multiphasic response" conceptual model treating the rural response to increased population pressure derives from an earlier, exclusively demographic

response proposed by the Berkeley demographer Kingsley Davis (1963). Davis problematized the tendency towards oversimplification in studying rural responses to threats to their living standards via population increase, and the tendency to investigate only a single hypothesis at a time, such as *only* contraceptive use or *only* delay in marriage. In the occasions that the single hypothesis turned out not to hold true, facile and vague explanations were cited, such as tradition (Davis 1963). Davis called for a more complex conceptualization of the responses to demographic change since they are, he argued, both reflexive and behavioral. In this way Davis situates any one response within a suite of possible responses, and recognized that the contextual circumstances would alter the nature of the responses exhibited. Urban migration, for example, would not be an option in areas where the urban centers lacked employment opportunities. Bilsborrow expanded this theory from the purely demographic framework, which assumed fixed land area and technology, and expanded it to include economic responses as well. In addition to the possibility of allowing an increase in the cultivated area, he challenged the Ricardian-Malthusian assumption of constant technology to include a more Boserupian response of increasing intensiveness of farming (1992). In her turn, however, Boserup had left out the possibility of a demographic response, so this new, more integrative conceptualization of the response to rising population density was comprised of three possibilities: (1) demographic (decreases in fertility arising from whatever source, such as increased celibacy or use of contraception, (2) economic (such as increases in land under cultivation or substitution of more productive crops in already cultivated areas), and (3) demographic-economic (migration, whether it be permanent or seasonal, or rural-rural, rural-urban, or rural-international) (de Sherbinin, Carr et al. 2007). Bilsborrow also expanded the suite of contextual factors given to potentially have an influence on the responses exhibited, highlighting especially the inclusion of more *physical* environmental factors. By elaborating upon the purely demographic responses mentioned by Davis, Bilsborrow expanded the question from focusing so much on the populations at hand themselves and introduced the possibility of using this framework for examining the environmental *impact* of these growing populations.

Bilsborrow and Okoth-Ogendo (2002) then sought to more explicitly gear this conceptual framework towards addressing the role of population-driven land use change in developing countries. They proposed four stages of response to population-growth. Though consecutiveness is implied, they can alternatively be concurrent or cumulative. These four phases are classified as:

I. Tenurial – such as distribution of idle lands for agricultural use, more equitable distribution of lands, and a reclassification of access rights. Because the most likely way this will manifest itself in the park will be parents dividing their land for their children or to sell to more recent in-migrants, and because tenurial could easily be confused with the subject of land tenure (legal title to the land, instead of (sometimes tenuous) usufruct rights), I will refer to this category of response as tenurial/division.
II. Land appropriate or extensification – this is the out-migration response, seeking arable and unoccupied land, which may be in a frontier environment. This may bring migrants into conflict with existing indigenous groups in the destination area, or, in the case of the SLNP, into conflict with the management of the conservation areas, ironically one of the only remaining locations where

unoccupied land is available to grab. Other destinations are also possible, however, such as the local urban area or, in contrast to what Dr. Carr saw here in 1998, many have chosen the US as their destination. Park communities are not expanding their land holdings into park land in their immediate area, but must "purchase" (often in the extra-legal market) or rent from their neighbor if their claimed plot is not adequate for their needs. Alternatively, they must migrate elsewhere if available land does not meet their livelihood requirements. As such, I will call this category appropriation/migration.

III. Adoption of new technologies of land use – in the instance of population growth, technological change is most often associated with more intensive (productive) use of the land. Because technology is used in the Boserupian sense, meaning an increase in intensity of land use by an increase in frequency of cropping. I will refer to this category as technology/intensity.

IV. Demographic – fertility reduction though postponement of marriage and/or reduction in marital fertility. This is usually the last response, if no intervention is made from the outside. Because of confusion as to the meaning of the "demographic" category in Curran's (2002) review of the multiphasic framework, I will refer to this category as fertility reduction.

As stated above, there is a notion of consecutiveness in the phases, but the extent to which members of a household implement one determines in part the extent to which they will implement another. Phase IV, a reduction in fertility, for example, may not be necessary if there are plenty of migration destinations or if an increase in *in situ* productivity was successful to the extent of providing plenty of food for growing households. Also, once again, the notion of context becomes crucially important in determining what responses are possible or appropriate, including but not limited to: natural resource endowments, institution and attitudinal factors, and government policies

Of the four categories of response presented in the multiphasic framework (tenurial/division, appropriation/migration, technology/intensity, and fertility reduction), I will be addressing one which relates to *in situ* land management, the tenurial/division aspect. Many studies treating the topic of farm fragmentation define it as a single household using more than one parcel of land (Pan, Carr et al. 2004; Barbieri, Bilsborrow et al. 2005), while others define it as the subdivision of a single land parcel into multiple farms under operation by different households (Barbieri, Bilsborrow et al. 2005). Both phenomenon emerge in the frontier farm area of the SLNP, though the dominant process most likely will be the fragmentation of parcels, as seen in the Northern Ecuadorian Amazon (NEA) (de Sherbinin, Carr et al. 2007). Similar between the SLNP and the NEA, the frontier is effectively closed (as in all available land in the area was claimed years ago), yet the population has continued to increase from natural increase and in-migration. New households, therefore, need a place to settle, which has resulted in a documented prevalence of farm fragmentation in the NEA (parcels surveyed in 1990 supported almost twice the original number of independently managed farms nine years later). In the SLNP, many families have sold a portion or their entire parcel to several households. More people supported in a given area typically leads to more forest clearing, while smaller average plot size tends to stimulate intensification (de Sherbinin, Carr et al. 2007).

As mentioned above, Boserup (1965) posited the possibility of more intensive agriculture to raise production per unit of land in areas of higher population density. Thus greater investments of labor and/or technology provide more food to feed more people, and can come in many forms. As Bilsborrow and Geores (1994) state, of the possible land intensification methods, those forms which are the most amenable to measurement are a reduction in the fallow period and a shift from annual to multiple cropping, as well as increased use of modern inputs such as fertilizer and irrigation, as well as adopting new crop varieties and new seeds.

Carr (2002) collected data on intensification measures, such as fallow length, and the use of green manure and purchased inputs (i.e. fertilizers, herbicides, pesticides), but never examined nor presented this data through the lens of intensification measures. Therefore his data on this topic remains a heretofore unexamined way of characterizing the change which has taken place in the area in response to the increasing population density in the area.

Background of the study site

Guatemala in general and more specifically the Petén and the Maya Biosphere Reserve have received considerable attention from researchers, though falling far short of the amount of attention bestowed on larger tropical forested areas such as the Amazon. A take a snap-shot of the locations of frontier deforestation in Guatemala (mostly in the buffer zones of the mega-conservation complex, the Maya Biosphere Reserve), would show that the majority of deforestation having taken place at the hands of small-scale subsistence farmers. This remains in contrast to frontier areas of the Amazon, where one witnesses both the small-scale subsistence producer and the large-scale agro-business as agents of frontier land conversion (Margoluis 2004). For this reason, the most facile explanation for frontier deforestation in Guatemala is the slash and burn agriculture of peasant farmers, characterized as an ecologically inappropriate farming technique which soon exhausts the marginal soils, leading to a repeated cycle of frontier deforestation and degradation (Zimmerer and Carter 2002). However, if one were to take the snap-shot view of *all* the agricultural areas in Guatemala, one would not see the arable land-surface dominated by subsistence production, but instead by large-scale pasture and export fruit and vegetable production. The 1979 agricultural census, reflective of the conditions under which northward migration began in earnest, showed 31% of all farms (the smallest category of farm area, those less than 0.7 ha) occupying 1% of the land area, while the largest farms (greater than 45 ha) occupied 65% of Guatemalan farmland (Grandia 2006).

Migration to the Petén began in earnest during the civil war, as a government-encouraged escape-valve for the lack of land reform, but also spontaneously to escape the violence and take advantage of the available land. Migration continues today, though there is little land technically still considered available for appropriation (Brandon and Wells 1992).

To stave off further migration into these areas, international and Guatemalan conservationists worked in the early 1990s to establish a vast network of protected areas across the country. Guatemala now has more than ninety protected areas, covering 28% of national territory (three million hectares); approximately half of Guatemala's protected areas by area are located within Petén. The 1.6 million hectare Maya Biosphere Reserve

forms a conservation corridor with protected areas of Belize as well as Chiapas and the Yucatan in Mexico, with the whole tri-national conservation called the "Maya Forest" (La Selva Maya). The MBR is comprised of many different protected areas with varying levels of access, such as core areas in which no human habitation or extractive activity is permitted, surrounded by "multiple use" zones and/or buffer zones, where land-use is permitted but ostensibly restricted. However, these distinctions are not well delimited on the land, nor is there adequate enforcement to prevent encroachment into the more restricted areas. In response CONAP (Consejo Nacional de Areas Protegidas, or National Council of Protected Areas) has permitted continued permanence within some areas of the national parks such as Sierra del Lacandón, though there are also communities arising more recently in the supposedly "untouchable" zones. The population of the MBR when it was established in 1992 is unknown, but by 1998 it was estimated there were at least 90,000 people living inside this protected area, with most living in the multiple-use and buffer zones (Carr 1999).

Within the MBR, the SLNP comprises one of the four core biological and Mayan cultural heritage conservation zones in the Maya Biosphere Reserve. The state has difficulties keeping pace with further encroachment into conservation areas, with the ironic result that this conservation area, like many in the world, is vulnerable to land conversion (2002). Since the late 1980s, arriving waves of colonists are estimated to have reached 20,000 individuals in the park by 1999 (2002). Concomitantly, approximately 11% of the park's forest canopy was eliminated.

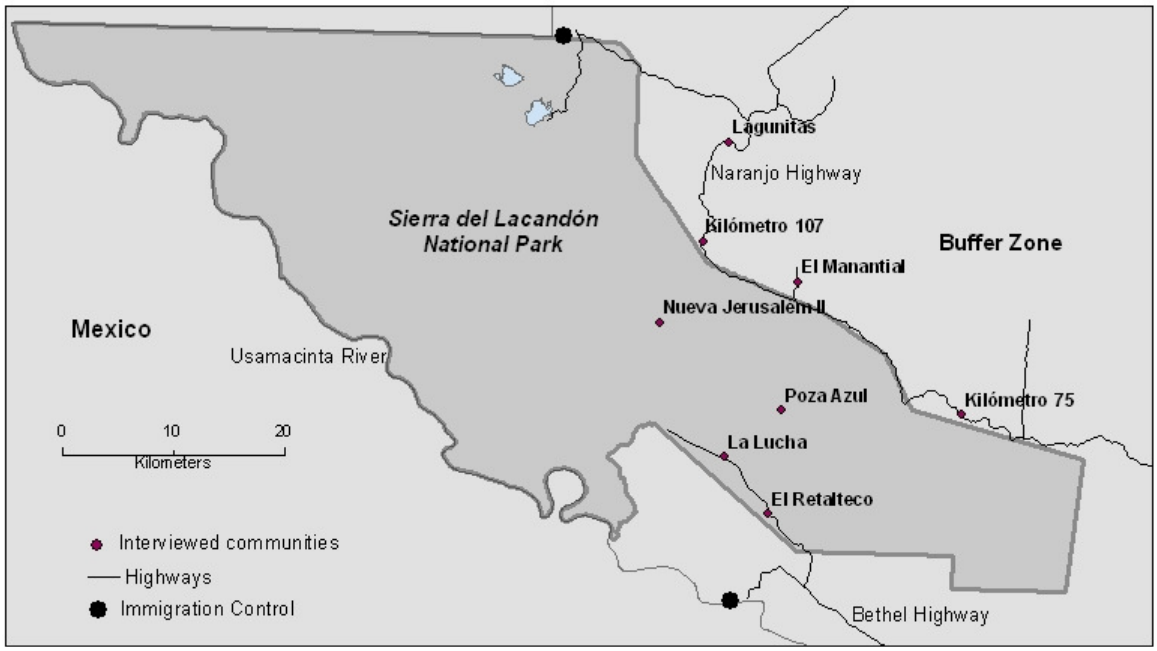
The coadministrators of the Sierra del Lacandón, *Defensores* and CONAP, have to varying degrees reached accords with many of the communities occupying areas of the park, negotiating their continued settlement in the area. Each community visited in this research is ensconced within a delimited area, either constrained by a footprint drawn by the co-administration or, more often, by abutting communities. For this reason the multiphasic framework is relevant; the possible responses of a growing population within a fixed area of agricultural production. This leads to the main question addressed here: as population density increases in the area due to continued in-migration and high rates of natural increase, how will these new households be accommodated (as in, where will we see these tenurial/division shifts predicted in the multiphasic theory)? How will the possible responses be predicated upon other responses theorized within the multiphasic model, such as outmigration and land use intensification.

However, population increase is only one change in the area since the previous sampling in 1998. National, and international transportation networks have improved, the urban centers within a few hours' distance have grown, the national park the communities fringe (or in some cases, are wholly contained within) has been in existence longer, the management of the park has changed, NGOs have come and gone, trade liberalization is taking place between Central and North America, and both legal and illegal markets have changed. These are but a few of the confounding factors in the study area. Many of these changes, such as improvements in local transportation, are taken to be part and parcel to frontier development, just as a growing population is, so knowledge of their impact on farm fragmentation is of interest. Others, such as the intensification of drug smuggling through the area, are much more idiosyncratic. Though probably not generalizable (that is, negatively impacting external validity), these types of idiosyncratic occurrences still contribute to interesting land use outcomes. Therefore, how are these

possible responses enabled or constrained by the context in which they are made? Employing a multiphasic framework acknowledges that there are multiple possible responses and that a household can undertake any possible combination of them. Likewise, it acknowledges that the responses exhibited are also a function of the environment in which they are made.

Methods

Map 2: Detail of the Sierra del Lacandón National Park and the eight subject communities



In 1998, selected eight communities as a clustered probability sample of the communities with households located within the park boundaries. In these eight communities, Dr. Carr interviewed 247 randomly chosen households using survey instruments comprised of questions on migration and land use that incorporated demographic (e.g., household size and composition, fertility, and migration), political-economic (e.g., government subsidies, road-building, land titling practices), socio-economic (e.g., household assets, household characteristics previous to migrating, ethnicity, knowledge and attitudes about conservation, farm location, size of farm, land management, and off-farm employment) and ecological (e.g., farm topography and soil) factors. Household surveys were fixed-format with a few short open-ended questions per subsection. Of these 247 households, 241 qualified for inclusion in his land use modeling efforts (Carr 2002), with six households not included in the land use modeling because they neither "owned" nor rented land for farming purposes. My goal upon return to the area in 2008/2009 was to follow up with all 247 households and, of the 186 who were land "owners", follow up at the unit of the land parcel as well, interviewing all new owners of the land. Additionally, so that the sample would be representative of the current population residing in the eight communities, I also intended to select a number

of households randomly for interviewing. I collected, therefore, data on three distinct but overlapping samples of households (see also Table 1):

Sample 1: Follow up on the 247 households interviewed in eight communities in 1998, regardless of their current location.

Sample 2: Follow up on the 186 "owned" land parcels of the 1998 interviewees, including 1998 interviewees who kept at least a portion of their 1998 landholdings plus all new, current owners of those 1998 landholdings.

Sample 3: A randomly selected, representative sample of households currently living in the eight communities. This sample is comprised of a portion of randomly selected households, as well as a randomly selected subset of those in sample 1 and sample 2 whose household is currently residing in the communities of interest.

Sample one

After several months of rapprochement with community leaders, followed by public assemblies in which I explained the purpose and methodology of the survey to community members, I spent several weeks piecing together the presence or absence of households previously interviewed in 1998 with community leaders. If a household was no longer available in the same community, I sought someone familiar with the household to interview about the departed household, preferably a relative. In several cases I arranged interviews with departed 1998 subjects in their new location. As shown in Table 1 below, of the 247 household heads interviewed in 1998, follow ups were done with 244 households, either with the subjects themselves or someone familiar with the household if the household was no longer present, though full interviews were not administered in all cases (details to follow).

Sample two

This phase of following up with the 1998 interviewees was succeeded by following up at the level of the land parcel unit. If a household had claimed to be land "owners" in their 1998 interview, I determined either with the household or with people familiar with the household whether or not they had sold all or a portion of their 1998 land, as well as who is/are the current owner/s. The current owner/s were then interviewed, or someone familiar with the current owner if they were not present in the community, totaling to 86 additional interviews with current owners or representatives of current owners. These 86 new current owners are in addition to the original 1998 interviewees who kept at least a portion of their 1998 farm parcel, discussed below, or the original 1998 interviewees who coincidentally bought a portion of another 1998 interviewee's parcel

Sample three

I also randomly selected additional households within those currently residing in the community, in order to construct a sample of those currently present in the community and have it be representative of the current community. Omission of randomly selected households would result in the sample being solely comprised of those households either previously interviewed or the current owners of the land of those previously interviewed. Details describing the construction of the "current present" sample to follow. In all categories of interest mentioned above, we also administered a

separate interview to the female partner in the household, when present. As detailed in Table 1, we therefore cumulatively conducted 822 interviews or follow-ups with 822 people in 481 households (HH).

Table 1: Total number of interviewees per category of interest in eight communities

Community	Followed up 1998 Households (indicates total number interviewed in 1998)	Current owners of 1998 farm parcels	Randomly selected	Female partners of any of the preceeding categories	Total HHs	Total people
Retalteco	33 (33)	15	21	58	69	127
Poza Azul	24 (24)	14	15	38	53	91
La Lucha	22 (22)	9	21	38	52	90
Lagunitas	33 (36)	13	21	48	67	115
Nueva Jerusalén II	36 (36)	8	9	34	53	87
Kilómetro 107	42 (42)	8	28	54	78	132
Kilómetro 75	21 (21)	11	15	34	47	81
Manantial	33 (33)	8	21	37	62	99
Total	**244 (247)**	**86**	**151**	**341**	**481**	**822**

Details on Sample 1: Follow up on the 247 households interviewed in eight communities in 1998, regardless of their current location.

The first sample of interest was the 247 households interviewed in 1998 by Dr. Carr's team of interviewers. All of these households had migrated to the agricultural frontier at some point in the proceeding decades, with the maximum being 36 years prior and the average as 10 years prior, with a standard deviation of 6 years. Given that only a tiny proportion of all migrants are classified as rural-frontier, where, therefore, do frontier migrants go when they leave a frontier location? What is the retention of frontier migrants in a particular place? What factors at the household or community level contribute to retention, and which promote further migration? Since panel data is rarely collected in the agricultural frontier, just establishing the presence or absence of households interviewed 11 years prior offers a tremendous opportunity to examine frontier population dynamics. In depth interviews with households who remain in the community, those who left but could be located for an interview in their destination community, or with family members or friends of those who have departed offers a chance to follow the trajectory of frontier migrants and examine its implication in terms of both household wellbeing and ecological/conservation impact. Also, it is a rare example of migration interviews conducted in the migrant sending origin communities; most migration interviews are conducted in destination areas, with preference given to urban and international migration destinations.

Table 2 details the current location of the 1998 interviewee households, and with whom, if anyone, interviews were conducted. Of the 247 households interviewed in 1998, 63% of them still live in the same community, while 9% have moved to a nearby, also frontier, community, for a cumulative total of 72% still living in proximate frontier communities. Santa Elena, the nearest metropolitan area (approx. 2.5 hours distant), and its nearby peri-urban communities, attracted 5% of the 1998 households, while other areas of the same department (similar to a state) of Petén attracted 6% of the migrants,

leading to a total of 84% still living in Petén, whether in an urban or rural community. Guatemala City, and other departments of Guatemala, attracted cumulatively 7% of the migrating families, while the USA attracted 1%. In the case of eleven households, no one knows their current location, while there are six households which no longer exist because no surviving household heads remain. And finally, three of the households interviewed in 1998 could not, eleven years later, be connected with anyone, suggesting perhaps they were short term residents who no one remembers or perhaps they gave false names at the time of the interview, precluding their subsequent identification.

As mentioned above, I always attempted to interview the same household heads in the 2009 interview, but in the case that was impossible, I attempted to contact a family member, friend, or neighbor to ask about the departed household and conduct as full of an interview as possible about the departed household. This was successful to varying degrees, as some relatives had current knowledge of the 1998 interviewees, and/or they had only recently left. The recent proliferation of cell phones and cell towers in the area meant that in a few cases relatives even called the departed households to verify an unknown point. But an interview conducted with someone else, however, means that in many cases there are many questions about the departed 1998 interviewees' current situation, such as the number of children in the household, for example, or the amount of farm land they now possess, which were unanswerable. Please note that in 43 households (18%), the male household head was away, most often working in the USA, and in that case we interviewed the female household head. In the table below, an interview with the female household head in lieu of the male is counted in the "same person" category of interviewee.

Finally, even in the case of no formal interview conducted, I still did manage to piece together small amounts of information, such as information on their land sale, by working backwards from the interviews conducted with those who had purchased said land. Therefore, an interview with the "same person" means (usually) a full interview, an interview with "someone else" can mean almost a full interview or an almost incomplete interview, depending on their knowledge of the household, and "no interview" subjects usually have at least some information available. Only the three "unknown person" households had absolutely no information taken about them.

Table 2: Current (Spring 2009) location of 1998 interviewee households, and who was interviewed on their behalf, if anyone

		Current location of Household											
		Same town	Nearby frontier	Santa Elena or near	Other Peten	Other Guate-mala	Guate-mala City	USA	Unknown location	HH no longer exists	Unknown person	Total	Total %
Interview conducted with:	Same Person	150	5	3	3	1						162	66%
	Someone else	1	18	10	13	14	2	3	7	6		74	30%
	No interview	4							4		3	11	4%
	Total	155	23	13	16	15	2	3	11	6	3	247	
	Total %	63%	9%	5%	6%	6%	1%	1%	4%	2%	1%		

Details on Sample 2: Follow up on the 185 "owned" land parcels of the 1998 interviewees, including 1998 interviewees who kept at least a portion of their 1998 landholdings plus all new current owners of those 1998 landholdings.

The second sample of households examined is those who are the current owners of the 1998 "parcels of interest". Of the 244 households interviewed in 1998, 186 claimed to have been "owner"s of a farm parcel in the area, while the remaining 58 households either rented land from other community members or did no farming on their own behalf, typically working as wage laborers on the farms of others. Although there are several compelling arguments for tracking the frontier households to create a panel data set (which I have also done), following the farm parcel over time also carries many theoretical advantages. In creating a panel data set which tracks the evolution of the frontier and its changes in land cover over time, the data cannot be attached to the shifting cast of characters which come and go in the frontier but instead must follow that which does not move, the land itself. This choice of unit, the parcel vs. the household, is supported by research which posits (though has not, as of yet, conclusively shown), that a more dominant process in shaping land use in a frontier may not be the oft studied *household* lifecycle, but might instead be more strongly determined by the *plot* lifecycle. Attempts to tease out the effects of plot vs. household lifecycle are still in its incipient phase (Barbieri, Bilsborrow et al. 2005; VanWey, D'Antona et al. 2007).

In order to track the farm parcels of interest from 1998, therefore, first I had to confirm that the 1998 interviewees who had claimed to own land in 1998 had in fact owned the land, and then determine if they had sold some or all of their 1998 farm parcel. I use the term "sold", but in fact there were many mechanisms by which farm land changed hands in the communities, including inheriting it to a family member, abandoning the land, or having the land involuntarily taken. Regardless of the mechanism, if a 1998 interviewee landowner had sold some or all of their 1998 parcel, I then located the new owner of the purchased portion of the land, or a representative if the new owner was not present, as was the case in several instances. The breakdown of the composition of the total sample of 2009 current owners of the 1998 parcels is shown in Table 3. Of the 186 households who, in 2009, confirmed that they had been 1998 land owners (several had claimed to own land in 1998 who were, for example, anticipating receiving land which they in fact never received), half (97 households) sold at least a portion of their 1998 parcel, while 101 households retained at least a portion of their 1998 parcel. As noted in Table 1 above, 86 new households were interviewed as the new current owners of the 1998 parcels, although the total sample of those interviewed as new owners is 89 households, as shown in Table 3. This is because several of the 1998 interviewees (12 households) were, coincidentally, the purchasers of land subsequently sold by their 1998 fellow interviewees, 3 of whom were not continuing owners of their own 1998 land parcels and therefore appear uniquely as a current 1998 landowner through their purchase from a different 1998 interviewee. . The total number of households comprised in the sample of 2009 current owners of a 1998 parcel, therefore, is the 101 households who kept at least a portion of the 1998 parcel, and the 89 households who purchased at least part of a 1998 parcel, totaling to 190 households in the sample.

Table 3: Sample of current owners of 1998 parcels of interest

	1998 households who were 1998 land "owner"s	Number of 1998 land "owner"s who "sold" some or all of land	land "owner"s who kept at least part of 1998 land	Number interviewed about purchase of 1998 parcels of interest (includes some	Total current owners of 1998 parcels of interest
Retalteco	18	11	12	16	28
Poza Azul	21	12	9	15	24
La Lucha	20	8	12	9	21
Lagunitas	27	12	17	13	30
Nueva Jerusalén II	33	13	20	8	28
Kilómetro 107	34	17	18	8	26
Kilómetro 75	16	12	9	11	20
Manantial	17	12	5	9	14
Totals	186	97	101	89	190

Details on Sample 3: A randomly selected, representative sample of households currently living in the eight communities

In order to make comparisons between the frontier population and land use of 1998 and the same place eleven years later, it is imperative to have a random sample of households which currently reside in the same eight communities. To this end, in every community I always selected a number of households randomly, the number of households selected dependent on the overall number of households in the community. However, omitting completely from selection those households from the 1998 sample which were reinterviewed, or those who were the new current owners of 1998 land parcels, would have comprised almost as much bias as selecting only from within these two groups. I therefore constructed a pool of "less random" households, consisting of reinterviewed 1998 households who still live in the same community and the new current owners of the 1998 land parcels, and randomly selected from within that population. This was then combined with the households who I selected randomly in 2009, to form a random sampling of households which currently live in the eight communities. Table 4 lays out the exact numbers which go into the final sample of the 278 households which form the 2009 random sample. Of the 244 households from 1998 which were followed-up on, 151 currently live in the communities and were successfully interviewed. Of the 86 households interviewed uniquely as current owners of the1998 land parcels (that is to say, not also reinterviewed as a 1998 interviewee who also happened to have coincidentally bought land from another 1998 interviewee), 61 actually currently live in one of the communities. Of this total pool of 212 "less random" households, 128 households (60%) were selected for inclusion in the final pool of random households, in combination with the 150 households which were chosen completely randomly. Ultimately, the completely randomly chosen households comprised 54% of the random sampling of the 2009 population.

Table 4: Composition of households comprising Sample 3, a randomly selected, representative sample of households currently living in the eight communities

	"Less randoms" 2009		"Randoms" 2009		Subset of "Less Randoms" 2009		Total sample	
Community	Reinterviewed 1998 HHs who live in community	Buyers of 1998 parcels who live in community	Randomly chosen 2009 HHs	Total 2009 interviewees who currently live in the communities	Number	%	Number	% of whom are "Randoms" 2009
Retalteco	23	14	21	58	21	57%	42	50%
Poza Azul	18	11	15	44	15	52%	30	50%
La Lucha	14	6	21	41	16	80%	37	57%
Lagunitas	22	11	20	53	21	64%	41	49%
Nueva Jerusalén II	20	4	9	33	16	67%	25	36%
Kilómetro 107	28	4	28	60	16	50%	44	64%
Kilómetro 75	15	7	15	37	14	64%	29	52%
Manantial	11	4	21	36	9	60%	30	70%
Total	151	61	150	362	128	60%	278	54%

Surveys and interviews

Survey instruments were developed using as a template those employed by Dr. David Carr in the same communities in 1998 (Carr 2002), which were then modified by myself to address the theoretical points pertinent to the multiphasic model, described above. Similar to Dr. Carr's surveys, mine were a mix of demographic, political-economic, socio-economic, and ecological factors, with particular attention paid to land use and farming techniques. The most striking difference between the survey used by Dr. Carr and myself is mine contains a section on out-migration from the household. As the multiphasic model seeks to examine how people cope with rising population density in an area with fixed land availability, out-migration strategies figure prominently into this response. Even if the nucleus of the household stays in the same community (as in approximately 60% of the 244 households from 1998), where does the next generation go to support themselves, how do they earn their living, do they acquire land in their destination, and do they send support back to their parental household? All these factors carry potentially significant ramifications for the wellbeing of the individuals and families involved, as well as the potential ecological impact in both the migrant sending and receiving areas.

To help me with the interviews I hired six Peteneros (three men, three women, all originally from the department of Petén) from the urban and periurban areas near Santa Elena who were recommended to me by contacts and who had studied at least through secondary school. The interviewers received an extensive training on how to conduct interviews, on the meaning and significance of the interview questions, and on privacy and confidentiality. The six interviewers accompanied me on four months of field work from January through April of 2009, conducting household interviews in 16 communities (the eight communities for this study, plus eight additional communities requested by the local NGO facilitating my fieldwork, Defensores de la Naturaleza). Of the 712 interviews performed with or about households in the 16 communities, I personally performed only 34 of the interviews, all but three of them about households which had departed from their respective community and about whom only the barest of information was available. I decided that interviews performed by fellow Peteneros would yield more consistent results.

After I had selected my target households for interviewing, a local community member served as my guide in each community and accompanied me to visit the

households I wished to interview. I met briefly with each household I wished to interview in order to explain further the purpose of the interview, clarify that their participation was voluntary, determine if a Q'eqchi'-Spanish translator would be required, and to set a day and time for the interview. At the appointed time, one of my six interviewers arrived at the house with the local guide, and when necessary, a locally hired translator. The guide then left to drop off the next interviewer at the next appointment. Each interview lasted approximately an hour to two hours, usually depending on the loquacity of the interviewee. The interviewers were primed prior to the interview exactly which sample category/ies their interviewee fell into (1 and/or 2, or 3, detailed above), and therefore knew which sections of the interview to include or omit. A household which is the current owner of a 1998 farm parcel (sample 2), for example, does not need to be asked about a sale of a 1998 land parcel, but they do need to be asked about the purchase of a 1998 land parcel. Upon completion of each interview, the interviewer checked the survey instrument for completeness, followed by a check performed by myself, followed by corrections done by the interviewer, and if necessary, facts verified with the interviewee.

Results:

In order to first comment on the maturation of the agricultural frontier, I shall present comparisons of the 244 households in eight communities randomly chosen by Dr. Carr in 1998 and the 2009 random population of 278 households in the same eight communities chosen by myself (Sample 3, detailed above). Demographic, socio-economic, and information on agriculture will be presented in tabular form. This will be followed later by an examination specific to the 244 households from 1998 on their livelihood strategies for the next generation.

Comparison of 1998 and 2009 representative populations

Estimated population

Overall, the population in the eight communities has grown by an estimated 55% (Table 5), from approximately 7,324 to 11,353 individuals. Of the eight communities, the largest growth in terms of absolute numbers was in the already relatively large community of Kilómetro 107, named for the now obsolete schema of marking distance on the highway to the municipal capital of La Libertad. This roadside community (Map 2) grew by 1,934 people, an 86% increase over its 1998 population. The largest relative growth took place in a community located within the park's interior, Poza Azul, which grew 211% of its 1998 population size. Although the overall trend was towards growth, a few communities did decrease in population, namely the buffer zone community El Manantial (-49%), Nueva Jerusalén II (-8%), and Lagunitas (-12%). Theories positing an explanation to this counter trend will be put forth below. The overall trend towards population increase, however, makes this area an apt application of multiphasic modeling.

Table 5: Estimated population in the eight communities, 1998 and 2009, and absolute and relative change between the two dates

	Estimated population^			
	1998	2009	Change in population	Percent change
Retalteco	818	2347	1529	187%
Poza Azul	394	1225	831	211%
La Lucha	277	465	188	68%
Lagunitas	2144	1888	-256	-12%
Nueva Jerusalén II	527	486	-41	-8%
Kilómetro 107	2250	4184	1934	86%
Kilómetro 75	281	434	153	55%
Manantial	633	324	-309	-49%
Total	7,324	11,353	4029	55%

^Number of individuals in the community estimated by multiplying average household size as calculated from the data by the number of households in the community as provided by community leaders

In-migration

The SLNP communities are comprised almost exclusively of families which migrated to the area from more southerly areas of Guatemala, consistent with findings that the more important component of frontier population growth comes from in-migration, not natural population increase, despite unusually high fertility rates amongst frontier populations in general and in the frontier region of the Petén in particular. Of the 244 randomly selected households interviewed in 1998, not one was headed by an individual who had been born in the current community; almost three quarters of the household heads originated in the Southeast or Pacific Littoral regions of Guatemala, with the remaining ~30% evenly distributed among the Highlands, the Verapaces, or elsewhere in Petén (Carr 2002). The average year of arrival amongst the 1998 sample was 1989, with the median year of arrival 1990. This is significantly different ($p < 0.01$) than the average year of arrival of the randomly selected population (sample 3) of 2009, which is 1993. Of the 278 households selected for interviews, only one household head was born in the same community of their current residence. In both interview periods, the most recent arrivals had arrived the very year of the interviews, with the latest household to arrive in my 2009 sample arriving only two weeks prior to the interview.

Table 6: Statistics on year of arrival of the 1998 and 2009 (sample 3) randomly selected households

	Year of Arrival in Community*	
	Interview Population 1998	Interview Population 2009
Average year of arrival	1989	1993
Std Dev (years)	6.0	8.5
Median year of arrival	1990	1993
Earliest year of arrival	1962	1962
Latest year of arrival	1998	2009

*significant at $p < 0.01$

Household characteristics

The number of individuals typically comprising a household did not differ significantly between the two periods (Table 7), with the average number of members per household for 1998 and 2009 at 6.5 and 6.3 individuals respectively. This is despite the fact that the average ages of the male and female household heads have significantly increased in the intervening eleven years (Table 8). Male and female household heads both increased in age by average of around six years, presumably time in which additional births could increase the average household size. The role of out-migration from the household in maintaining a similar household size is discussed below. Counter intuitively to what one might expect in a developing frontier, there was no change in the sex ratio of the area, with slightly more males than females present at both sampling periods. A frontier environment such as this location is typically characterized by a ratio > 1, meaning more males than females, but with the discrepancy between the sexes evening out as the frontier matures. This frontier, though definitely showing signs of becoming a more developed environment in many areas (infrastructure, for example), may still be too young to show maturation in this regard.

Table 7: Statistics on household size between the two sampling periods

	Household Size	
	1998	2009
Average	6.5	6.3
St Dev	3.1	2.7
Median	6	6
Minimum	2	1
Maximum	16	15

Table 8: Average age of household heads

Average ages of household heads (St dev)*			
1998		2009	
Male household head	Female household head	Male household head	Female household head
40.4 (13.6)	34.6 (12.3)	46.8 (14.0)	40.7 (13.6)

* Difference between sample periods significant at the p < 0.001 level

Table 9: Sex ratio

Sex ratio	
1998	2009
1.13	1.13

Ethnicity and Religion

Overall, the communities have not shown a great shift in their ethnic composition (Table 10), with the vast majority of the population overall still of Ladino (mixed indigenous and European descent) in both time periods, followed by several Mayan ethnicities, with the highest proportion of these being Q'eqchi Mayan. There has been a significant shift in the religions professed by the population between the two time periods, with most of the change coming from a shift between the "None" category in 1998 to the Evangelical category in 2009. This may be evidence of one area of infrastructure development in the area, namely the building of Evangelical places of worship welcoming those who previously had no spiritual home. Although nation wide Evangelical religions are enjoying increasing numbers of worshipers, usually that comes at the expense of the number of Catholic worshippers. In this instance, however, the

number of households who profess Catholicism has not changed as dramatically as the shift from no religion to Evangelical.

Table 10: Ethnicity

	Ethnicity	
	1998	2009
Ladino	74%	70%
Q'eqchi	14%	17%
Qiche	2%	5%
Mam	3%	2%
Other	6%	5%

Table 11: Religion

	Religion*	
	1998	2009
Catholic	49%	45%
Evangelical	27%	41%
None	24%	14%

*significant at $p < 0.01$

Employment and sources of income

Although far and away the vast majority of male household heads in both time periods work as agriculturalists (Table 12), there has been a small but certain shift towards other means of earning their livelihood. The number of household heads employed in business, for example, or who self identify as ranchers has increased, as has those employed in means too disperse to form their own category ("Other"), but which include a teacher, a security guard, and bricklayers.

As in 1998, most farmers in 2009 farm primarily corn, with the goal of providing sustenance for the household and selling what remains for cash income. As shown in Table 13, the amount of corn produced on average has gone down significantly, from 230 *quintales* (23,000 lbs or 10,454 kg) in the previous year to 179 (17,900 lbs or 8,136 kg) *quintales.* Whether this reduction in quantity produced can be attributed to declining soil fertility, a shift into other livelihoods, or a shift into emphasizing other crops shall be explored in future publications. As the sale of surplus corn has historically been the main cash income source in the area, at first glace this reduction in average production suggests dwindling household income as well.

Table 12: Primary employment of male household heads

	Primary Employment				
	Farmer	Business	Rancher	Day laboror	Other
1998	96.4%	0.8%	0%	0%	2.8%
2009	88.4%	2.5%	3.2%	1.1%	4.7%

Table 13: Total maize production the previous year, in *quintales*, hundred pound weights

Average Total Production previous year (St Dev)*	
100 lb. weights of maiz	
1998	2009
230 (239)	179 (225)

* Difference significant at the $p < 0.05$ level

In contrast to the decline in corn production between the two periods, Table 14 demonstrates that in 2009 substantially more households own cattle than did so in 1998, with the percentage of households with cattle more than doubling from 11% to 26%. The

average number of heads of cattle per household in 1998 was 1, while by 2009 it had grown significantly to 5.4 heads per household. Though households may now be earning less from corn sales, some may have compensated by the production of livestock, either for sale and/or for household consumption. Interestingly, the maximum number of heads of cattle owned by a household has increased practically nine-fold, from 35 to 300. Amongst those with the highest number of heads of cattle included in the 2009 random sample, many of them were the same sort of "humble beginnings" frontier farmers typical of the area, and not extensive cattlemen buying up already cleared land, as posited in "vicious cycle" theory of frontier settlement. However, there were some buyers of the 1998 interviewee parcels typical of the latter pattern, though they were more likely to be difficult to successfully interview.

Another area in which one can see a possible increase in household income is in the amount of time household heads engaged in off-farm work for wage income in the previous year (Table 15). Although there was a slight decrease in the proportion of household heads working off-farm (43% to 41%), the average number of weeks worked off-farm doubled.

Table 14: Household cattle ownership

	Cattle ownership	
	1998	2009
Proportion of households with cattle	11%	26%
Average number heads of cattle (St Dev)*	1.0 (4.1)	5.4 (22.5)
Maximum number heads	35	300
* Difference significant at the p < 0.01 level		

Table 15: Off-farm employment for wage income

	Worked off-farm the previous year		
	Yes	Average # weeks worked*	St Dev
1998	43%	7.2	11.8
2009	41%	14.7	15.4
*Difference significant at p < 0.01			

Finally, to end the discussion on changes in household employment and income, we turn to remittance incomes currently sent to the household, regardless of the destination, followed by special attention paid to migrants sending income from the USA. Throughout much of the developing world remittances sent home from migrants abroad can be an important source of household income. In Guatemala, remittance income accounted for 10.1% of the 2006 GDP (IFAD 2007). Despite the importance of remittance income at the national level, in these frontier communities of the SLNP remittance income was of negligible interest in 1998, with no households heads sending income at the time of the interview, and only 5.7% (14 total) household heads reporting ever having been to the USA. In the intervening eleven years, the importance of remittance income incomes has risen dramatically, with 26% of households receiving remittances regardless of destination, and 22% receiving remittances specifically from migrants to the USA. In both cases, remittances were sent either by a household head or

by another family member who had out-migrated from the household. Amongst the households receiving remittances, many received income from more than one sender, with an average of 1.4 senders per receiving household regardless of destination, and 1.5 per receiving household amongst those sending from the USA.

Table 16: Current remittance incomes; all destinations and USA

	Households receiving remittance income			
	All destinations (including USA)		USA only	
	Percent of families receiving remittances	Number of remittance senders per family receiving	Percent of families receiving remittances	Number of remittance senders per family receiving
2009	26%	1.4	22%	1.5

Land claims

The vast majority of households interviewed in 1998 stated that their reason for coming to the area was related to land, citing their desire for more land (68%), better quality land (8%), or land they could own (5%) (Carr 2002). In origin areas, even good quality, affordable rental land is often difficult to encounter. The sample of 2009 interviewees showed the same theme motivating the vast majority of migrants to seek the frontier. This begs the question of whether frontier migrants actually achieve their goal of possessing land in the frontier, be it as legal owners of private property, squatters, somewhere in the privatization process, or as renters. Table 17 shows the percentages of households in 1998 and in 2009 which possess land, and the average amount the households possess, regardless of classification of ownership or rental. There has been a slight decrease in the number of households which do no farming for themselves. This could be due to rising difficulty in finding land to rent in some park communities, particularly in areas which have been given over largely to pasture; it could also be attributed to the slight increase in household heads working at occupations other than subsistence farming, including those living abroad and sending home remittances. When considering only the households who possess some amount of land and averaging land area over this group, there is a slight but not significant decrease in the amount of area a household possesses, be it rental land or "owned" land, going from 35 to 30 hectares in the intervening eleven years. When considering the entire population, however, regardless of whether or not they have access to farm land, there is a significant decrease in the average farm area per household, from 34 to 28 hectares, between the two time periods. Later examination of the land transactions which took place with those original 1998 interviewees and their "owned" parcels may help elucidate the process of diminishing parcel size.

Table 17: Percentage of households who possess land (whether "owned" or rented), average amount of land in possession of households *with* land, and average for all households, including those with no land

1998			2009		
% HH w/ land	Average land (Ha) for HH w/ land (St Dev)	Average land (Ha) for all HHs (St Dev)*	% HH w/ land	Average land (Ha) for HH w/ land (St Dev)	Average land (Ha) for all HHs (St Dev)*
97%	35 (22)	34 (23)	95%	30 (33)	28 (33)
*Difference significant at the p < 0.05 level					

Although there has only been a slight decrease in the number of households with access to any land (Table 17), there was a two-fold increase in the percentage of total households in 2009 which do not "own" land (Table 18), meaning they either have access to no land at all or they only rent land (households which rent land in addition to "owned" land are not included here). The breakdown of this statistic amongst the individual communities seems of particular interest here, given the earlier estimate (Table 5) that despite overall trends towards a population increase of over 50%, one community stood out for having *lost* almost 50% of its 1998 population, El Manantial. Table 18 shows that the same community already stood out in 1998 for having an exceptional number of renting or landless households (39%), and remains exceptional in 2009 (63%). Future work will examine the effect landlessness has in fomenting outmigration from frontier communities.

Table 18: Comparing land for 1998 interviewees and 2009 current present interviewees

	No land or rental land only*	
Community	**1998^**	**2009**
Retalteco	24%	38%
Poza Azul	13%	20%
La Lucha	0%	24%
Lagunitas	15%	39%
Nueva Jerusalén II	0%	8%
Kilómetro 107	14%	41%
Kilómetro 75	14%	34%
Manantial	39%	63%
Grand Total	16%	35%

*significant at p < 0.01

^ from 1998 data, does not include amendments made while collecting 2009 data

Agricultural techniques

As mentioned in the earlier discussion of the multiphasic theory, agricultural intensification counts as one of the possible responses to increased population density on the fixed resource of farm land. Table 19 shows data on some different intensification techniques, the use of agricultural inputs (fertilizers, pesticides, herbicides) and the application of additional labor via the planting of the nitrogen-fixing legume velvet bean (*Mucuna pruriens)*. The use of purchased inputs has risen dramatically, with purchased pesticide use rising fifteen-fold, and herbicide use doubling. At the same time, the use of the more labor intensive technique, velvet bean, has dropped to almost one-quarter of its 1998 use. The elevated use of purchased inputs may point to diminishing soil quality after multiple farming cycles and/or increased connectivity of these remote communities, facilitating access to purchase points of these products. The reduction in use of the velvet bean may be in response to the availability of other, more labor saving techniques (the purchased inputs) and/or the dearth of NGOs in the area actively promoting their use, in contrast to the 1998 period.

Table 19: Percent of households which use agricultural intensification techniques

	Use of Agricultural Inputs*	
	1998	2009
Purchased fertilizers	7%	20%
Pesticides	2%	31%
Herbicides	42%	83%
Velvet bean (green manure)	37%	10%
*significant at p < 0.01		

Credit

The lack of readily available credit to the peasant farmer has often been cited as a hindrance to their investing in more sustainable agricultural techniques, which usually require some capital outlay. Credit remains in short supply overall to farmers in these communities, having not risen when one compares only the previous year. However, when one examines the previous five years, credit, while still touching only a small portion of households, does suggest a higher penetration in the population. I hypothesize that the 1998 interviewees who received credit may see a significant difference in their retention of the original land claim, either because they were able to invest in their land, or conversely, they may have sold their land at a higher rate to pay off debts.

Table 20: Percent of households which received credit in the previous year or five years

1998	2009	
Previous year	Previous year	Previous 5 years
5%	5%	14%

Succession of land parcels from 1998 interviewees

Multiphasic theory posits that land will be redistributed to accommodate rising numbers of households. The number of distinct land owners found in a given area can have a profound influence on land cover of the land, which may in turn influence the household well-being. Patterns seen elsewhere in Guatemala, where the majority of small farmers have plots below the subsistence level, is one of the motives what originally spurred migration to this agricultural frontier. Is this process being replicated again in the new agricultural frontier? Tracking the succession of land ownership in this developing frontier and documenting how land changes hands from original peasant settlers to new owners, therefore, may be revelatory of the mechanisms which have resulted in land owning inequalities in other areas of Guatemala. What follows is a study tracking the land transactions of the farm parcels "owned" by the 1998 interviewees (regardless of regularization status of the land).

Land "owned" in 1998 and subsequent transactions

Of the 244 households interviewed in 1998 (Table 21a), 186 households (76%) "owned" a quantity of agricultural land, meaning either with legal property title, informal squatters' rights, or at some stage of the process in between (e.g. land had been surveyed). Almost one-quarter of the sample (58 households) did not own any land, meaning they either rented or did not have any access to land. The figure quoted in Table 21a (24% of households) differs from that quoted in Table 18 (16% of households) because Table 21a has the amended figures, corrected in retrospect by the 1998 "owner" or family during their 2009 interview. Several 1998 interviewees, for example, never

received the parcel they were anticipating in 1998, or were caretaking the parcel of another family and did now own the land themselves. The 186 confirmed landholdings of the 1998 interviewees, therefore, are the parcels of interest and shall be followed through the possible transactions which would bring them under the management of a different household. Of the 186 households who owned land in 1998, almost half (48%) maintained the original parcel intact, selling no portion of it. An almost equal number (45%) sold their entire parcel, sometimes as one unit, sometimes in pieces. A small number (7%) of households maintained part of their parcel and sold a portion of it to another household. Ultimately, the number of land "splinters" created by splitting up parcels in multiple land sales may be extremely important because it results in more households being supported by a given area, possibly overtaxing the environment. Also, it may result in households with land parcels below the minimum size for sustaining a large family typical of the area. Table 21b summarizes the total number of land transactions which took place in the intervening eleven years, with the 97 total households who sold all or a portion of their land engaging in 113 land transactions. The discrepancy between these two figures (16) plus the number of households who sold only a portion of their land (an act which split up the original parcel of 13 households) results in the number of transactions which contribute to the splintering of the original parcels, 29 transactions in total. Although most land transactions had one household as the recipient, a fair number went to multiple persons, such as a father inheriting each of his several children a portion of his land, or brothers pooling money to purchase a parcel. Possibly in these scenarios joint owners will manage the asset together, but just as likely multiple owners will result in further subdivision of the original parcel or subparcel.

Table 21a: Land transactions of parcels "owned" by 1998 interviewees

	Of the 244 interviewees from 1998		Of the total number of 1998 land "owners"		
Community	Not land owners^	Land "owners"	% who sold none	% who sold some	% who sold everything
Retalteco	45%	55%	39%	28%	33%
Poza Azul	13%	88%	43%	0%	57%
La Lucha	9%	91%	60%	0%	40%
Lagunitas	18%	82%	56%	7%	37%
Nueva Jerusalén II	8%	92%	61%	0%	39%
Kilómetro 107	21%	79%	48%	3%	48%
Kilómetro 75	24%	76%	25%	31%	44%
Manantial	48%	52%	29%	0%	71%
Grand Total %	24%	76%	48%	7%	45%
Grand total #	58	186	89	13	84
^ Includes amendments made to 1998 data when collecting data in 2009					

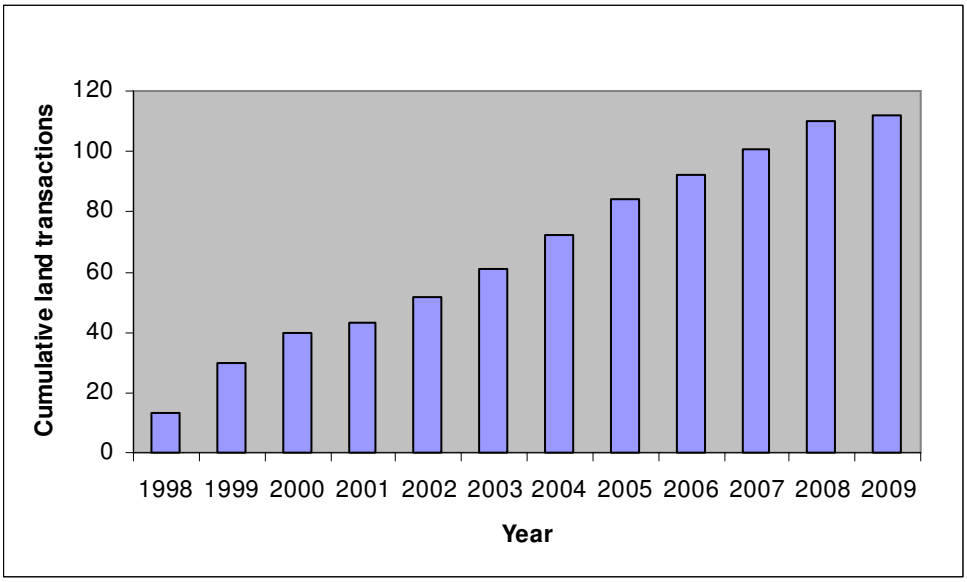
Table 21b: Land transactions of parcels "owned" by 1998 interviewees (continued)

Community	Sum of households who sold all or a portion of their parcel	Total number of land transactions	Number of transactions which result in splitting original parcel	Avg # recipients per land transaction
Retalteco	11	13	7	1.9 (2.7)
Poza Azul	12	14	2	1.5 (1)
La Lucha	8	13	5	1.6 (0.9)
Lagunitas	12	15	5	1.3 (0.5)
Nueva Jerusalén II	13	14	1	1.1 (0.5)
Kilómetro 107	17	17	1	1.3 (0.5)
Kilómetro 75	12	15	8	1.3 (0.9)
Manantial	12	12	0	1.1 (0.3)
Grand total #	97	113	29	1.4 (1.1)
^Does not include one outlier transaction in which a parcel was sold to 28 relocated households				

Year of transaction

Figure 1 shows the cumulative number of land transactions per year from the original interview year of 1998 up till the recent interviews of 2009. Land transactions took place at a relatively constant rate, with no years particularly standing out aside from 1998 to 1999. There does seem to be a pronounced gain between these two years, possibly because of the relocation package offered to the residents of Nueva Jerusalén II at around this time.

Figure 1: Cumulative number of land transactions over time (total 113)



Motives for land transactions

Just as most households were largely motivated to migrate to the agricultural frontier in quest of land, upon attaining land in the area these 97 households which sold all or a portion of their land would require some motivation to do so. Studying these motives could be of great importance to policy-making aimed at staunching the flow of landless migrants into conservation areas. Table 22 details the motives for each of the 113 land transactions, when known. Most motives fall under one of eight categories,

with a few standing out in particular. Selling land in order to pay for medical treatment, for example, is the single most commonly cited motive, suggesting that land acts as an insurance policy or savings account in difficult times. Many sold their land out of a desire to live elsewhere, sometimes returning to their place of origin. In the case of Nueva Jerusalén II, residents were offered a relocation package by a consortium of NGOs and GOs to leave the conservation area for a collective land concession outside of the protected area (which failed after approximately seven years, casting forth landless farmers once more). Buying different land was also a common motive, often in the same community. Another common motive was inheriting land to children or other relatives, often upon retirement, in anticipation of death, or upon death. Several landholders sold or lost their land in a conflict over ownership, either losing it directly to the individuals with whom they were in conflict, or selling it to a third party to relieve themselves of the contentious property. Finally, all totaled, many landowners sold land to pay off a debt, finance a trip to the USA of themselves or a child, or to invest in a business proposition.

Table 22: Motives for land transactions

Community	Buy land elsewhere	Leave location / relocated	Medical needs	Inherit / end of life	Finance trip to USA	Invest else-where	Pay debt	Conflict over land	Other	Un-known	Total
Retalteco	1	1	8	1		1				1	13
Poza Azul	3	2	4	0	4		1				14
La Lucha	1	1	2	3		1	1		1	3	13
Lagunitas	2	4	2	3		1	1	1	1		15
Nueva Jerusalén II	1	6	4	1					1	1	14
Kilómetro 107	1	4	3	0		1	2	3	3		17
Kilómetro 75	2	1	2	4	1		1	3	1		15
Manantial	3		2	2	1			1	1	2	12
Total	14	19	27	14	6	4	6	8	8	7	113
% Total	12%	17%	24%	12%	5%	4%	5%	7%	7%	6%	100%

Table 23 demonstrates that the household's status as a land owner, land seller, and its current location. Of the 244 households interviewed in 1998, there is a significant difference in the current locations of households based on whether they owned no land in 1998 ($p < 0.05$), and whether or not the kept any of the land they owned ($p < 0.01$). The class of people most likely to have remained in the same community is those which owned land in 1998 and still own at least some of the land. Those least likely to have remained in the same community are those who owned land in 1998 and sold all of it. Whether or not they moved as a result of selling their land or if they sold their land in anticipation of a move remains to be seen, though the prevalence of relocation (Table 22) as a motive for land sales suggests the latter.

Table 23: Current (Spring 2009) location by land ownership in 1998 and possible sale

	Same town	Nearby frontier	Santa Elena or near	Other Peten	Other Guate-mala	Guate-mala City	USA	Unknown location	HH no longer exists
All 1998 households	64%	9%	5%	7%	6%	1%	1%	5%	2%
"Owned" land in 1998, sold all*	39%	13%	8%	14%	11%	1%	2%	6%	5%
"Owned" land in 1998, kept some or all*	93%	4%	0%		3%				
No "owned" land in 1998**	47%	14%	10%	7%	5%	2%	2%	10%	3%
* Difference from "All 1998 households" significant at the p < 0.001 leval									
* Difference from "All 1998 households" significant at the p < 0.05 leval									

Conclusion

This paper is presented as an examination of the maturation of the agricultural frontier and also as a case study for the application of multiphasic theory. The intervening eleven years between Carr's 1998 interviews and my 2009 interviews have seen some dramatic and some not so dramatic changes. The population of the area has grown, is significantly older, and comprised of households which arrived more recently. On the other hand the population has not dramatically changed with regards to household size, sex composition, or ethnicity. The same crops are primarily being farmed, and while the use of agricultural inputs has increased substantially, the amount of corn harvested seems to be diminishing. Cattle, however, are on the rise in the area. Most households interviewed in 1998 have remained in the same communities, while a substantial number have moved on to other destinations or even returned to their place of origin. Through all these changes, however, the amount of land available for cultivation has remained a relatively fixed and finite resource. These traits of increasing population density coupled with the fixed resource of land makes this locale apt for an examination of multiphasic theory, meaning that households can respond to this situation with one or more possible reactions, including intensifying their land use, redistributing land, reducing fertility, and/or out-migrating to seek land elsewhere. This paper examined primarily the response of redistributing land, tracking which of the 186 parcels "owned" by interviewees in 1998 were sold and the motives for doing so. The single most common motive for selling land was a family medical crisis (24%) requiring cash, pointing to the vulnerability of the rural poor.

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