DYNAMICS OF LAND USE AMONG MAYA OF SOUTHERN BELIZE

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

UNIVERSITY OF FLORIDA

2007

ACKNOWLEDGMENTS

I would first like to acknowledge the Tropical Conservation and Development (TCD) program for funding my thesis research. I would like to thank my supervisory chair, Rick Stepp, letting me learn on my own and for the confidence that comes with that. I would like to thank the other two members of my committee, Marianne Schmink, who could change the way I think with a few sentences, and Christian Russell, for his constant support. Additionally, I would like to thank everyone at the Land Use and Environmental Change Institute, especially Mark Brenner and Lin Cassidy.

My family and friends played a large role in this journey. I would like to thank my dad, Mike Binford, for being my secret weapon throughout my entire educational career. I would like to thank my mom and step dad, Patty and Mike Altshuler, for their endless positivity and support. I would also like to thank all of my sisters – Katie Altshuler, Elizabeth Altshuler, Katherine Binford, and Erin Lowry – for helping make me who I am today. My friends in Gainesville kept me sane; thank you all. I would like to thank all of the Diamond Dogs, especially Kari MacLaughlin and Jenny Haddle, for reminding me that I wasn't alone. My best friend, Joanna Reilly-Brown, helped me through the hardest parts in the best ways. And last, I would like to thank my boyfriend, Rick Fabiani, for believing in me and keeping me in the present.

I would like to express my gratitude to all the people in Belize who made this research possible. First, Dave and Ellie Buck and their daughter Eliza made my transition to fieldwork practically enjoyable. Sean and Heather Downey and their son Wyatt were always welcoming in Punta Gorda. The Buck and Downey families provided a home away from home and a dose of anthropology whenever I needed it. I would like to give a special thank you to Rosalio Sho and his family. I found wisdom, history, advice, friendship, and sometimes dinner with the Sho family. Finally I would like to thank the farmers and families in the villages of Blue Creek, Aguacate, and Jordan for letting me into their lives despite their reservations.

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Abstract of Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science

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By

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December 2007

Chair: J. Richard Stepp
Major: Anthropology

The purpose of this study is to assess the drivers of land use and land cover change among Mopan and Kekchi Maya in southern Belize. The overall objective is to identify both historical and contemporary links between land use and population movement while also considering the influence of development projects and tenure relations in the area. A mixed-method ethnographic approach was used to collect qualitative and quantitative data from three farming communities in the Toledo District of southern Belize during the period of February-April 2007. The majority of the data was gathered using semi-structured interviews with farming heads of household in the target communities and this social data was combined with land use and land cover information and compared to spatio-temporal datasets of the area. The results of this research illustrate the complexities of human-environment interaction in the tropics. Length of residence does not directly correlate with land use as predicted, but likely with the strength of social networks and access to local resources. Migration in the study area is frequent and occurs over short distances while availability of land is the main factor at work in decision-making regarding relocation. In addition, development projects in the area have dramatically affected land use and land cover change among residents of the three study villages.

CHAPTER 1
INTRODUCTION

Statement of Problem

Most rural populations in developing countries rely overwhelmingly on local environments for subsistence (Mamo et al. 2007; Scherr 2003). This means a dependence on natural resources such as fertile soil, fresh water, and forest resources. Population pressure on the natural resource base can lower the standard of living and endanger ecological function. These pressures can be relieved by out-migration, but often this means movement to frontier areas where land is cleared for new agriculture and cattle-raising, putting the health of the world's forests at risk. As global resources are exploited and the state of the natural environment changes to one less able to support human livelihoods, it is increasingly important to understand the factors at work in migration and land-use decision-making.

Tropical Central and South America include 46% of the tropical forests worldwide and contain an estimated minimum of 40% of the world's tropical plant and animal species (Gallopin and Winograd 1995). Forests cover nearly 85% of Belize; a majority of these forests, found in central and southern Belize, are considered moist tropical forests (World Bank 1996). Worldwide, tropical forests act as reservoirs for biodiversity and play an important role in soil conservation and climate change. They also serve as a source for wood, medicinal plants, and other non-timber products (Levasseur and Olivier 2000). For these reasons, deforestation and environmental degradation are increasingly subjects for institutional concern around the globe. The largest threat to these forests is expansion of agriculture and pastures; about 13 million hectares of forest are cleared each year for these purposes (FAO 2006). The availability for land that can be used for food production, both commercially and for subsistence, decreases with the increase of population density and natural resource overuse (Barbier and Burgess 1997).

At the same time, these environmental concerns give rise to another global issue-that of international and internal migration. Conservative estimates indicate that there were 185 million migrants worldwide in 2004 (McKinley 2005), approximately 3 percent of the world's population, and that number increased to 191 million in 2005 (United Nations 2006), but these estimates are lacking in context. Migration can be a temporary outlet for population pressure, but often it only creates new population pressures and new environmental degradation in regions of in-migration. Meaningful analysis of migration-environment linkages requires detailed research on the motivations for migration and a greater understanding of the temporal and spatial complexity of migration patterns (Locke et al. 2000).

Migration dynamics are determined by demographic, economic, sociocultural and ecological factors (Afolayan 2001). Additionally, differences in land-use strategies may be seen as a result of differences in the influence of these forces and interactions. To address this issue of land use as it relates to migration dynamics, I will examine how people with a history of migration in southern Belize have brought land-use practices to their new environments, and how the origins of people influence their initial land-use decisions. Other influences on land use and land cover change, such as tenure dynamics and the impact of development projects in the area, will also be included. Actual land-cover change data will be incorporated by using satellite remote sensing techniques. The integration of household demographic information and land-cover change data from remote sensing improves our understanding of the processes of land use and land cover changes (Mertens et al. 2000). The country of Belize has experienced unique patterns of migration and development that have dramatically altered the demography of the country (Bolland 1986; Everitt 1984; Woods et al. 1997), and natural environment (Gregory 1984; Howard 1975). Over the last century and a half Mopan and Kekchi peoples have settled in the lowlands of Belize, consequently altering the landscape through subsistence. This research examines land use among Maya in the Toledo District of southern Belize, specifically the relationship between land use and migration.

Research Objectives

Rural populations in the Central American tropics are influenced by social, political, and economic factors when making decisions about land use (Bilsborrow and DeLargy 1990; Cowgill 1962; Klepeis and Turner 2001; Marquette 1998; Shriar 2001). Historical components of migration and their relationship to subsistence have received relatively little scholarly attention. This paper is based on the thesis that cultural traditions and characteristics of an individual derive from the individual's place of origin and the associated physical geography. Physical geography in this case refers to an area's geology, soil characteristics, climate, and hydrology. When displaced persons migrate from areas with specific physical geography to an area with different environmental characteristics, their ideas about land-use may not produce optimal land use decisions in the new setting. This sort of frontier land allocation and use can degrade the natural environment by inappropriate use of soils, water, and other natural resources, resulting in higher rates of deforestation, decrease in soil fertility, and loss of ecosystem maintenance.

This research aims to examine the relationship between migration and deforestation via land use among the Maya of southern Belize. Rural migration has been shown to have significant impact on the environment in developing countries (Bilsborrow and DeLargy 1990). For example, according to Pichon (1997), "Colonists who have recently settled in the Amazon...bring to the region agricultural practices they are familiar with in their places of origin but which may be poorly adapted to the intricacies of rain forest ecology (p. 69)." A deeper understanding of the link between migration and land use will supplement current knowledge of frontier encroachment and the associated environmental degradation, as well as sociocultural knowledge of resettlement and livelihood of rural peoples.

The goal of this research is to study the effect of geographic heritage on the land-use decisions of Mopan and Kekchi migrants who now reside in the lowlands of Belize. Geographic heritage is used here for convenience to encompass all attributes associated with subsistence livelihoods and population movement, specifically an individual's origin area before migration, the physical geography and climate of that area, and practices of land use that are appropriate for that area. The research was initially motivated by the following questions: 1) Does length of residence affect land use among rural Maya farmers in southern Belize? 2) Does geographic heritage influence an individual's success through land use? 3) Do length of residence and place of origin correlate with environmental degradation, specifically deforestation, caused by subsistence practices?

In addition to the aforementioned questions, this study aims to compare spatial data with ethnographic data to help determine causality of land use and land cover change. Can differences in land use be attributed to migratory patterns and histories, and how does the spatial movement of families in the study area relate to land use and land cover change? Are land use practices utilized by rural peoples in southern Belize different than tropical subsistence patterns across Central and South America, and what might these differences mean? Lastly, what is the relevance of remotely-sensed data analysis in the absence of ethnographic on-the-ground data, when land cover is an expression of land use?

Contribution to Science

This research aims to inform the realm of human-environment interaction studies within the context of land use at the individual and community scales. There are several main intellectual merits of this research that should be mentioned. First, it will provide a comprehensive survey of indigenous land use in an area where such a study has not yet been undertaken, while providing demographic data about migration in an area where population flux has not been sufficiently evaluated. While research involving immigration dynamics may be prevalent, our understanding of the consequences of migration, particularly environmental consequences, is often lacking or inadequate (Afolayan 2001). Similarly, most migration studies focus on rural-urban movement and research on rural-rural migration has been relatively minimal. Secondly, the results will contribute to the growing body of literature on conservation of Central American tropical forests, as well as to the field of indigenous studies. Conservation efforts in areas of population flux benefit from incorporating an understanding of the likely land-use practices of immigrants in order to work with newly settled people to make their practices more appropriate for the new environment. Third, this research will highlight the need for interdisciplinary collaboration and the need to develop coherent methodologies that address land-use and land-cover change within the social sciences. The issues at hand integrate aspects of the fields of anthropology, ecology, and geography. Finally, this study will inform the issue of rural-to-rural migration and its associated environmental degradation. Changes in land use and land cover take place during the interaction between natural and human forces and are a major source of environmental degradation (van der Veen and Otter 2001).

The implications of this study have the potential to be far-reaching. Information about the complex effects of immigration and emigration on subsistence and livelihood can aid in policy decisions regarding resettlement programs (Oberai 1988). A significant portion of migration is rural-rural, and it is this migration flow that is directly linked to global deforestation (Carr 2004). Because governments of developing countries are increasingly attentive to the environmentally-detrimental affects posed by different forms of farming, this knowledge can also inform the many agricultural aid programs already in place in countries of the tropics.

My research addresses the need to connect demographic factors to human-environment research. The link between migration and frontier deforestation and environmental degradation will be further explored in order to contribute to understanding the current and future implications of settlement and land use. Migration is a prerequisite to frontier forest conversion, thus "the potential for future deforestation lays not where farms already are but where they may yet be (Carr 2004: 603)."

Thesis Overview

This thesis will describe subsistence land use patterns employed by farmers in three villages in southern Belize. Chapter 2 is a review of the literature regarding traditional subsistence and swidden agriculture, migration, and the relationships between the two, as well as some background on the application of remote sensing to such a problem. Chapter 3 provides contextual background for rural southern Belize and the histories of Maya migration and study villages. Chapter 4 explains the methodology used to collect and analyze data, which includes participant observation, semi-structured interviews, and land cover and land use evaluation. Chapter 5 provides the results of this study, including demographic information, land use patterns, migratory movement, and remote sensing data. Chapter 6 discusses the implications of the results and provides suggestions for future research.

CHAPTER 2
LITERATURE REVIEW

Introduction

This chapter will focus on a review of the literature relevant to the context of this study. Land use in the tropics is historically uniquely adapted to the tropical environment and employs different strategies for success. In the study area of this research there has been a significant amount of population movement that has impacted land use strategies for nearly a century. This section will address the theoretical implications of this movement and the connection between migration and tropical land use. It will also examine past theoretical contributions to the use of geographic information systems (GIS) and remote sensing (RS) within anthropology and cultural land use studies.

Livelihoods among the cultural groups in consideration involve a diverse set of strategies to account for uncertainties that may be seasonal, market-based, or due to climatic variation. This means investment in a variety of crops, most of which are used in the household but that can also be taken to market should a surplus be produced. These characteristics of subsistence in the study area are directly linked to land use practices as well as historical and contemporary population movement.

Traditional Land Use

Rural communities in southern Belize are characterized by subsistence-oriented livelihoods. Among the Mopan and Kekchi cultural groups of the region traditional farming is the dominant land-use strategy (Bolland 2003; Wilk 1991). In the Toledo District it is estimated that 80% of farmers are Maya who practice swidden agriculture based on indigenous knowledge (Emch 2003), incorporating the cycling of fields between fallow and diverse crops (Batabyal and Lee 2003). Livelihoods of the rural Maya in this area are based on long-term fallow subsistence in scattered settlements with supplemental household income from harvest of non-timber forest products and external work as laborers (Atran 1993; Woods et al. 1997).

Traditional agriculture of the lowland Maya region typically consists of swidden, or shifting, cultivation characterized by long fallow periods and a rotation of crops. This system of agriculture requires that the area of uncultivated land be several times larger than the area of cultivated land (Carniero 1956). This form of agriculture is considered well-adapted to tropical climates and soils and is easily accessible to farmers because of its low cost (Metzger 2003).

Slash-and-burn agriculture is practiced by more than 250 million people in tropical regions of the world (Metzger 2003). While researchers generally agree on the importance of slash-and-burn agriculture in tropical developing countries, they tend to disagree about the ecological sustainability of this form of cultivation (Batabyal and Lee 2003). Certain shifting slash-and-burn techniques are the traditional Maya mode of subsistence and are based on indigenous knowledge of the dynamics of forest regeneration (Emch 2003). This form of subsistence is believed to be ecologically sustainable in the long term, provided there is ample land and little population pressure. High rates of population growth and increased pressure on land often lead to environmental degradation in the form of deforestation, erosion, or soil depletion. In areas with low population densities, however, swidden agriculture with shifting cultivation has minimal long-term impact on tropical forest (Shriar 2001). Traditional agricultural practices, like those common among the Mopan and Kekchi present practical alternatives to large-scale intensive agriculture that minimize detrimental effects on the environment (Emch 2003). Past research has shown that in many instances, slash-and-burn agriculture is ecologically and economically sustainable in tropical forests (Batabyal and Lee 2003; Emch 2003).

In many areas, farmers are able to exploit the same piece of land for successive years, sometimes for decades. Before each planting, secondary growth is cut with a machete and allowed to dry before it is burned. Between and week and a month after burning farmers will plant the area, newly enriched with nutrients leached from the burned biomass. Those that do not burn will often practice what is termed “slash-and-mulch” agriculture, in which brush is cut and allowed to rot for some time, providing nutrients for the soil and the next round of cultivation. Traditional swidden farming allows for forest regrowth and soil regeneration through nutrient cycling provided by fire, demanding little in the way of outside capital or inputs. In contrast, with little capital, small landholders who practice large-scale intensive agriculture grow to depend on chemical fertilizers once soil nutrients are depleted or else they must move on to more fertile land. This leads to more forest clearing for new agriculture, destroying an already shrinking tropical forest. This agricultural expansion is by far the leading cause of deforestation in the biodiversity-rich tropics (Carr 2004b). Agricultural expansion and deforestation due to immigration have been seen as environmentally damaging and harmful to the biodiversity of the tropics (Geist and Lambin 2002; O'lear 1997).

Length of fallows is one of the most debated issues of swidden agriculture. Boserup (1965) described a natural evolution of subsistence characterized by, among other things, shortening fallow over time which leads to unsustainable yields. Many studies of tropical swidden agriculture have investigated fallow length and production in testing the Boserup’s hypotheses. Longer fallows have been reported in many areas of the neotropics: seven to ten years in southeastern Campeche, Mexico (Abizaid and Coomes 2003); seven years fallow after one year cultivation in Cayo, Belize (Levasseur and Olivier 2000);

Cowgill (1962) found that farmers reported fallows anywhere between two to six years as ideal, but determined that actual rest periods were somewhat longer that those reported. Four years seemed to be the optimal resting period, but in this case in Petén, Guatemala there was no shortage of land at the time (Cowgill 1962). Carter (1969) on the other hand found that Kekchi farmers near Lago Izabal believed that five to six years fallow was ideal but in practice fallow periods were much less.

In Belize land tenure has been a controversial issue since the beginnings of British colonization. Over half of the land area of Belize is still owned by the government but only a small portion is available to residents in the form of lease-to-own plots of land. Purchase prices are determined by a formula that creates higher prices for smaller parcels than for larger parcels (World Bank 1996), further alienating marginalized populations. Most government land is allocated to one of several reservation categories, administered by the Forestry Department.

Between 1935 and 1954 a total of 217,000 acres of land had been declared "Indian Reserves" by the Belizean government (Iyo et al. 2003). There, however, Maya have only usufruct rights to land because it remains under government ownership (IFAD 1998). The lack of land rights security decreases incentives to improve productivity of land and enhance sustainability and also makes it harder for farmers to obtain credit (World Bank 1996). The issue of land tenure for residents of Toledo will be further discussed in chapter 3.

Property rights often dictate access to and distribution of natural resources, yet most research dealing with untenured land users typically deals with common property and open access (Fernandez 2006). Those without private property rights degrade natural resources faster; the same has been shown to occur with a lack of a bequest value for common property rights (Fernandez 2006). This often results from a dominance of short-term unsustainable farming practices. Adding bequest or secure tenure gives incentive for longer-term agricultural decisions (Fernandez 2006). Conventional economic wisdom holds that tenure security results in more sustainable land use, preservation of biodiversity, and less deforestation (Nelson et al. 2001).

There are a variety of land tenure forms in Belize and much of the lands in use do not have legal titles. Freehold land is registered under the "common law" deeds system and is essentially ownership while there various kinds of leases under which land users rent the land from the government (World Bank 1996). Leases are difficult to obtain in Belize because history of ownership of land is required and can only be obtained by means of adjudication, a process that can be lengthy and expensive (Hyde 1991). Indigenous lands are those recognized as reserves and were established in the first half of the 20th century. Under adverse possession laws in Belize, a person may claim property rights after twelve years of occupation on private lands and thirty years on public lands (World Bank 1996).

Migration Theory

In the 1880s, Ravenstein put forward the Laws of Migration, positing that the main causes of migration are economic, most migration is from agricultural areas to urban centers, and that each stream of migration produces a counter-stream (Todaro 1976). This provided a base for the future evolution of migration theory. Lee developed the idea that there are positive and negative characteristics of both the origin and destination of migration, and that in between movements are likely to be influenced by obstacles. To some degree migrant influences can be reduced to "push" and "pull" factors in addition to "intervening obstacles" (Lee 1966). The presence of negative factors of the origin area, for example population pressure and land scarcity, may push out-migration, while positive factors, such as land and job availability, may pull migrants to the destination area. It is essentially perceptions of spatial differences in opportunities that motivate migration (White and Woods 1980). Decisions to move are based on political, economic, and personal circumstances (Carr 2002; Carvajal and Geithman 1976; Dorigo and Tobler 1983).

Theoretical conceptualizations of migration are centered on economic motivations and are generally applied to rural-urban population movements. While much of rural-urban migration theory cannot be directly applied to rural-rural movement, it is still nonetheless important to understand the evolution of migration theory in the social sciences. Little research has focused on rural-rural or rural-frontier migration processes (Carr 2002), especially in the developing world (White and Woods 1980). In the rural tropics, the largest factor influencing migration is land since agriculturalists represent the largest demographic group. This can come in the form of a push: people leaving overcrowded or deforested areas or degraded soils; or a pull: families moving towards the promise of available fertile land.

Population pressure has been cited as a factor behind out-migration to the frontier in many areas of the Central and South American tropics (Barbier et al. 1997; Bilsborrow 1987, 2002; Carr 2004b; Carvajal and Geithman 1976; Marquette 1998; Moran et al. 1994; Perz 2001; Pichón 1996). In each of these cases population pressure operates as a push factor in origin areas along with influences such as land and employment scarcity while low population pressure acted as a pull to the frontier (Oberai 1988).

While individual characteristics and their influence on decisions to migrate have been thoroughly examined in past literature (eg. Carr 2002; Perz 2001; Walker et al. 2002), their relation to rural and frontier migration has not. Young, unmarried, or recently married adults are most likely to migrate, in many cases to establish an independent household (Carr 2002; Todaro 1976). In some cases, men will migrate first to establish a farm before bringing the rest of the family to establish residence. Migration decisions are ultimately made at the individual and household levels, and it is on this scale that land cover changes initially occur.

The macroeconomic approach to migration analysis holds that people will compare potential earnings in the place of destination to expected incomes in places of origin when making their migration decision (Todaro 1976). Migrants will make decisions based on economic costs and benefits according to this model. Todaro's thesis is generally supported by subsequent theory regarding rural out-migration and rural-rural migration in the developing world (Carr 2002; Oberai 1988). It has generally been found that high urban wages pull people to urban centers and low urban wages push people from urban centers, while rural wages do not have a significant impact on migration flows (Carvajal and Geithman 1976).

Migration networks may also play a part in decisions to migrate, as destinations where family and friends reside may alleviate some of the stress associated with migration (Lee 1966; Todaro 1976). Information received regarding the destination can be a factor in decision making and community ties can be a strong pulling influence.

Environmentally-induced migration studies have focused primarily on populations displaced due to natural disasters; very little research has been concerned with migration motivated by gradual environmental degradation (Lonergan 1991). But when migration is induced by poverty and malnutrition due to a decline in agricultural yields environmental degradation generally proves to be a significant underlying cause. When people are faced with the inability to subsist due to nutrient depletion of soils or other ecological deterioration they must decide whether to further invest in agricultural land or to abandon that land for more fertile land elsewhere on the frontier or for jobs that can replace subsistence and market production (Barbier and Burgess 1997).

Population Movement and Subsistence

Most research dealing with internal migration in developing countries focuses on rural-urban migration, despite the fact that a great deal of migration in these countries is rural-rural and it is this flow that is directly linked to much of the planet's deforestation (Carr 2004b). Deforestation and forest conversion are the most conspicuous expressions of land-use change and population growth, and are often associated with successive shortened fallow periods in shifting agriculture (United Nations 2001). Traditional long-fallow shifting cultivation can support a stable small population without environmental degradation, however when population density increases fallow times are shortened, decreasing the time allowed for forest regeneration. When rural-to-rural, migration may be environmentally detrimental because it often involves deforestation and clearing for new agriculture, drainage of wetlands, or use of steep slopes to expand production (Bilsborrow and DeLargy 1990).

The livelihoods of newly resettled farmers in tropical forest areas depend on land cleared for agricultural or pastoral use (Carr 2005; Marquette 1998). Because displacement by poverty, landlessness, or other social or political pressures are often causes of migration, newly cleared lands for agricultural expansion often come to be managed by those with fewer resources and inputs at their disposal (Pichón 1996). Farmers make land management decisions based on needs, limitations, and potentials of their household and its members (Müller and Zeller 2002). With access to fewer resources and inputs, decisions made by small farmers may not regard environmental sustainability as a priority.

A well-known study asserts that increases in population pressure will result in decreases in fallow lengths (Boserup 1965). It is this same population density that has been shown to be the greatest influencing factor on land use elsewhere in Central America (Kok 2004). Assuming low population growth and adequate available land, this form of subsistence agriculture can prove sustainable in the long term. It has been shown that rural indigenous populations utilize subsistence patterns that do not lead to overexploitation of natural resources (Coomes et al. 2000). Some agroforestry practices have even been shown to maintain forest biodiversity and ecosystem function (Atran 1993).

Empirical research has demonstrated the demographic attributes, such as size of family (Marquette 1998; Pichón 1997b), household life cycle (Godoy et al. 1997a; Perz 2001), number of male laborers (Walker et al. 2002), and the dependency ratio (Walker et al. 2000) can affect both rates of deforestation and crop subsistence patterning. However, most studies analyze change only within one generation and cannot account for differences that span multiple generations. Intergenerational aspects of land use appear to play significant roles in advancing the agricultural frontier but have yet to be extensively studied (Walker et al. 2002). Research involving land use and migration has not focused on deeply entrenched cultural traditions and characteristics that affect land-use decisions of newly settled farmers. Within household life cycle studies in the tropics, mature households (related to changing household demographic, those with ten or more years of residency) move to more economically productive activities like cattle raising, which are also less labor intensive (Bilsborrow and DeLargy 1990; Marquette 1998; Perz 2001). Household life cycle studies also account for availability of labor as a factor of how much land is cleared, among other attributes of land use. The structure and function of households and the decisions they make continues to be an important subject in the study of land use and land cover change in tropical forests (Walker et al. 2002).

Economic household characteristics such as wealth (Pichón 1997a; Walker et al. 2002) and access to markets (Godoy et al. 1997b) have also been found to have significant affects on agricultural decision making. Those households with more assets will have more options for intensification and investment and farmers living close to markets will have lower costs of transport.

Among tropical subsistence agriculturalists a strong positive relationship exists between population density and agricultural intensity (Turner II et al. 1977). This supports the general concept put forward by Boserup (1965) that an increase in population will lead to more intensive cultivation, and is an important conclusion to consider within migration studies.

Past research has demonstrated that cultural histories contribute to core lifestyle decision making, and differences in livelihood strategies can be attributed to these histories (Atran et al. 1999; Carr 2004a; Steinberg 1998). Atran and colleagues (1999) found differences in ideas and attitudes about land use and the environment between three cultural groups, in Guatemala's Department of Petén. Land and resource use patterns differed between two indigenous groups, and between indigenous groups and a ladino group living in the same area.

Stocks and colleagues (personal communication, 2007) compared land use of residents of two indigenous groups to that of mestizo colonists in the Bosawas International Biosphere Reserve in Nicaragua. Indigenous residents cut significantly less forest than mestizos per capita, utilized tenure systems that encouraged forest connectivity, and fallowed longer resulting in more forest regrowth (Stocks et al. 2006).

These studies have investigated differences between cultural groups and related information to migration trends of their respective study sites. This research, however, aims to identify differences within cultural groups that can be attributed to geographic heritage, with a focus on subsistence farming and related deforestation.

Integrating Land Use and Land Cover Change

Much of the human-environment interaction research conducted today focuses on the various uses and conversions of land cover by humans. Land use and land-cover change

(LULCC) research is motivated by concern over global environmental change and the rate at which such change is occurring. These changes have the potential to affect ecosystem processes and to influence climate and biodiversity. Systematic analysis of LULCC, like that of this study, can aid in understanding the processes and forces at work on multiple spatial and temporal scales.

Beyond helping to identify patterns in land cover change, LULCC research is useful in investigating linkages between human action and physical changes in the landscape (Geist and Lambin 2002). An emerging methodological approach to assessing humans' impact on local, regional, and global ecosystems combines high-resolution satellite imagery, geographic information systems (GIS), and socio-economic data to model the human-environment interactions that drive land-use change (Liverman et al. 1998). The spatial framework facilitates the integration of social and environmental data and allows for a better understanding of driving forces, factors and outcomes of land cover change (Müller and Zeller 2002). Both location and timing of these land-use changes are key for evaluating environmental changes but most research dealing with these interactions has been focused on identifying socio-economic forces that explain spatial patterns of landscape development (Vance and Geoghegan 2002).

Vance and Geoghegan (2002) developed a method to integrate GPS-assisted field surveys and available satellite imagery. They were able to spatially associate individual farmers with their farms and also track land-cover changes within the same area temporally. This farmer-level analysis can be combined with land cover change trajectories which provide a means to detect change, allowing for temporal analysis of landscape change (Mertens et al. 2000).

In the geographic region of the study area, tropical Central America and the circum-Caribbean, swidden agriculture is the dominant subsistence strategy for rural populations. How these populations interact with the environment is important not only because of the ways they may alter the landscape but also because these populations are by nature in constant flux. Shifts in the physical environment, brought on by migration or climate change, will inevitably result in landscape change, be it natural or anthropogenic. This study will utilize past research regarding swidden agriculture and migration to investigate the relationship between the two in southern Belize.

CHAPTER 3
RESEARCH CONTEXT AND STUDY SITE

Belize is an interesting country with a diverse population and a heterogeneous landscape. It is important to understand the context through which southern Belize became what it is today. This chapter will first briefly describe the history, physical geography, and demography of Belize and the Toledo District. Next, it will provide an account of historical Maya migration in the area and specific village histories for those included in the study. Lastly, institutions of land tenure and development will be described as they relate to this research.

History of Study Site

As a former British colony, Belize has a culturally and linguistically diverse population. For the purposes of this thesis the history of the area will be reviewed as it pertains to the Maya population that lives today in the southern portion of the country. Political and economic phenomena have shaped both Belize and the Toledo District, and have thus impacted their residents in specific ways.

The present-day country of Belize (Figure 3-1) is located within what is considered the eastern part of central Maya civilization, specifically that of the Classic period. The collapse of these Maya kingdoms came in the early ninth century, but when Spaniards arrived in Central America early in the 16th century they found a significant population of Maya peoples.

The British entered the Caribbean in 1560, by which time Spain had consolidated the conquered territories of Mexico, Guatemala, and Honduras, surrounding Belize on three sides. Around 1660 the British began to cut logwood for dyes for the European market at the Bay of Honduras, which is now mainland Belize (Thomson 2004). Some logging labor was provided by the Maya inhabitants of the area. Then, in the 1690s, the indigenous Manche Chol inhabitants of what is now southern Belize were rounded up by the Spaniards and relocated to the highlands of

Guatemala (Thompson 1930; Wilk 1991). At that point it is unknown if any Maya remained in the area that is now Toledo District.

Founded in 1839, Young, Toledo and Company was the largest logging firm in southern Belize, accumulating over a million acres before going bankrupt forty years later (Wilk 1991). Logwood as well as mahogany exportation decreased dramatically in the middle of the nineteenth century when the supply of easily accessible timber was exhausted and prices plummeted, but by this time there were several permanent settlements and British Honduras was well on its way to becoming a formally recognized British colony. The firm was forced to liquidate its landholdings, but land was rarely sold to the laboring population, the Maya, Caribs, and Creoles. Instead huge tracts of land were converted to sugar plantations. The colony continued to export raw goods, namely banana and sugar, to Europe as a colony of Britain. In the 1960s the administration began to prepare for the transformation to a self-governing Belize and in 1981 the nation was granted its independence.

With a population of less than 300,000, there are approximately twelve Belizeans per square kilometer (CIA 2006). The District of Toledo had a population of 27,600 as of mid-2005, of which 81.8% live in rural areas and 65.4% are considered Maya (Government of Belize 2006), totaling around eighteen thousand people. In the district some 22,600 people reside in rural areas (Woods et al. 1997) and almost 80% of residents are poor. Population density is low in Toledo's 61 villages and both Q'eqchi' and Mopan-speakers are well-represented. Punta Gorda is the District seat and also functions as the market center for the area villages (Figure 3-2).

In Toledo access to quality healthcare is a significant social issue. For many healthcare comes in the form of a mission or group of doctors from the U.S. who set up a clinic for one week a year and distribute prescriptions. Infant mortality is high at 15.5 deaths per thousand live births, and only 8.2% of the population has access to postnatal care (Government of Belize 2006). Diabetes is a growing problem as processed sugars make up a larger part of residents' diets and renal failure is a common cause of death among the elderly.

Physical Geography

Belize is located in northern Central America on the Caribbean coast. It is bordered to the north by the Mexican state of Quintana Roo, and to the west and south by Guatemalan departments of Petén and Izabal. Belize's barrier reef is the second-longest in the world and runs adjacent to much of the 386 km coastline. The land area of the country totals 22,960 km^2 with a boundary 516 km long. The southern boundary with Guatemala is largely defined by the Sarstoon River, and the northern by the Hondo River.

The geology of Belize consists mainly of limestone, with the exception of the predominately granite Maya Mountains that run northeast to southwest across the southwest part of the country. The oldest land surface in Central America, the Mountain Pine Ridge plateau, is surrounded by karst topography of sinkholes, caves, and underground rivers and streams. These hilly karst areas are characterized by fertile soils that have been cultivated during at least the past 4,000 years. The northern half of Belize lies on the Yucatán Platform.

Belize is a tropical country with distinct wet and dry seasons, although there are significant variations between regions and from year to year. Average rainfall ranges from 1,350 millimeters in the north and west to over 4,500 millimeters in the far south. The dry season typically begins in January and continues on through April or may, while the wet season, normally from about August to December, begins after a shorter, less rainy period usually occurring around July after the initial onset of the rainy season.

The District of Toledo is the southernmost district of Belize. Of its total area of 4,650 km^2 about 100,000 ha are suitable for annual crops, fruit trees, and pastures (IFAD 2004).

Approximately one-third of the district was forested in 1999 and the Belizean government has in the past decade sold logging rights for at least 75,000 ha (Emch et al. 2005). Precipitation ranges between 2,750 and 4,500 mm per year within Toledo District.

The country has been repeatedly affected by hurricanes. Most notably, Hurricane Hattie hit the central coastal area in 1961 with winds over 300 kilometers per hour and four-meter storm tides. This prompted the relocation of the capital inland eighty kilometers to the city of Belmopan. In 2001, Hurricane Iris devastated much of the southern tropical forests and destroyed many buildings in the Toledo District. The forests in the north of the district have not recovered and most of the tall trees were knocked over by the high winds.

Maya Migration in Toledo

Groups of Q'eqchi' and Mopan have been migrating to the Toledo District since the 1850s when the British rule of the colony became attractive relative to the harsh Spanish rule in Guatemala and southern Mexico (Bolland 2003; Steinberg 1998). Maya in Guatemala and Mexico were often forced to provide labor for coffee plantations for little or no pay. In addition to Maya cultural groups, British privateers, African slaves, mestizos, Chinese, Syrians, Garifuna, East Indians, and Mennonite farmers have all migrated to and resettled in Belize (Collins 1995). Thus, the history of Belize has been characterized by social and cultural pluralism, with a population composed of culturally differentiated groups (Gregory 1984).

The two main cultural groups, while alike in many ways, differ substantially. The Mopan historically originated from the tropical lowland area that is now Petén, Guatemala, and western Belize. Under Spanish rule this group experienced forced labor, taxation, military servitude, and repeated resettlement (Thompson 1930). The Q'eqchi' were living further south in the highlands of Alta Verapaz, Guatemala, during the period of conquest (Carter 1969). Both were vulnerable to diseases brought by European conquerors and conversion to Catholicism at the time. German plantation owners forced the Q'eqchi' to work on coffee and sugar plantations and to pay rent to the Germans for small plots of land (Wilk and Chapin 1991). The Q'eqchi' traditionally live in more isolated villages while the Mopan live in larger villages and surrounding satellite hamlets.

Historically, identity among Mopan and Kekchi Maya is tied more with community than with ethnicity, with ethnic identities secondary to community identities (Wilson 1993). "Mopan" and "Q'eqchi'" did not initially refer to cultural groups, but to linguistic groups. "The cornerstone of community identities is location, the local geography (Wilson 1993)."

The distribution of ethnic groups in Belize has been largely conditioned by these historic patterns of settlement in accordance with the time and place of their predecessors' original migration into the country (Bolland 1986). Historically there have been several points of entrance for Maya migrants that can be seen in the settlement patterns of Maya villages, visible in the distribution of rural villages in the Toledo District. The border town of Jalacte, Belize, is an hour by vehicle from the large trading town of San Luis Petén, Guatemala. This has been the most active route of immigration into Toledo, as many Guatemalan Maya have settled in the villages of San Antonio or Pueblo Viejo upon entrance to Belize. Further south, the village of San Benito Poite is a little over a mile from the official border in a very hilly and densely forested part of the Maya Mountains, and has been an entry point primarily for Q'eqchi' migrants coming to Belize. Immigration of these cultural groups into Belize, especially the southern half of the country, is further encouraged by the large long-term resident population of Maya language-speaking peoples (Collins 1995).

Mopan migration into the area that is now Toledo District began in 1886 when a small group traveled from Petén, and finally established the village of San Antonio in 1889 (Gregory

1984). Settlement of Maya in southern Belize was encouraged by the British for several reasons: this population flux increased the agricultural base, and, in a region of relatively low population density, it also solidified the Belizean claim to disputed territory along the border with Guatemala (Everitt 1984).

The road between San Antonio and Punta Gorda was first constructed in the 1930s (Figure 3-3), integrating the Maya population into district market economics (Gregory 1984). The village of San Antonio is one of the largest in Toledo, and it continues to be a key cultural center for the Mopan population (Wilk and Chapin 1991). Here, foreign doctors set up temporary clinics to treat the residents of the district, major political meetings are held, and important cultural festivals are carried out.

The arrival of Mopan Maya in the late nineteenth century was followed shortly by an influx of Q'eqchi' Maya from the Guatemalan departments of Petén and Alta Verapaz (Gregory 1984). More recently, waves of migration since the 1960s have been motivated by violence and land disputes in neighboring areas as well as by the promise of economic opportunity, upward mobility and better education for migrants' children (Everitt 1984). Immigration in the 1980s was unprecedented due to increased violence in neighboring countries, especially Guatemala; in 1991 it was estimated that 15 to 25 percent of the total Belizean population were refugees (Collins 1995).

Both immigration and emigration in Belize have transformed the ethnic composition of the country. Many recent immigrants to Belize, indigenous and mestizo alike, have been refugees from El Salvador and Guatemala, a majority of which have come from rural areas where farming is the dominant livelihood (Collins 1995). Like much of rural Central America, in neighboring Petén, Guatemala, swidden is the most common form of agriculture (Shriar

2002). Migrants into Belize have brought with them livelihood strategies and farming techniques and in turn altered the landscape.

Land, Politics, and the Economy

The Mopan and Q'eqchi' Maya have managed to retain a substantial part of their cultural identities, speaking their native languages, participating in traditional institutions, cultivating land as they have for generations (Wilk and Chapin 1991). A substantial portion of farmers in Toledo have farms on public or reservation land. While the national and district governments have approved countless development projects in the area to increase agricultural production and integrate rural people into the economy, there has been no attempt to secure land rights for those same people. This is part of an overarching trend that remains from colonial governance, keeping marginalized populations on the periphery.

Land Tenure

Traditionally the Maya of southern Belize farm on communal land governed by each village's leaders. Between 1920 and 1940 reservation lands were set aside by the colonial British government for this purpose, but in past decades this system has been complicated by politics and outside economic interests. Few rural residents have leases on land, and it seems that this formal recognition of land rights is becoming rarer and more difficult to obtain.

Reservation land was granted by the colonial government first in 1924, in the form of an "Indian Reserve" given to each recognized village. The residents were to pay a yearly fee of $5 to an elected village alcalde who also was responsible for settling disputes within the village and judging minor crimes (Wilk 1997). In 1933 the reservations were amended to include several other villages. There are eleven land reserves for the Maya covering 77,000 acres in southern Belize (Clark 1999). Under this system the land remains the property of the government who can eliminate Maya land rights without discretion (TMCC 1997). The government has in fact issued concessions for logging to international corporations and has given permission for oil exploration essentially in the backyard of Toledo villages, often on land used communally for farming. In 1992 the Ministry of Natural Resources gave logging concessions to a Malaysian timber company for land that included areas within the reserves. The system also makes it impossible for farmers to gain formal rights to the land in the form of titles. There is no indication today that the $5 fee is still in effect, but people do complain about the yearly costs the government charges for leased land.

For the Maya, obtaining a lease for land is virtually impossible. The fees involved in an application are oftentimes unaffordable for the subsistence farmer and traveling to and from the capital of Belmopan for paperwork can be difficult. In addition to these constraints, the government of Belize does not encourage this marginalized cultural group to legally use land, and in fact many times will not grant approval to a lease application by a person with a Mayan surname. Accounts of the process usually include being told by government employees that the farmer will have to use the land for another ten or twenty years before becoming eligible for a lease, even when that farmer may already have been on the land for thirty years.

There do exist, however, orderly systems that recognize various degrees of rights to land within and among villages. The basic principle is that once a man has cleared a plot of forested land he has the usufruct right to use it thereafter (Wilk and Chapin 1991). This right can be loaned, given, or inherited but not sold. In many areas the population has moved away from the original reservation lands, using public lands in undeclared reserves for farming. And in much of the originally delineated reservation, land has been parsed out to foreign corporations or the government has sold logging rights.

Development Programs and Cash Crops

The Toledo District has been the setting for an impressive number of development programs and projects that aim to increase agricultural production and integrate rural areas into local, regional, and global markets. Some projects have paved or improved roads, constructed water pumps or sanitation systems, or built clinics throughout the district, while many have been targeted at intensive agriculture. In most cases, this means advocacy for abandoning traditional shifting agriculture for more sedentary intensive farming. There have been several phases of attempted development in the past two decades, totaling over $30 million dollars. Agricultural development projects have focused on citrus, rice, and cacao production. To date there have been no projects that aim for intensified corn production.

The people of Toledo have become wary of development initiatives and external aid (Government of Belize 2006) as many of these projects are oriented toward national development goals without concern for the needs of the farmers themselves (Wilk and Chapin 1991). According to a 2006 publication from the Government of Belize, $61.8 million dollars in external funds, half loans and half grants, has been allocated to the district since 1978 to stimulate economic activity and alleviate poverty. Of the agricultural programs of the past, all that remains is a small amount of education, and anxiety among residents regarding future development projects.

From 1984 to 1988, USAID funded a project to encourage cultivation of cacao called the Accelerated Cocoa Production Project (ACPP) (Emch 2003). This was likely related to the agreement between the Belizean government and Hershey Foods Corporation that they would provide a market for fermented and dry cacao. Through the ACPP, seeds and seedlings were made available to farmers in Toledo and workshops and extension officers provided information on fermenting and drying methods. Following this project, the Toledo Agriculture and

Marketing Project (TAMP) was funded to integrate small cacao farmers into the export agriculture market. TAMP made in-kind loans available to farmers who pursued cacao.

Between 1990 and 1993, after the world market price of cacao dropped dramatically and Hershey pulled out of Belize, cacao farmers in Toledo were left without a market after only three harvest years. People had no choice but to pursue different cash crops or find jobs which in most cases meant abandoning their cacao trees. Then in 1993, the Toledo Cacao Growers Association (TCGA) made a deal with a British organic chocolate company, Green and Black's, for Toledo cacao farmers to be the exclusive supplier of cacao for a chocolate bar called Maya Gold (Emch 2003; TMCC 1997). The TCGA has a five year rolling contract with Green and Black's and the current price for cacao is BZ$ 1.65 per pound (US$ 1 = BZ$ 2, fixed rate). The organization does not require leases but does encourage farmers to apply for them. In 2006 the association bought 96,000 pounds of cacao beans from Toledo farmers. Maya Gold not only carries organic certification but is endorsed by the Fairtrade Foundation.

Throughout the 1990s the production of cacao increased steadily and by the end of the decade a steady market had been established. Then in 2001, Hurricane Iris destroyed as much as 85% of the cacao trees in the Toledo District (Emch 2003). Backed by a development grant funded by the UK Government Department for International Development (Fairtrade Foundation 2005), the TCGA staged a massive planting in 2004, providing seedlings, seeds, and bags for transport of beans. A large crop is expected for next year, as the trees will then be three to four years old and will begin producing abundant fruit. The TCGA provides extension officers and training programs for interested farmers, helps facilitate loans through the Teacher's Credit Union in Punta Gorda, and provides information on pests such as carpenter ants and stem boring weevils.

The largest rice program was initiated by the British Development Division in the Caribbean (BDDC) in the late 1970s and was part of the Toledo Research and Development Project (TRDP). Farmers were encouraged to apply for leases for between five and thirty acres for mechanized rice. This form of cultivation often required chemical inputs that were typically paid for by loans. The combines themselves were free as part of the project, but transporting rice to the mill close to ten miles away was not. One problem posed by mechanization was that all the rice in the area would mature at the same rate and need to be harvested at the same time, but according to one informant there were only five combines in the district. If one did not come in time the rice would spoil and the farmer would go farther into debt. One farmer who participated in this study reported that he had gotten a loan for $5000BZ that he had still not paid at the time of the interview.

The project tried several different tactics to deal with the heavy rains, poor infrastructure, fragile ecosystems, and persistent weeds, only to abandon the idea of paddy rice by 1983. Farmers that participated in this project recall that for five years the combines would come to till the land and harvest rice but then suddenly they stopped being free, and no-one could afford to pay for them. Countless rice fields were abandoned, and can be seen today along the side of roads covered in a dry, coarse grass.

Small-scale projects through the Ministry of Agriculture have continued to focus on mechanized rice production, but in recent years a fall in market price has persuaded most farmers to abandon the venture. The rice mill at Big Falls formerly worked as a broker, buying from farmers and selling to the market. Now the mill cannot pay up front for rice due to low prices and it has all but shut down.

The USAID-sponsored TAMP aimed to create a market for citrus near Dump and encouraged Toledo farmers to start citrus groves. For this project, too, leases were generously handed out to those who planned to plant citrus trees. Once citrus was being harvested, it became apparent that it would be impossible to actually create a market.

New Directions of Development

Several recent development projects have the potential to dramatically affect life in the Toledo District. The southern highway stretches between the towns of Dangriga and Punta Gorda and is paved with the exception of nine miles between Golden Stream and Big Falls. The highway was paved between 1997 and 2001 and the dirt portion is supposedly scheduled to be paved soon, although no timeline has been set. In addition to this highway, the Government of Belize is considering a project to pave a road between the Southern Highway at Dump to the Guatemalan border at Jalacte. This would definitely increase local trade between the two countries, and is likely attractive due to the demand for agricultural products on the other side of the border. Relevant to this project is the proposed Plan Puebla Panama (PPP), a development project that would run from Mexico to Panama, creating an elaborate infrastructure of highways, ports, airports, and power plants. While to date the project is on hold pending international agreements as well as funding through the World Bank and IMF, a highway from the Yucatan is slated to run through Belize south into Guatemala. Clearly the introduction of not just an international highway but a continental thoroughfare would have serious affects on communities whose main livelihoods are subsistence agriculture as well as on tropical ecosystems in Central America.

The possibility of oil and natural gas reserves in southern Belize is currently changing the economic atmosphere of the area. Multinational corporations are pushing hard for oil explorations outside the village of Santa Cruz and in the protected area between the Sarstoon and

Temash Rivers. The communities in these two areas have mobilized and called for impact assessments but oil companies have been granted permission for exploration by the national government. Should significant reserves be found in southern Belize, natural resource use attitudes would dramatically shift from conservation to exploitation. The discovery of oil or natural gas in the area, combined with the introduction of international highways, would also result in a major increase in international investment.

Migration in Belize has been affected by all the topics discussed in this chapter: physical geography, national and cultural histories, economic changes, and politics of land. And in turn each has been impacted in some form by patterns of migration among Maya in Toledo. Population movement is not homogenous and will continue to affect change on the landscape, economy, and politics of southern Belize.

Figure 3-1. Map of Belize[1]

[1] Image courtesy of University of Texas.

Figure 3-2. Saturday market in Punta Gorda. Wednesday is also a market day.

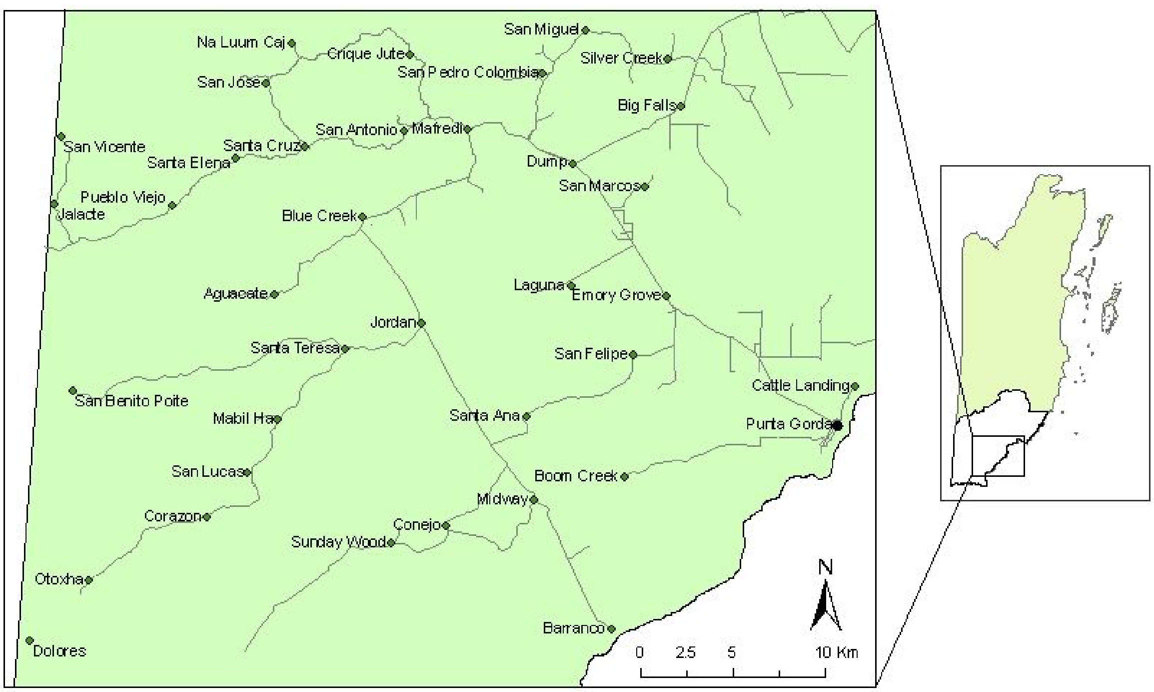


Figure 3-3. Map of Toledo Villages.

CHAPTER 4
RESEARCH LOGISTICS, DESIGN, AND METHODOLOGY

The primary methodology of this research was collection of both qualitative and quantitative data in the field. Each type of data was used to supplement the other to help explain variations in responses. Semi-structured interviews were the primary form of data collection, while ethnographic observation, purposive conversations, land use inventories, and spatial analysis were also employed in this study.

Semi-Structured Interviews

The main method used to collect data was the semi-structured interview, administered to the farming head of each household in the sample. This interview was designed to gather data regarding basic household demography, economic characteristics, migratory histories of each family, and information on land use.

Sampling Procedures and Accuracy of Data

Sampling of households within the three chosen communities was non-probabilistic and purposive. Sampling was limited by space and time constraints, as well as by the absence of many heads of household due to seasonal labor in the tourism industry. Farmers were chosen by their willingness to participate and their presence during fieldwork. Thirty-three heads of household were surveyed in the three villages, fifteen in Blue Creek, eight in Jordan, and ten in Aguacate. Each sample represents about one-third of the households in each village; more will be discussed on the study villages' populations in Chapter 5. The selection of these households was purposive, based on availability and relevancy.

The unit of analysis was the individual farming head of household within the context of the household due to the nature of questions in the demographic section of the interview instrument.

Because this research was focused on land use, purposive sampling was necessary to find farming individuals for interviews. Purposive sampling allows the researcher to determine appropriate populations for intensive study, targeting only those individuals of interest (Bernard 2002). Women were not targeted as farming activities are principally performed by men in the study area, and thus women's economic activities could not be taken into account. Several households were not included in the study if none of the adults participated in agriculture. The sample used for this study did not meet probabilistic standards and was not statistically significant to represent the defined population. Further, the research design involving mixed methods and combined qualitative and quantitative data does not require a large probabilistic sample. Conclusions in this thesis refer mostly to the communities of individuals participating in the study, but can be extended to the larger study region in many cases.

The collection of data used informant recall for many of the questions asked, such as harvest yields, years of fallow and cultivation, and migratory histories. The utilization of informant recall in anthropology is a widely used method of data collection (Stepp 2002). Most households that provided information do not keep written agricultural or financial records, so responses to such interview questions may not be entirely accurate. In some instances, respondents indicated that they could not accurately remember specifics, such as the exact year their family moved to their current village, or how many consecutive years they had been planting the same plot. Overall, responses among farming heads of household do illustrate general trends and ranges within answers to questions.

Interview Instrument and Procedure

The interview consisted of 40 questions designed to elicit economic, demographic, agricultural, and family history information. The instrument included a mixture of closed-ended and open-ended questions (Appendix A). Closed-ended questions provided demographic information about interviewee households and land use practices. Open-ended questions involved perceptions about deforestation and slash-and-burn agriculture, as well as information about migration histories of individuals and households.

Interviews were conducted in person with farming heads of household willing to participate in the interview. All interviews were carried out in English by me. I conducted over 35 hours of semi-structured interviews with 33 farming heads of household in the three villages chosen. Most interviews took place at participants' houses, but several were conducted on-site at farmers' agricultural plots. A large majority of the interviews were recorded on a worksheet developed to make the interviewing process easier, and these worksheet responses were immediately transcribed following each day's round of interviews. In most cases, farmers were proficient in English, but in several cases some help from a translator (usually the farmer's wife) was necessary for certain technical questions.

The three villages of Blue Creek, Jordan, and Aguacate were involved in this research. All interviews in these villages were conducted in March and April 2007. My first two weeks at the study site were spent familiarizing myself with the physical geography of the area and the residents of the village of Blue Creek. It proved necessary to invest time in relationships with the residents of the area so that they would understand the motives behind this research. Many residents expressed concern that I might profit financially from their responses, or that information they provided might somehow be used to harm them.

Farming heads of household were approached and engaged in discussion about the purpose of the research and the format of the interview, should they choose to participate. These individuals were notified of their rights as a participant and ensured confidentiality of responses.

Further, it was explained that I plan to conduct a follow-up visit to the communities in order to report my results to interested parties and leave a copy of this thesis with village leaders.

Participant Observation

Participant observation was utilized to validate qualitative and quantitative data collected through other methods, to build trust among participants, and to generally help with understanding the meaning of data gathered. I spent time with farmers in their fields, traveling to and from agricultural plots, and helped shuck dry corn for sale. I also spent social time with farmers at local shops or in town on market day and, when invited, at their houses with their families.

I was able to travel to plots to observe harvesting and clearing by farmers and men that helped in exchange for reciprocal labor. I was not at the study site during planting time, so I was not able to personally observe that stage of swidden agriculture. During interviews I asked farming heads of household if I could accompany them to their fields and each consented, although most could not understand why I would want to hike into the bush to look at dry corn fields.

This method of data collection proved to be valuable in that it provided visualization of actual field techniques that could have never been accurately described in an interview setting. Particularly important information gathered through this method included specifics about desirable physical geography for swidden agriculture that only became apparent once I had visited several farms. Participant observation allows the researcher to observe what people do, while other empirical methods are limited to evaluating what people say they do (Gans 1999).

Land-Cover Inventory

A basic land-cover inventory was conducted as a proxy for land use, which allows for comparative measurement of farmers. Land cover was recorded as a nominal variable with several classes and was measured by walking parcel boundaries with a GPS receiver recording coordinates. This method compliments data gathered from participant observation and semi-structured interviews about crop diversity and related practices, such as intercropping, and also allows for comparison with past research that evaluates the influence of household maturity (specifically Perz 2001) on land use.

A modified training sample section was created as part of the interview worksheet to simplify the linking of household and parcel (Appendix B). Each distinct crop species was recorded along with average diameter at breast height (DBH) for any emergent trees, dominant species of any emergent trees, and managed species not part of formal cultivation were noted. When possible, soil type and farmers' opinions about the quality of the environment for farming were also recorded. The worksheet contained a section for an illustration of the agricultural plot to aid my recollection of each farm.

Land-use data also included location (relative to household and UTM coordinates) and size of plots, and crop output. Information gathered in the field provides frequency data for components of land use such as crop selection and diversity, problems with agricultural pests, and chemical inputs.

Secondary Sources

Secondary sources supplement the field data: census data at the district and village level when available, village boundaries and land use data from the Department of Elections and Boundaries of the Belizean government, recent reports from various Ministries of government, and the Maya Atlas (1997), a publication created by the Toledo Maya Cultural Council, are among the main secondary sources utilized in this study. Reports done by independent agencies, such as World Bank (World Bank 1996), Toledo Research and Development Project (Osborn 1982), United Nations (United Nations 2001), and the International Fund for Agricultural

Development (IFAD 1998; 2004) were consulted as secondary sources that evaluated macro-level phenomena in the area, especially concerning development projects in Toledo.

Data Collection Schedule and Constraints

Fieldwork was carried out in March and April of 2007. Interviews lasted anywhere from fifteen minutes to two hours, depending on how interested the farmer was in talking about his farm and my project. Not all interview time was directed toward my interview questions; most interviews also involved small talk or questions from the respondents about me. This casual conversation helped build trust and rapport among residents of the villages, and was usually helpful in finding other farmers to interview.

For the first two weeks if was difficult to find farmers to interview. Once I had made acquaintances with several of the more powerful men in the communities, more often than not former alcaldes or village chairmen, it became much easier to approach other farmers. Most likely due to the history of research in the region, I was questioned frequently about my motives for this study. Many people were concerned that I would profit financially from the information they provided, or that I would never come back once they had given me what I was looking for. I tried to reassure those that expressed these concerns that I would not profit from their information and that I did not intend to disappear and forget about them, but that I did plan to return with my results for the communities involved.

While almost all of the farmers I asked to participate in my study agreed, several declined by avoiding me for the duration of my fieldwork. I was told by one informant that a few of those farmers that were avoiding me did not want to participate because their English was not good enough. None of the people that expressed concern about my motives declined to participate, but they did engage in lengthy conversation about the injustices done to them by visiting researchers and development workers. I do not believe that these concerns or suspicions affected responses given in interviews or casual conversations, and discussion of those concerns may have actually helped me to develop rapport though familiarity.

Of the eight weeks that comprised fieldwork for this study, five were spent gathering interviews and land cover inventories in Blue Creek. Since I resided in this village, it was important to make strong acquaintances among its residents because they would be the ones to connect me to farmers in the other two villages. Interviews were conducted over the course of two weeks in Aguacate, but could not be completed in successive days due to Easter weekend and the preparations involved for the holiday in the village. For three consecutive days interviews were conducted in the village of Jordan. Both Jordan and Aguacate are more than three miles from Blue Creek, so travel time cut into time available to do interviews. It was often difficult to find farmers in their homes during the week because they begin work on their farms early in the morning, so I would have to find them in the afternoon before the sun went down.

Data Analysis

Semi-structured Head of Household Interviews

Interview responses were recorded on a worksheet and then transcribed into a spreadsheet using Microsoft Office Excel 2003 (Microsoft Corporation 2003). This was useful mainly for demographic responses, such as age of household head, number of children, and education of household head. Demographic data was aggregated for village and region to determine general trends. Basic land use data collected in semi-structured interviews was entered into the spreadsheet as well.

Field Notes and Participant Observation

Notes taken during participant observation were transcribed and coded based on theme and similarity of topic. Microsoft Office Excel 2003 (Microsoft Corporation 2003) allowed me to create two tiers of codes so that I could tease out more specific trends within larger patterns.

Observations were coded inductively to discover patterns within field notes (Bernard 2002). For example, if a farmer related difficulties with a particular rodent or bird destroying corn plants, I gave the answer the specific code "animal" within the larger category "problems" regarding agriculture.

This proved valuable since in casual conversation the topic often shifted frequently depending on the people present, the context of the conversation, or other circumstances that did not allow for complete explanation of certain phenomena. Notes were transcribed every few days, which made it easier to determine holes in ethnographic data and helped me to identify things I did not yet understand. I used the coded field notes to help explain the variance in responses, for instance, all of my notes that referred to cacao cultivation were labeled "cacao" within the larger coded category of "production."

Land Use and Remote Sensing

Land-use information provided by informants was aggregated geographically by village and related to time series of remotely sensed satellite data. These observations helped to link migration histories with changes in land use within the footprint of each village. Liverman, Moran, Rindfuss and Stern (1998) provide a synthesis of the methodology for combining household information with remotely-sensed data. The challenges faced when using this approach are: (1) defining the appropriate level of aggregation of both household and environmental information, and (2) identifying appropriate linkages between household level and remote sensing datasets (Liverman et al 1998; Mertens et al 2000). As described by Liverman and colleagues, "Remote sensing offers an additional source of contextual data for multilevel analyses."

Evaluating the spatiotemporal variation of the Normalized Difference Vegetation Index (NDVI) and Tasseled Cap Transformation allow for statistical analysis of reflectance values recorded by the seven bands that represent land cover changes over time. These two statistical analyses of spectral data provide information on ecosystem health via wetness and greenness of land cover. This is useful for determining the stress of local ecosystems in relation to agricultural intensity. For each village, a subsistence catchment area was determined using information from semi-structured interviews, land use inventories, and GPS data. NDVI and Tasseled Cap were performed for each of the three catchments in each of the three scenes available.

Spatial data is available through the Land Use and Environmental Change Institute (LUECI) at the University of Florida. For this study, three scenes of the Toledo District were analyzed for temporal changes in land use and land cover. Remotely sensed spatial images, specifically Landsat Thematic Mapper (TM) reflectance data, were selected for geographic extent and minimal cloudcover. Satellites used to collect remotely sensed data are in constant motion orbiting the earth, and very few scenes of the humid tropics have the visibility necessary for analysis. Three scenes of the study area are available. Analysis was performed using ArcGIS and ERDAS Imagine software and equipment maintained by LEUCI, and was conducted immediately following fieldwork.

CHAPTER 5
RESULTS

The goals of this research were threefold: to evaluate and document land use and subsistence patterns among the three study villages, to determine the relationship between migration and land use in the region, and to assess the extent of land use change over the period that corresponds with selected satellite imagery. This chapter will detail the results obtained in this study. All cultural data was gathered using ethnographic methods and semi-structured interviews.

The general demographic of study participants will first be presented followed by a summary of traditional land use. This section will address many facets of subsistence in the study area, including chemical inputs and challenges to production. Cash crop production and participants' perceptions about land tenure will be assessed with regard to the three villages included in this study. Migration histories of participants will be briefly summarized and related to decision-making factors regarding the choice to relocate. And finally, the results of land use and land cover change analysis will be presented.

Setting the Scene

This study was carried out in rural southern Belize (Figure 5-1). Unless noted, histories of the three villages included in this study were compiled from interviews with community residents and leaders. The Maya Atlas (TMCC 1997) and several other secondary sources were consulted and their contents compared to data gathered in the field.

The three villages of Jordan, Blue Creek, and Aguacate were chosen not only for their distinctly different histories but also because they are each located in an area physically different from the others. Jordan is situated in a flat wetland area that is seasonally flooded by the Mojo River in the rainy season. Because of this seasonality and the moist conditions that generally prevail in the area, the land around Jordan is particularly well-suited for growing rice and dry season corn. Annual floods deposit sediment on the river bank replenishing soil nutrients so corn can be planted year round on the river banks, as there are no fertile hills in the area. Aguacate is surrounded on all sides by low mountains. Houses are built on slopes and farms are carved out of the dense bush between hills and along streams that separate the mountain ridges. This landscape allows residents to raise pigs because they remain in the valley near the village and will not travel to farms and destroy crops. Blue Creek's physical geography is a combination of that of the two other villages. Situated at the base of a main mountain ridge, residents have access to land both in the hills and along river banks on the edge of a flat plain.

Around 1950, there were several families who had come from San Antonio living in a community called Rio Blanco, also the name of the river (TMCC 1997). The village of Blue Creek began when three brothers traveled from this settlement in 1954 to plant corn in an unpopulated area next to the river a little downstream. The men cleared two acres of forest each, burned the vegetation, planted corn in April, and traveled back to Rio Blanco. The following year the brothers returned with their families to build their homes. They brought with them pigs, chickens, ducks, and turkeys and defended their homes and animals from jaguars in the area. Soon after, the government of Belize changed the name of the village from Rio Blanco to Blue Creek. Around 1962 a road was constructed by the government with the help of the agricultural industry. At present about 280 people live in Blue Creek.

In 1979 a few families came from the Santa Theresa area and settled south of the Mojo River. They stayed for nine months, planted corn, and built houses in their fields before moving 1.5 miles north and establishing the community that is now Jordan. Around the same time a large group of families left their village of Machaca and moved to Jordan. A road was built through the village by the government for logging by about 1982. Then the village flooded, as it sits on very low swampy ground, and most families left. Six families stayed, including the original three, and they comprise a significant portion of the population of about 95 people today.

Aguacate is said to be the second oldest village in Toledo. As early as 1908 the village had a church (Wilk 1997). Further, there are records from a school dating to 1952. Most residents and their families came from Guatemala, and the village was at one point a trading center for the surrounding communities of Machaca, Blue Creek, and Santa Theresa. Today the population is around 300.

Considering its ties to the three villages included in this study, a brief history of Machaca is also necessary. This village was about three miles west of Aguacate by footpath and was also connected by a path to San Benito Poite. No road was ever built because of the mountainous terrain, but the presence of British soldiers made living there possible. They provided supplies and airlifted people out who needed medical attention. In the 1960s, Britain began to phase out their presence in Belize. Once the soldiers were gone the residents of Machaca decided to leave and move elsewhere where they would have easier access to the market and medical care. Between 1975 and 1979, all residents of Machaca moved from the village, many to Aguacate or Jordan, and others to Santa Theresa and other villages.

Study Demographics

From the three villages selected for this study, a total of 33 households were interviewed. Male heads of household were the target respondents, with occasional participation or help from female heads of household. Males were chosen for semi-structured interviews as the primary actors in agricultural activities. The average age of male heads of household was 42.3 years, ranging between 65 and 20 years with a median age of 38 years (n=33).

Table 5-1. Demographic summary of study participants.

Demographic	N	Percent
Age		
Under 30	4	12%
30-39	16	48%
40-49	8	24%
50-59	4	12%
60 or over	1	3%
Number of Children		
Zero	2	6%
1-3	6	18%
4-6	10	30%
7-9	12	36%
Over 9	3	9%
Education of Household Head		
None	1	4%
Some Primary School	26	96%
Completed Primary School	16	59%
High School	9	33%
Post High School	3	11%
University	2	7%
Language		
Mopan	7	21%
Q'eqchi'	22	67%
Both Mopan & Q'eqchi'	4	12%

These households averaged about six children with 4.4 (n=33) currently living at home and each had a male and female head within the household (Table 5-1). Half had children that were grown and had moved out of the household, and there were no children living at home in 11.5% of households. A surprisingly large number of grown children had chosen to enter the Belize Defense Force after leaving home. Others were attending university, had moved to Belize City for jobs, or were working in tourism elsewhere in the country. Fewer people of the most recent generation stayed in the area to farm; only three heads of household included in the sample were under 30 years of age. Male heads of household averaged 6.3 years of formal education. Only one participant reported attending no school at all. The distribution of the sample reflects participants' ages, illustrating the increase in availability and perceived importance of education in Toledo. In Aguacate, all heads of household interviewed spoke Q'eqchi', while one also spoke Mopan. Five heads of household in Blue Creek spoke Q'eqchi'; three spoke Mopan; and four used both languages at home. Households exhibited varying degrees of accessibility to public services (Table 5-2).

Table 5-2. Study villages' access to water and electricity

Households Access to Amenities	
Aguacate	
Pipe Water	79.5%
Electricity	77.3%
Blue Creek	
Pipe Water	91.7%
Electricity	86.1%
Jordan	
Pipe Water	47.1%
Electricity	64.7%

Traditional Land Use

The Mopan and Q'eqchi' Maya of southern Belize traditionally employ swidden agriculture as their primary means of subsistence. Corn, beans, and rice are the main staples. Beans and rice are cultivated less frequently than corn, which is planted twice each year. There are two seasons for planting corn, the dry season and the wet season. Milpa corn is generally planted in the rolling hills in the end of the dry season before the rains start. Matahambre is planted at the end of the wet season, typically November or December. While the dry season usually runs from about December to May or June, each year climatic fluctuations alter planting and harvesting schedules in the region.

The most apparent differences between households were not necessarily in land use but in livelihood diversification. Households were generally found to be at extremes on the spectrum, either with exceptionally diversified farming and income activities or fully dependent on a corn crop alone. Diversification related also to village networks. Families with multiple income activities had extensive social networks, but those whose livelihoods were dependent on one or two activities did not. Farming households with some wealth or assets are able to retain diversification options and may be more able to deal with political and economic changes (Batterbury 2001). Diversification of livelihood activities may be the key to economic success in the study area.

In Toledo, it seems that development programs have had a significant impact on farmers, at least those directly exposed to extension officers and program information. Attitudes about deforestation and chemical input use reflected these impacts, but it is unclear what effect they have had on actual land use. Many people did express that burning swidden plots was "bad for the forest," but it seemed that very few had completely abandoned the practice. Slash-and-burn instead was presented as a last resort for replenishing soil nutrients when a farmer could not move to a new plot. Farmers' attitudes about chemical herbicides, pesticides, and fertilizers were somewhat complex. While most related the dangers of chemical use, such as retention in the soil and toxicity, this did not stop the practice. Some farmers preferred one chemical over another for the same purpose because of a belief that the first was not quite as bad for the environment.

The geography of development has been important in the trends in rural-rural migration, although the extent to which it influences migration decisions is not certain. In the case of the community of Jordan, the construction of the road attracted many families to the newly formed village. Developing infrastructure also had a role in the growth or demise of the other villages concerned in this study. For example, Machaca was abandoned due to a complete lack of infrastructure while road improvements led to growth in both Aguacate and Blue Creek and the construction of the road to Jordan essentially facilitated to its development.

Staple Crop Production

In the three study villages beans and rice are not commonly cultivated but each household has at least one piece of land under corn cultivation. The average amount of land under cultivation per household was 2.9 acres (n=28) but may be more accurate when calculated without two unusually high responses as 2.5 (n=26). Agricultural plots are an average distance equivalent to a 42 minute walk (n=31) from households and are typically 600 meters to one kilometer from the nearest road. A significant majority of farmers ride bicycles to their farms and distance walking may not be an accurate representation of distance to farms. Regrowth, often called *huamil* (also *guamil*), a Spanish derived term that means "low secondary growth" (Carter 1969), took between two and four man-days per acre to clear, and there were not discrepancies between huamil and "high bush." Participants reported that planting a corn field, without any reference to size, takes 6.4 man-days (n=19) and harvesting takes 12.95 man-days (n=21).

Harvests averaged around 4,200 lbs. of corn, or about 50 bags, with a range of responses between 800 and 9,000 lbs. Only about a quarter of farmers interviewed sold any of their harvests; many replied that a farmer must have a harvest over 100 bags in order to have some left over for market after meeting family requirements. Those who did take a significant amount of their corn harvest to market sold between a quarter and a third of their total harvest. All corn farmers cultivate white corn, while only a few try hybrid breeds, black, or yellow corn (Figure 5-2).

Matahambre

In November and December, farmers plant a dry season corn crop called *matahambre* (Figure 5-3), which is Spanish for "kills hunger." This crop is planted along river banks, where alluvial flooding produces fertile soils that can be used year after year. Slash-and-burn is not practiced on the river bank, but each year before planting weeds must be chopped and allowed to rot before planting can commence. In Mopan this second season corn is referred to as *begc*, and in Q'eqchi' as *sak'ewaj* (Emch 2003; Wilk 1997).

Planting of matahambre typically takes place over three or four hours of one morning. A farmer asks friends and family to aid in the planting and in return will supply his labor for planting their fields. Anywhere from six to twenty men stand in a line, planting seeds every few feet as they walk across the field. Matahambre fields range from 1 acre to about 3 acres.

Some farmers described this crop as a ninety day crop but then reported that the white corn had really taken four or five months to mature. The corn is left on the stalk to dry because dry corn is easier to harvest and carry back to the household (Figure 5-3). The corn itself must be dried before it can be husked and ground. By April or early May, the matahambre has dried sufficiently for harvest.

During the growing period, fields must be weeded and protected from birds and rodents that can destroy immature corn plants. Strong winds can also harm crops; these problems will be addressed below.

Milpa Between the Hills

Towards the middle and end of the dry season, usually May or early June, farmers begin to prepare for planting milpa fields. Last year's plots must be chopped and allowed to dry before burning. Not everyone practices slash-and-burn, and in fact, many farmers expressed that they believed burning was bad for the forest and stated that they no longer burn. Instead these men practice what is termed slash-and-mulch agriculture, chopping overgrowth before the last rains and allowing it to decompose slightly.

A single farmer will usually take about two weeks to clear a plot of around two acres, often working from 7:00am to around 3:00pm during the week and several more hours on Saturdays. Clearing is better in the mornings when weeds and grasses are wet and soft, and therefore, easier to chop. Once a farmer is confident that the last of the rains has come, he will burn the vegetation. Planting typically takes place about a week after burning to preserve nutrients released from the burned vegetation.

Like matahambre, milpa corn is planted with reciprocal labor groups of extended family or friends in one day. Often the farmer's family is responsible for feeding the men that help plant. Milpa fields typically range from about 1.5 to five or six acres (Figure 5-4). Traditionally, squash seeds are planted in the same holes as corn seeds. Squash is an important wet season crop and also provides groundcover that helps prevent the growth of weeds.

This corn, too, must be weeded regularly and protected from pests. Some farmers have adopted the use of the mucuna bean (*Mucuna* spp.) in their plots; more will be discussed about this nitrogen-fixing legume below. Weeding takes place in the mornings, leaving afternoons open for wage labor should the opportunity arise. Maintenance of the milpa is especially important in early stages of plant growth as overcrowding and pests can destroy vulnerable young corn.

Milpa corn is also left on the stalk until it is dry to make it easier to harvest and transport. Around October or November, farmers will begin to harvest their milpa corn. More so than matahambre, farmers may ask for help in harvesting milpas. It seems that harvests for milpas are significantly higher than those of matahambre, but that may be a result of more availability of land in the hills than along rivers, and thus larger agricultural plots.

Fallowing and Slash-and-Burn Agriculture

Swidden agriculture is defined by shifting of crops and/or plots. In the three villages that comprise the study area of this thesis, the traditional practice of shifting is not always visible. Fallow periods in some cases were completely nonexistent. Some farmers reported using matahambre fields for twenty consecutive years while others preferred to use a field for six years before letting it rest for one year. These men often had adjacent fields that were fallow, where in one year the huamil can grow to be six feet high. This was explained to be a sign of good soil both in the hills and along the river bank. Milpa fields were not used over twelve consecutive years and were more often than not burned each year before planting.

Overall, it seems that an adaptive management approach is appropriate to describe patterns of fallow in the study villages. For example, one farmer said of the regrowth, "when it gets low you change the place again." In Blue Creek another reported using a matahambre plot for six years before letting it rest for two years during which regrowth reached seven meters.

Like those regarding fallow patterns, responses about slash-and-burn agriculture varied greatly. Decisions to burn also seem to be rather adaptive to climate and geography. Slash-and-burn allows farmers to cultivate the same piece of land for many consecutive years. Some reported farming the same plot for 12 to 15 years. Because the soil is fertile in small valleys between the hills slash-and-mulch agriculture also allows for consecutive cultivation, but fields usually have to be left fallow after four to six years of planting. Fallow periods ranged from two years in valleys to over ten years on slopes. In some cases, however, plots on slopes are not cleared and replanted in a farmer's lifetime and secondary forest replaces those areas.

Milpa plots are often cleared with the help of friends and family (Figure 5-5). Burning usually takes place in May and seeds must be planted within one week or the bush will grow back and cover crops. Farmers must wait until the rain has sufficiently stopped in May or June before burning because if there are heavy rains after vegetation is burned it can rot. Some participants expressed concern that burning can be dangerous if there are a lot of grasses and only one farmer said that he burns matahambre fields.

More than expected, farmers in the study villages practiced slash-and-mulch in their matahambre fields. Because they are planted on river banks that periodically flood, replenishing soil nutrients, fallows were rare and fields were often planted every year. Land in these riparian areas was highly coveted and in a few cases has been passed down for several generations. Because of the nature of this form of agriculture, as population grows people cut high bush further from their homes alongside the river. When the trees on the river bank are cut down too, the bank erodes and forces farmers to expand their fields in the opposite direction, frequently cutting taller forest near the river. This practice does threaten river ecosystems somewhat, but more so the increased chemical use can be detrimental to the environment. Because these fields are use for successive years, weeds and grasses increase and prompt increases in chemical use.

Fertilizers, Herbicides and Pesticides

A variety of chemicals are used in both milpa and matahambre agriculture. Half of participants do use some form of chemical input on their farms, while half reported that they do not use chemical fertilizers, herbicides, or pesticides. The most commonly mentioned chemical was Gramoxone, used most often during the clearing phase before planting to destroy vegetation. This chemical can be purchased by the liter at the farm supply store in the market town of Punta Gorda for BZ $16. Gramoxone is the commercial name for paraquat, a highly toxic chemical that participants reported using as fertilizer, mixing with water and spraying under corn plants to “make corn green.” However, in herbicide literature paraquat is used only for weed control and as a defoliant in some cases.

Many people also reported using 2,4,D (2,4,Dichlorophenoxyacetic acid**)** to control broadleaf weeds, which costs BZ $11 per liter. Roundup, the brand-name version of 2,4,D, is a broad-spectrum herbicide used to kill tough grasses in corn fields but is “bad because it stays in the ground for years.” A majority of 2,4,D users reported that it is only used in matahambre fields and said that they use it only to kill grass instead of “the poison ones that kill everything: paraquat and Roundup.” Others said that Roundup and Gramoxone cannot be sprayed on corn or it will spoil the plants. At the farm supply store the price for one liter of Roundup is BZ $25, while its generic competitors cost BZ $16 per liter. These herbicides are typically mixed with water and sprayed on grasses, one sausage tin of chemical in five gallons of water. Prices may seem reasonable but in many cases chemicals are too expensive for subsistence farmers. Farmers expressed understanding of the negative health effects that chemical herbicides and fertilizers pose for people but were more concerned with increasing harvests.

The mucuna bean (*Mucuna puriens*), also called the velvet bean or green manure (Shriar 2001), is a nitrogen-fixing legume that not only acts as a fertilizer but also provides dense groundcover that prevents the growth of weeds (Figure 5-6). This technique may have been introduced by a development project in the 1990’s, though I could not discern from participant responses which project or who was involved. Utilization of the mucuna bean requires more time investment from the farmer than does traditional slash-and-burn cultivation because beans must be planted one year before the corn crop. This means the field must be cleared one year before crops can be planted, and this takes away time and energy from the farmer’s other fields. Most farmers expressed that they could not afford to sacrifice one year of cultivation for planting mucuna. Once the mucuna bean is established after one year, the plants are chopped and corn is planted. The vine of the bean will grow back in a dense layer of groundcover while allowing the corn stalk to grow vertically. Another problem with mucuna beans is that the fer-de-lance (*Bothrops asper*) is very attracted to the cool shade the plant provides. The fer-de-lance, also referred to as the "tommygoff" in Belize, is the deadliest snake in Central and South America. Participants in the study reported incidents of dog and horse deaths, but no human fatalities from the snake.

Challenges to Traditional Production

Four main difficulties of traditional subsistence were discussed by participants in this study. The most prevalent problem is damage to crops caused by animals. Birds eat the small husks but rodents seem to be the worst problem. Pecary, "gibnut" or paca, and agouti, destroy the corn "when it starts to grow." They also eat fallen husks that would otherwise be included in the harvest. Some reported staking out fields and shooting gibnut, while others use insecticide to try to keep rodents away.

Another serious issue is growth of tough grasses that strangle corn plants. One farmer explained that when a field is used for successive seasons, each season more weed seeds are brought on farmers' boots from the road, so more grasses grow. Corn grass (*Rottboellia cochinchinensis*) or "camalote" were reported as the most difficult to kill and often is not completely eradicated by Roundup or by burning.

The challenge to production mentioned the least was erosion of the riverbank. Each year the farmers lose some land to the river and are forced to expand their matahambre in the other direction. Cacao trees can be planted along the riverbank to prevent soil erosion, but there were none at any of the farms surveyed for this study.

Hurricanes and wind damage present a different sort of challenge for corn farmers. While animals, grasses, and erosion can be actively dealt with, hurricanes and wind can be unpredictable and are not preventable. In October of 2001, Toledo's milpa corn and mechanized rice crops were virtually wiped out by Hurricane Iris. Wind damage can happen at any time, and it is said if you plant too early corn will be more vulnerable in high winds that can cause plants to die before they mature.

Supplemental Subsistence Trends

Every farming head of household interviewed reported growing white corn in both the dry and wet seasons. Few invest time and land solely in this crop, while most also planted beans and maintained fruit trees either on their farms or at home. Most families purchase rice, flour, and beans throughout the year and said they used all or almost all of the corn harvested in their household. Swidden agriculture is often supplemented by wage labor in the village or in nearby towns. Tourism is a large wage-supplying sector in Toledo, and many people are drawn to resorts for the income they provide.

Most households do participate in animal husbandry, raising chickens for meat and eggs. Many households in Aguacate also raise pigs. Heads of these households indicated that pigs are raised for sale, which often means transporting them to nearby villages. Pigs are neutered and sold once they reach about 125 lbs. In these households selling corn is in effect out of the question because it is used for feed for both pigs and chickens. Those families that do not raise pigs expressed desire to do so but were concerned with increasing their corn harvest for feed. Respondents explained that pigs are not raised in Blue Creek and Jordan because they would destroy crops planted in farms that are relatively close the village.

Many fruit trees are grown by the study households. Fruit trees are grown both next to houses and in swidden plots. Bananas are the most frequently grown fruit while plantains and cassava are also common. Other food plants cultivated include peanut, sweet potato, mango, citrus, tomato, pineapple, coconut, cashew, grapefruit, avocado, soursop, cabbage, and cilantro.

The Mopan and Q'eqchi' Maya traditionally utilize their environment for building materials, medicinal remedies, crafts, and other plants that are used for food or cooking. Sugar cane grows wild in the forests surrounding these villages and is not only harvested for household use, but is eaten by farmers during long working days. The jipijapa is a palm that is used to make baskets for sale and for use in the household as storage containers. The heart of this palm, along with wild sugar cane, is also eaten during long days working the farm. Young fronds are taken prior to blooming, smoked, and woven into baskets. These fronds turn a shade of white when smoked and are often accentuated in the baskets by mature fronds, which turn black when smoked. In Blue Creek, baskets and other handmade crafts are sold at the base of a trail that leads to a cave frequented by tourists.

The cohune palm (*Orbigyna cohune*) has many uses among the Maya of southern Belize. The tree's large fronds are commonly used for thatch roofing for houses and shelters for dry or drying corn. The core of the palm, called "cohune cabbage," is a frequent addition to regional diet. The fruit itself is also consumed after being roasted in banana leaves. One key advantage this tree has over others in the tropics is that it can generally survive burning. Farmers are able to maintain the usefulness of the cohune palm even after years of slash-and-burn agriculture in the same plot. Cohune oil is commonly used in Toledo as well, but none of the participants in this study indicated that they make the oil themselves.

Immature fruit from riparian fig trees is used to fish for the most commonly eaten river fish, machaca (*Brycon guatemalensis*). Historically this has been a very important fish throughout Toledo District for populations that migrated and created new villages along the Moho, Temash, and Sarstoon Rivers.

Cash Crops

Few farmers in the three villages were cultivating rice during this fieldwork. Farming rice has become unprofitable as a cash crop and requires more labor than is practical for household consumption alone. In Blue Creek and Aguacate, rice is grown only in the hills during the wet season. In Jordan, however, the physical geography allows for almost year-round cultivation due to the low-lying swampy plains. Rice requires fertile soil and cannot be grown in the same field for more than two consecutive years without completely depleting the soil's nutrients. Because I did my fieldwork in the dry season, I did not experience the activities of rice farming. My questionnaire included general questions about farming that did not distinguish between each crop, but rather aimed to solicit general information about farming practices. It did not, however, include detailed questions about rice farming such as amount of harvest or specific practices unique to rice farming. Because so few farmers in the sample were active in rice cultivation, I feel that omitting these details did not detract from the overall results of the study.

In the past few decades development projects have encouraged mechanized rice production by providing loans, seed, and combines. Prior to the 1980s many people did grow rice for household consumption, but since mechanization was introduced most have lost interest, presumably because of a decrease in market price for both buyer and seller. Now growing rice on a large scale is too expensive because of the costs of transportation, chemical inputs, and paying for combines. One informant reported that there are only five operating combines in the Toledo District. This makes it virtually impossible to ensure that a combine will be available when mature rice must be harvested, since all over the district crops mature at the same time.

Additionally, the market for rice has been very weak for the past twenty years or so. Some farmers cross the border into Guatemala to sell rice and beans because there is such a great demand for agricultural products. In recent years the rice mill in Big Falls has become unreliable, unable to guarantee a fair price for wet or dry rice and sometimes not being able to buy at all. Most families purchase rice at local shops where it is relatively inexpensive.

Cultivation of cacao in Toledo (Figure 5-7) is not widespread but is the most secure form of cash cropping. Prices are set at BZ$1.65 per pound and there is a rolling five year contract with the buyers who purchase from TCGA in Punta Gorda on the condition that it is grown organically. Growing cacao, however, requires a lot of labor up front to maintain trees that do not produce substantial fruit until they are five or six years old. Additionally, a farmer cannot provide for his household solely with income from several acres of cacao trees.

Seeds are available from TCGA for free and extension officers stationed around the district provide information about cultivation and pest management. In one acre, a farmer can plant 300-400 trees. The first few years require large labor inputs from the farmer, mostly clearing and weeding around the saplings. Dense weeds can suffocate the trees' roots and kill them. Nevertheless, mature trees shade the ground well, and shade and leaf litter prevent weeds from growing. Because cacao is a cash crop, the principle of reciprocal labor does not apply. The current rate a farmer must pay for help on a plantation is BZ$25 per day.

There are two seasons for cacao cultivation much like the two corn seasons. Beans are usually harvested in May, and then trees will flower again in June or July to produce a crop in November. Five-year-old trees produce 200-300 lbs of beans per acre and six-year-old mature trees can produce up to 700 lbs per acre. Once harvested from the tree, beans and pulp are removed from the pod and allowed to ferment for eight days. The pulp liquefies and the beans are then dried, usually in the sun. One informant stated that 800 lbs on the tree is 600 lbs dry (Figure 5-7).

Of the 33 farming heads of household interviewed, three were actively engaged in growing cacao as a cash crop; another four had young trees that did not yet produce fruit; and only three planned to plant cacao trees in the near future. While there are not many farmers engaged in cacao cultivation, very few of those who are not expressed the desire to do so. Cacao farming requires years of labor input before a profit can be seen, and most feel they cannot afford that wait. One successful cacao farmer said that to grow cacao it was not a matter of money, but "you have to have the interest and work."

Many of the cacao farmers reported interacting with an extension officer from TCGA, and most had received seeds or saplings from the association. The TCGA also provides training programs for interested farmers and information on the various pests that can affect the cacao crop. Stem boring weevils and "wee wee ants" (carpenter ants) were the only pests identified by study participants. Fermented and dried beans can succumb to a fungus called *monilia* which may cause the harvested beans to be rejected by the TCGA. To test for quality twenty beans are taken from each bag and checked for aroma and for fungus; 95% of beans in the sample must meet the standard or the bag is rejected.

The TCGA has also set up deals with companies to sell certain spices at free trade prices. Nutmeg, yellow ginger, allspice, and annatto are grown for sale only by the most resourceful and diversified farmers. The TCGA does provide some assistance for these spices as it does for cacao. Many are often sold at market by families from all over Toledo along with a variety of vegetables. Two varieties of cilantro are used in almost all contemporary traditional dishes, which nearly always include beans and rice, and are sold by almost all vendors at market.

Land Tenure

Farms are by and large located on reservation land, often called "crown land." While legally much of the land south of Santa Cruz may not technically be designated as reservation land, residents of the three villages in the study area reported that the areas used for farming were part of the reservation.

Only four of 33 respondents reported having leases on land in the study area, and three of the four said they lease 30 acres or more to Mennonites for rice farming. This land was reported to be acreage obtained during the TRDP rice project in the 1970s and 1980s on which Maya farmers could no longer afford cultivate rice. Of those that reported farming on reservation land a significant majority expressed the desire to obtain lease land. Some farmers had been told that they had to occupy a piece of land for ten years before they were eligible for a lease, only to be told at the end of that period that they had to be there another ten years before they could apply.

One head of household, actually the chairman of the village council in one village, said that before eight years ago it was much easier to get leases. This correlates with the last period of development programs in the region. He explained how villagers were encouraged to get leases for land so that they could participate in rice or citrus programs and that is how many people came to have legal right to land. In contrast, another farmer complained that there is too much lease land surrounding the village of Blue Creek and that because of this the status of reservation land is much more contestable. Mennonites and other people not connected to local Maya villages have been collecting lands near the study villages and sometimes within reservation boundaries for over thirty years for intensive agriculture.

Migration

Historically the District of Toledo has been the setting for several waves of migration and this is illustrated in the responses of participants in this study. Late in the 1800s and the during the early 20th century, both Mopan and Q'eqchi' Maya were traveling over the border into Belize to escape harsh Spanish rule, forced labor, and German plantations in Mexico. During this phase of movement, settlements like Machaca, Aguacate, Dolores, and Otoxha were established. Then later in the middle of the twentieth century a wave of out-migration due to overcrowding in San Antonio led to the creation of communities of San Miguel, Blue Creek, and Laguna. Similarly, in the 1970s and 1980s families began to leave crowded communities to set up settlements in less-populated areas, resulting in the establishment of villages like Jordan, San Lucas, and Corazon. Each village, of course, has its own unique history but these general migration trends are important in understanding the movement of people throughout the Toledo District.

There are several general trends apparent from interview responses about factors influencing decisions to migrate. Analysis of these patterns is limited by informants' ability to recall events that happened during their childhood and by knowledge of past generations. A majority of participants knew where their parents were born, and slightly under half knew something about the migration of their grandparents.

Most movement takes place in young adulthood, either single or as a couple, or when a family's children are still of primary school age. The average age of migration among farmers interviewed was 16.1 years; slightly less than half reported moving to their current location before turning 13 years of age. Because of this trend, some heads of household could not recall why their families had moved since they had been young children at the time. Others remembered walking over an hour to farm, stating that availability of land was a primary reason for moving. Those that moved alone had varied answers to why they chose to relocate; among them were the search for land, jobs, and spouses. Individuals who moved to a different village to live with a new spouse reported land and access to fresh water as the most influential factors in their decisions. They also mentioned the strength of family ties as important.

There seems to be a forty year cycle of migration among Maya in Belize and Guatemala. It began around 1890 and forty years later, in the 1920s and 1930s, there was another wave of settlement that resulted in villages like Aguacate, Otoxha, Crique Jute, and Santa Teresa. Forty years after that, the 1970s also saw a wave of migration that led to the founding of villages like Corazon, Santa Anna, and San Marcos. This makes sense in terms of the family life cycle-if migrants are likely to relocate as single or newly married adults, around forty years later their children's children, the second generation, will be of migrating age. Thus every second generation will be confronted with population growth and may choose to out-migrate. Of course, not all migration can be explained with this pattern, and it does not explain the settlements of Blue Creek, Laguna, and San Miguel in the 1950s. It is likely that these villages were simply a reaction to population pressures on land in other villages. There does, however, seem to be an overarching trend.

Immigrants to Aguacate came overwhelmingly from Guatemala two or more generations before study participants were born. Movement was not always direct, however, and many families stopped in Machaca, Santa Theresa, or San Benito Poite before settling in Aguacate. Because there are five major families in the village, many people can recall the movement of previous generations of their families. More so than in the other two villages, a large portion of the studied population was born in Aguacate. In some cases, participants' parents and grandparents were also born in the village. Aguacate's migratory history is complicated by the nearby abandoned settlement of Machaca because it is located on the path from Guatemala used by many migrants that eventually ended up in Aguacate, but it is hard to say how many because most of this movement took place in the first half of the 20th century.

The history of Blue Creek largely dictated the responses of participants in the village regarding their family histories. The three largest families in the village are descendant from the three original families that settled Blue Creek in the 1950s. These families came from San Antonio, attracted to the abundant land along the bank of what was then the Rio Blanco and is now called Blue Creek River. Residents of the village have come from San Antonio as recent as the current generation of farmers, and have also come from San Antonio via Santa Cruz. Several heads of household could recall their parents coming from Guatemala to San Antonio before settling in Blue Creek, but others came from Guatemala and lived in Santa Cruz, Santa Theresa, and San Miguel before finally moving to Blue Creek.

Jordan was settled much later than the other two villages in the study, and among residents the actual history of its creation remains rather convoluted. There are two families in the village that report being the first family in the area and each came from a distinctly different place. Many of the residents of Jordan came from nearby Laguna in 1981 with their extended families in tow. Others, reportedly six families, came from Machaca. When the village was abandoned in the late 1970s a group of families went to Aguacate while a larger group moved to Jordan. Several of the heads of household who formerly lived in Laguna reported having family that came from Guatemala a generation or two before.

The major movements of participants to the three study villages seem to flow largely from two regions. From the north, many people have resettled from San Antonio looking for more land for farming. From the south, families have often traveled through Santa Theresa and San

Benito Poite. As stated earlier, these two routes of migration are representative of long-term flows from Guatemala.

Because a large portion of families in Toledo rely on subsistence livelihoods, it is understandable that availability of land would be the primary push and pull factor of migration (Figure 5-8). Most heads of household did report land as a significant reason for relocating, but there were several other factors at work. Sometimes when a couple was married, they would relocate to whichever village offered the most in the way of resources. More often than not, the husband would move to the wife's village, and gave that as his reason for migration. Another key component of the decision to resettle was the availability of fresh water, specifically access to the river. Several families indicated access to clean water for washing, bathing, and cooking as their reason for moving. Availability of jobs was a factor among a few respondents, particularly jobs created by the citrus development projects in the 1970s and 1980s.

It seemed that the most important factor influencing decisions regarding resettlement was availability of land both along the river and in the hills (Figure 5-8). Distance to farms was very important to residents in the study area, as they often related having to travel several miles to agricultural plots before relocating. Respondents did not seem to directly evaluate the fertility of land, but rather looked for "high bush." High bush is essentially low dense forest regrowth, and to residents it signifies fertile soils. Some participants recalled leaving villages with "low bush" in search of better land for farming. Only a few mentioned nutrient levels of soil, but that was usually in conjunction with discussion about chemical use.

As stated above, access to fresh water was also an important component in decision-making. In the rural areas of Toledo water pumping systems are not standard in each village and many people rely on rivers for water that is used for drinking, cooking, washing dishes and clothes, and bathing. In the dry season, many smaller streams dry up completely or stop flowing and stagnate, so the deeper rivers are very attractive. In villages with pump systems, water is drawn from the aquifer into a large tank from which water is piped to houses but is not treated. This is the case in Blue Creek where 91.7% of households use "pipe water," although the village's pump is broken and a borrowed pump is used today. If the borrowed pump breaks as well, the village will be forced to use the river for all water needs until it can finance the purchase of a new pump. In Aguacate there is a pump system but it is extremely inefficient and expensive to use, so people often take advantage of the many streams in the area. There, 20.5% (n=44) of households do not have access to pipe water, and a similar number are without electricity. Jordan also has a pump system that connects to just fewer than half the village's households and most families do use the Mojo River (Figure 5-9A) for at least some portion of their water needs. Piped water is pumped from the underground aquifer and is not treated.

The least reported influence on migration decisions was availability of jobs. Because relatively high-paying jobs will always be in urban centers or in tourism along the coast, those are not the jobs that draw people to this region. Rather, it was specifically citrus and rice development programs, notably those conducted by the Toledo Research and Development Program (TRDP) in the 1980s, that attracted people to Blue Creek and Aguacate in particular. Once the programs had run their course, however, the projects were discontinued and so were the jobs.

Clearly, people choose to migrate in response to negative aspects of the origin area or positive aspects of the destination area, or both. In the case of this research, land is the main contributing factor to migration decision-making. While availability of land for agricultural use is a requisite for resettlement in the destination area, it is not always the primary reason for moving.

People decide to move for political, socioeconomic, environmental, and personal reasons. The residents of the study villages were likely to move to villages where they had friends or family, and these social networks seemed to give migrants an advantage economically. It is typically these networks that provide information about destination areas to potential migrants, thereby influencing decisions about migration (Todaro 1976). Access to clean water was an influential factor for migrating people, in some cases second to available land. For these subsistence farmers, wage labor was not a key part of decision-making due to the structure or seasonal labor within Belize. Men and women are able to temporarily migrate to participate in wage labor jobs in tourism, citrus production, or fisheries.

Wage Labor Activities

Outside of typical subsistence activities wage labor provides money for the cash economy of Toledo District. Of 32 responses, 68.75% reported working at some point in the last year. Participation in wage labor varies by village due to job availability. Close to half of participants both in Aguacate and Jordan said they had had a job of some sort, while in Blue Creek 86.7% worked for wages (n=15).

The most common jobs were either in tourism or were related to agriculture. Many younger men and women are attracted to the pay at resorts or along the coast in tourism towns. Working in landscaping is common, as is working as a tour guide for various natural and archaeological attractions. In Blue Creek several male heads of household have made a reputation as tour guides to the village’s cave, but there is no set price for the tour and it often varies depending on the resort that transports the tourists to the village. Very few people reported working on citrus plantations but several families had a male head of household who traveled for several months out of the year to work at shrimp farms in central Belize and resorts in Placencia or other coastal towns. The most common form of employment, however, comes in the form of sporadic daily wages for clearing agricultural land.

The Mennonites within and outside of each of the three villages will pay BZ $20 for a day of chopping, but usually only employ one man for several days at a time about twice a year. At a rice mill up the road from Blue Creek, one head of household reported earning BZ $22 per day. In contrast to these local jobs, those who worked in tourism reported earning up to BZ $35 per day on the coasts or at resorts.

In the case of Toledo, ethnic segregation may have some influence on migratory patterns. The only urban area in the district, Punta Gorda, is primarily inhabited by creole and Garifuna families, and does not offer many wage labor jobs. The Maya that may travel further north, to Stann Creek district or on to Belize City, compete with Creole and Hispanic groups for jobs. For the subsistence-oriented individual, these areas may not be attractive as outside income sources.

Land Cover and Remote Sensing

This chapter will evaluate results of analysis of land use and land cover over the period between 1991 and 2001 and will illustrate the changes in land cover and land use during the period of available imagery. For each of the villages a land use catchment area was determined using GPS and ethnographic data, and for each village catchment rates of clearing and growth were determined. Maps for each time period will illustrate where growth and clearing have occurred. Land cover trajectories will show the sequence of land cover change over the time period, and maps will provide land cover classes for each year allowing for a temporal picture of the landscape in each village as well as in southern Toledo. These trends will be evaluated on the village level for comparisons between villages and on a regional level to identify larger patterns.

Color composites of satellite images illustrate differences in vegetation density as well as showing general topographical features of the area. The densest vegetation appears a dark green, while the most developed areas appear bright pink (Figure 5-10).

The Normalized Difference Vegetation Index (NDVI) has been used to measure a wide variety of vegetation conditions, vegetation health, greenness, and relative biomass (Pelkey et al. 2002). Since NDVI is a good measure of greenness (Figure 5-11), it can easily differentiate between roads, water, and sparse vegetation and dense forest biomass (Sader et al. 1991). In this study NDVI analysis shows clearing primarily concentrated along rivers and roads in each of the study villages. This is to be expected in areas of dense vegetative forest.

According to NDVI subtraction analysis (Figure 5-12), it seems that in many cases areas that were cleared between 1991 and 1996 were fallowed by 2001. This suggests maximum fallow lengths as short as eight or nine years after one or two years of cultivation. An overall trend of regrowth occurred between 1991 and 1996, while the opposite is true for the period between 1996 and 2001. With respect to Blue Creek, NDVI analysis suggests that plots cleared and farmed before 1996 were left to fallow by that year and farmers traveled farther from the village for subsequent cultivation. Areas around Jordan and Aguacate that were fallowed between 1991 and 1996 were often cleared again in the years immediately following. Cultivation by residents of these three villages is spatially limited by steep slopes with dense vegetation near Aguacate and Blue Creek and by low infertile plains outside of Blue Creek and Jordan. These features are clearly visible in the vegetation index.

Land cover was classified using ERDAS IMAGINE 8.4 software. First, unsupervised classifications were performed to identify natural breaks in spectral variance and then supervised classifications were completed using training samples collected in the field. Five classes were eventually selected for analysis: forest, low bush, agriculture, bare, and water. Land cover classification was done for the entire Toledo District, and then a subset of the village catchments was created.

Land cover trajectories (Figure 5-13) provide a succinct image of land cover change over time. In this case land cover class for each image year is recorded for each pixel. This enables the researcher to examine trends of change spatially and temporally. In the time frame of 1991 to 2001, 45.3% of area in study village catchments did not change; of this area, 17.9% remained forest, 26.4% remained low bush, while less than one percent each of areas classified agriculture, bare, or water remained the same across the time scale. In the 54.7% of catchment area that did change over time the most common classification was change between low bush and forest; 16.95% of area was classified forest-low bush-forest, 16.3% was low bush-low bush-forest, 11.3% was low bush-forest-forest, and 12.6% was forest-low bush-low bush.

Blue Creek had the highest rates for land cover under agriculture (Figure 5-14) while Aguacate and Jordan had comparable amounts of land under agriculture during the same time period. Blue Creek also had the highest rate of bare land cover. Of the three villages, Blue Creek is the most developed and is more tied into the regional market so it makes sense that it would have more cultivation and bare land. Jordan had the highest rates of forested land while Aguacate and Blue Creek had comparable amounts of forest land cover. The overall trend in land cover change for the area of the study suggests a decrease in land used for agriculture in the mid 1990s. In 1991 half of the landscape was low bush; this number climbed to over 60% in 1996 and then dropped to 45% by 2001. This is a logical result of agricultural land abandoned and the subsequent secondary growth that would occur in most agricultural plots. Area actually classified as agriculture dropped from 6% in 1991 to less than 3% in 1996, but was followed by a rise to 5.4% in 2001. Forest decreased in the mid 1990s to less than one-third of the area but increased to 45% of the village catchment area by 2001.

In Blue Creek and Aguacate more low bush was cleared and converted to other land cover than in the other study village, while more low bush grew to be classified as forest in Jordan than in the other two villages. Secondary growth that was classified as agriculture in 1991 was two times more likely to be low bush than forest in later years. Most areas classified as bare in 1991 experienced secondary growth in the first five years and were classified as low bush in 1996. While about two-thirds of this area remained low bush, very little grew to forest and in some cases the land cover reverted to bare.

The most common class in the trajectory was area that remained low bush throughout the time frame of the analysis. Of the areas in the village catchments that did experience change over the time trajectory, 64.5% were classified as either forest or low bush the entire time. The most common of these classes were forest-low bush-forest and low bush-low bush-forest. Including those areas that did not change, nearly 80% of land cover remained forest, low bush, or some combination of the two.

There was a general trend among the three study villages regarding clearing and growth of land cover; prior to 1991 a significant amount had been cleared but between 1991 and 1996 less land was converted from low bush and forest to cleared land and agriculture (Figure 5-14). The land cover of the area utilized by residents of Aguacate experienced significantly more regrowth than clearing with a growth rate of just over 5% between 1991 and 1996. Between 1996 and 2001, however, 3.5% of the landscape was cleared for conversion. The area around Blue Creek experienced a slow rate of regrowth (1.6%) that countered any clearing that occurred between 1991 and 1996. A growth rate of 4.7% during the next five years followed that time period.

Jordan experienced large rates of regrowth and minimal rates of clearing in the time frame of interest. Almost 12% of the land area experienced regrowth between 1991 and 2001, while 6.4% did in the subsequent five years.

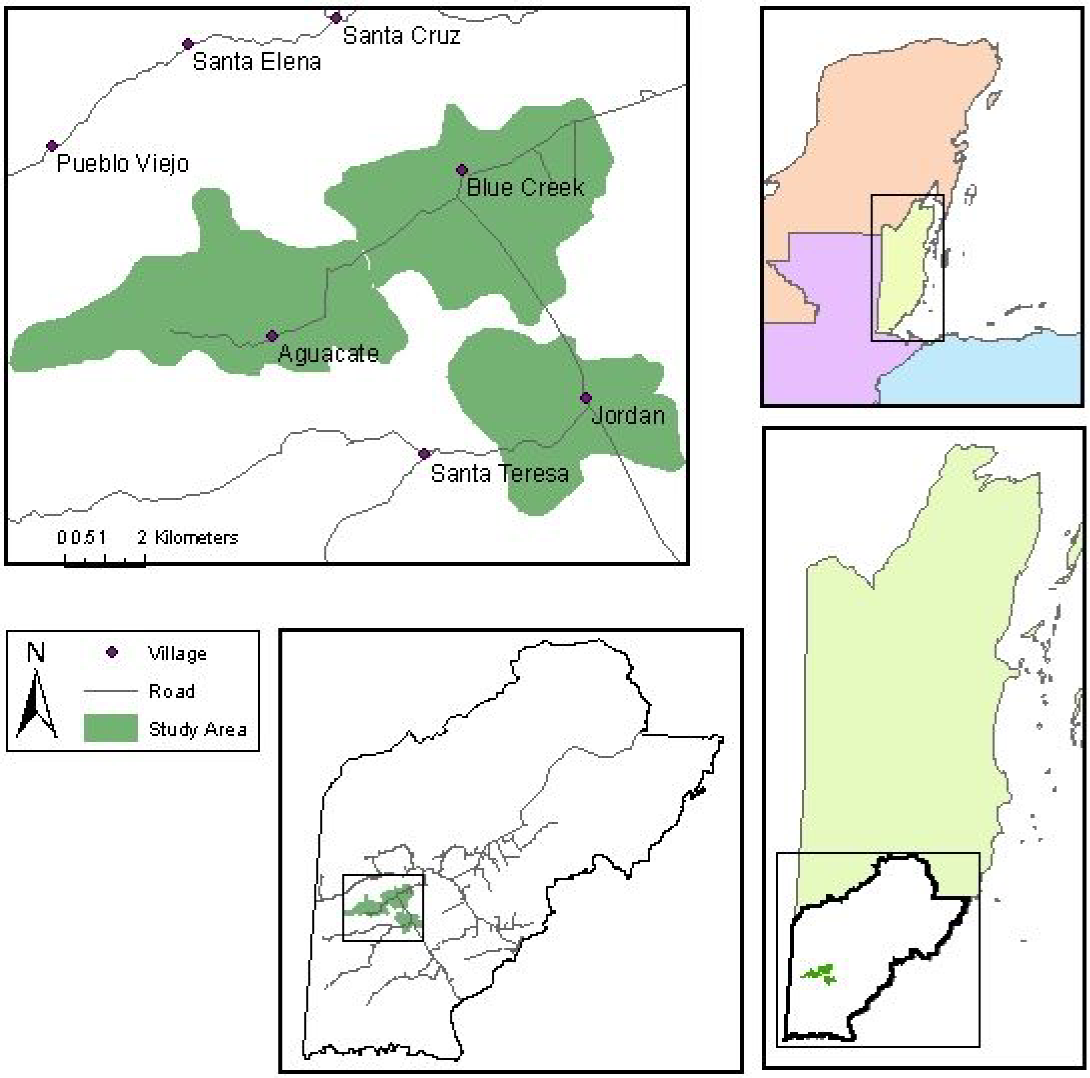


Figure 5-1. Location of study area.

Figure 5-2. Local farmer shucking white corn after it has dried.

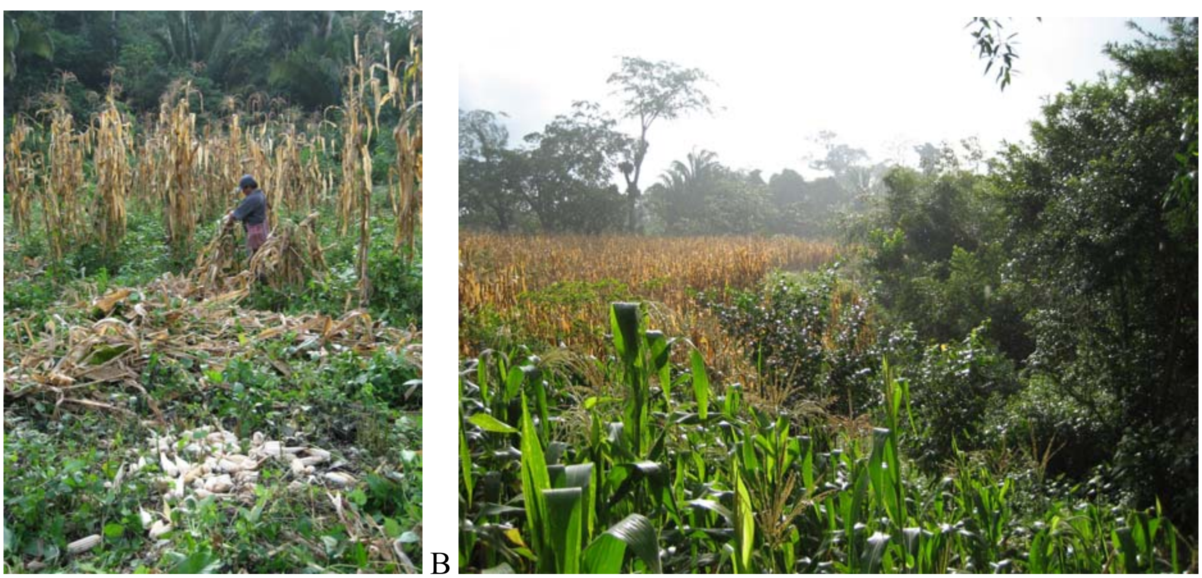
A  B

Figure 5-3. Matahambre fields. A) Local farmer breaking dry corn stalks to harvest white corn in matahambre field. B) Matahambre field next to Blue Creek River, not yet ready for harvest.

Figure 5-4. Milpa field in fallow. This farmer has planted sweet potatoes in the foreground and recently cleared the hillside for corn.

Figure 5-5. Clearing in preparation for burning and milpa planting.

Figure 5-6. Mucuna bean plant.

Figure 5-7. Cacao. A) Farmer in Aguacate shows off his dried cacao beans. B) Mature cacao tree.

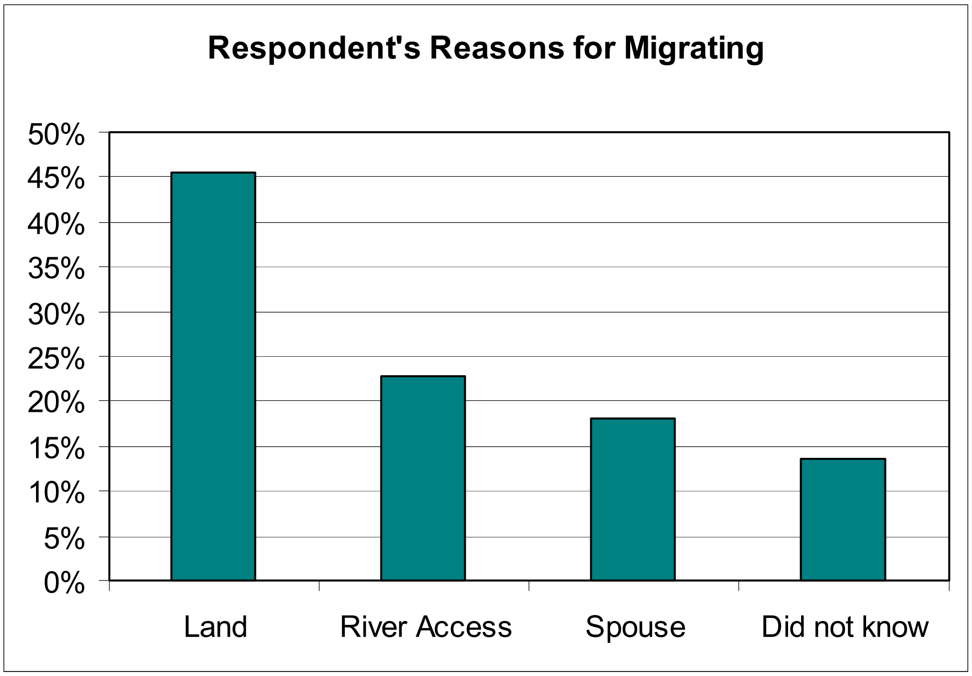


Figure 5-8. Reasons for respondents' decisions to migrate.

A B

Figure 5-9. Study area rivers. A) Mojo River outside Jordan; B) Aguacate River.

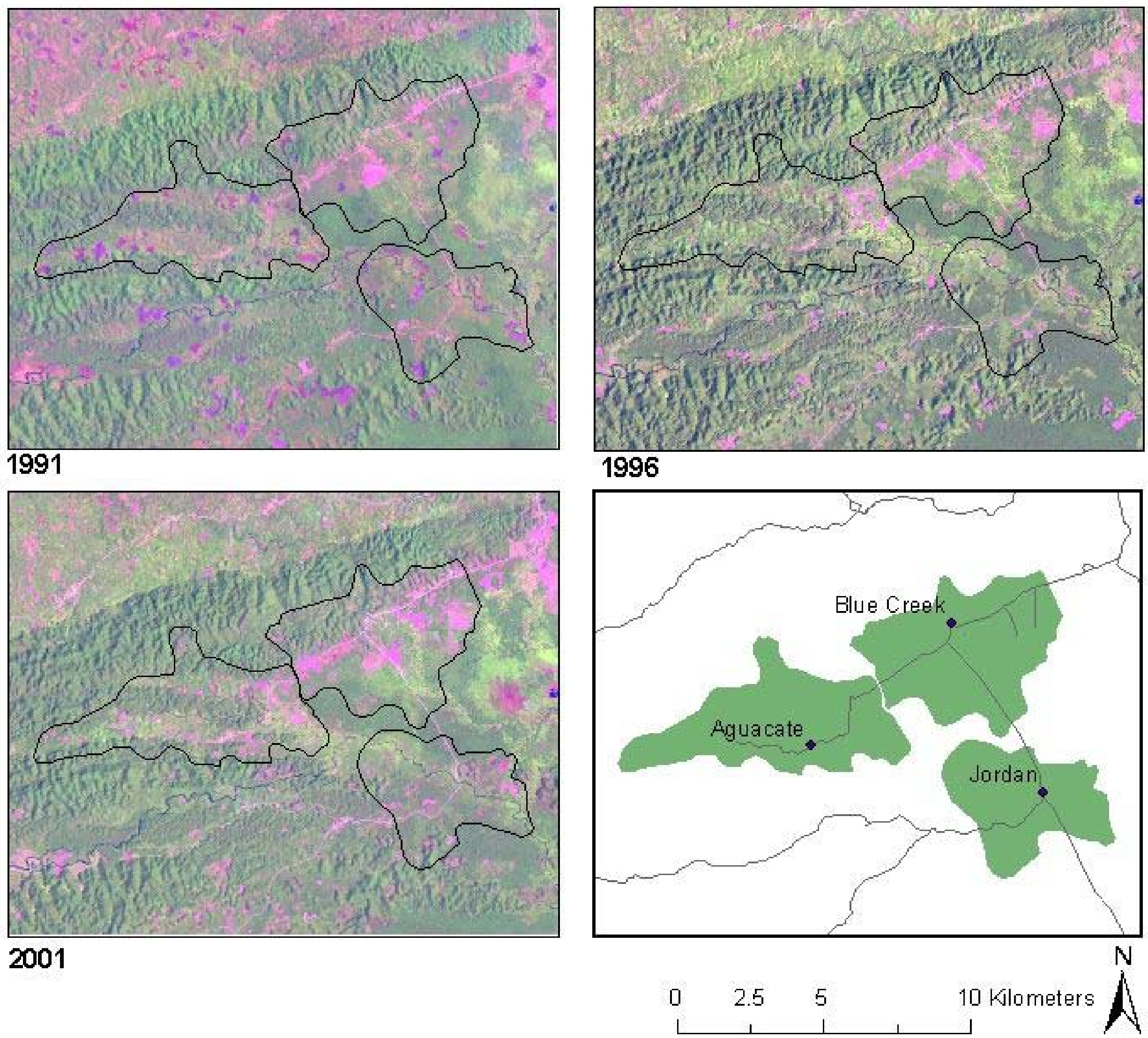


Figure 5-10. Color composite of satellite imagery from 1991, 1996, and 2001 of the study area (composite of bands 5,4,3).

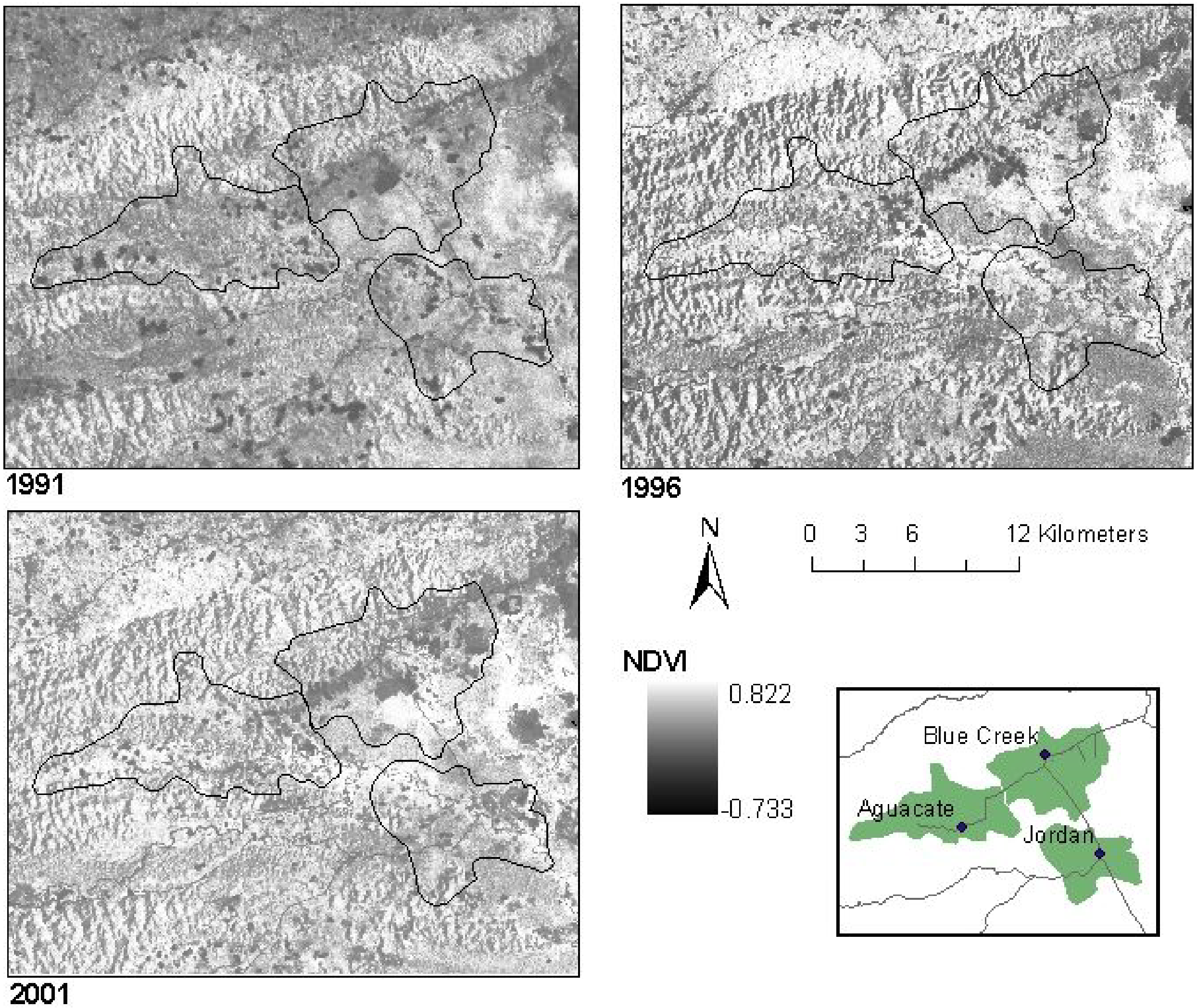


Figure 5-11. Normalized Vegetation Difference Index of study area.

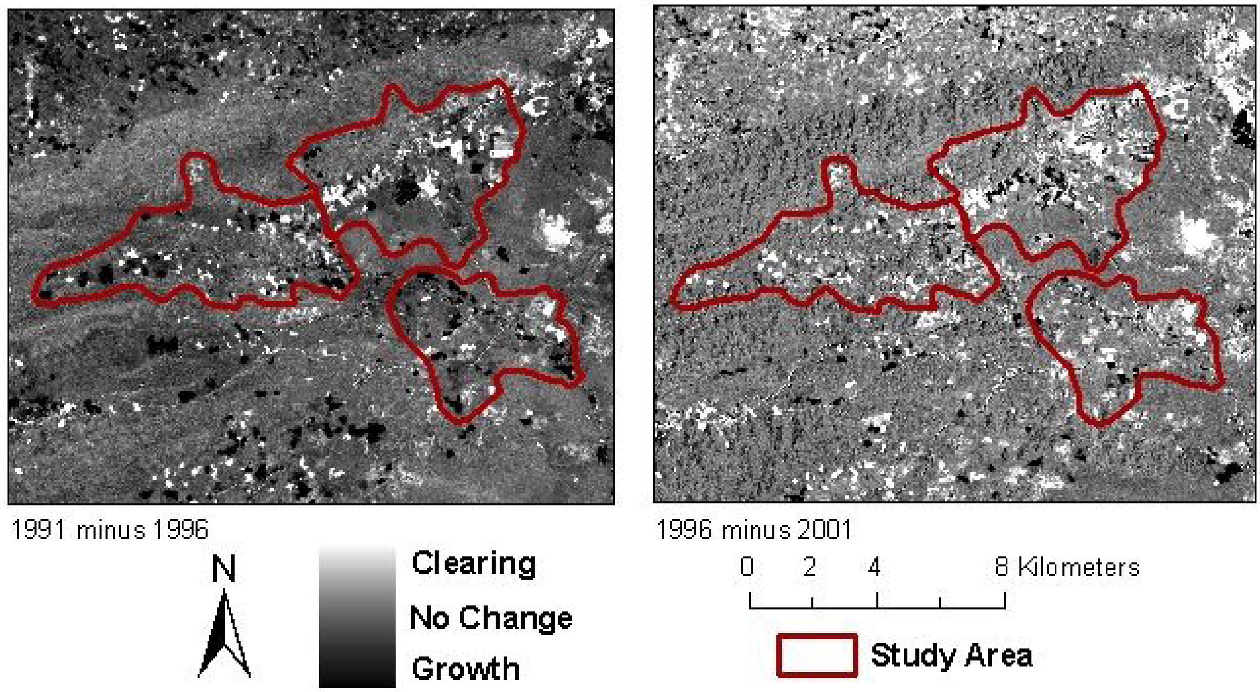


Figure 5-12. Image subtraction of NDVIs

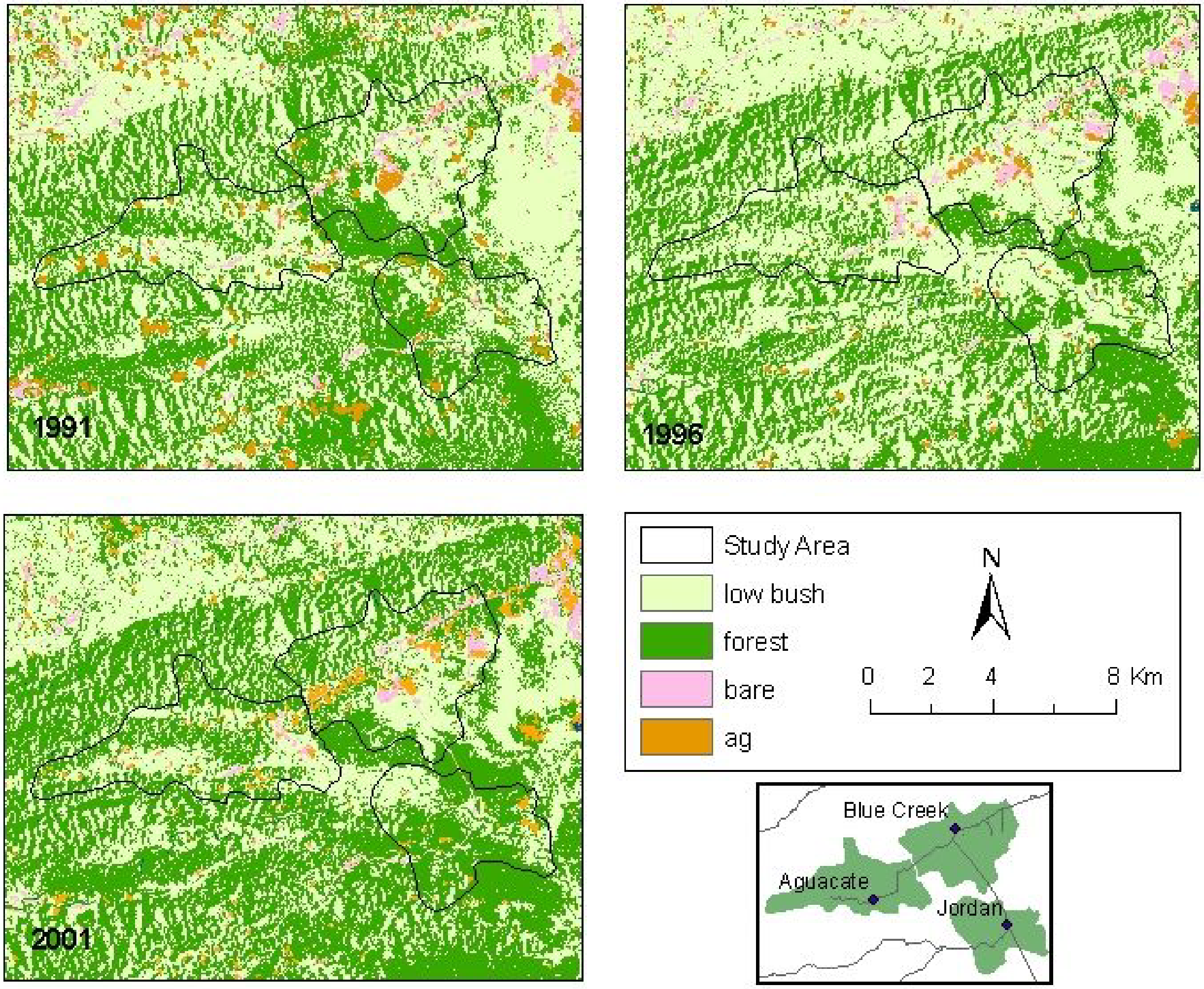


Figure 5-13. Land Cover Classification

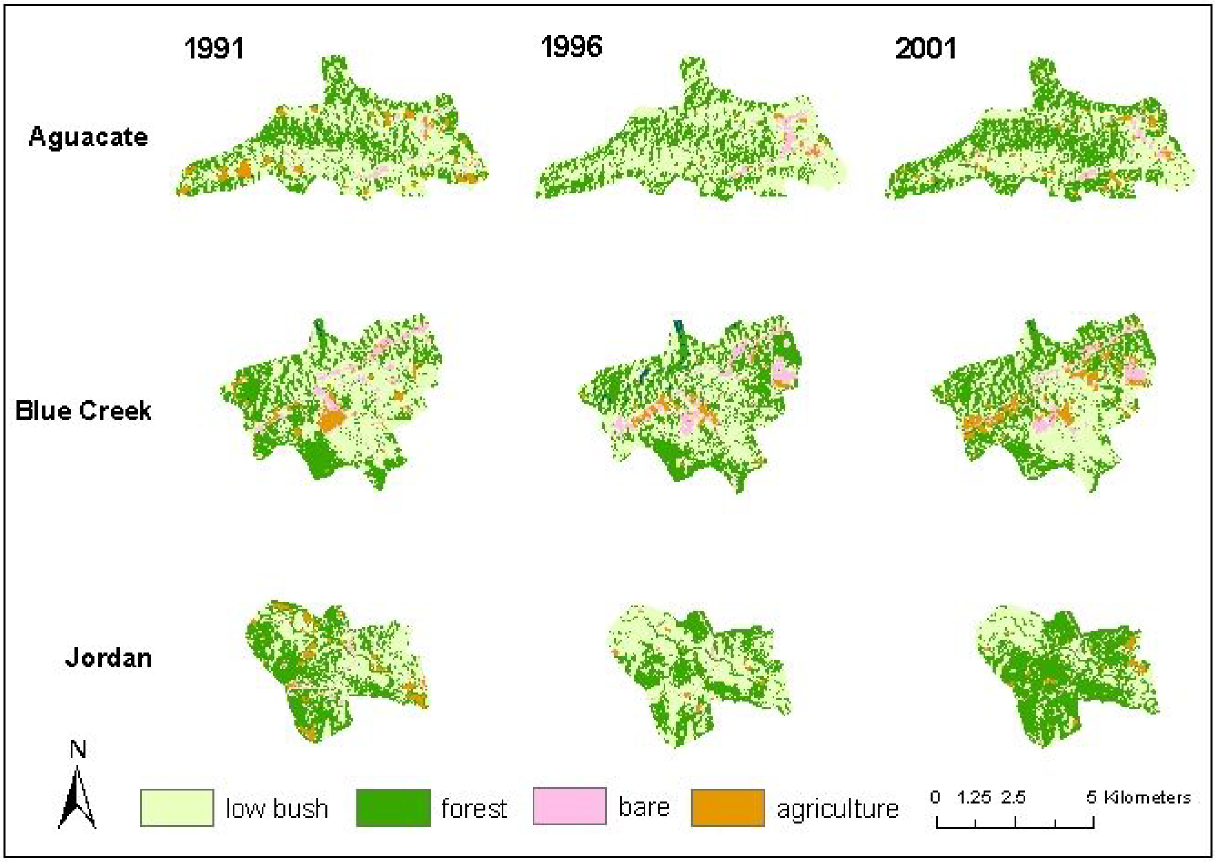


Figure 5-14. Land change by village by year

CHAPTER 6
DISCUSSION

The main objective of my study was to characterize the relationship between migration and land use in the study area while assessing land use practices and patterns of migration. Specifically, I set out to answer several specific questions: 1) Does length of residence affect land use among rural Maya farmers in southern Belize? 2) Does place of origin influence an individual's land use decisions at the destination place? 3) Do length of residence and place of origin correlate with environmental degradation caused by subsistence practices? In addition to investigating these questions, I wanted to document land use practices among the residents of three villages in southern Belize and collect demographic data about households and farmers. What I found was that the factors that influence land use and subsistence practices are very complex and the impact of migration on land use may be unique to the individual case. While differences in land use may not correlate directly with migratory patterns, the movement of families into the area can be traced spatially and temporally.

This chapter will briefly summarize the results as they apply to the objectives of this study, followed by a discussion of the implications of the results. Specifically, I will discuss whether or not differences in land use can be attributed to migratory patterns and histories, and how the spatial movement of families in the study area may relate to land use and land cover change. I will also asses land use practices utilized by rural peoples in southern Belize and their relevance on a larger scale. I will address the appropriateness of remotely-sensed data analysis in the absence of ethnographic on-the-ground data in general and also in the study area. Lastly, this thesis will explore the future of land use and migration in the tropics and give some recommendations for improving the relationship between rural communities and governing bodies regarding land use and migration policy.

The main purpose of this thesis is to determine the relationship between migration and land use. While studying migration can help in understanding the processes of environmental degradation in the tropics, examining land use change can also help illuminate migration patterns and processes (Carr 2002).

Land Use in Southern Belize

This study set out to examine the relationship between where people migrate from, the origin area, and their land use in the destination area. It is unclear what specific effect those components included in the generalization of geographic heritage might have on land use in the destination area. Motivations behind land use are complex such that any influence past subsistence patterns have had on current land use strategies is indeterminable though the methods of this study. What is clear is that over the past thirty years or so development projects have had a significant influence on land use and land cover change in the study area.

Length of residence does not seem to directly impact land use, although there are some overarching trends associated with length of residence in the destination area. The main difference between those farmers who have lived in the area for generations and those that have been there for only months or years is knowledge of the area's physical geography, specifically topography. A newcomer would undoubtedly have to learn where other farmers keep their plots and how to get there, but would not necessarily be lacking knowledge of which crops grow best in which areas or of seasonal variation in climate or cultivation. This is similar to moving to a new city-you must learn the roads and layout of the area but you know what to expect when you go to a grocery store.

Because individual identity is largely tied to village and local identity, geographic heritage does not greatly influence land use strategies or successes. Becoming a resident of a new village requires that the farmer surrender to the current circumstances of land use, meaning he must be allotted land for housing his family and he will likely have to communicate with village leaders about where to first clear secondary growth for farming. Thus he becomes tied into the village's social system, shedding social roles he may have had previously at the origin area. Subsistence success is more likely related to the farmer's social network. A farmer who moves to a new village where he has family or friends increases his family's chances of economic success. Or, similarly, after a decade or more of residence in a village post-migration, a farmer is more likely to have developed social ties to others in the village.

Length of residence is related to environmental degradation in several ways. In areas where subsistence farming is the dominant livelihood, relocation to a new, frequently frontier, area will logically result in the clearing of some land for farming. The degree of deforestation that results from this clearing, however, is not necessarily related to length of residence or place of origin, but rather to the quality of soils, density of vegetation in desirable areas, and access to other resources such as fresh water. It seemed that those farmers who had lived in the area for more than a generation were likely to experiment with different or hybrid corn seeds, but it is unclear whether this is related to length of residence, knowledge of the area, or social support in the case of crop failure. Traditional ecological knowledge does seem to be more prevalent among farmers and families that had resided in the area longer, in accordance with other research in nearby Petén (Nesheim et al. 2006), but this may also be a factor of age. Younger couples with small children and young single adults are the most likely to migrate to new areas. Older farmers, who most likely had spent a good deal of their adulthood in their current village, tended to diversify which generally meant there was more food availably for family and for sale, while younger farmers often invested only in one field with one crop per season.

In this study, a farmer's place of origin does not noticeably impact land use patterns. Most migration was reported to occur over short distances and relatively frequently, such that there were not dramatic differences between origin and destination areas socially or environmentally. Climate, geography, and economy remain relatively homogenous in rural villages in and surrounding the study area. Where a farmer and his family migrated from could affect rates of clearing if the place of origin was characterized by population pressure and competition for scarce land resources, in which case a farmer might feel the need to claim more land than needed to sustain his family. In this study, however, that did not seem to be the case.

Migration theory centers on economic motivations, while in reality reasons for migration are complex and may be unique to individuals and circumstances. Rural populations are in many cases tied to the land through livelihood. Humans are forever changing landscapes, and in turn landscapes have profound affects on human populations. It is this interaction between human groups and the environment that is the focus of ecological anthropology. People in southern Zambia migrated in response to population pressures and land hunger, citing social conflict that limited access to land and other resources as reasons for migration (Copestake 1998). Economic factors may be influential, but availability of land is particularly important (Amacher et al. 1998). In the tropics, patterns driving deforestation are cyclical: increased pressures on resources caused by population growth generally induce out-migration and land use adaptations to these pressures typically precede demographic responses (Bilsborrow 1987). The intergenerational aspects of family succession and expansion are clearly complex in their interactions with land use but have yet to be extensively studied (Walker et al. 2002).

Insecure or changing tenure circumstances likely affected land use change across the time period assessed by spatial analysis. The 1980s and 1990s experienced relatively rapid economic change and market expansion, and, coupled with the abundance of development schemes, these changes could have inspired small farmers to expand production. Policies that encourage capital and support commercial agriculture often have unintended impacts on local employment and attitudes about the economy (Amacher et al. 1998). Additionally, insecure tenure in times of economic expansion typically motivates farmers to clear more land in an attempt to secure their hold on land they have. Barbier and Burgess (2001) provide a clear overview of the influence of tenure insecurity on land use in forested tropical areas, but in this study very few farmers had actually obtained tenure security so there was not an alternative to compare to those farmers who reported having no tenured land.

The patterns of migration gathered in this study cannot directly explain the land cover changes found through spatial analysis because the spatial extents of each vary considerably. Migration generally did not occur between the three villages included in the study, but instead between the villages in the study area and about a dozen other villages in the Toledo District. The patterns of migration here can, however, illustrate larger trends of population movement in the area.

Integration of Remote Sensing and Ethnography

In recent years there has been an initiative to supplement cultural studies with spatial data just as there has been a shift towards integrating social data into spatial research. Remote sensing and ethnography are complimentary methods, but one without the other provides an incomplete picture of the phenomena at work on the ground. Spatial thinking has long been a part of anthropological inquiry, and space is an intrinsic property of life and society (Aldenderfer and Maschner 1996).

That remote sensing alone cannot tell the whole land use and land cover change story is illustrated in relationships between livelihood and land use in the literature (McCusker and Carr

2007). Remote sensing cannot substitute for intensive ethnography, and neither can ethnography alone begin to address the temporal change analysis possible with remote sensing (Guyer and Lambin 1993). Remote sensing can, however, help in the analysis of social hypotheses that would otherwise be too complex to address, and can allow for systematic comparison of land cover data and cultural information. Walker and colleagues (2002) found that land cover change models that do not include household-level data are likely inaccurate. The omission of such on-the-ground variables can provide an incomplete picture of phenomena at work. Using remote sensing analysis alone, Emch and colleagues (2005) found an aggregate forest loss rate of almost 10 percent in Toledo District. This finding does not agree with the results of this study, probably because no logging areas exist within the study area of this research that would have been included in district-wide land cover change analysis. And although some findings of the aforementioned research were witnessed during fieldwork for this thesis, such as increased deforestation along the border between Belize and Guatemala connected to population growth and migration, those findings were not included in this study.

In this study, data gathered through interviews and ethnography is limited by respondents' abilities and desires to accurately report information. Ethnographic methods may fall short when dealing with temporal changes in open systems because they will inevitably rely heavily on description and recall (Guyer and Lambin 1993). Often estimations are made about harvest amounts or how much land is cultivated and for how long. For the purposes of anthropological inquiry, estimations are generally accepted. However, with the inclusion of analysis of land cover I was able to map farms, eliminating reporting error and establishing accurate numbers for things that were measurable on the ground. In addition to this being useful for examining land use practices, spatial data gathering also proved valuable for comparing respondent's answers to actual measurements.

Similarly, without extensive knowledge of the history of development in the study area, remotely sensed data would have provided an incomplete picture of land cover change. The population of interest in this study does not generally obtain titles and engage in intensive large scale agriculture that is visible in some areas of the spatial scene.

This study is a good example of the need to integrate remote sensing and cultural analysis. As humans continue to alter the surface of the earth, a deeper understanding of the interactions between the landscape and people will prove impertinent in future policy making, conservation efforts, and scientific research. Because mechanisms of cause and effect are strongly temporal it is difficult to deduce such patterns from data that provides merely a "snapshot" in time (Goodchild 1996). Combining spatial and cultural methods can resolve this issue when applied to appropriate research questions.

Directions for Future Study

The main purpose of this study, as stated previously, was to determine the relationship between migration and land use in southern Belize. While the data yielded some trends and patterns, much more research is needed in order to understand the complex ways that population movement and people's subsistence patterns interact. Future research in this area will not only provide useful for furthering academic knowledge about population movement, human-environment interaction, and subsistence, but can provide policy-makers with in depth information and can arm conservationists with understanding about the ways policy and social systems affect the environment.

Past research has largely ignored how household reactions to the human and physical environment in one place may affect land cover change in another place (Carr 2002). Studies that involve data from migrant destination and origin areas in land use and land cover change analysis are needed to understand the processes of out-migration, frontier colonization, agriculture, and deforestation in the tropics. Researching variability at the individual and household level at the destination area does not provide the whole picture.

Much research has investigated the role of the household life cycle in migration to the frontier and the associated land use and land cover change (Carr 2005; Chimhowu and Hulme 2006; Godoy et al. 1997; Perz 2001; Walker et al. 2002; Zimmerer 2004). The life cycle of the household may partly explain the evolution of the landscape given that land users and their families experience changing needs and capabilities that inevitably influence their economic decision making (Carr 2002). Clearly more research involving the relationship between household evolution and the landscape is necessary.

Policy makers are clearly in need of a better understanding of the results of complex land use change over time so that they might design and implement regionally adapted policy interventions which can stimulate benefits and counteract negative consequences of land use change (Müller and Zeller 2002). This means considering the various economic, environmental, and social objectives of policy and compromising accordingly. Major forms of environmental damage associated with migration-deforestation, desertification, and soil degradation-could be greatly alleviated by appropriate government policies and programs (Bilsborrow and DeLargy 1990). For example, policies that support commercial agriculture and international trade often negatively impact employment, unintentionally encouraging migration which leads to environmental damage at the frontier (Amacher et al. 1998).

APPENDIX A
INDIVIDUAL SURVEY PROTOCOL

History of Settlement and Family Information

How old are you and the members of your family?
Do you speak Mopan / Q'eqchi? Do the members of your family?
How many years of education did you receive?
How many children do you have?
How many live at home?
When did your family settle in this village?
Where did your family live before moving here?
Where were you born?
Where were your parents born?
Why did you leave?
Why did you choose to settle here?
Did you have access to more or less land there?
What are the main differences in the land between where you live now and where your family lived before settling here?

Land Use and Agricultural Practices

What crops do you typically plant?
How many fields do you usually plant for one season?
What types of corn do you grow?
Was the land here open or covered with forest when your family came here?
How many years in a row do you plant the same field?
How long does a field have to rest before it can be planted again?
What is the average size of a planted field?
Do you ever mulch instead of burning? Why?
How much tall forest have you cut for fields in the last 5 years?
Do you use fertilizers or pesticides? How much and for which crops?
Do you raise animals for food?
Do you have a garden at home?
Is the soil in your fields good / bad?
Are there any crops that people grew in the past but don't grow anymore? Why?
Do people use any new (improved) varieties of any of the main crops? Why or why not?
Do you cut forest every year for crops? How often?
Do you ever lose an entire crop?
Do you think too much forest is being cut in Toledo District?
When do you plant?
When do you harvest?
Have you ever participated in citrus or mechanical rice programs?

Economic and Subsistence Information

How much of your harvest do you sell at market?
Which market do you go to?
How much of what your family eats comes from the market?
Is there enough land here for the people of Toledo District?
What is the cost of fertilizers here?
How much labor did you hire in the last year?
How much wage labor did you work in the last year?
Does your family earn income outside agriculture? Doing what?
About how much cash comes into your household each year?
Titles and loans?

APPENDIX B
LAND USE AND TRAINING SAMPLE PROTOCOL

Observation type** (check one)**: ☐ Within-site observation ☐ Edge observation ☐ Vantage observation ☐ Interview only

RESEARCH ID: ______________ **COUNTRY**:_____________ **COLLECTOR NAME**:__________________

DATE (mm/dd/yr): ____ /____ /______ **LOCAL TIME**__________ **VILLAGE**:__________________________

GEOGRAPHIC COORDINATES IN FIELD: UTM Zone _________ Datum _________

UTM Easting (X)_____________________ [m] UTM Northing (Y):______________________ [m]
ELEVATION:___________msl

GPS: Point FILENAME:_________ Perimeter FILENAME:_________ PDOP:_________ Est. Accuracy:______

LOCATION OF PLOT TOPOGRAPHICALLY: Ridge______ Slope_______ Flat_______ Steepness of Slope:________° (0-90°)
Azimuth (downhill direction of maximum slope in which water would naturally run)_______ (0-360°)

OWNER NAME:____ **MINUTES TO WALK:____________**

LANDUSE CLASS: Milpa ☐ Huamil ☐ Sec Forest ☐ Pri Forest ☐ Pasture ☐ Bare/Village ☐ Urban ☐ Water ☐

FALLOW STATUS (prior to clearing): __________________ EST. SIZE (acres)___________ DIST TO ROAD (m):__________

CROPS PRESENT:		MILPA STAGE:		**IEK:**			
Maize – white		Cleared field		QUAL FOR MILPA:		BEST CROPS:	
Plantains		Burned field		Poor		Maize – white	
Casava		1st yr Dry crop		Fair		Plantains	
Banana		1st yr Matahambre		Average		Casava	
Pineapple		2nd yr Dry crop		Good		Banana	
Rice		2nd yr Matahambre		Excellent		Pineapple	
Cacao		Other:				Rice	
Coco				SOIL TYPE:		Cacao	
Beans		LAND OWNERSHIP:		Black		Coco	
Ground foods		Reservation		Red		Beans	
Other:		Lease		Yellow		Ground foods	
		Village		Ixb'alamke pek		Other:	
		Private		Other:			

Days/men to clear huamil:_____________ Days/men to plant:_____________

How many years of use before fallow:_______________
Days/men to clear highbush:____________ Days/men to reap:_____________

How many fields planted per season:________________

Chemical inputs? Fertilizer ☐ ____

Pesticide ☐ ____

Other ☐ Explain:____

When did you plant?__________________________ When will you harvest?__________________________

Next season (hills) ?____

DIAGRAMS OF GENERAL OBSERVATIONS: Show GPS point, North arrow, major features

Aerial View	**Profile Diagram** (parallel to maximum slope)
(include land marks, north arrow and scale bar)	(overall draw of vegetation and slope, include vertical scale)

LAND USE HISTORY

Time (mm/yy)	Owner		Time	Owner		Time	Owner	
LAND USE:			LAND USE:			LAND USE:		
Milpa			Milpa			Milpa		
Huamil			Huamil			Huamil		
Secondary Forest			Secondary Forest			Secondary Forest		
Primary Forest			Primary Forest			Primary Forest		
Pasture			Pasture			Pasture		
Bare Soil / Village			Bare Soil / Village			Bare Soil / Village		
Urban			Urban			Urban		
Water			Water			Water		
Other:			Other:			Other:		
Fallow Status (yrs):			Fallow Status:			Fallow Status:		

LAND COVER

Use ground cover estimate sheet:
% herbaceous _______; % litter _______; % rock _______; % water ______; % treefall ______
Canopy closure: ______% cover Average canopy height:__________m,
Height of emergent trees:_________m No trees:________
Average DBH of canopy trees:
10-20 cm____; 20-30cm____; 30-50 cm____; 50-70 cm____; 70cm-1m____; > 1m _____
Average DBH of emergent trees:
10-20 cm____; 20-30 cm____; 30-50cm____; 50-70 cm____; 70cm-1m____; > 1m _____

DOMINANT SPECIES (Sci. name/common name)
____
____

MANAGED SPECIES (agriculture, agroforestry, plantation): Number of managed species (inc. planted)________

Sci. Name (Family/Genus/Species):_____________________________________

Common name:__________________ Density: Absent_____, Few _____, Moderate_____, Abundant _____

Sci. Name (Family/Genus/Species):__________________________________

Common name:__________________ Density: Absent_____, Few _____, Moderate_____, Abundant _____

Sci. Name (Family/Genus/Species):_____________________________________

Common name:__________________ Density: Absent_____, Few _____, Moderate_____, Abundant _____

Others:____

Number of photos taken: _______ Image #: N ______ S ______ E ______ W ______ U ______ D _______
Other _______________

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BIOGRAPHICAL SKETCH

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