

ROADS, GOVERNANCE AND LAND USE IN THE BRAZILIAN STATE OF ACRE

By

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To the people of Alto Acre

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The dissertation examines the relationships among roads, governance and land use in the Western Brazilian Amazon. Given the often negative social and environmental impacts of past road construction projects in the Amazon, in recent decades, the Brazilian government and civil society have come together to develop various forms of environmental governance, such as extractive reserves and regulations on land clearing and burning, designed to minimize these negative impacts. The dissertation draws on a case study in the Inter-Oceanic Highway corridor in the state of Acre to examine both the impacts that roads have had for land use and the role that governance has had in influencing these impacts.

The dissertation focuses on two forms of migration that have accompanied the opening and subsequent paving of the road—in-migration and rural-urban migration. Ethnographic and multivariate regression analyses revealed that many of the differences in terms of land uses that once characterized agriculturally-oriented migrants and extractivism-oriented Acreanos have disappeared after more than two decades of co-existence. An exception is the tendency of Acreanos to more heavily exploit Brazil nuts than do migrants. More recently, the paving of the road has led to the emergence of “bi-localism”—a tendency of households to invest their time and resources simultaneously in both rural and urban settings. This trend disproportionately

affected women. Furthermore, households in which female household heads spent greater amounts of time in town had lower Brazil nut production and households with fewer adult women present had significantly smaller cattle herds. Qualitative analysis suggested that this last tendency is related to gendered cattle production systems—in which herds own by women tend to grow more quickly than those owned by men.

Findings provide an optimistic evaluation of the potential for governance to moderate some of the most critical land use and land cover changes that have occurred in the road corridor. Multivariate analysis showed that environmental governance, as represented by government-mandated administrative units, was significantly related with lower levels of deforestation and smaller cattle herds.

CHAPTER 1 INTRODUCTION

Roads, Governance and Land Use in the Brazilian Amazon

A central issue in discussions about sustainable development in Brazil involves the implications of roads in the Amazon Basin. While road construction and paving carry the promise to improve access to goods and services among previously isolated rural and urban communities, they have also been shown to bring about negative environmental and social consequences, including deforestation and the displacement of rural smallholders, under pressure from in-migration and land-speculation. In academic and policy circles, a considerable debate exists regarding the capacity of governance to prevent these potential repercussions from highway paving (e.g., Nepstad et al., 2001, 2002; Laurance et al., 2001, Soares-Filho et al., 2004). Relevant examples of governance include the implementation of a deforestation monitoring program in Mato Grosso (Fearnside, 2003), ecological-economic zoning in Rondônia and Acre (Mahar, 2002, Governo do Acre, 2000) and, at smaller scales, the activities of rural workers syndicates to promote sustainable land use among members. While much of the existing literature uses landscape-level models to predict social and environmental changes arising from road construction and governance, to date, relatively little detailed research has focused upon these processes at the household and community level.

The dissertation addresses the relationship between roads, governance and land use at household and community levels in the municipalities of Brasiléia and Assis Brasil in the Alto Acre region of Acre, Brazil. It draws upon a political-ecological framework to contextualize household-level land use decisions within a multi-scaled political, economic and ecological context. Through such a perspective, it becomes easier to interpret the complex and often

contradictory economic, ecological and political forces shaping land use decisions in Acre's highway corridors.

Historically, the opening of roads in the Brazilian Amazon has been accompanied by large-scale deforestation, often followed by even more massive deforestation events when these roads are eventually paved (Hecht and Cockburn, 1990; Schmink and Wood, 1992; Fearnside, 2000b; Laurance et al., 2002). In the Amazon region, while deforestation within 50 km buffers of unpaved roads generally ranges from 0-9%, within similar buffers of paved roadways 29-58% of the land area has been deforested (Nepstad, 2002). For instance, in the state of Rondônia, the paving of the BR-364 highway in the early 1980's led to a massive influx of settlers from outside the region who brought with them livelihood systems that relied not upon the forest, as had the existing indigenous and rubber tapper populations, but upon the removal of the forest and its replacement with agricultural fields and pasture (Browder and Godfrey, 1997). While deforestation in Acre's early road corridors in the 1970's and 1980's generally occurred on a smaller scale than in neighboring Rondônia, the presence of an organized resistance among the rubber tapper community led to direct and widely-publicized conflicts between incoming groups seeking to acquire and clear land and the rubber tappers who sought to both maintain land rights and preserve the forest that provided a significant portion of their livelihoods.

The impact of roads upon land use change has become an especially salient issue given the *Avança Brasil* (Advance Brazil) program of the federal government. As of the mid-2000's, the program had begun providing all-weather roads in regions previously served by seasonal unpaved roads. *Avança Brasil* consists of 338 projects in Amazônia with US \$43 billion allocated for the first eight years (Fearnside, 2002b). In all, some 6245 km of existing seasonal roads have either been paved or are scheduled to be paved (Nepstad et al., 2001). As the amount

of land in the Brazilian Amazon within 50 km of paved highways will nearly double under the *Avança Brasil* program—from 16-28%—extrapolation from past trends shows that the project could greatly accelerate deforestation in the Amazon Basin. In a socio-environmental evaluation of the project, Nepstad and co-authors (2001) predict that, due to the project, 120,000-270,000 square kilometers of primary forest could be lost in the next 25-35 years.

In Acre, as in other parts of the Amazon Basin, both the greatest challenges and opportunities for combining economic development with forest conservation will likely occur in highway corridors (Kainer et al., 2003). On one hand, given increased accessibility, following road paving, adjacent areas become subject to greater population movements and, due to the access to new markets, land uses such as large-scale cattle ranching become more economically feasible, leading to further deforestation. On the other hand, the increased access to urban centers and markets may also prove to be beneficial in promoting forest-based economic development. For example, in roadside areas such as PAE Cachoera and Porto Dias and in the newly established Antimari state forest, all in the state of Acre, sustainable timber projects take advantage of the improved access to urban markets. While improved transportation in Acre's road corridors has facilitated out-migration to cities, it has also, by providing both better access to urban services and easier transportation for urban-based teachers, extensionists and medical care providers, improved living conditions in many rural communities (personal observation).

Ironically, despite the increased threats to the forest, the capacity of governance regimes may actually be strongest in highway corridors. The director of the Brasília office of the National Institute for Colonization and Agrarian Reform (INCRA) attested that the paving of the BR-317 highway had eased his office's task in working with local associations and enforcing environmental regulation; whereas a visit to some of the more distant areas administered by the

agency (up to 110 kilometers each way) once could take several days, with the paving of the road, it became possible for an INCRA team to make field visits and return within a matter of hours (Regional Director, Brasília Office of INCRA, personal communication).

In Acre, the arrival of roads has brought many benefits to local residents. It has eased the isolation once felt by rural families—facilitating their access to urban-based services such as schools, banks and hospitals. It also has brought increased access to markets and to outside capital. With the notable exception of Brazil nut extraction, which has benefited from improvements in road access, these changes have led to a general shift away from forest-based land uses to other more lucrative and less labor intensive practices—especially cattle ranching—giving rural families an opportunity to purchase goods and services that might otherwise remain out of reach (Faminow, 1998; personal observation). For example, in the field site, numerous families attributed their ability to build new homes, acquire solar panels and generators and purchase motorcycles or other vehicles and pay off farm debt and emergency health bills directly to profits from cattle ranching.

However, in addition to increased access to urban-based services and unprecedented prosperity brought by the road, the people of the region have found themselves facing unprecedented economic and environmental risks. Increased connectivity to regional and global markets has also brought new economic risks, such as the sudden shifts in prices for the forest and agricultural commodities upon which many families depend for monetary income—as witnessed by recent price fluctuations for beef and Brazil nuts. Due to the often lucrative nature of cattle production in the region, many farmers have chosen to clear forest and plant pasture grasses. Due to the difficulty of growing crops in land that has previously been used as

pasture, increased allocation of land to pasture represents a decreased opportunity to allocate land to other uses should beef prices fall.

Whereas deforestation under traditional shifting cultivation generally allowed the eventual regeneration of forest cover, deforestation followed by pasture creation leads to the long-term displacement and fragmentation of ecologically-important tropical forest. Compounding the direct impacts of deforestation and pasture establishment, the associated use of fire in clearing forest and maintaining pasture has brought further negative impacts for the region. During the burning season, thick smoke has led to increases in traffic accidents and respiratory illnesses (Mendonça, 2004), and during increasingly common dry years (such as 2005), uncontrolled fires threaten not only the state's forests, but also devastate pastures, corrals, fences and livestock, ironically threatening the cattle industry itself in more extreme instances. Furthermore, deforestation and fire may combine to bring devastating climactic and hydrological impacts at both regional and global levels. Within the Amazon Basin, rivers run dry during the increasingly-intense dry seasons, game and timber become scarce and adverse meso-climate change (including regional warming and drying) has shifted from a hypothetical proposition to an acknowledged fact of life for many of the area's residents, as noted in numerous interviews. And, at the global scale, changes in the Amazon's hydrology resulting from deforestation and fire may in turn change rainfall patterns elsewhere in Brazil, North America and Eurasia (Maslin et al., 2006).

Environmental governance, by shaping the trajectory of land use change in highway corridors, has direct implications for both forest conservation and economic development both within and beyond the highway corridors. In recent decades, governance in the Brazilian Amazon has been oriented toward the often contradictory tasks of promoting economic

prosperity and avoiding environmental risk through mandated stewardship of the region's forests. It is the complex relationship among these political, economic, and ecological contexts in affecting household and community-level land use change that my research project seeks both to describe and explain.

Research Questions

My research project addresses three broad questions related to the relationship between roads, governance and land use in the Alto Acre region. The first question addresses the relationship between the Inter-Oceanic Highway and land use.

As will be shown in the following chapter, researchers have pointed to the negative impacts of increased migration and market integration in past road construction projects, predicting that they are likely to continue in more recent road projects, such as the paving of the BR-317. Regarding migration, as will be shown in Chapter 3, in the Alto Acre region, the BR-317 has facilitated the migration of families from outside of the state into the region. It has also led to intra-regional migration between rural and urban areas. The road has also provided improved access to and the growth of urban markets, and in so doing has dramatically changed the land use options available to the region's rural residents. Addressing these linkages between the road and land use, I ask "how has the Inter-Oceanic Highway, by affecting migration and market integration, in turn affected land use in the road corridor?"

This question of the road's impacts upon land use leads to a second question about the capacity of governance to mediate these impacts. As will be shown in chapter 2, a considerable debate has emerged regarding the capacity of governance to mediate the impacts that new roads will have for land use in the Brazilian Amazon. While some researchers anticipate that past patterns of predatory land use will continue in current road projects, others argue that the development of legal mechanisms designed to protect Amazonia's natural resources and the rise

of an increasingly empowered civil society following Brazil's return to democracy in the mid-1980's can avert much of the negative social and environmental consequences of past infrastructure projects in the region, even bringing new opportunities for integrating economic development and forest conservation. In order to address this debate in the context Acre's BR-317 highway corridor, I ask "What role does governance play in influencing land use change in the BR-317 corridor?" The final question addresses the differential impacts of two forms of governance—centralized and participatory—upon land use in this region. In this region, centralized governance, while based in a democratic system, relies heavily upon decisions by governmental bureaucracies. The establishment and enforcement of legal limits on private property deforestation would be one example. In the research site, this form of governance is most visibly represented by the "administrative unit" (e.g., extractive reserve, colonization area, etc.), each of which are differentiated by legal deforestation limits, by presence of governmental agency and by the availability of environmental courses and projects. The other form of governance is more participatory in nature and is most conspicuous at a household level. Examples would include participation in associations, rural workers syndicates and in NGO-sponsored environmental courses. In Alto Acre, this participatory form of governance stems largely from the grassroots social movement that emerged in the 1970's and early 1980's to protect land rights and livelihoods of forest-dependent peoples such as rubber tappers. To address the differential impacts of these two forms of governance upon land use, I ask "what is the relationship among political-economic context, various forms of governance, environmental subjectivity and land use in Alto Acre?"

Organization of Dissertation

In this chapter, I offer an introduction to the research questions, the research site and methodology used in the collection and analysis of data. The following chapter outlines the

theoretical background, highlighting especially the possibilities for applying a political-ecological perspective to land use change in the Amazon. Drawing upon this foundation, I operationalize the various independent and dependent variables that are used in subsequent chapters to test relationships among the road, governance and land use. Using these variables, I outline the hypotheses that will be tested in chapters 3 and 4.

In chapter 3, I study the impacts of the Trans-Oceanic Highway for land use. In this chapter, I first address the relationship among roads, migration and land use—focusing upon the role that place of origin and rural-urban migration have for land use. Chapter 3 then addresses the question of market integration, focusing specifically upon the impacts of road access and the expanding cattle economy, for land use. Chapter 4 addresses the impacts of governance for land use in the region. The first portion of the chapter discusses the structure of governance in the region, including the intersections among land tenure, institutional design and land use. The latter portion of the chapter addresses the implications of centralized and participatory governance for land use.

Chapter 5 applies an explicitly political-ecological framework to consider the findings in chapters 3 and 4. Special attention is given to the ways in which different forms of governance affect (or do not affect) land use and the importance of the regional political-economy in mediating this relationship. Drawing upon this analysis, the chapter concludes with several policy recommendations for reconciling environmental governance with local economic realities.

Research Site

The research was conducted in the Alto Acre region of the state of Acre in the Western Brazilian Amazon (Figure 1-1). The Alto Acre region is so named due to its location in the upper regions of the Acre River watershed and is comprised of four municipalities—Assis Brasil, Brasília, Epitaciolândia and Xapuri. It is home to some 55,000 people (IBGE, 2004), who,

while rarely differentiating themselves along ethnic lines, tend to come from a combination of European, African and Amer-Indian ethnic backgrounds, with non-Indians tending to have arrived in the region either by river from Northeastern Brazil in the late 1800's and early 1900's to tap rubber or followed roads from South and Central Brazil in the mid to late 20th century. The population is roughly half rural and half urban. The entire urban population is concentrated in the towns of Assis Brasil, Brasiléia, Epitaciolandia and Xapuri, capitals of their respective municipalities and the only urban areas in the region.

While the service sector, light industry, and, increasingly, the public sector, employ many people in rural areas, agricultural and forest production form the backbone of the private economy, especially in rural areas, but also among urbanites who often have land and/or cattle in surrounding rural areas. With the exception of some specialized professions, most workers earn the national minimum wage—which at the time of research was \$300 reais (US\$140) per month.

Predominant land cover includes open semi-deciduous forests, which consist of a broken canopy interspersed with palms and bamboo, closed semi-deciduous forest, which has a denser canopy and more open understory, anthropogenic grasslands (cattle pasture) and agricultural plots, and abandoned agricultural lands in various states of succession (Governo do Acre, 2000). In the study region, soil types are dominated by Red and Yellow Agrissols; while these soils tend to have high aluminum content, it rarely reaches the point of aluminum toxicity (Governo do Estado do Acre, 2000). In my research area, informants commonly offered a perception of the area's soils and climate as being apt for agriculture.

The study lies on the border of Brasiléia and Assis Brasil, measuring some 50 kilometers east to west and 30 kilometers north to south and is bisected east to west by the Inter-Oceanic Highway (Figure 1-2). The majority of the research site lies in the municipality of Brasiléia—

with the westernmost portion lying in Assis Brasil. As of 2004, the 4,852 individuals in Assis Brasil and 16,940 living in Brasília were roughly divided between urban and rural residence (IBGE, 2004). The site is bounded by the Rio Acre and Bolivia to the south and the Rio Xapuri and the RESEX Chico Mendes to the north.

The study area formerly was comprised of four adjacent *seringais* (plural of *seringal* or rubber estate)—São Pedro, Sacado, Etelvir and Porto Carlos, each of which was bisected by the roadway. Each *seringal* came to a different fate after the coming of the road in the late 1970's, the subsequent violent land disputes between ranch workers and rubber tappers in the late 1970's and early 1980's, and the subsequent implementation of agrarian reform and extractive reserves in the area.

As of the time of research in the mid-2000's, the four original *seringais* were represented by six contiguous administrative units: 1) Quixadá, a Colonization Project (*Projeto de Assentamento Dirigido* or *PAD*), 2) Santa Quitéria, an Extractive Settlement Project (*Projeto de Assentamento Extractivista* or *PAE*), 3) RESEX Chico Mendes (the portion lying within *Seringal Etelvir*), 4) the privately-owned *fazenda* (ranch) Santa Rita, 5) the largely un-administrated *Terra Solta* and 6) *Seringal Porto Carlos*. The administrative units differed by land tenure system, government agency responsible (if any), legal deforestation limit and the presence of government and NGO-sponsored courses and projects related to forest conservation. These differences and their implications for land use will be analyzed in depth in chapter 4.

PAD Quixadá

Following the axis of the Inter-Oceanic Highway lays the colonization area officially known as *Projeto de Assentamento Dirigida Quixadá, Gleba 6*, or what is locally known more simply as “Quixadá.” *PAD Quixadá* is one of the numerous colonization areas the federal government has implemented in the Brazilian Amazon. In Acre alone, colonization areas occupy

some 1.4 million hectares (Governo do Acre, 2000). Historically, these areas have been administered by INCRA and divided into rectangular family farms or “*lotes*.” In Acre, *lotes* ranging from 60 to 100 hectares have been given to current occupants and to landless families from other parts of the country—all of whom are commonly referred to as *colonos* (Governo do Acre, 2000). These areas have generally been designed in distant government offices, with little consideration for on-the-ground terrain, agricultural suitability and water availability. Furthermore, due to the small size and the fact that few *lotes* coincided with pre-existing rubber trails, traditional forms of forest extractivism proved unviable, even for occupants with traditions of forest extractivism (Governo do Acre, 2000). In more recent years, due to a decrease in available land and increased emphasis upon forest conservation, in the state of Acre, the formation of new PADs has slowed considerably—and the size of newly-demarcated *lotes* has decreased considerably as well¹.

The history of PAD Quixadá lies in the violent confrontations between the area’s traditional rubber tapping populations and newly-arrived ranch workers². In an effort to stem the growing violent land conflict in the region that had led to the assassination of the president of Brasília’s Rural Worker’s Syndicate, Wilson Pinheiro, and a retaliatory lynching of the ranch manager widely believed to have been responsible, INCRA expropriated several ranches located in this area to form the Projeto de Assentamento Dirigido (PAD) Quixadá. The initial project was implemented in 1982, with the westernmost section—Gleba 6 (the portion of the PAD lying

¹ In Quixadá—Gleba 6, during 2005, some 11 families were settled onto a 300 hectare area that had not been developed by INCRA when the project was formed in the early 1980’s. Landholdings were considerably smaller than past *lotes*—with most families receiving slightly less than 30 hectares of land.

² By “ranch workers,” I refer to both the ranch managers (*gerente*) and ranch hands (*peões*) that directly operated the ranches in the region. The word “rancher” (*fazendeiro*) is more properly applied to the ranch owners—individuals who, due to the fact that they have often maintained residency in other parts of the state or country, rarely were directly involved with the day-to-day operations and with personal confrontations with rubber tappers during this era.

in the research site) —implemented shortly thereafter in 1983. In PAD Quixadá, Gleba 6, lots ranging from 70-100 hectares in size were demarcated in areas of Seringais São Pedro and Sacado formerly occupied (though not necessarily cleared) by the ranch that had been managed by Nilo. The area stretched along the edge of the highway and, in some areas, along access roads leading further to the north and south. First priority was given to the area's current (Acreano) inhabitants—most of whom received the lot in which their homes happened to be located. Unoccupied lots were given to landless families who were brought by INCRA from Paraná and other states in the south in 1983.

Many of the area's current residents had received their lots from INCRA in 1983. Many other current inhabitants represent later migrants or children of the first recipients who purchased lots from prior inhabitants who moved, most commonly to urban centers in the region. As a colonization area, among the administrative units included in the study, Quixadá contained the highest concentration of residents born outside of Acre, with 72% of sampled households in the PAD having at least one head born outside of Acre or neighboring areas of Peru and Bolivia.

INCRA carried official responsibility for overseeing the colonization project. However, some families had received full title to their lots, and the agency intended to fully privatize the project in the near future. Livelihoods were dominated by subsistence annual and perennial agriculture as well as some market-oriented agriculture—most notably cattle and, to a lesser degree, Brazil nuts. Timber—mostly from land destined to be converted to agriculture—served as an occasional source of supplemental income for many families. Deforestation was very advanced in this area and nearly all lots had far exceeded the 20% deforestation level permitted by law. According to estimates from the director of INCRA's regional office in Brasília, some 60%-70% of the project area had been deforested as of 2003. No over-arching local governance

structure existed in the region. Rather, most residents belong to one of eight local associations, each of which is autonomous from the other.

PAE Sta. Quitéria

Covering approximately 44,205 hectares, and home to at least 277 families, PAE Santa Quitéria was created in 1988, the second PAE to be created in Acre (Governo do Acre, 2000). Under INCRA's original plans, the entire area was to be divided into lots and incorporated into the PAD. However, the implementation of lots was halted as various stakeholders, including local residents and the National Council of Rubber Tappers (CNS), recognizing that traditional extractivist livelihoods were impossible on 70-100 ha lots, lobbied INCRA to implement a different system of agrarian reform that would recognize local families' traditional rights to multiple rubber tapping trails (ranging from three to eight trails for most families, with each trail being considered roughly equivalent to 100 hectares) and would give land to its original rubber tapping occupants and not to landless agriculturalist families from outside of the region.

The PAEs were established in an attempt to implement agrarian reform while respecting traditional *colocação* land tenure systems and forest-based livelihoods. As such, the PAEs served as an early experiment in the integration of agrarian reform and forest conservation. In these precursors of extractive reserves, such as Santa Quitéria, INCRA maintained official ownership of the area (extractive reserves, such as the globally-renowned Chico Mendes Extractive Reserve, would be administered by IBAMA, the federal agency charged with environmental protection, without a role for INCRA, an agency traditionally charged with agrarian reform issues).

PAEs were developed as an alternative to the PAD modality, an alternative in which traditional rubber tapper tenure systems would be maintained. While the distribution of lots in the PAD recognized rubber tapper rights to the land they occupied, they recognized neither

traditional livelihoods nor land tenure structures. As in other extractive reserves, land in the PAE is owned by the Brazilian state, and families have use rights to large areas (generally 200-300 ha) that are defined not by firm boundaries, but by the rubber-tapping trails within them (generally three to four per family). Local governance systems tend to focus upon local associations and the Association of the Residents of PAE Sta. Quitéria (AMPAESQ)—a centrally-located association intended to serve as an umbrella organization for local associations and to represent the project's residents in external political concerns.

RESEX Chico Mendes—(Seringal Etelvir)

Seringal Etelvir was sub-divided into three tracts and sold to ranching interests in the early 1980's, but the owner of the northwestern tract, as of the late 1980's, had still not expropriated local families nor cleared the forest for pasture, and unlike the more accessible southern segment of the former seringal, it was never expropriated for colonization by INCRA. As a result, this approximately 8000 hectare area was still largely forested and lightly inhabited when the Chico Mendes Reserve was created in 1990. Following its appropriation by IBAMA and incorporation into the reserve, this seringal fragment stands at the southern fringe of the RESEX, bordering PAD Quixadá and lying a mere four kilometers from the highway at its southernmost point. The area is arguably more directly impacted by road construction and market access than most other seringais within the RESEX. Indeed, evidenced in Figure 1-2, Seringal Etelvir is not only a bulwark of the RESEX facing southward toward the highway, it is also a major exit point and first or final resting point for the residents of at least five seringais located further inside the reserve.

As in PAE Sta. Quitéria, land tenure in the RESEX is based upon the relatively large *colocação* property unit, and properties are subject to a 10% ceiling on legal deforestation (as in the PAE but in contrast to the 20% in all other parts of the research site). Like Sta. Quitéria, a

two-tiered association structure exists, with local associations (two exist in this area) falling under the umbrella of the Association of Reserve Residents of Brasília (AMOREB) situated in Brasília.

Fazenda Sta. Rita—(Seringal Etelvir)

The northeastern segment of Seringal Etelvir was purchased to create three adjacent ranches, the largest of which is Santa Rita. The ranch's former owner, locally known as "*O Alemão*" ("The German"), until his death in a traffic accident in the late 1980s enjoyed relatively harmonious relations with his rubber tapper neighbors compared to neighboring ranchers and ranch workers who often killed and at times were killed by rubber tappers in land disputes. The Alemão, on the other hand, differentiated his ranch by purchasing land from not only the estate owner, but from the resident rubber tappers who lacked formal title to the land. This practice lowered animosity among displaced rubber tappers and is generally believed by locals to explain the continued existence of Santa Rita while so many other ranches were expropriated by INCRA as it attempted to stamp out land conflict in the region. While representing nearly half of the deforested area in the research site, the privately-owned Sta. Rita and its two ranch neighbors have played a relatively minimal role in more recent deforestation. Unlike other areas where deforestation rates have steadily increased, the deforestation of Sta. Rita largely occurred in two massive phases, first in the early 1980s and again in 1988, just as Amazonian deforestation was catching the attention of the world and the Brazilian government.

Terra Solta

The area alternatively known as the *Cinturão Verde* ("Green Belt") or the *Terra Solta* ("Loose Land") received its names from the facts that it forms a two kilometer largely-forested "belt" extending some six kilometers between the fazenda and RESEX Chico Mendes and, as land that was left out of the RESEX due to a surveying error, neither of the two major federal-

level agencies involved in land use policy—INCRA and IBAMA—has responsibility for the area. Most of the residents were either Acreanos or the grown children of Quixada’s aging original settlers. Although there was a general property boundary understanding between most (though not all) residents, no formal land titling system existed, documentation of residence through Rural Workers Syndicate being the only documentation possible. Nor did residents have a common association. Rather, most residents belonged to one of three local associations located outside the Terra Solta while several others remained unassociated.

Porto Carlos

The approximately 100 families of Porto Carlos lived in what was, as of the time of fieldwork, one of the last existing seringais in Alto Acre, and the only one lying along the BR-317 highway corridor. Traditionally, seringais were owned by a rubber baron, with the rubber-tapper residents having some use rights, but no legally recognized rights to tenure of the land on which they lived. While Porto Carlos had long ceased to be a functional seringal, the owners, while still managing a few prime areas for Brazil nut and cattle ranching, had allowed most of the seringal to fall under the *de facto* tenure of its ex-rubber tapper residents. Residents were still subject to federal environmental law (for instance, all landowners were subject to a 30 hectare deforestation limit, calculated as 20% of the 150 hectares officially held in each property³). And while kinship ties were strong in nearly all the communities, Porto Carlos demonstrated a remarkable level of kin-based social capital, with nearly all residents belonging to one of two families (which traditionally tended to inter-marry). Compared to the other more heterogeneous and divided communities, Porto Carlos tended more often than not to speak with a (near)

³ While all properties were recently documented as 150 hectares, properties could be up to 600 or more hectares. This has encouraged some of the larger owners to settle family members on their property so as to maintain *de facto* ownership of their original *colocações*.

common voice in matters of local and regional politics. While not all residents participated, a single association existed representing the peoples of Porto Carlos (Association Porto Carlos, located near the geographical center of the seringal).

From both a theoretical and policy perspective, as no formal governmental decision had been issued regarding the future of the area, Porto Carlos was an especially interesting area in the research site. Faced with the mixed successes and failures of other land tenure systems, both the state government and INCRA—which was gradually assuming responsibility for the area—were challenged with the task of implementing a system that maintains the area’s wealth in forest resources while appeasing both the region’s landless and the residents of this politically important seringal. Hence, according to local INCRA officials in Brasília, it appeared likely that parts of the area would be sub-divided for agrarian reform while other areas would be destined for a Sustainable Development Project (*Projeto de Desenvolvimento Sustentável* or PDS) managed by INCRA. However, as of the time of research, neither the proportion of the area to be opened to colonization nor the exact nature of the PDS to be created were yet known.

Methods

Site Selection

An original research site consisting of PAE Sta. Quitéria and PAD Quixadá, Gleba 6, was selected through analysis of maps and in discussion with key informants knowledgeable about the region during an initial visit in 2002. A key factor in selecting the site was the proximate location of these two land tenure units to the final stretch of BR-317 which was to be completed later that year. During subsequent visits, the other sites were added, as I felt that they offered interesting comparisons with the original two sites and also contributed to a more thorough understanding of the variation in the drivers and processes of land use change and governance in this area. Seringal Porto Carlos represented a land tenure system dating from the rubber era, yet

was in a state of transition as INCRA was considering the implementation of an extractive reserve and/or colonization area within it. Also, due to a growing awareness of the ecological importance of the area as one of the few areas in Alto Acre in which a heavily-forested area bordered the road, NGOs and the government had recently begun offering courses and projects in the area. The Terra Solta⁴ represented a control scenario, in which no formal land tenure system had been implemented and no environmental courses or projects had been offered. Finally, due to both the lack of permanent inhabitants and its relatively static land use system, Fazenda Rita was not included in quantitative analysis; however it was included in descriptive portions of the dissertation, due to its significance in the history of the area.

Sampling

Strictly random sample selection proved impractical due to local social realities and census data limitations in the region⁴. A total of 92 households were selected (aside from Santa Rita which has no permanent inhabitants and where only the ranch manager and several part time workers were interviewed), 41 (44.5%) from PAE Santa Quitéria, 26 (28%) from PAD Quixadá, 15 (16%) from Seringal Porto Carlos, 6 (6.5%) from RESEX Chico Mendes, Seringal Etelvir, and 4 (4.5%) from the Terra Solta. Using a stratified sampling strategy, for each administrative unit, I attempted to include 20% of the total population parameter of households in the sample⁵ (see Table 1-1). Households were selected using a stratified snowball strategy that relied both on

⁴ Due to their remoteness, it sometimes proved impractical to make return visits to households where no one was home during the initial visit. Additionally, due to informal land sales and exchanges, in most areas, it was not possible to obtain a fully accurate list of residents. Furthermore, early attempts to follow a strictly random design drew suspicion from some potential informants—who learned that they had been chosen as respondents due to their location on a list provided by a government agency. While potentially less statistically significant, as a foreign researcher, I found that a stratified snowball approach allowed me to balance the goals of obtaining a representative sample and operating within local social norms (that is, asking to conduct interviews after being introduced to an individual by a prior acquaintance / informant in a non-interview setting).

⁵ In most cases, due to time and logistical constraints, samples more closely approximated 15%. Exceptions were the Terra Solta and RESEX Chico Mendes where, in an effort to compensate for small populations, I sampled larger proportions of the total population.

satellite imagery and past informants. I used satellite imagery of the area to ensure even spatial distribution, and that households with large, medium and small-scale land clearing would be represented. In most cases, I relied upon past informants to introduce me to potential new informants—thus reducing the anxiety and distrust that might otherwise be associated with an interview by an unknown researcher. I also relied upon information from early informants to maximize the representativeness of sampled households in each community, such as including both migrants and non-migrants (if present) and members of various different extended families in a community.

Data Collection

Data collection occurred during May-June, 2002, May-June of 2003 and again from June, 2004 until July, 2005. A subsequent visit during May-August 2006 provided an opportunity to obtain information about changes during the preceding year (e.g., wildfires in various communities in the research site and a state-wide ban on pasture burning).

During 2002 and again in 2003, I met with potential research collaborators and also with local community leaders, in both Brasília and the actual field site, to discuss the proposed research project, both explaining my research and seeking feedback regarding its proposed content, form and potential relevance to the community. In the 2004-2005 field visit, while many informants were already somewhat aware of my research project, prior to interviews, the project's content, direct relevance and limitations were explained. Potential interview subjects were also informed about the optional nature of participating in the study.

Semi-structured interviews with heads of sampled households represented a central research method. Interviews were conducted with household heads, most commonly male though sometimes female. Interviews ranged from 30 minutes to three hours. I applied a semi-structured questionnaire (Appendix A). The questionnaire addressed questions of household

demography, participation in governance, land uses and environmental attitudes. The information from the questionnaire was written in a notebook and recorded using a handheld audio recording device. Semi-structured and unstructured interviews with other household members (spouses, elderly parents, etc) gave additional insights. Accompanying on-farm interviews, when possible (approximately half of all interviews), I conducted farm-transects accompanied by the landowner. These walks provided an opportunity to assess the accuracy of interview data and gain additional input from farmers that did not always arise within the more formal context of a sit-down interview.

In addition to the household sample, key informants in the research area provided further data relevant to the research question. I conducted key informant interviews with governmental leaders at various levels, including the presidents of 11 local associations, the president of AMPAESQ, the vice-president of AMOREB, the president of the STR, employees of SEATER (Secretary of Technical Assistance and Rural Extension), various NGO representatives, members of the directory of the Center for Small Rural Farmer Associations of Epitaciolândia and Brasília (*Central de Associações de Pequenos Produtores Rurais de Epitaciolândia e Brasília* or CAPEB), Brasília's Secretary of the Environment and representatives of INCRA, IMAC and IBAMA in Assis Brasil, Brasília and Rio Branco. These interviews were complemented by informal conversations on other occasions with many of the same individuals as well as members of the local media and the *prefeitos* of Brasília and Assis Brasil.

Finally, in order to develop a deeper ethnographic understanding of governance and its articulation in this region, I relied heavily upon participant observation. For instance, in both the field site and Brasília, I frequently participated in association meetings and assemblies as well as meetings and courses organized by IBAMA, STR and other NGOs. In addition to offering an

opportunity to witness the on-the-ground articulation of governance, they provided a forum for me to explain and answer questions about my research project to members of the community. Participant observation in day-to-day farm activities such as hunting, fishing, collection of cupuaçu fruits and cattle vaccination gave me a better understanding of the material and symbolic significance of productive activities based on both forest and non-forest land covers.

In order to create a spatially-linked database, GPS points were taken for all landholdings included in the study. Points were collected for important features such as homes, associations, road intersections and farm and administrative boundaries. Satellite-based maps proved useful for several purposes. They assisted me in the selection of spatially distributed farms with low, medium and high levels of deforestation. Prior to entering the field, a land cover map of the area was created using recent LandSat 7 ETM imagery in Erdas Imagine. Administrative and (in the case of PAD Quixadá) property boundaries were obtained through the INCRA office in Rio Branco and overlaid onto the image in order to create a field map. Using a handheld GPS unit, I obtained UTM coordinates for houses, fields and property boundaries which could then be correlated with their location in the imagery.

I conducted participatory map interpretation with those informants who were both able and interested in doing so⁶. This served several purposes—it proved a useful tool in aiding informant’s memories about past land use and in offering comments about land use on neighboring farms. This often led to rich discussions by local residents including, for instance, associating various family histories to specific areas, and thus allowing me to “link people to

⁶ Due to the difficulty that some (mostly older) informants faced in understanding and interpreting the map, this technique was neither applied systematically nor used in quantitative analysis.

pixels”⁷ (Liverman, et. al., 1998). It also allowed for an analysis of social networks—with many informants correctly associating most or all of the satellite-detected land clearing plots in the community with their owners.

Data Analysis

In the process of data analysis, I first conducted descriptive statistics to gain an understanding of the means and variances inherent in the various independent and dependent variables. Subsequently, I conducted bivariate analysis of individual independent and dependent variables⁸. Bivariate analysis allowed me to test for both linearity and significance of relationships between independent and dependent variables. Given the fairly small size of the sample of households, significance was established as $p < .1$. Relationships that were both linear (or curvilinear) and significant were then subjected to multiple regression analysis in order to control for possible effects of covariates. An exception to this rule was made when bivariate analysis revealed non-significant linear relationships and a suppression effect from covariates was suspected. In these cases, multiple regression analyses were conducted to control for suppression effect from covariates, even when results from initial bivariate analyses were not significant.

Limitations

Several data limitations should be noted as caveats in the data analysis that appears later in the dissertation. As previously noted, due to on-the-ground limitations, a strictly random sample design was not followed. Hence, caution is due when extrapolating these results beyond the

⁷ Examples included, for example, a woman who told me that an area of her property was light green because she and her husband had lost their cattle herd at the time the imagery was taken, causing the pasture to grow up. Another family explained that a small forest fragment on their property visible on the map was an area of forest they had left, upon a parent’s suggestion, in order to preserve an exceptionally strong spring that lay within it.

⁸ The specific bivariate test employed depending on the nature of the independent and dependent variables (e.g., continuous versus categorical). Bivariate analysis included Pearson correlations, t-tests and F tests.

sample. However, I have attempted, to the greatest degree possible, to minimize potential bias in the sample by including households from the various communities in the field site. Within each community, I also attempted to minimize bias in the sample by including households from various extended families and with small, medium and large amounts of forest clearing. While diverse, the sample does not necessarily accurately represent the proportion of different sub-groups in the population.

A second caveat applies to analyses of the impacts of governance, at the level of the administrative unit, for land use. Given both the small population parameters and small samples from two of the administrative units—Terra Solta and RESEX Chico Mendes—samples cannot be assumed to be representative of the entire administrative unit. In the most extreme case of Terra Solta (4 households sampled from a population parameter of approximately 14), I ultimately elected to remove this administrative unit when testing the relationship between governance at the level of the administrative unit and land use.

A third limitation comes from the possibility of inaccuracies, both deliberate and accidental, in reported data from informants. This was especially of concern when obtaining data about household deforestation. Due to the fact that many households had exceeded their legal deforestation limits and were continuing to clear land, this variable was especially susceptible to under-reporting. In order to minimize the implications of this possibility in data collection, prior to arriving at a given household, I developed an approximate estimate of deforested area on the property using both visual analysis of satellite imagery and personal inspection of the pastures that usually surrounded rural homes. When reported estimates of deforestation differed greatly from my own, I would attempt to triangulate deforestation estimates with those given by neighbors to determine the source of error. As a last resort, in the

few cases where I was unable to reconcile reported figures with my own estimates, deforestation values were recorded as missing.⁹

⁹ An example included an elderly divorcee who estimated that she had some 10 hectares of pasture, when both satellite imagery and my own visual calculation were closer to 40 hectares. As the sons who cared for her cattle herd were not present during my initial and subsequent visits, I coded the area of pasture and of total deforestation as “missing” in this case.

Table 1-1. Sampling by Administrative Unit

	Households Sampled	Total Households (approximate)	% of Households Sampled
Terra Solta	4	14	28%
Seringal Porto			
Carlos	15	100	15%
PAD Quixadá	26	150	17%
PAE Santa			
Quitéria	41	277	15%
RESEX Chico			
Mendes	6	17	35%

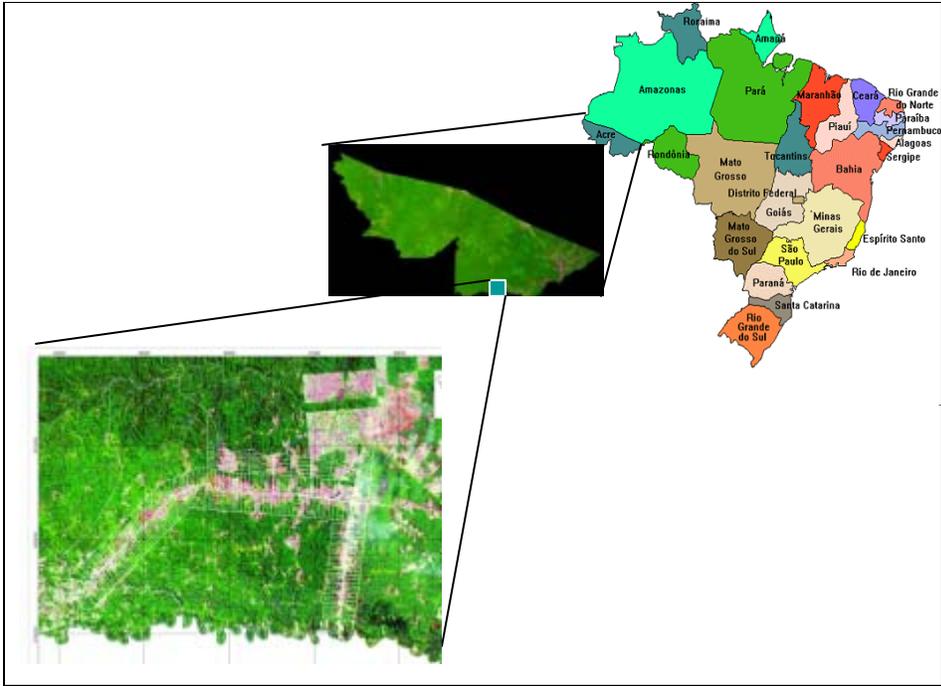
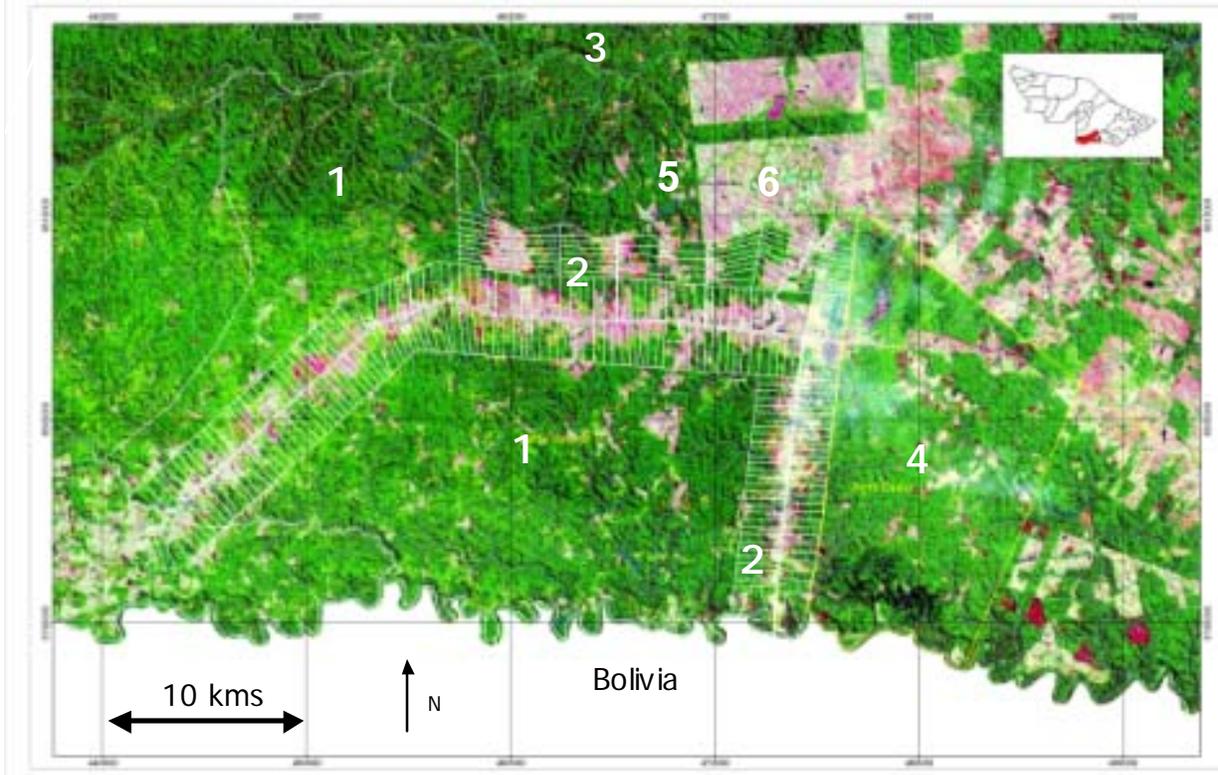


Figure 1-1 Field Site in Context of Acre and Brazil



Administrative Units: 1=PAE Santa Quiteria 2=PAD Quixada 3=RESEX Chico Mendes
 4=Seringal Porto Carlos 5=Terra Solta 6=Fazenda Santa Rita
 Green=Forest (Primary and Secondary); Red=Deforested (Pasture and Crops)

Figure 1-2 Research Site with Administrative Units

CHAPTER 2 THE POLITICAL ECOLOGY OF ROADS, GOVERNANCE AND LAND USE IN THE AMAZON

A large body of literature addresses the issue of land use and land cover change, with a significant portion focusing specifically upon the Amazon Basin. While some broad treatments and meta-analyses of the topic of LULCC exist (e.g. Geist and Lambin, 2001), due to the breadth of the topic, most research has focused on specific manifestations (e.g. deforestation) and drivers (e.g. agricultural expansion, public policy) of LULCC. However, due to the diverse disciplinary backgrounds of LULCC researchers, while research in this subject area has given great insights into the various factors driving LULCC, much less work has been done to advance theoretical understandings of LULCC. In this study, I draw upon political-ecology to both focus upon certain phenomena and processes occurring in the Inter-Oceanic corridor and to understand the relations among them.

In this chapter, I begin by offering a discussion of the LULCC literature as it relates to the topic of roads and governance in the Brazilian Amazon. I first discuss the major land cover change affecting the study site—deforestation. I then discuss two land use practices that are intimately tied with deforestation in many portions of the Brazilian Amazon—cattle ranching and the use of fire. I then address two drivers of LULCC that are of special concern to the research topic—roads and public policy. Subsequently, I discuss the theoretical background of political ecology, especially as it relates to the issues of governance and scale. Then, drawing upon the LULCC and political ecology literature, I outline and operationalize the independent and dependent variables used in the dissertation as well as the hypothesized links existing among them.

Land Use and Land Cover Change in the Brazilian Amazon

Considered broadly, the over-arching dependent variable considered in the study is land use and land cover change (LULCC). In recent years, the subject of land use and land cover change has gained recognition as an emerging research agenda of profound theoretical and policy implications. While theoretically diverse, much of the LULCC literature is united in striving to transcend simplified narratives of causality such as population growth and shifting agriculture, looking instead to develop a more nuanced understanding of the causes of LULCC (Angelson and Kaimowitz, 1999; Geist and Lambin, 2001; 2002; Schmink and Wood, 1992). Countering meta-theories which attempt to offer broad explanations of deforestation, researchers have generally argued that tropical deforestation is determined by different combinations of proximate causes and underlying driving forces, varying between geographical and historical contexts (Geist and Lambin, 2002).

Land use and land cover change is becoming an increasingly important interdisciplinary field of study. Growing human populations and technological change are associated with rapid changes in global land use and land cover—with anthropogenic land covers becoming increasingly common. In the early 21st century, crop and pasture land has come to represent a dominant land cover globally—rivaling forests—extending to approximately 40% of the Earth's terrestrial surface (Foley et al., 2005). Land use change often has direct impacts upon land cover. For example, the shift among inhabitants of the rural Brazilian Amazon from extractivism toward cattle ranching is associated with a shift from forest to grassland (pasture) land cover. Furthermore, land use and land use change can have more indirect impacts upon ecosystems, including for example, changes in water cycles, evaporation and run-off (Foley et al., 2005).

Deforestation

Deforestation, at the household level, is a key dependent variable considered in the study. A large amount of literature has been written about deforestation in the Brazilian Amazon, including both its political-economic and ecological implications (e.g., Schmink and Wood, 1992, Wood and Porro, 2002). Paleoecological and paleoclimatic records suggest that the Amazonian forest ecosystem has been in continuous existence for more than 55 million years. However, despite the Amazon's resilience to the various climatic and geological changes occurring during its existence, the continued resilience of the Amazonian forest is uncertain in light of recent anthropogenic changes, including, most conspicuously, deforestation (Maslin et al., 2006). During the twentieth century, approximately 16% of the Amazon forest area was cleared, primarily for cattle pasture and, more recently, for the cultivation of soybeans (Fearnside, 2001a; Maslin et al., 2006). Estimates of recent rates of deforestation range between approximately .38% and .5% of existing forest per year (Maslin et al., 2006; Houghton et al., 2000; Davidson and Artaxo, 2004). Under the current "business as usual" scenario (without increases in governance), researchers have argued that, by 2050, nearly half of the Amazon's original forest cover may be lost (Soares-Filho et al., 2006).

Much has been written about the actual and likely future impacts of deforestation at various scales. Climate change is an implication of tropical deforestation that is likely to be felt at local, regional and global levels. As the Amazonian forest plays an important role in both moderating temperatures and in recycling water into the atmosphere during the dry season, on local and regional levels, large-scale deforestation may result in warmer and drier conditions in the region (Foley et al., 2005). This, in turn, would increase the region's susceptibility to wildfire—further endangering the forest.

Research has also addressed the risks that carbon released through deforestation and associated activities (such as fire) may have for regional and global climate. Research suggests that the Amazon forest, in an undisturbed state, functions as a net sink of atmospheric carbon (Carvalho et al., 2004). However, under current land use practices—including logging, pasture burning and deforestation, Amazonia has become a globally significant source of atmospheric carbon. Amazonian deforestation and associated burning releases some 2-4% of annual global carbon emissions (200-300 million tons), representing more than 2/3 of Brazil's total (Fearnside, 1997; Houghton et al., 2000; Carvalho et al., 2004).

Cattle Ranching and Pasture Formation

Cattle production represents an important dependent variable considered in the study. In the Brazilian Amazon, as in many parts of Latin America, cattle ranching has been the most common form of agricultural expansion into previously forested areas (Geist and Lambin, 2002). Brazil's cattle herd is the world's largest (Kirby et al., 2006). While the majority of Brazil's cattle production occurs further south, production in Amazonia has been increasing in recent decades. Historically, the spread of cattle ranching in the Brazilian Amazon has been accelerated through governmental policies (Fearnside, 2000; 2002a). Seeing large-scale ranching as a productive use of the Amazon Basin, the Brazilian government until recently offered heavy subsidies for this industry; between the years of 1971 and 1987, the cattle industry received some \$5 billion from the Brazilian government (Hall, 2000). After Brazil's return to democracy, most subsidies for cattle ranching in the Amazon were removed.

Due to both the scale and the relatively permanent nature of most cattle pastures (as opposed to swidden plots which, if not planted in pasture, are usually allowed to return to forest), cattle ranching represents the single most important proximate driver behind deforestation in the Brazilian Amazon (Hecht, 1985; Fearnside, 1990; Cardoso, 2002). Various authors have argued

that cattle ranching, in the absence of governmental supports, is generally not profitable in the Amazon (Hecht and Cockburn; 1990; Schwartzman, 1992; Fujisaka et al., 1996). Due to mineral deficiencies in most Amazonian soils, it has been argued that pasture maintenance requires chemical treatments to maintain productivity—including phosphates—a substance with few known deposits in the Amazon region (Fearnside, 2002a). Furthermore, due to the difficulty of preventing natural succession and weed development, in situations of abundant inexpensive land (a scenario that no longer applied in much of the Amazon and most of Alto Acre as of the mid-00's), it has sometimes proven less expensive to simply clear new forest tracts for pasture than to rehabilitate older degraded ones (Fearnside, 2001). Many authors further argue that land speculation has been a major driver of pasture creation, with individuals anticipating rising land prices as new roads gradually bring forested lands into greater connectivity with market centers (Hecht and Cockburn, 1990).

However, other authors, while considering pasture expansion as an important driver of deforestation, present a different and somewhat more complex picture of its social and ecological implications. Faminow (1998) argues that, rather than being an outgrowth of governmental subsidies, the expansion in cattle production in the 1990's stemmed primarily from the growth in regional demand, associated with an expanding and increasingly affluent urban Amazonian population (see also Browder and Godfrey, 1997). In rural Amazonian communities, in addition to serving as a capital investment, cattle represent an easily transportable and liquidable commodity, thus serving as an insurance substitute. That is, cattle represent a fairly secure form of stored wealth that can be quickly transformed into cash in cases of medical or other emergencies (Perz, 2001a). Furthermore, unlike horticulture and rubber extraction, the labor requirements of cattle ranching are relatively low and product transportation is generally simple

(Arima and Uhl, 1997). And, given appropriate agricultural practices, such as rotational stocking (Rueda et al., 2003) and grass-legume mixes (Carneiro and Valentim, 1997, Burns et al., 2004) productive pastures can be maintained for decades or indefinitely while chemical inputs are reduced or eliminated.

In an extensive discussion of the relationship between cattle production and deforestation in the Amazon, Faminow (1998) points to the fact that many of the dire predictions offered by scholars in the 1980's regarding the impacts of cattle expansion assumed an exponential growth in deforestation rates, which in most cases has not been realized. Furthermore, he finds fault with arguments coupling land speculation and pasture degradation as drivers behind pasture expansion. Were this train of thought correct, he argues, it would assume an infinite supply of irrational land speculators willing to pay incrementally higher prices for increasingly degraded land.

Faminow begins his argument by countering assertions that Amazonian soils are unfit for long-term agriculture, pointing to the similarities between Amazonian soils and those of the Southeastern U.S., many of which have been in continuous cultivation for more than 200 years. Furthermore, in light of recent evidence from the Amazonian cattle industry, Faminow and other researchers have questioned the assumed lack of viability of cattle ranching as an economic endeavor—pointing out that, despite the reduction of government subsidies, cattle ranching has generally been shown to be economically productive (Faminow, 1998, Mattos and Uhl, 1994, Arima and Uhl, 1997; Machagata and Brown, 2003). Under such arguments, the spread of cattle ranching arises less as a result of speculation and land degradation than as a function of economic decision-making by property owners operating in the existing political and economic system (Machagata and Brown, 2003).

Various researchers have further argued that it is less cattle production per se than inefficient grazing practices that threaten Brazil's tropical forests (Arima and Uhl, 1997, Faminow, 1998). Researchers have found that heavier stocking rates (stocking rate > 1 head/hectare) and better managed pasture rotation, by minimizing the accumulation of senescent forage, actually improve long-term pasture quality (Machagata and Brown, 2003; Faminow, 1998). Arguing that cattle-related deforestation currently arises from herd expansion rather than land speculation, Machagata and Brown assert that intensification of cattle production, in many cases, will slow deforestation. Coupled with improved enforcement of existing environmental laws limiting deforestation, such intensification should be able to improve local livelihoods without raising deforestation rates (Arima and Uhl, 1997; Machagata and Brown, 2003).

Fire

Another land use practice given close attention in my research project is the use of fire. In the Brazilian Amazon, fire is a commonly-used low-cost tool to establish and maintain pastures, especially in extensive cattle production systems. As most cattle production in the Amazon—especially at smaller scales—is based on continuous rather than rotational stocking, cattle producers often rely upon fire as a strategy to remove the low-quality senescent plant material that tends to develop in such systems. Fire can have positive impacts for pasture development and maintenance, such as the elimination of invading plants, reduced shading, and improved carbon:nitrogen ratios through the release of nitrogen and the volatilization of carbon in senescent plant material (Heringer and Jacques, 2002). However, it also results in negative effects as well—including the volatilization of nitrogen and potassium and increased susceptibility to erosion (Almeida, n.d.). And while grass regrowth yields a short-term increase in palatable dry matter production, animal weight gains are generally lower than those in similar unburned pastures (Almeida, n.d.). Further negative impacts of fire include the loss of crops,

fodder, livestock, timber, fences and other infrastructure in the cases of wildfire (as occurred in several communities in the field site in 2005).

From the farmer's perspective, fire can have further negative impacts when forest areas are accidentally burned. For example, researchers have noted a general decline in tree fruiting and in the populations of frugivorous vertebrates in burned forest in the Amazon (Barlow and Peres, 2006). This in turn can have negative impacts for local populations who depend on non-timber forest products (NTFPs) and hunting for part of their livelihoods. The reduced production and eventual destruction of Brazil nut trees that have been affected by fire is a case in point.

While these impacts are of great concern at the level of the household and local community, the impacts of wildfire upon the forest and for the larger socio-ecological system are of even greater importance at regional and societal levels. Of particular concern are the potential impacts of fire in damaging standing forests, affecting regional rainfall and affecting the health and general well-being of local populations.

Burning of pastures tends to kill existing trees and prevent regeneration of new recruits—leading to the long-term replacement of native forest vegetation with exotic grasses and fire-adapted weeds. Furthermore, wildfire entering surrounding forests can lead to positive local-scale feedbacks setting the conditions for future fire (Cochrane et al., 2003; Hoffman et al., 2003; Alencar et al., 2004). While an initial fire will usually remain in the understory, the increase in solar radiation from canopy gaps and in fuel load from dead or damaged trees provides the conditions for successively more intense future fires (Cochrane et al., 2003). Reinforcing this positive feedback is the probable impact of fire upon regional climate. Several researchers have drawn attention to the possibility that smoke, by augmenting the number of condensation points,

may inhibit the creation of large atmospheric water droplets and thereby reduce regional rainfall (Maslin et al., 2006; Cochrane et al., 2003).

In addition to the impacts for rural livelihoods and the natural environment, fire and smoke have immediate negative implications reaching both rural and urban populations, including a notable rise in respiratory illnesses (Mendonça, 2004). Mendonça (2004) estimates that as much as 8% of all hospital-treated respiratory cases in the Brazilian Amazon are directly attributable to the burning of biomass; in 1998, an El Niño year in which large areas of the Amazon succumbed to wildfire, the number of cases reached 13,000.

Roads

Roads are generally recognized as the strongest single predictor of tropical deforestation due to their numerous direct and indirect impacts upon land use (Kaimowitz and Angelson, 1998; Geist and Lambin, 2001; 2002; Pfaff, 1997). Road construction in places such as the Brazilian Amazon generally increases the profitability of timber and agricultural production and, by improving access, facilitates land speculation and colonization (Soares-Filho et al., 2004; Chomitz and Thomas, 2001). In an extensive cross-national review of prominent deforestation literature, Geist and Lambin (2001) found that road construction or paving served as a driving factor in two-thirds of the cases examined.

Various analytical approaches have been used in the study of roads and their impacts on tropical deforestation. In a ground-breaking paper, Chomitz and Gray (1996) used a spatial econometric analysis in their study of deforestation in Belize. Using this technique, they found that roads were correlated with agricultural land use, with soil fertility acting as a mediating variable. Roadside areas with good soils had an especially high (50%) probability of conversion to agriculture. Common in the literature on roads and land use has been the extrapolation of historical patterns to future projections within road buffers. This approach has been applied, for

instance, in recent studies of the probable impacts of current highway paving projects in the Brazilian Amazon (e.g., Laurance et al., 2001). However, the extrapolation of past to current and future trends is an inherently error-prone procedure; it requires that other factors contributing to land use change (such as government policy) be held constant—a problem that has surfaced in widely differing predictions for future deforestation due to the *Avança Brasil* highway paving program.

Historically, Amazonian roads have contributed to agricultural expansion and deforestation by changing migration patterns and opening the region to populations from other portions of the country in search of land for subsistence or for investment (Moran et al., 1980; Schmink and Wood, 1992). In the case of Acre, the opening of roads in the 1970's and 1980's led to an increase in in-migration, in turn leading to numerous land conflicts (Bakx, 1986). While government-sponsored colonization of the region has largely ceased, the impact of the now-paved road for migration—especially between rural and urban areas—has continued into the mid 2000's.

Various predictions have been made regarding the likely implications of the *Avança Brasil* project. Predicted deforestation resulting from the project varies widely—due largely to differing assumptions underlying the predictive models used. In particular, some models extrapolate past patterns of governmental unwillingness or inability to create and enforce conservation policy to the future (e.g., Laurance et al., 2001, Fearnside 2003), while others (e.g., Nepstad et al., 2001, Silveira, 2001, Soares-Filho et al., 2004) allow for the possibility that recent political changes in Brazil indicate a greater likelihood that viable systems of forest governance can emerge to control land use in roadside forests. This topic will be addressed in greater detail subsequently.

Public Policy

Public policy is a commonly cited factor affecting deforestation (Skole et al., 1994), including both overtly pro-deforestation policy and policy that has deforestation as an unintentional consequence. It also includes policies oriented toward forest conservation, as Acre has witnessed in the late 1990's into the 2000's (Kainer et al., 2004). As with roadways, policy rarely functions alone in its impacts on land use but rather most often occurs in conjunction with other drivers. Geist and Lambin (2001; 2002) found policy and governance to be a factor in 78% of the cases of deforestation they considered—most often operating in tandem with other drivers. This tendency holds true in the case of recent literature addressing the combined effects of roads and governance in the Brazilian Amazon (e.g., Nepstad et al., 2001, Laurance, 2001, Nepstad et al., 2002; Fearnside, 2002, Soares-Filho et al., 2004).

Among the recent government initiatives intended to control land use change and deforestation in the Amazon has been agro-ecological zoning. Dennis Mahar of the Economic Development Institution and formerly a member of the World Bank's POLONOROESTE project, describes the mixed successes encountered by an ambitious agro-ecological zoning initiative in the Amazonian state of Rondônia (Mahar, 2000). The prescriptive zoning program was intended to impose order in a state that had witnessed the squandering of forest resources and displacement of traditional peoples during a 1980's land rush accompanying the World Bank-funded paving of the BR-364 highway through the state. Under the zoning plan, land use was to be regulated based upon both current practices and ecological suitability. Despite the program's relative successes in controlling deforestation, Mahar points to several limitations. Among the criticisms include the fact that few incentives exist for local-level governments to enforce zoning rules and that perverse incentives exist for land owners to deforest illegally in the hope of changing their land's zoning status.

A major platform of the Acre State *Governo da Floresta* has been Ecological-Economic Zoning (ZEE) (Kainer et al., 2004). The concept of ZEE stems from language in the Federal Constitution promoting the decentralization of governmental decision making—especially in the area of environmental protection—including Articles 21, 23, and 30. Presidential Decree number 99.540 of 21 September, 1990 created a Coordinated Commission for Ecological and Economic Zoning of the National Territory (Governo do Acre, 2001)—outlining a conceptual and legal framework for ecological and economic zoning to be implemented at the state level—with the Legal Amazon defined as a priority area. ZEE represents an instrument to guide governmental investments in socio-economic development in a way that recognizes and builds upon the natural comparative advantages of each region. Through ZEE, planners in new agricultural and settlement frontiers (such as many parts of Acre) have hoped to avoid the anarchy, environmental destruction and social injustice of past occupation processes in the Amazon. Implementation has been underwritten in part by financing from the PPG7 program of “integrated environmental management projects” (PGAI) (Governo do Acre, 2001), with further assistance from the GTZ.

In the past, agrarian and social policy in Brazil, by subsidizing colonization and pasture expansion in the Amazon, tended to directly stimulate deforestation (Schmink and Wood, 1987; 1992). Since democratization in the mid-1980’s and the coinciding domestic and international concern about the fate of the Amazon’s forests, many of the policies promoting deforestation have been changed and new environmental regulations (e.g., establishment of national parks and 80% forest reserve regulations on private land) have come onto the books. However, the ability of the government to effectively enforce these regulations is still in question and much of the land conversion occurring in the Brazilian Amazon today continues to be illegal (Carvalho et al.,

2002). Compounding this problem, under-staffed Brazilian authorities often have great difficulty detecting and combating violations (Carpentier et al., 2000).

Perhaps the largest debate regarding road paving and deforestation in the Brazilian Amazon centers upon the ability of frontier governance systems to mediate this relationship. Several researchers have offered qualified optimism in their projections for *Avança Brasil*'s impacts upon deforestation. Soares-Filho et al., (2004) estimate that deforestation in the Brazilian Amazon may be reduced by 1.3 million hectares by 2050 given a governance scenario in which current environmental regulations are enforced. Such predictions are often based upon the shift at the federal and, in some cases, at the state level away from policies that have historically promoted deforestation in the region's highway corridors. An early example of this shift was the creation and implementation of the RESEX model due to political pressure from social movements in the 1980's and early 1990's (Schmink and Wood, 1992). More recently, at the local level, researchers have noted the growing capacity of local governments in environmental and development planning and the overall increasing effectiveness of governance as a means of minimizing deforestation (Nepstad et al., 2002; Silveira 2002).

Nepstad points to the Environmental Crimes bill of 1998, authorizing IBAMA to levy fines and jail sentences for unauthorized fire and land clearing and the specific case of PROARCO—a recent fire control program—as evidence of the potential effectiveness of governance in positively affecting land use change. Subsequent to the implementation of PROARCO in 2000, Nepstad notes a two to four-fold decrease in the number of fires in satellite images of heavily-settled areas of the southern and eastern Amazon (Nepstad et al., 2002). Other researchers have found corroborating evidence for the effectiveness of governance as a means of minimizing deforestation in other parts of Brazil that have not necessarily been recently affected by road

paving. For example, Fearnside (2003) notes that in the state of Mato Grosso, a state-level deforestation licensing and enforcement program has demonstrated positive results.

Furthermore, areas of the state with the strongest enforcement have witnessed the greatest declines in deforestation rates.

A counter-argument asserts that Brazil's return to democracy and the introduction of environmental legislation will not be sufficient to significantly slow deforestation along highway corridors. While environmental regulation has generally increased since the mid-1980's, Laurance et al., (2001) note that, despite a dip during the early 1990's, deforestation rates actually increased during the late 1990's, largely due to improved economic stability resulting from the federal government's *Plano Real* monetary reform program. Like the *Plano Real* program, even various governmental incentives designed to be pro-forest or forest-neutral have had perverse effects. For example, Almeida and Uhl (1995) illustrate how the Brazilian Rural Land Tax—a tool intended to encourage efficient and productive land use—actually penalized farmers who wished to invest in forest-conservation and intensification of cattle production.

In the case of *Avança Brasil*, Laurance estimates that between 269,000 to 506,000 hectares of forest land will be lost annually due to the program (Laurance et al., 2001). Non-enforcement of existing laws has been a commonly cited concern; despite improvements in remote monitoring, it nonetheless remains difficult to monitor land use and enforce regulations, especially in remote areas. According to this perspective, the problem is exacerbated by corruption at various levels. Researchers have also pointed to problems intrinsic in the political process behind *Avança Brasil* and similar projects that may contribute to deforestation. Fearnside (2003) notes several specific problems in the environmental legislation process common in Brazil. In many projects, such as *Avança Brasil*, the project is proposed on its

own—without a suite of alternative projects. Furthermore, efforts are often made to secure funding prior to impact assessments—consequently building political support that will help ensure the project’s ultimate vitality regardless of the environmental impacts. Finally, little impact assessment comes from within the project programs, but as in the case of *Avança Brasil*, studies tend to come largely from independent research organizations outside of the project.

Political Ecology

My research draws heavily upon a political-ecological approach to land use and land cover change in this region. A political-ecological perspective explores the relationships between human society and natural resources, giving special attention to the role of politics as individuals and groups contest rights to these resources (Bryant and Bailey, 1998). The term “political ecology” can be traced to the early 1970’s in Eric Wolf’s call for an approach integrating land use with a local-global political ecology (Wolf, 1972; Peet and Watts, 1996). In response to both Neo-Malthusianism and closed-system ecological anthropology, early political ecology drew upon a Neo-Marxist perspective to bring politics and class struggle into what previously had been a largely apolitical view of human-environment interactions (Schmink and Wood, 1987; Peet and Watts, 1997; Bryant and Bailey, 1998).

Informing the environmental movement of the 1960’s and 1970’s, Darwinism and Neo-Malthusianism saw unregulated population growth as a key factor in global environmental degradation (Peet and Watts, 1997). For example, the acceleration of tropical deforestation at this time was, in both academic circles and in the popular media, often blamed on faceless rural peoples whose unabated population growth drove them ever further into the forest in search of cultivable land (Jarosz, 1996). Seeing these explanations as inadequate, early political ecologists looked to political and social factors to better explain phenomena such as environmental degradation and famine (Watts, 1983; Moore, 1996).

Systems-based ecological anthropology represented another key paradigm spurring the early development of political ecology (Watts, 1983, Peet and Watts, 1997). In particular, political ecologists drew exception to the homeostatic equilibrium-based models then dominant in ecological anthropology (e.g. Rappaport, 1967, Orlove, 1980). Such work tended to focus upon energy and resource flows in closed-system societies (Bryant and Bailey, 1998). For instance, in the book *Pigs for the Ancestors*, Roy Rappaport (1967) used a systems ecology approach to explain the livelihood system of the Maring—an isolated tribal group living in New Guinea. As part of his argument, Rappaport claimed that ritual slaughtering of pigs served as a means whereby the Maring maintained equilibrium within their environment and society. In addition to his use of an equilibrium-based model, Rappaport was also criticized for his inattention to the wider political-economic context in which the Maring lived. In contrast, political ecologists argued that human-environment interactions could only be understood within the context of local-global articulations and linkages among the local community, the nation-state and international institutions (Biersack, 1999).

Political ecology emerged as a distinct theoretical framework in the mid-1980's through analyses of the political-economy of environmental degradation. In a discussion of soil erosion in the developing world, Piers Blaikie (1985) argued that environmental decision-making at a given scale is best explained when contextualized into the political-economic context of the next larger scale. Consequently, he called for a bottom-up research perspective which begins with the smallest decision-making level and progressively scales upward to the level of state and international political-economic structures in order to understand the forces shaping local level land use.

In one of the first works to apply an explicitly political ecological approach to the Amazon, Schmink and Wood (1987) discussed the ways in which the wider socioeconomic and political context of the Brazilian Amazon have affected human use of natural resources while also looking at the implications of this relationship for environmental policy in the region. Schmink and Wood proposed a political-ecological model that links the Amazonian political-economy—including, among other factors, the state, markets, and class structure—to patterns of resource exploitation in the region. Like Blaikie, Schmink and Wood focused upon local scale land use decisions, but saw them as being largely determined by larger-scale political-economic phenomena like capitalist expansion.

In their study of frontier expansion in the Brazilian Amazon, Schmink and Wood (1992) considered frontier expansion and land conflicts surrounding the town of São Felix do Xingu in the state of Pará. This discussion is couched within analysis of the regional, national and international settings. The authors offered a temporal contextualization of the problem—placing the processes occurring at these multiple levels within a broad historical context encompassing nearly 500 years. In this study, the authors expanded beyond this largely top-down framework in their earlier work. The authors addressed not only the ways in which political and economic structures have affected land use in the São Felix do Xingu region. They also addressed the ways in which individual actors, through their land use and through their contestation of rights to land, shaped the wider political and economic environments. Hence, they brought a sense of individual agency to questions of political-economy and land use that had largely been absent in earlier political ecological work.

Wood and Porro (2002) offer an implicitly political-ecological framework for conceptualizing the relationship between the socio-economic and biophysical drivers of

deforestation in the Amazon Basin. In this model, the ultimate agent of land use and land cover change—the household or firm—is contextualized within increasingly larger-scale socioeconomic and biophysical drivers. The household or firm's land use and land cover outcomes, in turn, have feedback effects for all scales of socio-economic and biophysical drivers. Hence, Wood and Porro, like Schmink and Wood (1992), introduced a multi-directional chain of causality into their model of LULCC. However, the feedback effect occurs not through the direct agency of the household (or firm) responding to and contesting the larger scale political-economic context, but through the land use and land cover outcomes themselves.

Through the 1980's, political ecology tended to draw upon a neo-Marxist perspective to look at local conflict largely in terms of capitalist penetration and class conflict (Bryant and Bailey, 1997). Subsequently, however, political ecologists have begun to draw upon a wider range of theory to explain human-environment relationships—including, among others, gender analysis. Using a gender analysis approach, researchers have found that the traditional focus upon social class in political ecology has overlooked other key variables affecting human-environment relations (Sontheimer, 1991; Rouchelleau, et al., 1996; Schmink, 2000).

Environmental policies may have very different impacts for men and women when they do not account for gendered patterns of resource access and use (Schroeder and Suryantata, 1996). For example, in her study of a government-sponsored agroforestry project in the Gambia, Carney (1996) found that, by overlooking the role of gender in shaping local resource access and the traditional male control of tree resources, the project effectively shifted the balance of resource control toward men and encouraged the economic marginalization of women in the affected communities.

While offering a gender analysis of governance and land use is not the primary purpose of the dissertation, attention to gender provides an understanding of the variable ways in which roads and governance affect households and individuals within households in the BR-317 highway corridor. Specifically, I address the variable ways in which the road has affected men and women, addressing gender-specific migration patterns between rural and urban areas. By tying this analysis with gendered land use practices (i.e. approaches to cattle production), I demonstrate the way in which gender can serve as a mediating factor between road paving and land use.

Governance and Institutional Design

Although it doesn'tWhile not falling directly within the rubric of political ecology, other like-minded authors have addressed issues of governance and their implications for land use. Complementing political ecology, a considerable body of literature addresses the questions of institutions and institutional design and the implications for the management of collective resources (Ostrom, 1990, Agrawal and Gibson, 1999, Ostrom, 2005). Ostrom defines institutions as "the prescriptions that humans use to organize all forms of repeated and structured interactions including those within families, neighborhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales" (Ostrom, 2005: 3; see also: Agrawal and Gibson, 1999; Kiser and Ostrom, 1982; and Adger et al., 2003). Institutions may represent mechanisms of self-organization by communities or may be created and imposed by external entities such as state governments (Poteete and Ostrom, 2002). Institutions include both the overall institutional framework and the specific institutional arrangements of particular sets of rules—and often form nested structures in which larger-scale institutions limit the alternatives available at lower levels (Adger et al. 2003).

Like political ecology, institutional theory developed in opposition to Neo-Malthusian theories forecasting the inevitable demise of common pool resources not subject to privatization or state control. For example, in his much-cited study, Garret Hardin (1968) argued that in common pool resource systems—such as commonly held grazing pastures—the rational choice of each participant is to overuse the resource as s/he appropriates full benefit from each marginal unit of use while the impacts of resource degradation are distributed among all members. Such authors recommended alternatively for government control or privatization (Demsetz, 1967; Posner, 1977). Implicit in both arguments is an assumption that local resource users are incapable of designing effective means of self-governance (Ostrom, 1997). While institutional theorists generally accept that Hardin’s “tragedy of the commons” may in fact apply to truly unregulated open-access resources, in many cases, communities have been able to avoid this situation through institutions of self-governance—allowing joint use that is not permitted to exceed some threshold of extraction (Ostrom, 1990; Ostrom et al., 1999; Agrawal, 2001)

While institutions shape nearly every aspect of human life, a significant body of literature focuses specifically upon the institutions of land use. According to Agrawal and Gibson, institutions of land use face several shared tasks: they establish rules about the use, management and conservation of resources, the implementation of the rules that are created and the resolution of conflicts that consequently arise (Agrawal and Gibson, 1999). Ostrom (2005) points to several elements of institutional design that are generally requisite for effective management of shared resources. Among the elements of successful design are: clearly defined boundaries, proportional equivalence between benefits and costs, graduated sanctions, conflict-resolution mechanisms, collaboration between local and government authorities in the enforcement of rules

and trust between members—whether through shared cultural norms or repeated interactions, or both (Ostrom, 2005).

Political Ecology in the Dissertation

In the dissertation, I have utilized a political-ecological approach to explore the relationship between government agrarian, forest and infrastructure policies and household and association-level land use decisions. In this process, while I have focused upon the household as the unit of analysis, I have framed the study of a household's land management decisions within the association and the administrative unit, through the state, federal, and international contexts of environmental governance. While the dissertation does not focus exclusively upon political drivers of land use change, it is grounded in an understanding that the multi-directional relationship between a household and wider political arenas plays an important role in shaping how land use decisions are made.

By considering local-level governance systems and the role of individuals in interpreting, responding to and reshaping governance systems through their land use practices, I have attempted to avoid deterministic interpretations based on top-down chains of causality between large-scale government policies and an individual's land use decisions. In the dissertation, I use a political-ecological approach to explore the relationship between centralized governance systems and household-level land use decisions. Similarly, I explore the implications that a household's elective decision to participate in or opt out of the various institutions of governance available to them affects their land use. I also address the ways in which individuals and households, through their participation in wider structures of governance, reshape the landscape of environmental governance.

In a 1983 essay entitled “Against Political Ecology”, (Vayda and Walters, 1999), Andrew Vayda and Bradley Walters offer several critiques of political ecology, including the scant

attention it often gives to ecology. However, most important, I would argue, is their argument that political ecology makes an *a priori* assumption that politics is always central to the use of natural resource issues. In this article, they draw on a case study of mangrove deforestation in the Philippines to show how other non-political factors, such as tidal action and local preferences for certain timber species have been equally, if not more important than politics in shaping the extent and composition of the mangroves. An exclusive focus on political contestations for rights to resources would have overlooked other important explanations for deforestation occurring in this region.

While not seeing it as a ground for the out-right rejection of political ecology, Vayda and Walter's concern about the tendency in political ecology to prioritize politics as the *a priori* explanation for any and all phenomena involving natural resources has guided my thinking as I apply a political ecological perspective to the topic of roads, governance and land use. For instance, in quantitative analyses, I recognize the importance of and control for largely apolitical explanations of land use such as property size and years of residence. Similarly, in the final chapter, when exploring the contradictions between the concern that people express about the environment and their actual land use practices, I recognize that multiple factors, including, but not limited to politics, are likely involved.

Another critique that has been leveled against much political ecological literature, even that which addresses questions of agency and feedback loops between political economic structure and local land use decisions, is the tendency to make an *a priori* judgment that political decisions made at the local level are preferable to those made at larger scales. For example, Brown and Purcell (2005) argue that the question of scale should be treated as an object of inquiry in political-ecological studies. They note that much political-ecological work has fallen

into a “local trap,” in which local scale actors and organizations are assumed to be more effective in promoting positive outcomes such as environmental sustainability and social justice. They argue that political-ecological research should carefully address the question of scale without making a priori assumptions that one scale should be preferred over another.

The question of scale is treated implicitly throughout my research project—for example, consideration is given to the land use implications of regional and national scale migration on land use; similar consideration is given to the land use implications of the actions of governmental agencies from municipal to national levels. Furthermore, scale is treated as an explicit question of analysis in two discussions about the relationship between governance and land use. First, addressing Brown and Purcell’s concern about the “local trap” in political ecology, I consider the effectiveness of associations operating at two distinct spatial scales: at the level of the administrative unit and of the community. That is, in each hypothesis concerning governance and land use, I use two measures of governance—one operating at the household level (e.g., participation in courses, STR, etc) and one at the level of the administrative unit (e.g., deforestation limits, IBAMA presence, etc)—to assess at which scale (household or administrative unit) the impacts of governance upon land use can be best measured.

In drawing upon political ecology, I have also recognized its limitations. While not necessarily a weakness, due to its interdisciplinary nature and numerous theoretical influences, political ecology has not developed into a coherent unified theory but represents a broadly-defined approach and area of interest that can be integrated into a diverse array of perspectives on human-environment interactions. Furthermore, as political-ecology tends to focus upon narrative explanations of human-environment interaction it is rarely, in and of itself, well adapted to rigorous hypothesis testing (Peet and Watts, 1996). In the case of my research, I have

sought to overcome this limitation by drawing both on political ecology and the broader LULCC literature. While theoretically diffuse, the LULCC literature does provide fertile material for developing testable hypotheses. A case in point is the argument between Laurance and Nepstad about whether or not governance reduces predatory land use in road corridors. Hence, I have drawn largely upon the LULCC literature to identify key variables and hypothesize causal relationships between them. Political ecology and institutional theory perform an important complementary role by focusing the analysis on key factors not commonly discussed in the LULCC literature—including individual agency, contestation for the rights to resources and to define the “rules of the game”, and the implications of scale in affecting the role that governance has for land use.

Variables Used in Analysis

Drawing upon the LULCC literature, especially that which focuses upon issues of roads and governance in the Brazilian Amazon, I identified five land use and land cover variables which are treated as dependent variables and 10 variables that can be considered drivers of LULCC and are treated as independent variables in chapters 3 and 4.

Dependent Variables

Deforestation

Deforestation is a continuous variable which refers to the net area, in hectares, of mature or secondary forest that had been removed by the family from the time of arrival on the property. As interviews occurred over a one year period, I used 2005 as a base year for calculating this variable. To obtain this information, I subtracted the amount reported as deforested at the time of the household’s arrival on the property from the amount deforested at the time of the interview. Household-level deforestation represents the area in hectares of forest (primary and secondary) that had been converted to non-forest during the family’s tenure on the property. As

mentioned in chapter 1, this method can be subjected to under-reporting. However, given the techniques available to minimize this bias (also addressed in chapter 1) and the difficulty of determining the exact property boundaries in most portions of the field site, I elected to use reported values rather than remote sensing.

Cattle herd size

Herd size reflects the total number of cattle owned by household members, including cattle held both on and off-farm. Data were also collected for on-property cattle herd size (regardless of owner). As my unit of analysis in the dissertation was the household and not the land parcel, I elected to use the former measure rather than the latter.

Brazil nuts

Brazil nut harvest is a continuous variable measuring the amount in *latas* (1 *lata* = 18 kilograms) of Brazil nuts that were harvested by the household in 2004—including those destined for consumption and for sale.

Annuals

Annuals is a continuous variable representing the area, in hectares, that the household had dedicated to the production of annual crops (e.g., beans, rice, manioc, maize) at the time of the interview.

Last burn

Years since last burn is a continuous variable referring to the number of years that had passed since the last time the household had intentionally burned an area of established (as opposed to new) pasture on their property¹. Since interviews were conducted over a one year period, I used the year 2005 as a baseline for calculating this variable. Years since burning

¹ While great variability exists between families in terms of fire use as a pasture maintenance strategy, given the general non-existence of technological alternatives to fire when forming pasture in the region, fire is used nearly universally when new pasture is established.

established pasture reflects the number of years between 2005 and the last time fire was intentionally used in established pasture on the property (excluding fire used to establish new pasture).

Independent Variables

Place of origin

Place of origin was coded as a binomial variable. Households with both heads born in Acre or neighboring regions of Bolivia or Peru² were labeled “Acreano” and coded as 0. Households that had at least one head that was born outside of Acre or neighboring areas of Bolivia or Peru were labeled “Migrant” and were coded 1.

Distance from road

Distance from road is a continuous variable that measures the distance (in hours) that a household lies from the Inter-Oceanic Highway. As an individual may use various forms of transportation (walking, bicycle, horse, motorcycle, truck, etc) on different occasions, I standardized this measure by using travel time by foot.

Bi-localism (male and female)

Male and female bi-localism are dichotomous variables and represent the frequency with which male and female household heads, respectively, traveled to an urban area each month and were coded as binomial variables (0=low and 1=high)³.

² All individuals in the sample who were born in Peru and Bolivia were ethnically Brazilian, most of whom traced their ancestry to people from Brazil’s Northeast who had come to Acre and neighboring regions of Peru and Bolivia to tap rubber several generations earlier.

³ Male and female bi-localism were initially coded as four-category categorical variables (0=never/almost never, 1=less than monthly, 2=monthly, 3=more than monthly, but less than weekly and 4=weekly or more). Given the lack of variance in the 0 category (n=1 for both male and female bi-localism) and the lack of large differences between some categories, I recoded the five categorical variables as binomial variables. For both male and female bi-localism, the lower level (codes 0,1 and 2) was coded as 0 and the higher level (3 and 4) was coded as 1.

Adult labor (male and female)

Adult labor (male and female) are continuous variables and represent the number of “working age” (15+ years of age) males and females in each household. I used household labor as a proxy measure for out-migration. While the number of working age household members does, of course, reflect other factors beyond out-migration (e.g. births, mortality), it is also intuitive that the effects of fewer working-aged adults upon land use would parallel the effects of adult out-migration.

Years of residence

Years of residence is a continuous variable measuring the number of years that a household has resided on the property. As fieldwork was conducted over the course of a year, this measure was standardized using 2005 as a base year (i.e. if a family arrived in 1985, the value would be 20). This variable serves as a control in multiple regression analysis.

Property size

Property size is a continuous variable measuring the area (in hectares) of the household’s land holding. This variable serves as a control in multiple regression analysis.

Governance (administrative unit)

Unit governance is an ordinal variable based on a four point index of the governance characteristics of administrative units in the region. This index is explained in detail in chapter 4.

Participation in governance

Participation in governance is a continuous variable. It is a factor-weighted index based on principle component factor analysis of 12 individual measures of participation in governance. This index is explained in detail in chapter 4.

Hypotheses

Roads and Land Use

Within the first general research question about the impacts of the road for land use, I address four specific issues and how they relate to land use. First, regarding the impacts of the road by opening the region to colonization in the 1970's and 1980's, I posited the following four hypotheses about the lasting impacts of place of origin and land use:

- H 3.1⁴ Migrant households tend to exhibit higher rates of deforestation than those with heads born in Acre.
- H 3.2 Migrant households tend to own more cattle than those with heads born in Acre
- H 3.3 Migrant households tend to produce more Brazil nuts than those with heads born in Acre
- H 3.4 Migrant households tend to burn their pastures more frequently than those with heads born in Acre

Secondly, to address the implications of rural-urban migration and bi-localism that have been facilitated by the construction and especially the paving of the highway, I posited the following eight hypotheses:

- H 3.5 Higher levels of female bi-localism are associated with less production of annuals.
- H 3.6 Higher levels female bi-localism are associated with less production of Brazil nuts.
- H 3.7 Higher levels of female bi-localism are associated with larger cattle herds
- H 3.8 Higher levels of male bi-localism are associated with less production of annuals.
- H 3.9 Higher levels of male bi-localism are associated with less production of Brazil nuts.
- H 3.10 Higher levels of male bi-localism are associated with larger cattle herds.
- H 3.11 Lower numbers of working age females are associated with less production of annuals.

⁴ Hypotheses starting with 3 are addressed in chapter 3. Hypotheses starting with 4 are addressed in chapter 4. For example, H 3.1 is the first hypothesis addressed in chapter 3.

- H 3.12 Lower numbers of working age females are associated with less Brazil nut production.
- H 3.13 Lower numbers of working age females are associated with larger cattle herds.
- H 3.14 Lower numbers of working age males are associated with less production of annuals.
- H 3.15 Lower numbers of working age males are associated with less Brazil nut production.
- H 3.16 Lower numbers of working age males are associated with larger cattle herds.

Thirdly, to address the implications of access to the highway for land use, I posit the following two hypotheses::

- H 3.17 The greater the distance from the roadway, the lower the deforestation.
- H 3.18 The greater the distance from the roadway, the smaller the cattle herds.

To address the implications of the expanding cattle economy that has developed in the wake of the road's construction and paving, I posited the following four hypotheses:

- H 3.19 The larger the cattle herd size, the less area dedicated to the production of annuals.
- H 3.20 The larger the cattle herd size, the lower the production of Brazil nuts.
- H 3.21 The larger the cattle herd size, the more frequently pasture is burned.

Governance and Land Use

To address the role of governance, at the level of the administrative unit, in affecting the land use in the highway's area of influence, I posit the following three hypotheses:

- H 4.1 Higher levels of governance at the administrative unit level correspond with lower deforestation.
- H 4.2 Higher levels of governance at the administrative unit level correspond with smaller cattle herds.
- H 4.3 Higher levels of governance at the administrative unit level correspond with less frequent pasture burning.

Finally, in order to test the implications of participation in governance for land use, I posit the following three hypotheses:

- H 4.4 Higher levels of participation in governance correspond with lower deforestation.
- H 4.5 Higher levels of participation in governance correspond with smaller cattle herds.
- H 4.6 Higher levels of participation in governance correspond with less frequent pasture burning.

CHAPTER 3 ROADS AND LAND USE CHANGE IN ALTO ACRE

A central issue in discussions about sustainable development in Brazil concerns the effects of highway paving on social-ecological systems in the Amazon Basin. While road paving promises to improve access to goods and services among previously isolated rural and urban communities in Amazonia, it can also have negative environmental and social consequences, including deforestation, widespread use of fire, and the displacement of rural smallholders. Roads in tropical ecosystems have brought negative ecological impacts including fragmentation of forest cover, the release of carbon into the atmosphere, increased fire frequency and species extinctions (Cumming et al., 2005). In the case of Amazonia, this has been accompanied by negative social impacts such as the increased violence and dispossession of traditional land holders (Schmink and Wood, 1992). In academic and policy circles, a heated debate exists regarding the land use changes brought by roadways and the capacity of governance to prevent them (e.g., Nepstad et al., 2001, 2002; Laurance, 2001, Soares-Filho et al., 2004). Given that households are often the ultimate agents of land use change in the Brazilian Amazon's highway corridors, a household-level research approach provides an important perspective in understanding the decision-making processes driving land use change in areas such as Alto Acre's Inter-Oceanic highway corridor.

The first part of this chapter addresses the question of migration—specifically how land use differs among migrants and natives, and among households of different age and gender combinations. It also addressed the impacts of bi-localism (the division of residence between rural and urban areas) for land use. The second portion of the chapter addresses the impacts that roadway access and expanding herd sizes have for land use.

Descriptive statistics for the independent and dependent variables¹ used in the analysis are shown in Table 3-1². Of the sampled households, 38% had at least one head born outside of Acre. On average, households had more male adults present (1.95) than female adults (1.38). However, women scored slightly lower on the measure of bi-localism than did men. On average, members of households included in the study had to walk 1.5 miles to reach the paved highway and had been on their properties for nearly 20 years. Property size varied greatly—from 40 to 1200 hectares, with the average property having 254 hectares. The majority (59%) reported using credit as of the time of the interview.

Brazil nut production was highly variable between properties, though most households produced modest amounts. The mean Brazil nut harvest for 2004 was 26.5 *latas*. The average household reported having cleared 24.24 hectares of land during their tenure on the property, though this amount varied from 0 to 298 hectares. Of the land that had been cleared, households reported an average of 3.35 hectares dedicated to the production of annuals as of the time of the interview. Like property size and Brazil nut production, cattle herd size was also variable—ranging from 0 to 800 head. The average household owned 58 head of cattle. On average, households had spent 3.19 years since the last time they had last intentionally burned their cattle pasture.

Roads and the “Occupation of the Amazon”

In the early 1960’s Amazonia’s long-standing isolation from the rest of Brazil came to an end. While previous administrations—most notably that of President Getulio Vargas several decades earlier—spoke of the importance of integrating Amazônia into the Brazilian mainstream,

¹ The variable “cattle” is used as a dependent variable when testing the impacts of migration for land use. It is used as an independent variable when testing the relationship between expanding herd size and other land uses. Potential issues of endogeneity in the use of cattle as an independent variable are discussed in that section.

² Descriptive statistics for variables occurring in both chapters 3 and 4 are displayed in Tables 3.1 and 3.2.

by and large this did not result in concrete action until the 1960's. In the early part of the decade, when the region's first major highway was constructed linking Belém with the new national capital of Brasilia, Amazônia's historical isolation began to change rapidly. During the 1960's, and even more so in the 1970's and 1980's, the federal government undertook an enormous effort to encourage the colonization of the Amazon through propaganda, road construction, and massive fiscal incentives (Moran, 1981; Schmink and Wood, 1992).

A number of explanations have been offered for this relatively sudden interest in the colonization of the Amazon Basin on the part of the federal government. Subsequent to the military coup in 1964, the government developed a xenophobic fear of the "internationalization of the Amazon." Informed by scholars such as A.F. Reis (Reis, 1960), government officials feared that a sparsely populated and poorly integrated Amazônia was vulnerable to threats from neighboring and northern nations interested in the region's vast resources. This fear was exacerbated by reports such as a 1971 United Nations Food and Agriculture Organization document suggesting that, if intensively farmed, the Amazon Basin could feed a global population of 36 billion (Pawley, 1971, Smith, 1982: 13).

Furthermore, the government's view of the Amazon as a "safety valve" for overpopulated and impoverished regions of the nation was another important incentive behind programs to construct roads and colonize the area (Bunker, 1985; Hall, 2000). In the Northeast, a series of droughts led to waves of out-migration to other parts of the country, including Amazonia. Exacerbating this problem, in both the Northeast and the South of Brazil, concentration of land ownership and the growth of agro-industry was forcing smallholders from their land (Smith, 1982). While hindsight shows that implementation of agrarian reform would likely have been a much more socially just and cost effective strategy to deal with these problems (Ozório de

Almeida, 1992), doing so would have run contrary to the right-wing dictatorship's philosophical stance and, more importantly, by angering wealthy land owners, would have undercut a fundamental component of the dictatorship's political base.

Combined with the desire to avoid the internationalization of the Amazon and to relieve political pressure for agrarian reform was a desire on the behalf of the government to exploit what was perceived as a vast untapped reserve of natural resources including timber, minerals, and agricultural land (Bunker, 1985; Ozório de Almeyda, 1992). The development of this region and its resources was intended to absorb investment capital and attract surplus labor from overpopulated and impoverished areas of Brazil such as the Northeast (Schmink and Wood, 1992).

Highway construction, especially in sparsely-populated areas, often led to negative social and environmental consequences including land speculation, rising land prices, population turnover and deforestation (Schmink and Wood, 1992; Hecht and Cockburn, 1990; Perz, 2001, Nepstad, 2001, 2002; Laurance, 2001). Road construction and colonization generally went hand-in-hand as large-scale colonization was only feasible given overland connectivity to regional and national markets and population centers. Indeed, the creation of the Amazon's major colonization poles (e.g., Trans-Amazônia and Rondônia) was inextricably linked to the roadways built through them (Browder and Godfrey, 1997).

Road Paving and Colonization in Alto Acre

In 1969, Acre's isolation from the rest of Brazil began to break, with the construction of the unpaved BR-364 highway linking the capital city of Rio Branco with Rondônia and the remainder of the country (Bakx, 1986; Sawyer, 1984). The following year, Governor Wanderlei Dantas, in a bid to stimulate outside investment in the state, offered a now infamous invitation to an audience of São Paulo ranchers and investors to "Produce in Acre, Invest in Acre, Export via

the Pacific.” Many accepted the invitation and, by 1971, a full-scale land rush was well underway (Bakx, 1986).

Initially, the roadway led to greater autonomy for rubber tappers, who consequently had freer access to markets for selling rubber and purchasing other goods (Cardoso, 2002). However, with the construction of the road and the arrival of Southerners came intense land conflict. Rubber barons, many of whom had largely abandoned their estates in prior decades, returned to reap the profits from soaring land prices, which had risen up to 2000% in highway corridors (Bakx, 1986). State policies were enacted and land exchanged hands with little, if any, recognition of the rubber tappers who continued to occupy the land. Indeed, many ill-informed ranchers and investors were surprised and dismayed to find their land already occupied (Bakx, 1986). As rubber tappers rarely possessed legal title to their land, they were commonly evicted, at times with threats of violence. Many crossed the border to Bolivia or relocated to the burgeoning periphery of Rio Branco; others remained to mount a resistance movement to protect their rights to the land (Bakx, 1986; Cardoso 2002).

By 1973, ranchers had begun resorting to violence as a means of removing rubber tappers (Keck, 1995; Schmink 1992) and, as a consequence, with the assistance of political allies, rubber tappers began to organize into a social and political movement. A principal technique throughout the struggle was the use of *empates*—or non-violent stand-offs—when rubber tapper land was threatened with clearing by ranchers (Keck, 1995; Barbosa, 2000; Kainer et al., 2003). As in other parts of the Brazilian Amazon, grass-roots resistance movements emerged to challenge the expropriation of land and destruction of rubber tapper livelihoods. However, the movement in Acre was undoubtedly among the most dynamic, widely publicized, and ultimately successful of the grassroots resistance movements of the Brazilian Amazon in this era. As it

gained in political power and publicity, the rubber tapper movement expanded into increasingly broader political spheres (Keck, 1995)—from household-level conflicts to regional, state and ultimately the international environmental movement (Schmink and Wood, 1992; Keck, 1995; Kainer et al., 2003).

In the early 1970's the Alto Acre region became one of the first areas in the state to be affected by the arrival of ranchers and speculators from Brazil's South (Bakx, 1988). It also witnessed some of the most intense conflict between the newcomers and resident rubber tappers defending their rights to the land they had occupied for generations. During the 1970s and 1980s, ranchers obtained and cleared large tracts of land in Alto Acre near the BR-317 highway—a spur from the BR-364 leading from Rio Branco to the Peruvian border. As a result, the Alto Acre region, and my research site in particular, was a focus of conflict, especially in the early years of the *empate* movement. Subsequent to the assassination of STR leader Wilson Pinheiro in 1980 and the retaliatory killing of the ranch manager widely believed responsible, the government saw the need to intervene before social unrest further destabilized the region. These conflicts helped lead to the creation of the colonization area and, several years later in 1988, PAE Santa Quitéria—one of the first experiments in extractive reserves to be implemented in the Brazilian Amazon. Ironically perhaps, some of the most out-spoken proponents of the PAE and the preservation of rubber tapper livelihoods (including some who are widely believed to have been actively involved in the violent stand-off with the rancher) have themselves become some of the area's largest ranchers and vocal critics of environmental regulations in the PAE.

While a handful of the older ranches, including Fazenda Sta. Rita, have persisted to the present, the majority were short-lived. In an effort to restore social calm in the region, many ranches in the area were ultimately appropriated by INCRA and redistributed as 60-100 hectare

lots in Directed Settlement Project Quixadá to both displaced rubber tappers and to landless migrants arriving from outside of the state. During the early and mid-1980's, INCRA registered and settled families onto 301 lots in PAD Quixadá, Gleba 6 (the portion of the Quixadá Project included in my research project), offering land and occasionally building material, and transportation to the region. While migrants came from many areas of the country, the majority came from Brazil's south, especially the largely deforested former agricultural frontier of Paraná.

Despite free land, the journey and subsequent fight for survival that migrants faced were difficult, with many migrants abandoning their lots and returning to their homelands in Brazil's South or relocating to the peripheries of neighboring towns after finding the extreme isolation and the difficulties posed by the lack of basic social services and technical isolation insupportable. This turnover is reflected in the fact that, though INCRA had discouraged the sale of lots, only a third of interviewed families from PAD Quixadá were either the original owners or children of the original owners of the lot.

While most of the migrants in the region initially settled in the colonization area at the highway's edge, as land became scarce in the colonization area, many subsequently moved into PAE Santa Quitéria and, to some degree, to the RESEX Chico Mendes, both of which lie behind the colonization area. While this has at times occurred through land invasion, the steady stream of out-migrants from the RESEX and PAE willing to sell their *colocações* for low prices has provided a means of doing so without outright social conflict.

One family living immediately behind PAD Quixadá in neighboring PAE Sta. Quitéria told me that they had initially migrated in the 1980's from the state of Goais, along with the husband's father, to a farm on the road's edge in the colonization area. As the then-young couple began to start a family of their own, rather than purchasing a lot along the road, they

decided upon a relatively inexpensive and completely forested 200 hectare land holding nearby in the PAE. While they would technically need community approval through AMPAESQ—an association representing the PAE’s residents—they were told by a contact in INCRA that they could proceed with the purchase, but with no guarantee that they would not subsequently be expelled by the community. Ultimately, the gamble paid off and they successfully received a *cartão de assentamento* (“settlement card”) from INCRA, entitling them to live in the PAE. While the majority of the residents of the PAE and RESEX were native-born Acreanos, such stories from migrants and their children were nonetheless common.

At the time of research, cultural differences between native-born Acreanos and southern-born migrants were reflected in stereotypes commonly held by each about the other group. On one hand, migrants—especially older Southerners—were often held to be rigid and money-oriented, with little concern for the forest, and at times insular and disinterested in participating in community organizations, such as associations. On the other hand, while many migrants boasted of their hard work in the hope of building a better future for themselves and their children, they would at times contrast their own ambitiousness with the complacency of many Acreanos who were perceived to be content to live on the threshold of poverty as long as the immediate needs of the present were met. As evidence for such “*preguiça*” (“laziness”), migrants would occasionally point out the modest homes, small clearings and lack of well-maintained pasture of native-born Acreanos.

Despite initial conflicts and lingering stereotypes between these two groups, relations generally improved over subsequent years and decades. Inter-marriage between native-born Acreanos and migrants became commonplace, and many younger members of migrant families had little or no recollection of the South, referring to themselves not by the place of their parents’

birth but simply as “Acreanos.” This is reflected in a statement made by a daughter of Paranaense migrants in her late 20’s who told me that she took personal offense when people spoke derogatorily about Acreanos—she scarcely remembered Paraná and despite her blond hair and blue eyes (commonly associated with southern migrants), she considered herself Acreana. Intermarriage between Acreanos and migrants was common; in PAD Quixadá, for example, 25% of married couples had one spouse from Acre and the other from elsewhere (in all cases, the husband being a migrant and the wife being Acreana). Through this process of inter-marriage and the coming of age of Acre-born children of migrants, the cultural distinctiveness of indigenous, northeastern and southern ethnic identities had largely melted into a shared Acreano identity, especially among younger individuals. Children of migrants tended to refer to themselves as Acreanos and not by their parents’ state of origin; inter-marriage between migrants and non-migrants was common (if not the norm); and, as shall be demonstrated, stereotypes aside, after controlling for other factors, few distinctions persisted between these migrants and native-born Acreanos in terms of their land use practices.

Testing the Relationship between Place of Origin and Land Use

The migrants coming to Acre in the 1980’s differed from their Acreano neighbors in terms of livelihood systems and history. Whereas Acreanos had a long tradition of forest-based livelihoods (e.g., rubber tapping), most migrant livelihoods depended upon mixed subsistence and market-oriented agriculture, including cattle production. Furthermore, it was almost entirely native Acreanos who participated in the rubber tapper movement that tied land rights with forest conservation, often in the form of extractive reserves. While many migrants had in fact been involved in struggles for land rights, rarely were they tied to forest conservation. Due to these historical differences, I anticipated a continuing differentiation between the two groups in terms of land use. In order to test hypotheses 3.1, 3.2, 3.3, and 3.4 (listed in Chapter 2) about the

impacts of place of origin and land use, I first conducted bivariate analysis of the relationship between place of origin and deforestation, cattle herd size, Brazil nut production, and pasture burning. As each test involved a bivariate independent variable (Acreano or migrant) and a continuous dependent variable, I relied upon t-tests.

Acreanos appeared to have a virtually equivalent mean level of deforestation (25.3 hectares) to migrants (22.3 hectares). An independent sample t-test of place of origin and household deforestation (equal variance assumed) failed to reveal a significant difference between native-born Acreanos and migrants ($t=.360$, $df=84$, $p=.720$). In contrast, migrants appeared to have a slightly higher mean cattle herd size (64.5) than migrants (54). As with deforestation, an independent sample t-test of place and origin and herd size (equal variance assumed) failed to reveal a significant difference between native-born Acreanos and migrants in terms of their land use ($t=-.423$, $df=89$, $p=.673$). Regarding Brazil nut production, Acreanos appeared to have a much larger mean 2004 harvest (52.3 latas) than migrants (8.9 latas). Unlike deforestation and herd size, an independent sample t-test (equal variance assumed) showed that Brazil nut production was significantly higher for Acreanos than for migrants ($t=3.592$, $df=83$, $p=.001$). Finally, regarding pasture burning, migrants appear to burn their pastures with slightly less frequency (3.47 years) than Acreanos (3.02 years). An independent sample t-test (equal variance assumed) failed to reveal that the difference was significant ($t=-.895$, $df=78$, $p=.374$). Based upon bivariate analysis, I rejected hypotheses 3.1, 3.2, and 3.4. Place of origin did not have a significant impact on deforestation, cattle herd size or use of fire in pastures. However, supporting hypothesis 3.3, place of origin did appear to be significantly related with Brazil nut production. Households originating in Acre produced significantly more Brazil nuts than migrant households.

Modeling Place of Origin and Land Use

In order to further test the relationship between place of origin and Brazil nut production, I subjected it to a multiple regression analysis, controlling for years of residence and property size. The model indicated that Brazil nut production was not significantly affected by years of residence. It was, however, significantly related to property size. Each additional hectare of property size was associated with an additional .08 *latas* of Brazil nut production. Of key concern to hypothesis 3.3, migrants were predicted to harvest 34.5 fewer *latas* of Brazil nuts than native-born Acreanos (Table 3-2). I therefore accepted hypothesis 3.3, that households with place of origin in Acre produce more Brazil nuts than migrant households.

Discussion

The stronger correlation between property size and Brazil nut production is intuitive, given that larger properties can be expected to have more Brazil nut trees. The fact that, controlling for covariates, Brazil nut harvests remain significantly related to place of origin lends a further insight into the relationship between place of origin and land use change. On one hand, native Acreanos seem to have readily adopted non-forest-based land use practices, such as cattle, as they became viable in the region. On the other hand, even though Brazil nut production has recently become a very lucrative activity, non-Acreanos have been less keen than their Acre-born neighbors to begin exploiting this forest-based resource.

Thus, while the BR-317 has, and still does, affect land use in the region (as will be further discussed in the next section), the cultural orientation of the migrants who followed the road to this area appears to play a limited role in this relationship several decades later. Cultural differences that once were very important in affecting land use between migrants and native Acreanos seemed to be, with some exceptions, diminishing as a common Acreano identity

formed and all groups responded to shared market forces and governmental policies that have followed in the highway's wake.

Intra-Regional Migration, Gender and Land Use

While two-thirds (66.3%) of households reported that they had modified their land use in some way because of the paving of the roadway, all but one (who complained of increased crime) indicated that their overall quality of life had improved because of the paving of the road—many referring to it as an *abenço* (blessing). Travel between their homes and the regional urban centers of Brasília and Assis Brasil became much more feasible, putting markets, schools, churches and medical services more easily within reach. A journey to town that previously would take up to several days could be completed in as little as an hour, allowing the majority of residents in the research site to travel to and from town in one day, even in the rainy season.

This travel to and from town was generally motivated by one or two primary goals: the economic transactions of selling farm products and purchasing food and other products unavailable in the *colônia*, and accessing a myriad of urban services—including banks, hospitals, government offices, secondary schools, brothels and *farró* dancehalls. Given the trade-offs between rural and urban residence, the paved highway has facilitated temporary and permanent micro-level migration between the two as well as an emerging phenomenon of bi-localism as families split their residence between rural and urban areas. Most families made multiple-day trips to town on a monthly or greater basis and while most stayed with family members while in town, 17% of interviewed households maintained a second residence in town.

It is important to recognize that bi-localism generally operates at the intra-household level. For various reasons, including the cost of transportation, on-farm responsibilities and fears of break-ins, it was usually individuals rather than entire families who traveled between the farm

and city. For example, if a family needed to make a bank transaction or treat a sick child at the hospital, one household head would usually go, leaving the other to care for the home and farm. Similarly, in families with adolescent children and sufficient economic means, most would invest in an urban secondary education for one or two children while the others remained to provide on-farm labor.

A telling indicator of gender-based differences in rural-urban movement is reflected in the numbers of men and women who had assumed longer term in-town residency. On average, sampled households had sent .23 men and .37 women to the city in the prior four years. Given the fact that men contributed the largest part of farm labor, the continuation of most on-farm activities required either the presence of males or sufficient financial resources—such as salaries or cattle—to contract male labor. Conversely, reproductive activities—including the care of children and the sick—were dominated by women and were often more easily carried out in an urban setting.

Girls and young women were more likely to pursue advanced studies in town than boys and young men. Girls were often perceived as being both more adept at academics and less prone to becoming side-tracked by the myriad temptations of city life than boys, making investment in their education less risky than investment in boys' education. Furthermore, in a growing service-based economy, women often found more opportunities for unskilled and semi-skilled urban work than did men. And increasingly, in the field of skilled urban labor (generally synonymous with the governmental sector in Alto Acre), a growing population of educated women were finding in-roads into positions once dominated by men as evidenced, for example, in the 2004 election of Brasília's first female *prefeita*. And while unintended pregnancy was a great concern for many parents as they decided whether to send their daughters to study in town

where they would be subject to less direct adult supervision, this risk was often accepted, especially given the preponderance of the same issue in the rural area as well, even with closer parental supervision.

Despite the advantages offered by urban residence, the possession of a rural land holding remained very desirable for most residents, the outright sale of rural land being most common among the elderly who desired to “cash-in” their accumulated farm investments and by the poor who did so out of necessity. Many informants boasted of the peacefulness, quiet, healthfulness, and relative safety from crime and pollution that they enjoyed in the countryside. Furthermore, while economic opportunities were generally limited to the agricultural sector, these were considered to be economically lower-risk activities—especially cattle raising—than urban economic ventures. For wealthier families, possession of a rural land holding provided at least three services: as a weekend “vacation” home, as a capital investment—especially when it sustained a cattle herd—and as a hedge against economic failure in the city (e.g., lost job or failed business venture). In such an event, possession of a rural land holding allowed the owner to retreat to a relatively secure, if modest, on-farm subsistence.

Natural population growth, coupled with temporary and permanent rural-urban migration, has contributed to rapid growth of the region’s towns. As in many parts of the developing world (Lambin et al., 2001) and in the Amazon in particular (Browder and Godfrey, 1997), the direct impact of urbanization upon LULCC by replacing fields and forests with urban sprawl has been negligible in Alto Acre. Urbanization, however, by changing the region’s political, social and economic landscapes, is a powerful indirect cause (and effect) of land use and land cover change in rural areas. For example, wage labor, refrigeration and the proximity of meat processing facilities contribute to a much larger per capita beef consumption in the urban versus rural areas;

hence as towns grow, so too does regional demand and price for beef. Also, the closely related phenomena of bi-localism and rural exodus that are directly tied with the urbanization of the region also have impacts upon land use in the countryside. In particular, one would expect that the part-time and permanent relocation of rural residents to the city would result in shifts from labor intensive land uses to activities that require less labor.

Testing the Relationship between Bi-localism, Out-Migration and Land Use

Most agricultural and extractivist activities conducted in the field site tended to be very labor intensive. This was especially true for the production of annual crops and for the extraction of Brazil nuts. In contrast, cattle ranching, while requiring a larger capital investment (e.g., livestock, fencing, corrals, vaccinations), was a much less labor intensive activity, especially once initial start-up labor investments such as the construction of fences and corrals had been completed.

Hence, I posited that as rural household labor supply diminishes—through both out-right migration to cities and through bi-localism, that households would reallocate the remaining household labor from labor-intensive activities such as the production of annuals and Brazil nuts to less labor intensive activities like cattle ranching. In order to test hypotheses 3.5 through 3.16 (listed in Chapter 2) about the impacts of household labor and bi-localism for land use, I first conducted bivariate analysis of the relationship between male bi-localism and deforestation, cattle herd size, Brazil nut production, and pasture burning. I repeated the tests using female bi-localism as the independent variable. I then conducted bivariate analysis of the impacts of household labor force for these same dependent variables. In the case of male and female bi-localism and land use, as each test involved a bivariate independent variable (high bi-localism and low bi-localism) and a continuous dependent variable, I relied upon t-tests. In the case of

household labor force and land use, as both the independent and dependent variables were continuous, I used Pearson correlation analysis.

Female bi-localism and land use

Households with high levels of female bi-localism had virtually the same mean area in hectares in annuals (3.2) as did households with low levels of bi-localism (3.3). An independent sample t-test (equal variance assumed) did not reveal a significant difference between the two groups in terms of their cattle herd size ($t=.093$, $df=76$, $p=.926$). Households with high levels of female bi-localism had lower mean Brazil nut harvests (18 latas) than those with low levels of female bi-localism (49 latas). An independent sample t-test (equal variance assumed) revealed a significant difference between the two groups in terms of their Brazil nut production ($t=2.274$, $df=75$, $p=.026$). Households with high levels of female bi-localism had smaller mean cattle herds (37.69) than households with low levels of female bi-localism (75.26). An independent sample t-test (equal variance assumed) revealed a significant difference between the two groups in terms of their cattle herd size ($t=1.345$, $df=77$, $p=.045$).

Hence, bivariate analysis failed to support hypothesis 3.5 that households with higher female bi-localism would be associated with less area in annuals. It also failed to support hypothesis 3.7 that higher female bi-localism would be associated with larger cattle herds. However, it did support hypothesis 3.6 that higher levels of female bi-localism would be associated with smaller Brazil nut harvests.

Male bi-localism and land use

Households with high levels of male bi-localism had the same mean area in hectares in annuals (3.4) as did households with low levels of male bi-localism. An independent sample t-test (equal variance assumed) did not reveal a significant difference between the two groups in terms of their cattle herd size ($t=.015$, $df=77$, $p=.988$). Households with high levels of male bi-

localism appeared to have lower mean Brazil nut harvests (24.8 latas) than those with low levels of male bi-localism (46.5 latas). However, an independent sample t-test (equal variance assumed) did not reveal a significant difference between the two groups in terms of their Brazil nut production ($t=1.613$, $df=75$, $p=.111$). Households with high levels of male bi-localism had smaller mean cattle herds (54.5) than households with low levels of male bi-localism (65.9). An independent sample t-test (equal variance assumed) did not reveal a significant difference between the two groups in terms of their cattle herd size ($t=.419$, $df=78$, $p=.676$)

Hence, bivariate analysis failed to support hypothesis 3.8 that high male bi-localism would be associated with smaller area in annuals. It also failed to support hypothesis 3.9 that high male bi-localism would be associated with smaller Brazil nut harvests. Neither did bivariate analysis support hypothesis 3.10 that high male bi-localism would be associated with larger cattle herds.

Adult females and land use

Pearson correlations failed to show a significant relation between adult female adults and area in annuals and Brazil nut production (Table 3-4). Hence, bivariate analysis failed to support hypotheses 3.11 and 3.12 that lower female labor would be associated with less area dedicated to annuals and lower Brazil nut production. A significant relationship did emerge between lower levels of adult female labor and smaller cattle herds. However, the direction of the relationship countered hypothesis 3.13 that lower levels of adult female labor would be associated with larger cattle herds.

Adult males and land use

Pearson correlations showed a positive relationship between number of adult males and Brazil nut production and cattle herd size. No relationship emerged in the relationship between male labor and area dedicated to annuals. Hence, bivariate analysis failed to support hypothesis 3.14 that lower levels of male labor would correspond with a smaller area dedicated to annuals.

It did however support hypothesis 3.15 that lower levels of male labor would correspond with less Brazil nut production. Finally, while adult male labor was significantly associated with cattle herd size, the direction of the relationship countered hypothesis 3.16 that lower levels of male labor would correspond with larger herd sizes.

Modeling Bi-localism, Household Composition and Land Use

I tested the first relationship between female bi-localism and Brazil nut production by using multiple regression to further test these relationships while controlling for other variables likely to affect land use (Table 3-5, column 1). Property size was significantly associated with Brazil nut harvest. For every additional hectare of property size, Brazil nut production increased by .084 latas. Of special concern to hypothesis 3.6, after controlling for years of residence and property size, Brazil nut production was significantly associated with female bi-localism. Female bi-localism explained 3.3% of the variation in Brazil nut production. Households with a high level of female bi-localism produced 22.57 fewer latas of Brazil nuts in 2004 than did households with a low level of female bi-localism.

I then replicated the test to determine the relationship between female bi-localism and herd size (Table 3-5, column 2). In this model, the only significant predictor of herd size was years of residence. For every additional year of residence, herd size increased by 3.392 head. After controlling for years of residence and property size, the relationship between female bi-localism and cattle herd size was no longer significant.

To test the relationship between adult males and Brazil nut production and between male adult males and cattle herd size, I ran multiple regression analyses to control for the influence of years of residence and property size in both relationships that proved significant in Pearson correlation analysis. In the first model (Table 3-6, column 1), property size had a significant impact on Brazil nut production, with each additional hectare corresponding with an increase of

0.104 in Brazil nut production. After controlling for years of residence and property size, the relationship between adult male labor and Brazil nut production was no longer significant. In the second model (Table 3-6, column 2), years of residence was the only significant predictor of cattle herd size. For every additional year of residence, herd size is expected to increase by 2.821 head. In the third model (Table 3-7), as in the second model, years of residence had a significant impact on herd size. For every additional year of residence, herd size is predicted to increase by 2.847 head. Of special concern to the question of household composition and land use, even after controlling for years of residence and property size, the number of adult females remained significantly associated with larger cattle herds. For every additional adult female present in the household, cattle herd size was predicted to increase by 34.327 head.

Discussion

Given the labor intensive nature of Brazil nut production and usual involvement of both sexes in its production, the relationship between female bi-localism with lower production of Brazil nuts may be due to labor shortfalls. Lower availability of female labor may cause families to shift away from labor intensive activities such as Brazil nut production. It is also possible that the relationship is spurious; for instance, greater possession of capital and assets in town (something not directly measured in the study) might necessitate that women travel more frequently to town while reducing the necessity of the family to focus on labor intensive farm activities for subsistence.

The relationship between lower levels of adult female labor and smaller cattle herds directly contradicts hypothesis 3.13 that lower levels of female, would be related with larger herd sizes. The finding initially seems counter-intuitive, especially given that the care (though not the ownership) of cattle, in this region, is an activity almost entirely dominated by men. In this case, it seems unlikely that labor shortfalls are the primary explanation for the relationship. However,

it is possible that variance in cattle production systems plays a role. Producers generally practice some combination of two general herd management schemes—selling off calves or keeping them—especially salient in the case of female calves. One strategy is to sell off most or all offspring—practiced both due to lack of additional pasture and desire for short-term income—representing a subsistence-oriented herd management strategy in which both the size of the herd and annual revenues from calf sales remain roughly constant. The other system, of keeping heifers with reproductive potential allows, under certain conditions (e.g., unconstrained forage availability), for exponential growth in herd size and, by extension, accumulated wealth in exchange for lower short-term income. Furthermore, under such a system, the sale of the majority of male calves not intended for reproduction can serve as a “dividend” payment while having a minimal impact on the long-term reproductive potential of the herd.

While I did not measure the phenomenon directly, in the course of interviews, subtle conflicts emerged between men and women in terms of their approach to cattle production. Specifically, women seemed most likely to show caution in the management of their herds, being careful to build herd size as a resource for family emergencies; men were often more prone to “cash-in” portions of their herds to purchase vehicles and other consumer goods. For instance, one elderly widower told me that his late wife had always preferred, when possible, to keep calves rather than selling them. Upon her death, he told me, the herd had diminished as he gradually sold it off. In another instance, when I asked a female informant how the family (which seemed to be of modest means) had afforded to purchase a car, she replied that her husband “*Perdeu a cabeça*” (“lost his head”) and sold off a large part of the family’s herd to buy the vehicle. This conclusion was corroborated by feedback from numerous community members (though more often by women than by men) when I returned research results in 2006. Such

anecdotal evidence, combined with statistical analysis, suggests that households with more adult females (and female decision-makers) present will tend to have the most rapidly expanding herds. Hence, the disproportional tendency of women to migrate, permanently or temporarily, may be having the effect of slowing the expansion of cattle herds in the region's rural areas.

Access to Roadway and Land Use

Two important dates stand out regarding the construction of the BR-317 roadway between Brasília and Assis Brasil. First was the construction of a dirt road in the mid-1970's which launched an initial wave of in-migration, land use change and deforestation. Another milestone occurred in 2002, when the long-awaited paving of this highway became a reality, and it became possible to travel from Brazil's heartland through Alto Acre, to the Peruvian border without leaving asphalt. While this had been a perennial campaign promise from numerous politicians, it was ultimately realized by Governor Jorge Viana, thus ingratiating him to the majority of Alto Acre residents, including many who were otherwise opposed to his Worker's Party.

With the scheduled paving of the Peruvian roadway stretching from Brazil to the Pacific coast, much speculation has been offered about the likely economic and environmental implications of this future asphalt link between Brazil's heartland, the Brazilian and Peruvian Amazon, the populous Peruvian Andes, the Pacific and, ultimately, China and other rapidly growing Asian economies. This prospect has raised fears of devastating social and ecological changes, most notably an increased marketability of soy from the Amazon's southern fringes (and resulting deforestation) in that region.

While the implications for Acre and the western Brazilian Amazon will undoubtedly be considerable, the extent of larger-ranging ramifications in Brazil is doubtful. In the case of soy, due to the distance involved and the formidable barrier posed by the Peruvian Andes—even on a paved road—it is unlikely that exporters will prefer this route over shorter existing routes from

Central Brasil through Bolivia and Chile or cheaper water routes through the Amazon and Atlantic Ocean. During a 2005 discussion with University of Florida students and faculty, Governor Viana himself downplayed the wider-scale national and international consequences of the highway—stressing instead that the major implications of paving to the Peruvian border and beyond have occurred and will continue to occur at the regional level of Acre, the Bolivian state of Pando and the Peruvian state of Madre de Dios.

As of 2005, Bolivia—especially the state of Pando and its capital Cobija—had become an important part of the social and economic landscape for many residents of Alto Acre, including my research site. For example, most of the Brazil nuts in the field site were sold to a Bolivian firm, and clothes, electronics and gasoline used by interviewed households commonly came from Cobija; many informants also spoke of family members who had gone to Bolivia searching for jobs or land. With the completion of the paved highway between the field site, Brasiléia, and the neighboring city of Cobija, the city's free trade area had become an important source for relatively inexpensive Chinese-made consumer goods not only for Acre's economic elite, but for all but the poorest of the field site's rural residents. Additionally, for those with cattle or other liquid assets, Cobija's private hospital provided health services that, while expensive, were universally considered superior to Brasiléia's free public hospital.

Furthermore, the availability of inexpensive nationally-subsidized gasoline—approximately one half of Brazilian prices—offered a considerable reduction in operating costs to tractor and chainsaw operators and especially to those with automobiles, including the owners of trucks running transportation routes between the region's rural and urban areas. In effect, as in other Brazilian regions bordering Bolivia, the economic development of Alto Acre has been able to free-ride upon Bolivia's politically-popular gasoline subsidies.

Additionally, the combination of improved transportation links between Brazil and Bolivia and the growth of governance capacity in the former relative to the latter led Bolivia to be seen as a new frontier for many Brazilians. Brazilians who had been displaced by the closing frontier and rising land prices on the Brazilian side could, in exchange for compromised economic and physical security, find opportunities unavailable in Brazil. Brazilian ranchers and loggers frustrated with increased regulations in their home country had begun to view Bolivia as a low-cost and lightly regulated arena in which to expand operations. Likewise, many landless Brazilians had found that Bolivia offered an opportunity to find wage labor and land. However, this came at a risk as no legal recourse existed for Brazilians in unsafe labor conditions and, without legal tenure, any investments in land were subject to confiscation. It is possible, though still unclear, that the recent election of Evo Morales of the Movement to Socialism Party as Bolivia's president will change the generally lawless atmosphere that had prevailed in this region of Bolivia previously.

As of the time of research, Peru had been less important than Bolivia in terms of its social and economic impacts upon the people of Alto Acre. However, with the completion of a permanent bridge between the two countries in late 2005, this could quickly change. Despite considerable population in the neighboring Madre de Dios province of Peru, little of the state's area had been converted to pasture, making the state a likely purchaser of Acre beef upon completion of the bridge and import clearance. Similarly, should the paving of an asphalt link between Acre and Peru's Pacific coast be achieved, the implications for Acre will likely be considerable. While it is doubtful that the Brazilian soy industry, concentrated in the nation's center, will find the Inter-Oceanic Highway to be a profitable export route, the road may, however, provide an incentive for soy production in Acre itself. Likewise, rising demand might

also occur for products from Acre's forestry and cattle sectors with increased connectivity to East Asia's expanding markets.

As of the mid-2000's, highway paving had led to increased market integration and increased marketability for relatively high value and/or easily transportable farm products including cattle, coffee, bananas and some NTFPs such as Brazil nuts. However, due to their low value and the difficulty of transportation, most annual crops such as rice, cassava and beans had been little affected by highway paving, as most of production was dedicated to household subsistence. While most families reported selling surplus crop production, many claimed that this tended to consist of relatively small quantities—as the majority of crops produced was dedicated to subsistence—even with improved road access. Various farmers told me that the paved highway had, in fact, hurt the profitability of some crops such as rice and beans as cheaper produce from mechanized farms in Brazil's South began to flood the region's markets.

Despite the recent paving of the road, the tide of migrants to the state of Acre has slowed, as less unoccupied land is now available for new colonization projects. Most of the region's land is currently occupied by extractive reserves, colonization areas, indigenous reserves or titled private property. In the occasional event of INCRA redistribution of unoccupied or expropriated land, given the large number of landless families relative to available land, new lots tend to be much smaller than in the past—tending to range from 5-30 hectares. However, the newly-paved road does provide improved access to markets for families already living in the area. Roads often serve as drivers of land use change by facilitating access to markets and promoting market-oriented agricultural activities that might not be viable in more distant locations (Chomitz and Gray, 1996). However, the benefits of road paving are not necessarily equal for all of the residents living near it. Due to the poor state of many of the region's secondary roads, some

households remain fairly isolated from regional population centers and markets, especially during the rainy season.

Testing the Relationship between Road Access and Land Use

One means of measuring the impacts of the highway upon land use is by looking at the relationship between a household's access to the roadway and its land use decisions, while controlling for other variables. Various techniques can be used to measure access to a roadway. Possibilities include measuring the linear distance between the home and the roadway and measuring the distance in terms of time required to travel from the home to the roadway. Due to the differences between paths and roads in terms of their quality and due to the fact that on-the-ground travel distances are often longer than linear distances, I chose the latter method. As area residents tend to rely on various forms of transportation at different times—including foot, bicycle, horses/mules/oxen, motorcycle and truck, I standardized the time-distance measurement by obtaining walking time-distance from each household.

Bivariate analysis (Table 3-8) revealed that distance from the road showed no relationship with deforestation ($r=-.073$; $p=.506$) and with herd size ($r=-.104$; $p=.325$). Even after controlling for other variables—namely years of residence, years of cattle ownership, legal deforestation limit and property size—no relationships emerged that could be clearly differentiated from chance. Hence, bivariate analysis failed to support hypotheses 3.17 and 3.18 that increased distances from the road would correspond with lower deforestation and lower herd sizes.

Discussion

In order to avoid overstating the lack of relationship between distance from the road and deforestation and cattle, it is important to note that all sampled households lie within five hours walking distance of a paved road. It is hence impossible, based upon the data, to draw a

conclusion regarding the relationship between distance to a roadway and deforestation for the numerous families living even further from the roadway and outside the scope of this study. A possible explanation for the lack of a relationship between distance to the road and deforestation and with cattle herd size may be due to the fact that all households could feasibly travel to and from urban market centers in one day if possible. This conclusion is supported by a study conducted in Columbia (Feaster, 1970) that found that distance from markets only significantly affected the land use among households where it was not possible to and from the market in a single day. Due to the difficulties imposed by spending a night away from home, such families enjoyed much less access to markets than those who could visit and return in the same day.

As seen in Figure 1-2, in the Alto Acre region as a whole, deforestation is most heavily concentrated in areas nearest the BR-317 while forest cover tends to be more intact in more remote areas. This conforms to various studies such as Moran (1982) who found that deforestation had tended to follow road corridors, especially in areas that have undergone colonization. While households living nearest the roadway certainly enjoyed easier market access for farm goods, including cattle, the distances at the scale of this study did not appear to be prohibitive in the production of cattle. Given the relative abundance of trails and secondary (unpaved) roads in my research site and the fact that cattle, unlike most farm products, are able to transport themselves even during the rainy season, most if not all families could reasonably expect to transport cattle from farm to the edge of the roadway (which provided all-season access for cattle trucks) within a day or less. Though not directly evaluated in the study, it is likely that the opportunity costs of cattle ranching for families living several days or more into the forest would manifest in lower herd sizes and less area dedicated to pasture.

Cattle and Land Use

In the Brazilian Amazon, cattle ranching has gained notoriety for replacing ecologically important forest with low-biodiversity grassland. Many researchers point to cattle ranching as a primary cause behind deforestation and social conflict in the Brazilian Amazon (Hecht, 1985; Cardoso, 2002). Others, such as Faminow (1998) see a more complex relationship between cattle and environmental degradation, with cattle production, in and of itself, being less important than the specific types of production used.

It was clear, through both interviews and direct observation over the course of a year, that many households' herds were rapidly increasing. While I did not systematically measure the change, on return visits to households both during fieldwork and when returning research results one year later, most households mentioned that their herds had increased since the time of the initial interview. Given the tendency toward herd expansion that was occurring in the region, especially given the facilitated market access that the paved road provided, I tested the relationship between herd size and other land use practices, particularly the production of annuals, Brazil nut harvesting, and the use of fire as a pasture maintenance mechanism.

Testing the Relationship between Herd Size and Other Land Use Practices

The strong correlation between herd size and deforestation seen in Table 3-8 is intuitive—larger herds require larger areas of pasture to survive. However, the relationship between cattle herd size and other land use practices is less obvious. In order to better understand the relationship between the size of a household's cattle herd and other land uses, I tested the relationship between herd size and the production of annuals and Brazil nuts³. I also tested the

³ The relationship between cattle and Brazil nuts and annuals should be interpreted with caution. Based on qualitative observations of land use and of herd dynamics, it is arguable that cattle herd size functions as a driver of changes in other land uses such as annuals and Brazil nuts. For example, I found numerous cases in which Brazil nut production had been decimated as herds, and pasture expanded. I found no cases in which herd sizes had expanded as households reallocated pasture land to Brazil nuts. With very rare exception, the same can be said for

relationship between herd size and use of fire as a pasture maintenance tool—a practice that can be detrimental to neighboring forest, crops and to the pasture itself (Cochrane, 1998, Nepstad et al., 2001, Almeida, n.d.).

As households have a finite supply of land and labor, I expected that cattle production would result in an inevitable trade-off with other land uses and that larger herd sizes would correspond with less production of annuals and Brazil nuts. I also expected that, due to their lower relative dependence on crops and Brazil nuts, owners of large cattle herds would see wildfire as a minimal risk to their livelihoods, consequently burning their pastures more frequently than families with smaller herds.

In order to test hypotheses 3.19, 3.20 and 3.21, about the impacts of herd size for annual production, Brazil nut production and use of fire, I first conducted bivariate analysis of the relationship between herd size and the three dependent variables. As each test involved continuous independent and dependent variables, in each case, I used Pearson correlations (Table 3-9).

Bivariate analysis revealed a significant relationship between cattle herd size and area dedicated to annuals ($r=.286$, $p=.007$). However, the direction of the relationship contradicted that which was posited in hypothesis 3.19 that larger herds would correspond with less area in annuals. This suggested that suggesting that, rather than presenting competing land uses, cattle ranching and annual production could be complementary. Bivariate analysis did not reveal a significant relationship between cattle herd size and Brazil nut production. Hence, the analysis failed to support hypothesis 3.20 that larger herds would be related with less Brazil nut production. Finally, bivariate analysis revealed a significant positive relationship between size

annuals. However, as both the independent and dependent variables are land uses, the possibility for endogeneity exists.

of cattle herd and the number of years since pasture was last burned ($r=.322$, $p=.004$). As the relationship was positive rather than negative, it ran contrary to expectations stated in hypothesis 3.21. I had expected that households with larger herds would be less concerned about the impacts of wildfire upon other land uses and therefore use fire more freely than those with smaller herds. Instead, I found that households with larger herds had passed more years since the last time they had used fire in their pastures.

Modeling Herd Size and Brazil Nut Production, Area in Annuals, and Use of Fire in Pastures

In multiple regression models, I further tested the relationships between cattle herd size and area in annuals and between cattle herd size and years since using fire in pasture. In both cases, I controlled for years of residence and property size (Table 3-10).

After controlling for the effect of years of residence and property size, a small, though significant, relationship did emerge between herd size and area in annuals. According to the model, herd size explains 5% of the variation in area dedicated to annuals. For every positive increment in the number of cattle owned, area in annuals increases by .007 hectares.

As previously mentioned, due to the possibility of endogeneity between the two land use variables, it is difficult to ascertain the direction of causality between herd size and area in annuals. However, the model does, in the least, suggest complementarity between the two variables. Countering hypothesis 3.19 that larger herds would be associated with smaller area dedicated to annuals, from this model we can conclude that cattle production does not, generally, represent a competing land use with annual production, and may possibly be a complementary activity. This conclusion conforms with interview data suggesting that production of annuals subsidizes cattle production, and vice versa. On one hand, due to the low market value of most annual crops, it is difficult for a household to recoup the large monetary and labor investments

necessary to clear a given area of mature forest in the two to three year period that the field remains productive. On the other hand, the generally lucrative nature of cattle compensates the costs of deforestation—but only in the long run⁴. Hence, according to both the model and qualitative interview data, annuals and cattle may subsidize each other by compensating the costs of deforestation in the near and long-term respectively. Furthermore, households with more cattle have both the financial means as well as the necessity to clear more forestland—land that under the predominant land use change trajectory, typically passes from forest to annuals to cattle pasture.

I further tested the relationship between herd size and years since last pasture burn using multiple regression, controlling for years of residence, legal limit, perennial production and use of credit (Table 3-10, column 2). Even after controlling for these variables, the relationship between herd size and years since last burn remains clear. In the model, herd size explains 10.1% of the variation in years since last pasture burn. For every additional head of cattle owned, the length of time since the last burn increases by .006 years. In other words, for every head of cattle owned, a household is predicted to have spent an additional 2.2 days since burning pasture. While the incremental increase is modest, given the wide variation in herd sizes and the capacity of herds to expand rapidly under ideal management conditions, herd size arguably plays a significant role in area households' decisions to use fire both at present and in the future.

Discussion

Qualitative data and personal observation corroborated this relationship between herd size and fire use. Lower use of fire may be less a sign of concern that wildfire might damage crops or

⁴ The economic costs of deforestation include the household or hired labor as well as chainsaw fuel required to clear the area. In cases of illegal deforestation, further costs include any fines levied if the event is discovered by an environmental protection agency. Indirect costs (less likely to directly figure in a household's decision to clear) may also include the opportunity costs of lost Brazil nut production and habitat for wild game species as well as reduced water availability if a stream passes through the area.

forest than an expression of concern for the pasture itself. Many individuals with large cattle herds told me that they had initially burned their pastures more frequently. However, through the course of experimentation, they learned that forage quality and quantity and, by extension, animal performance, improved when pasture was burned less frequently. At least two additional explanations may exist for the lower use of fire among larger-scale producers. Larger-scale producers, by having less dramatic fluctuations in their herd sizes run less risk of weed invasion (and hence less need for burning) than smaller-scale cattle producers⁵. Additionally, as larger-scale cattle producers by definition have more resources for capital investments such as fencing, they are more likely to use rotational stocking systems, a technique shown to improve forage quality and reduce the need for fire as a pasture management strategy (Rueda et al., 2003).

Conclusions

A number of tentative conclusions about the impacts of highways on land use—and policies to control these impacts—can be drawn from the study. While the initial wave of migrants who followed the highway to Acre may have brought new land use practices to the region, among the people interviewed in this study, few differences remain today that allow one to distinguish native Acreanos and migrants in terms of their land use. On one hand, native-born Acreanos have operated according to an economic logic, adopting the practice of cattle ranching as economic conditions have favored it. The same, however, cannot be said for migrants in their adoption (or lack thereof) of Brazil nut collection as an economic strategy, even given favorable market conditions. Statistical analysis coupled with qualitative data from interviews suggests

⁵ For example, in the event of a medical emergency, a family may have to sell ten or more cattle, depending on the costs of treatment. For a smallholder, this would severely deplete, if not eliminate, the entire herd, leaving the empty pasture susceptible to weed invasion until a herd is re-established. For a family with larger herds, such a sale would have minimal impact on overall stocking density and risk of weed invasion.

that many of these migrants have tended to shy away from forest extractivist activities even given clear economic incentives to do otherwise.

In the case of urban-rural migration and bi-localism, it appears that the exodus of females from the countryside may have especially profound implications for rural land use. Due to limitations in the data, it is important not to overstate the explanations offered for the relationships between female bi-localism and land use. However, whatever the exact mechanisms by which it occurs, the models do show a very clear relationship between temporary and permanent out-migration of women and decreased on-farm production. Hence, it is possible that, at a regional level, the female rural exodus may be causing a shift from a rural and primary goods-based regional economy to an urban service economy.

The expansion of cattle production that has followed the opening and paving of the highway appears among those interviewed to be working in synergy with another key proximate driver of deforestation—the clearing of forest for annuals. Hence, strategies aimed at reducing deforestation may need to address both land uses and, if possible, counter the synergies that exist between them. For instance, once a swidden field drops in productivity after two to three years, a farmer can make one of three decisions. S/he can allow the land to return to forest, thus forfeiting future returns on the initial investment in forest clearing (an option that seemed to be diminishing in popularity in the region). Alternatively, the farmer can continue to receive financial returns on the initial investment by seeding the abandoned field with grass for pasture. A third option is to plant legumes such as tropical kudzu (*Pueraria phaseoloides*) which, by fixing nitrogen, can extend the productive life of the field for many years, if not indefinitely (Valentim and Andrade, n.d.; Pereira, 2001; Shelton et al., 2005⁶). In this case, agricultural

⁶ In regions such as Alto Acre where cattle are nearly ubiquitous, the potential for invasiveness is minimal due to the fact that cattle prefer the legume for forage—completely eliminating it when allowed to do so.

extension and economic incentives may be able to promote the use of legumes such as tropical kudzu and therefore extend the life of swidden plots and, ultimately, slow the land use trajectory from forest to annuals to pasture.

A further conclusion pertains to the use of fire in pastures. As cattle herds expand, evidence from this study suggests that it is likely that farmers who had burned frequently will gradually diminish their use of fire as experience and word of mouth persuade them that better forage quality and animal performance can be attained by burning less. Should this occur, while overall deforestation may or may not be affected, incomes from both cattle and Brazil nuts should increase and, due to lower mortality among remnant trees and the occasional recruitment of fire-intolerant tree seedlings,⁷ cattle pastures should retain a larger presence of trees than the nearly tree-less pastures that dominate much of the region today. Reduction in pasture burning would also lower the number of ignition sources for the wildfires that have caused extensive damage to the region's forests, especially in dry years such as 2005. A combination of increased extension activity and strengthened governance regarding the use and control of fire might accelerate this process, resulting in increased farm incomes, more productive and more biodiverse pastures and fewer wildfires in surrounding forest.

⁷ Research has indicated the positive effects of partial shading upon both forage quality and animal performance in Amazonian pastures (Andrade et al, 2002, 2004). Many informants in the field agreed and had stopped actively removing desirable shade and timber tree seedlings from their pasture. However, the long-term survival of these seedlings is only likely when fire is reduced or eliminated as a pasture maintenance technique.

Table 3-1. Descriptive Statistics for Independent Variables in Chapter 3

Test Variables	Min	Max	Mean	Standard Deviation	Skewness	Valid n (n=92)
Place of Origin	0	1	0.38	0.49	0.5	92
Adult Males	0	5	1.95	1.129	0.87	84
Adult Females	0	5	1.38	0.86	1.13	84
Female Bi-Localism	0	1	0.36	0.49	0.56	79
Male Bi-Localism	0	1	0.41	0.5	0.36	80
Distance to Road	0	5	1.51	1.03	0.66	92
Control Variables						
Years of Residence	1	66	19.9	13.55	1.16	91
Property Size	50	1200	254.13	234.64	1.89	91
Credit	0	1	0.59	0.49	-0.39	86

Table 3-2. Descriptive Statistics for Dependent Variables in Chapter 3

Test Variables	Min	Max	Mean	Standard Deviation	Skewness	Valid n (n=92)
Brazil Nut Production (latas)	0	350	36.48	57.31	2.86	85
Cattle (head)	0	800	57.98	113.05	4.49	91
Years Since Last Burn	1	7	3.19	2.16	0.65	80
Annuals	0	15	3.35	3.04	1.70	88
Deforestation	0	298	24.24	36.96	5.27	86

Table 3-3. Brazil Nut Production Regressed on Place of Origin (OLS Regression Coefficients)

Independent Variable	Dependent Variable
	Brazil Nuts
	1
Constant	22.568
Yrs of residence	-0.097
Property Size	.08**
Place of Origin	
Acre (ref)	
Other state	-34.522**
R square	0.229

Notes: +p<.1, *p<.05, **p<.01

Table 3-4. Correlations among Adult Males, Adult Females, Area in Annuals, Brazil nut Production and Cattle Herd Size

Variable	Adult Females	Adult Males	Annuals (ha)	Brazil Nuts (latas)	Cattle (head)
Adult Females	1				
Adult Males	.513**	1			
Annuals (ha)	-0.098	0.041	1		
Brazil Nuts (latas)	0.122	.228*	.199+	1	
Cattle (head)	.316**	.246*	.286**	-0.064	1

Notes: +p<.1, *p<.05, **p<.01

Table 3-5. Herd Size and Brazil Nut Production Regressed on Female Bi-Localism (OLS Regression Coefficients)

Independent Variable	Dependent Variable	
	Brazil Nuts (latas)	Cattle (head)
	1	2
Constant	22.769	-1.3
Years of residence	0.071	3.392**
Hectares	0.084**	0.007
Female Bi-Localism		
Low (ref)		
High	-22.857+	-21.302
R square	0.194	0.173

Notes: +p<.1, *p<.05, **p<.01

Table 3-6. Brazil Nut Production and Cattle Herd Size Regressed on Adult Male Labor (OLS Regression Coefficients)

Independent Variable	Dependent Variable	
	Brazil Nuts (latas)	Cattle (head)
	1	2
Constant	3.063	-31.119
Yrs of residence	0.024	2.821**
Hectares	0.104**	0.025
Adult Males	4.119	15.019
R square	0.182	0.174

Notes: +<.1, *p<.05, **p<.01

Table 3-7. Cattle Herd Size Regressed on Adult Female Labor (OLS Regression Coefficients)

Independent Variable	Dependent Variable
	Cattle (head)
	1
Constant	-48.35
Yrs of residence	2.847**
Hectares	0.016
Adult Females	34.327*
R square	0.216

Notes: +<.1, *p<.05, **p<.01

Table 3-8. Correlations among Distance to Road, Deforestation and Cattle Herd Size

Variable	Distance to Road		Deforestation	Cattle
	(hours)			
Distance to Road		1		
Deforestation (ha)	-0.073		1	
Cattle (head)	-0.104	0.903**		1

Notes: +p<.1, *p<.05, **p<.01

Table 3-9. Correlations among Cattle and Brazil Nuts, Area in Annuals and Years Since Burning Pasture

Variable	Cattle (head)	Brazil Nuts (latas)	Annuals (ha)	Years Since Burning Pasture
Cattle (head)	1			
Brazil Nuts (latas)	-0.064	1		
Annuals (ha)	0.286**	.199*	1	
Years Since Burning Pasture	.322**	0.136	.233*	1

Notes: +<.1, *p<.05, **p<.01

Table 3-10. Area in Annuals and Frequency of Pasture Burning Regressed on Herd Size (OLS Regression Coefficients)

Independent Variable	Dependent Variable	
	Area in Annuals (ha)	Years Since Burning Pasture (Years)
	1	2
Constant	2.674	2.921
Years of Residence	0.032	-0.015
Hectares (ha)	-0.001	0.001
Cattle (head)	0.007*	.007**
R square	0.099	0.114

Notes: +<.1, *p<.05, **p<.01

CHAPTER 4 GOVERNANCE AND LAND USE CHANGE IN THE INTER-OCEANIC HIGHWAY CORRIDOR

In the decades from the initial construction of the BR-317 in the 1970's until the present, public perceptions and governmental policies toward the Amazon have changed dramatically. The Brazilian government once saw the Amazon as an under-inhabited and vulnerable frontier in need of agricultural development and colonization; the forest was perceived as an obstacle to development rather than as a resource to be carefully managed. Furthermore, global policies toward the Amazon were virtually non-existent. However, from the 1980's until the present, the region has become the focus of intense conservation efforts from civil society, the Brazilian government, environmental NGOs and international development agencies.

Recent conservation-oriented policies in the Amazon are largely rooted in two historical phenomena in the 1970's and 1980's. One was the rise of grass-roots social movements responding to social conflict as a result of government modernization policies in the Amazon. The other was the growing awareness, both in Brazil and internationally, of the Amazon's ecological importance (Schwartzman, 1989; Schmink and Wood, 1992). As a response to external threats to their land and livelihoods, during this time period, indigenous and rubber tapper populations of the Brazilian Amazon began to form coalitions to fight against invasions of their land and the disruption of their livelihoods. While these efforts initially involved political organizing and coalition-building at the grassroots level, cases such as the Kayapó tribe of Pará (Schmink and Wood, 1992; Barbosa, 2000) and the rubber tappers of Acre eventually gained international publicity and political alliances (Keck, 1995). The demands of both the social and environmental movements for the recognition of traditional land rights and for forest-based development have led to the creation and institutionalization of various systems of environmental

governance—ranging from the creation of grass-roots associations and rural workers’ syndicates to the demarcation of extractive reserves and indigenous reserves.

A major question regarding the impacts of such experiments in environmental governance in the Brazilian Amazon is their ability to control the negative LULCC dynamics commonly associated with road construction and paving. That is, can governance prevent or at least minimize the negative environmental and social impacts that have traditionally accompanied road construction in the Amazon? The term governance, as used in my research project, closely follows the definition proposed by Soares-Filho et al., (2004: 746): “actions by the State and civil society that protect public interests in natural resources and their utilization, including regulation, law enforcement, fiscal incentives, and the organization of informal networks of rural producers.” In the dissertation, governance is understood to occur at multiple scales. In the case of my research site, governance is represented by the state and other governmental actors operating at various scales from international collaboration between Brazil and other countries like Germany in programs targeting the entire Amazon to actions by municipal governments designed to protect key local watersheds.

In the specific case of Alto Acre, “administrative units” (such as extractive reserves and settlement projects) represent a bundle of such governmental actions and policies. For example, the RESEX and PAD are subject to differing environmental regulations and are overseen by different governmental agencies. Additionally, a second form of governance considered, which I term “household participation in governance” is less directly affected by the administrative unit and reflects, rather, decisions by households to participate in existing forms of governance implemented by government and civil society and to organize with other households into informal local governance organizations, such as associations. This chapter carefully addresses

both forms of environmental governance—both compulsory and elective—in their impacts upon land use change in the region.

In the Brazilian Amazon, environmental governance—in the form of numerous public policies and environmental monitoring—has been implemented to control both deforestation and wildfire. Policy measures have included, for example, the creation of the Brazilian Institute of the Environment (IBAMA) in the 1980's, which is a federal agency dedicated to environmental protection throughout the country, the creation of specific administrative units, such as extractive reserves, designed to preserve forest cover, the implementation of deforestation limits, and a licensing system for land clearing and burning. More recently, subsequent to the wildfires of 2005 (and the major portion of data collection), a state-wide moratorium on burning was put in place, with a permanent ban on fire in pasture areas appearing likely (personal communication, Francisco Rodrigues Chaves, Regional Director IMAC, Brasília).

At the grassroots level, other more participatory forms of governance have emerged to control deforestation and wildfire in Alto Acre. The Rural Workers Syndicate (STR) of Brasília and Epitaciolândia and various environmentally-oriented NGOs have played a crucial role in facilitating courses and projects at the community level in the region. Most families in the research site have gained some level of knowledge of the importance of forest preservation and fire control, through contact with such organizations. Furthermore, many have gained practical knowledge of alternative land use practices that minimize the need for deforestation and use of fire. For example, a large minority of households (25 of 92) had elected to participate in the ProAmbiente program, a program first proposed by the STR, then accepted and funded by the federal government and later implemented by PESACRE, a Rio Branco-based NGO. Through this program, participating households receive technical assistance, credit and direct payments in

exchange for environmental services rendered by reforestation and avoided deforestation and burning.

Research Questions

This chapter poses eight specific questions regarding the relationship between governance and land use in the BR-317 corridor of Alto Acre, four of which are qualitative in nature and four of which present specific hypotheses tested using both quantitative and qualitative data. Taking a longitudinal perspective from the advent of forest conservation policy in Brazil to the time of research, in order to illuminate the complexities of the cross-scale system of environmental governance in the region, the chapter begins with a qualitative discussion addressing the inter-related questions “what is the structure of the governance system affecting land use in the region in the mid-2000’s?” and “what are the relationships between institutions of environmental governance operating at various scales?” The discussion of these two questions provides the general background to contextualize the latter questions.

In the subsequent section, I discuss the historical relationship between land tenure and forest conservation; using qualitative analyses, I ask “what is the relationship between land tenure and forest conservation attitudes and practices in the research site?” This discussion gives special attention to the issue of continuities and discontinuities with past processes, using the example of land tenure and forest conservation as an example of the way in which political-economic factors embedded in administrative units have led to apparent contradictions and paradoxes between environmental attitudes and environmental practices. For example, given current political and economic realities, families with large cattle herds may find themselves supporting the creation of an extractive reserve as a means of promoting their own economic self-interest. The chapter then returns to the question of scale in local governance systems,

asking specifically “what are the on-the-ground implications in three distinctly-structured association types present in the research site?”

The discussion then turns to a more quantitative analysis of the relationship between two scales of governance and land use. I pose four specific questions regarding the relationship between governance and key land use practices common in the region and with important implications for forest conservation. Specifically, “what are the relationships between governance and deforestation, cattle production, pasture formation and pasture burning?”

Land Rights and Environmental Conservation—the Birth of a Coalition

Among the earliest collaborators in the rubber tapper movement were the Pastoral Land Commission and CONTAG (National Confederation of Agricultural Workers). Informed by Liberation Theology, the Pastoral Land Commission and local clergy served as early advocates of rubber tapper land claims and helped to publicize the movement beyond Acre’s borders. Early in the conflict between rubber tappers and ranchers in the mid-1970’s, CONTAG sent a delegate to the Acre rubber tapper movement. CONTAG effectively moved the land struggle into the national court system—demanding (often effectively) compensation for expropriated land. CONTAG was also active in organizing rural workers’ syndicates (commonly referred to by the acronym *STRs*), the first being in the town of Brasília in 1975 followed by Xapuri in 1977 (Keck, 1995).

The presidents of the Brasília and Xapuri Rural Workers’ Syndicates—Wilson Pinheiro and Chico Mendes respectively—quickly became outspoken leaders in the Acre rubber tapper movement, helping to lead their communities in organized peaceful protest against the appropriation of their land. The conflicts also attracted the attention of national and international media and the leader of Brazil’s incipient Workers’ Party—Luiz Ignacio “Lula” da Silva (later to

become Brazil's president in 2002). Ultimately, Pinheiro and Mendes would be assassinated by ranchers and become the most renowned martyrs of the rubber tapper movement.

Meanwhile, the global environmental movement was growing rapidly, as was international concern over the destruction of Amazonian forests (Barbosa, 2000). During the middle and late 1980's, several individuals with knowledge of the Brazilian Amazon and ties to the global environmental movement, including the anthropologists Mary Allegretti and Stephen Schwartzman, saw the possibility of mutual benefit for the two movements—the rubber tappers gaining financial and political support as well as publicity, and the environmental movement being able to put a human face on the fight against Amazonian deforestation (Keck, 1995). Working with the grassroots Conselho Nacional de Seringueiros (National Council of Rubber Tappers or CNS), they lobbied the federal government to give recognition to rubber tappers as “traditional peoples,” thus strengthening rubber tapper claims to land under Brazilian law. Subsequently, the CNS also collaborated with Amazonian indigenous groups to create a strategic alliance between the “peoples of the forest.”

The Advent of Extractive Reserves

Environmental activists and leaders of the rubber tapper movement devised a plan that would help preserve forests and protect seringueiro land rights through extractive reserves, a land tenure model designed to combine the two objectives. In 1985, the CNS held its first meeting in Brasilia. Shortly thereafter, in 1987, Schwartzman and Chico Mendes traveled to Washington D.C. to present the model to World Bank and IDB officials, ultimately securing publicity and international support and funding for the project. In the year following this visit, like Wilson Pinheiro, Chico Mendes was assassinated in Acre. While the assassinations of some 982 rural workers, including Pinheiro, in Amazonian land conflicts between 1964 and 1988 had largely

gone unnoticed outside of Brazil (Schwartzman, 1992: 54), the life and death of the high-profile Chico Mendes caught the imagination and attention of the international environmental movement. During his lifetime and subsequent to his death, a collaborative relationship between Amazonian social movements and the international environmental movement developed and has continued into the 21st century.

While the lives of Pinheiro and Mendes were cut short by assassination, their movement lived on and gained force after their deaths. In subsequent decades, the Rural Workers' Unions they headed in Brasília and Xapuri respectively, as well as the CNS, have continued to be important political forces, lobbying government agencies and NGOs on behalf of rural communities. Their efforts also contributed in the late 1980's and early 1990's to the creation of agro-extractive settlement projects (PAEs), extractive reserves (RESEX) and other pro-conservation policies in Acre and other Amazonian states. With the rise of the rubber tapper movement, the assassination of Chico Mendes and the increased awareness—nationally and internationally—of the importance of the Amazon forest for biodiversity and global climate, development policies in the Amazon began to place greater emphasis upon the conservation of the region's forests and less upon its conversion to non-forest agricultural production. An early sign of this shift appeared through the formulation and implementation of the extractive reserve model of integrated conservation and economic development in Acre and other parts of the Amazon in the late 1980's and early 1990's.

Extractive reserves originated with a 1985 proposal by the National Council of Seringueiros under the leadership of Chico Mendes (Fearnside, 1989). In 1987, INCRA answered these demands through an internal decree creating Extractivist Settlement Projects (Projetos de Assentamento Extrativistas or PAEs)—representing the first federally-recognized

non-indigenous common property system in Brazil (Barbosa, 2000; Cardoso, 2002). Extractive reserves were government-administered land use units that recognized traditional communal land tenure systems and the exploitation of forest resources as “productive usage” while protecting the inhabitants of these areas from displacement by outsiders (Schwartzman, 1989, 1992; Allegritti, 1990; Brown and Rosendo, 2000; Mahar, 2000). Extractive reserves were to be “public lands designated for the specific purpose of sustainable use of forest products such as rubber, Brazil nut and palm heart by the resident population” (Allegritti, 1990: 353). Under this system, no individual deeds were issued, preventing legal sale outside of the community; and with the exception of small-scale agriculture, only forest-based land uses were permitted (Fearnside, 1989).

The following year, a federal-level environmental protection agency (IBAMA) was established under President Sarney in order to coordinate, execute and enforce national policy for the environment (Cardoso, 2002: 75). In 1990, newly created extractive reserves came under the administration of IBAMA, though several pre-existing extractive settlement projects (including, PAE Santa Quitéria) remained under INCRA jurisdiction. By the late 1990’s, three million hectares had been brought under extractive reserve management (Fearnside, 1998). While specific land tenure systems and environmental regulations have varied, numerous new extractive reserves have subsequently been created. By 2004, some 67 state and federal extractive reserves existed in the Brazilian Amazon, with others still being created.

Legal and Institutional Structures of Environmental Governance in Alto Acre

The Alto Acre region serves as a case study of the relationship between governance and land use change in the Brazilian Amazon that, from both theoretical and policy perspectives, merits close attention. The confluence of several factors, including a recently paved road,

growing markets, especially for beef, a decades-old social movement that grew out of rubber tapper concerns for their livelihoods and the gradual confluence of this social movement with the political mainstream have led to an environment in which rural households must balance complex trade-offs as they make land use decisions. This complex political-economic environment has led many households to view forest conservation positively while continuing to make land use decisions that threaten the very forest that they desire to see protected.

It is difficult to imagine a site in which the contrasting forces of infrastructure-related pressure toward deforestation and governance systems designed to promote forest conservation come into more stark contrast. On one hand, as described in Chapter Three, from the initial opening of a dirt path through the forest between Rio Branco and Assis Brasil to its present incarnation as a paved international highway, the BR-317 has exacerbated land conflict and deforestation. However, arising from the region's unique history and relationship with the forest, especially as the birthplace of the rubber tapper movement and an early stronghold of Brazil's Workers' Party, it has developed an exceptionally deeply-rooted popular and institutional dedication to forest conservation.

In many respects, aside from the continuing pressures toward deforestation, Alto Acre in the mid-2000's represents a near-best-case scenario of environmental governance. At the policy level, the region is home to various experiments in environmental conservation, including PAEs and a RESEX and numerous conservation-oriented projects, the most notable being ProAmbiente, a credit and technological assistance program creating incentives for sustainable land use practices such as the reforestation of waterways and the reduction of the use of fire (Carvalho et al., 2004). ProAmbiente has been implemented in various pilot areas throughout the Brazilian Amazon, one of which is the Alto Acre region in which some 500 families have

been enlisted. As a result of both firsthand experience and the numerous environmentally-oriented courses and projects offered in rural areas of the region, rural residents—independent of their actual land use practices—tend to be both aware of the importance of forest conservation and see it as a worthwhile ideal. And, given the dominance of a single political party (the Workers' Party or PT) at all levels of governance, the implementation of pro-conservation policies faces far fewer obstacles than in other regions of the Brazilian Amazon with less political hegemony. And while local resistance to governmental policies certainly exists, the dominance of the PT at all governmental levels has also facilitated the creation of an environmental subjectivity, whereby many (though not all) rural households have come to accept and espouse governmental environmental policies.

Two governance entities deserving special note are the Syndicate of Rural Workers (STR) and the administrative unit. The STR is arguably the most dynamic entity in Alto Acre's governance structure. As a grassroots organization, it is directly responsible to the rural households that fund it and elect its leaders. As the official representative of the region's rural workers, it actively represents local concerns at the level of the municipality, state and federal governments, while helping direct governmental and NGO resources toward rural communities. It is also a frequent liaison between rural communities and the government. For example, an individual may request the assistance of the STR in a petition to be sent to a governmental agency, and a governmental agency or NGO may request the STR's assistance in implementing a course or project in a rural community.

As a bundle of environmental and agrarian policies, the administrative unit is somewhat more abstract than other more concrete entities, such as the STR, IBAMA and the municipality. However, it plays an important role in shaping which governmental agencies are active, which

external resources arrive, and which environmental regulations apply in a given area. For example, RESEX Chico Mendes is administered by IBAMA, receives a large amount of NGO and government-sponsored environmental courses and projects and is subject to a 10% deforestation limit. In contrast, PAD Quixadá is administered by INCRA, tends to receive fewer environmentally-oriented courses and projects and is subject to a 20% deforestation limit.

Governance at the Federal Level

In my research area, the system of land use governance is composed of a network of agencies and organizations operating at macro, meso and micro-scales (see Figure 4.1). At the federal level, several government agencies, including the Ministry of the Environment (*Ministério do Meio Ambiente* or MMA) and the Ministry of Agrarian Development (*Ministerio do Desenvolvimento Agraria* or MDA) execute federal environmental and agrarian law, with the sub-agencies of IBAMA (part of the MMA) and INCRA (part of the MDA) being the most visible in the region. In cases considered to be environmental crimes (e.g., unauthorized deforestation or use of fire), the Federal Police and the newly-appointed environmental prosecutor of Alto Acre (working within the state-level Ministry of Justice) assist in the enforcement of governmental environmental policies.

Among the various federal and federally-linked agencies and organizations operating in the field site, three are most important in terms of land use governance: the Brazilian Institute for the Environment and Renewable Resources (IBAMA), the National Institute for Colonization and Agrarian Reform (INCRA) and the Bank of Amazonia (BASA). The first two are governmental agencies working primarily with legal administration and regularization of land use while the third is a regional banking operation that has been instrumental in implementing governmental fiscal policies as it regulates financial flows into rural enterprises.

IBAMA was created in 1989 by law number 7.735. It was formed through the fusion of four pre-existing environmental agencies: the Secretary of the Environment (SEMA), the Superintendency of Rubber (SUDHEVEA), the Superintendency of Fisheries, and the Brazilian Institute for Forest Development (IBDF). Among its objectives, IBAMA-Brasília is charged with issuing licenses for forest clearing and burning, in reserve areas in the four municipalities of Alto Acre, including PAE Santa Quitéria and RESEX Chico Mendes. In addition to environmental law enforcement, IBAMA has also increasingly assumed the task of environmental education, for example collaborating with NGOs in community-based workshops on land management programs.

INCRA was established by Decree 1.110 in 1970—through the combination of two earlier federal agencies—the Brazilian Institute of Agrarian Reform (IBRA) and the National Institute of Agrarian Development (INDA). INCRA was charged not only with agrarian reform, but with the colonization of Amazonia (INCRA, 1984). In 1996, INCRA was placed within the newly created Extraordinary Ministry of Land Policy, later renamed the Ministry of Agrarian Development.

In my research site, INCRA has historically played a very large role in demarcating and distributing properties in the colonization area and in providing legal recognition to traditional land holdings in the PAE. While the PAE and the PAD continue to be officially administered by INCRA, the agency maintains a fairly low profile in most governance activities in the area now that the major tide of in-migration into the region has passed. INCRA continues to administer cartões de assentamento or “settlement documents”—which certify that the bearer is a recipient of INCRA and entitled to full benefits as such, and also function in lieu of title, as the bearers of such cards technically maintain usufruct rights but not outright ownership of their land.

Governance at the State Level: the “Forest Government”

Agencies such as the Secretary of Forests (SEF) and the Institute of the Environment (IMAC) implement and enforce land use policies at the state level. The state-level political environment in Acre changed dramatically in 1998 with the election of forester-turned-politician Jorge Viana and the Worker’s Party / Governo da Floresta (“Forest Government”) in the gubernatorial elections. Campaigning on a platform against government corruption and on the vision of a forest-based economy and society, Viana’s Governo da Floresta has helped shape Acre into a pioneer among Brazil’s Amazonian states in terms of innovative pro-forest policies. For example, in March, 2006, Acre became the second state in Brazil to create a special prosecutor for environmental crimes in the state legal system (personal communication, Dra. Nelma, Promotora do Alto Acre). The concept of *Florestania* or “Forest Citizenship” underlies the Governo da Floresta’s philosophy and approach to forest-based government. *Florestania* calls for responsible stewardship of the forest, respect for human rights and economic development built upon the sustainable management of the state’s forest resources.

The Institute of the Environment (IMAC) functions as a state-level counterpart to IBAMA, working with land use regulation. As a means of decentralizing land use law enforcement, in Acre, land use regulation on smaller scale properties (100 hectares or fewer) has been delegated to state-level responsibility with IMAC as the executing organ. The agency has been gradually extending its reach into various parts of the state, with offices recently opened in key municipalities, including Brasiléia, where it shared space with IBAMA before obtaining its own office in late 2005. In addition to its role as a state-level environmental regulatory agency, IMAC has also played a central role in environmental education and in the implementation of

state-wide Ecological-Economic Zoning (ZEE) and Regional Zoning (OTL) in the municipality of Brasília.

The State Secretary of Technical Assistance and Rural Extension (SEATER) is an important state-level agency involved in both technical assistance and the approval of agricultural loans in the region. SEATER focuses especially upon technical assistance and loan approval for households applying to the federal government's PRONAF credit program. The PRONAF program is divided into four categories—each targeted toward families in specific income ranges and with varying credit limits and repayment conditions. Among its benefits, PRONAF provides subsidized credit for small-scale farmers. Assuming that the credit implementation guidelines—as developed between the individual or association and SEATER—are adhered to and the loan is repaid within one year, the farmer receives a 22% discount. So, in the case of a R\$1000 (US\$450US) loan, R\$780 (US\$350) is repaid. PRONAF is available both for individuals and for associations, which can in turn use the funding for collective or individual purposes. As collective loans tend to carry more favorable conditions for the borrowers, associations serve an important role in making credit available to their members, a point that will be further discussed in a subsequent section.

An innovative program functioning at the state level but uniting various scales of governance from the international to the local association is the State Program of Ecological-Economic Zoning (ZEE). ZEE was created by State Decree 503 of 6 April, 1999. The program was directly linked to the Governor's office, under the coordination of the State Secretary for Planning and Coordination (SEPLAN-AC) (Governo do Acre, 2001). In Acre, executing agencies include the Environment Institute of Acre (IMAC) and the Technological Foundation of Acre (itself created in the 1980's with the assistance of Jorge Viana). The ZEE program

functions through additional assistance from other governmental and non-governmental organizations, including the German International Aid Agency GTZ, which has been involved in similar projects in Pará (Sombroek et al., 2000). As of 2006, the implementation process of ZEE in Acre had occurred at a broad state level, designating the comparative advantages and risks in human settlement and development in various parts of the state, with the intention of creating a basis for more concrete and finer scale implementation subsequently.

In Acre, the initial launching of ZEE began in 1999 with the systematization of mostly pre-existent data and the creation of maps at the 1:1,000,000 level covering the entire state, with finer scale zoning to be conducted subsequently. The second phase of ZEE, underway at the time of research, focused upon Regional Zoning (*Ordenamento Territorial* or OTL), with the municipality of Brasiléia as a pilot area. As of 2006, the State Secretary of the Environment (SEMA) and IMAC, in collaboration with the Municipal Secretary of the Environment and funding from the GTZ, had begun participatory meetings among various types of landholders throughout the municipality to determine the goals, obstacles and opportunities they faced in key areas such as agricultural production, land conflicts, and education. The purpose of these meetings was to gain an appreciation of the variety of such perspectives among various communities. For instance, in an OTL meeting in AMPAESQ in June, 2006, the community mentioned as key priorities the increased commercialization of agricultural production, the avoidance of illegal land sales and the preservation of the forest. In a separate meeting held with large-scale ranchers in the municipality, they showed less concern with environmental issues, but still shared many of the same concerns about increasing agricultural production (through

mechanization of pastures and fields) and diversification into other agricultural products beyond cattle, likely reflecting concerns about the cattle price declines in the prior two years¹.

Municipalities

The municipal government, or *prefeitura*, represents the smallest-scale institution implementing formal governmental policy, tending to work in tandem with the state and federal policies, especially in PT controlled municipalities such as *Brasiléia* and *Assis Brasil* where municipal policy generally works in close synergy with policies at higher (PT controlled) levels of governance. Under the federal system outlined in the 1988 constitution, the federal government creates legal norms which are complemented by laws and actions at the state and municipal levels. While the majority of Amazonian municipalities leave most environmental issues to the state and federal governments, this is much less true in *Alto Acre* where several municipal governments have taken strong measures to create and implement municipal and regional-level environmental governance (Toni and Kaimowitz, 2003).

In *Brasiléia*, the municipal government has recently created the Under-Secretary of the Environment, within the Secretary of Agriculture. While limited in terms of financial and human resources (it has only one full-time employee), the office has been active both in promoting environmental education in the municipality and in acting as a liaison between state and federal environmental agencies and the municipal government. Among the activities of the Under-Secretary of the Environment have been the municipal-level implementation of Regional Zoning (OTL), the creation of a committee for the prevention of wildfire; and environmental education (e.g., a local weekly radio broadcast addressing pertinent environmental issues).

¹ In 2006, prior interview respondents informed me that prices had fallen from approximately 250 to 190 *reais* for calves and from 500 to 370 *reais* for cows in this time period.

CONDIAC

In May, 2004, the Consortium of Inter-Municipal Development of Alto Acre and Capixaba (*Consórcio de Desenvolvimento Intermunicipal do Alto Rio Acre e Capixaba or CONDIAC*) was created as an initiative between the four Alto Acre municipalities and neighboring Capixaba as a means of augmenting the bargaining power of the region at higher (especially federal) governmental levels, especially in terms of obtaining resources benefiting the entire region. Prior to the formation of CONDIAC, due to their small populations, the individual municipalities faced difficulties obtaining more than modest federal funds, since federal policies favored both municipalities with larger populations and those operating in consortia (José Meneses Cruz, Director of CONDIAC; personal communication).

CONDIAC has been involved with OTL and also with the implementation of coordinated planning between the five municipalities. As such, CONDIAC has helped direct funding from the GTZ and the state intended for zoning in Brasiléia. It has also been responsible for obtaining federal resources for infrastructure intended to benefit the entire region including, for instance, vehicles for municipal governments, aquaculture projects, and a factory for making forest-derived sweets. Such resources serve the entire region and would have been difficult, if not impossible, for the municipalities to have funded if operating individually.

Administrative Unit

Additionally, at an intermediate level, specific land tenure systems—both official and unofficial—form an important level of governance shaping both land use practices and the form of governance in a given area. These land tenure systems correspond with what I term administrative units; in the field site, these administrative units are represented by RESEX Chico Mendes, PAE Santa Quitéria, PAD Quixadá, Seringal Porto Carlos and the *Terra Solta*.

As will be discussed in further detail below, these administrative units affect both the form and strength of the environmental governance system operating within them. Administrative units can best be understood as “bundles” of environmental governance. Administrative units affect both the form of governance implemented (e.g., deforestation limits) and the presence and activities of governmental agencies and NGOs. For instance, NGOs working with a copaiba extraction project will be much more likely to target an extractive reserve than a colonization area, and environmental infractions in a PAE or RESEX will be handled by the federal-level IBAMA while similar infractions in a colonization area will be handled by the state-level IMAC.

Non Governmental Organizations (NGOs)

Non governmental organizations (NGOs) play an important role both in facilitating government sanctioned projects and programs and also in representing rural communities at higher political levels. NGOs, especially those interested in forest conservation, maintain a very high profile in Rio Branco, Brasília and in many rural communities. These NGOs include grassroots organizations, such as the National Council of Rubber Tappers (CNS) and the Federation of Rural Workers (FETACRE) that arose during the social movements of the 1970’s and 1980’s. They also include local and international conservation and development-oriented NGOs such as PESACRE, CTA, WWF and Friends of the Earth (*Amigos da Terra*), which, while often working at the grassroots level, are based in Rio Branco, Brasilia or other countries.

In various parts of my research site, NGOs have been instrumental in facilitating courses and implementing projects related to forest conservation. In the research site, WWF and CTA have helped implement a copaiba-tapping project in AMPAESQ, and PESACRE has assumed responsibility for implementing the ProAmbiente program with four associations in the region. In many cases, NGOs are directly contracted by the government. For example, in the case of the

ProAmbiente program, local NGOs such as PESACRE are contracted to assume responsibility for local level implementation.

As another example of the importance of NGOs in the area's governance system, in 2005, INCRA requested a leadership capacitation course in an association in PAE Sta. Quitéria. INCRA contracted the state-level Secretary of Forestry (SEF) which in turn contracted an NGO—the National Council of Rubber Tappers (CNS)—which ultimately facilitated the course. This is one of various examples in which an NGO has functioned as a link between large federal bureaucracies and local associations

STR

Like the environmental NGOs, the Syndicate of Rural Workers (STR) of Brasília-Epitaciolândia plays an important role as an intermediary between local communities and government at all levels and is perhaps the only organization operating at virtually all levels of the governance framework outlined in Figure 4.1. That is, STR Brasília-Epitaciolândia representatives (most commonly the president) while frequently making appearances at local association meetings, are also regularly present in governmental offices in Brasília, Rio Branco and even Brasilia. However, unlike most NGOs, the accountability of the STR lies directly in the rural communities, as rural families support the functions of the STR with their membership dues, and elect the union's directory. Operating at an intermediate level between macro and local governance structures, the Rural Workers Union (STR) performs crucial roles.

In Alto Acre, the STR is arguably the most important organization in this intermediary role. In addition to serving as a representative of local communities and associations, the STR also assists outside organizations and agencies interact with local communities. NGOs, the federal, state and municipal government commonly count on the assistance of the STR when arranging meetings or implementing projects in rural communities. The STR is a nearly

omnipresent entity in my research site—its responsibilities including the mediation of land disputes between neighbors, assisting families and associations to obtain credit, facilitating courses and projects in remote rural areas, and defending the interests of Alto Acre’s rural residents at all levels—from Brasília and Assis Brasil to Rio Branco and the national capital of Brasilia.

As in other parts of Acre, the STR of Brasília-Epitaciolandia arose with the help of the Pastoral Land Commission (CPT) of the Catholic Church in the late 1970’s. Guided by Liberation Theology, clergy of the CPT formed Christian Base Communities (Comunidades Eclesiais de Base) among the rural working class as a means to resist land dispossession and promote a philosophy that “land belongs to those who work it” (da Silva, 2004:46). The STR was initially created as an organization to represent rubber tapper rights in the face of forced evictions. It continued as such through the early 1990’s—as of 1990, of the Brasília-Epitaciolandia STR’s 4,000 members, only 50 were colonists from outside of Acre (da Silva, 2004:45). However, as colonists have begun to face many of the same concerns for their livelihoods as have rubber tappers—including, for example, transport and markets for agricultural products and the availability of secondary education in rural schools—they have increasingly entered the ranks of the STR since the 1990’s, coming to represent approximately 1/6th of the STR Brasília-Epitaciolandia membership by 1998 (da Silva, 2004). The STR of Brasília and Epitaciolandia, under the leadership of former president Chicão in the mid and late 1990’s, began to open itself to colonists and reinvented itself as representative of all rural smallholders—regardless of their geographic origin. Although several migrant informants felt disfavored by the STR, most migrants, like native-born Acreanos, tended to hold positive views of the STR. One migrant informant told me that the current president of STR Brasília-

Epitaciolandia understood the differences and similarities between rubber tappers and migrants and consequently was highly capable of representing and responding to the needs of both.

Throughout its history, the STR has been closely allied with the environmental movement. While this alliance has helped the STR in meeting many of its goals, including the creation of extractive reserves and the implementation of the ProAmbiente program, it has also brought some criticism from members who felt that the STR had maintained loyalty to the goals of forest conservation at the expense of the welfare of the rural workers it represented. Despite the perhaps inevitable complaints from some members, the STR of Brasília was largely recognized as being more inclusive, better organized and more effective than many other STRs in the region. This is reflected in the fact that, among informants within and outside of the STR, 75% expressed partial or complete approval of the organization.

Associations

Finally, community associations, which can range from formal to informal institutions² represent the smallest scale unit of land use governance above the household. Associations serve to secure community needs—most often accessing agricultural credit, and caring for common property (e.g., rice husking facilities) and local secondary roads—both through community labor and through lobbying municipal officials. Associations are also often the recipients of land use oriented meetings, courses and projects organized by or in collaboration with government agencies and NGOs. Associations tend to work most closely with the STR and are often the target scale for environmental NGOs (as opposed to working with entire administrative units or with individual families). The administrative unit in which an association is located affects the types of resources and projects that arrive from NGOs and the government.

² The level of formality and institutional permanence of an association depends upon its structure and the scale at which it operates. This will be further discussed in a subsequent section.

In many rural areas of the Brazilian Amazon, including Alto Acre, rural communities have organized into associations to represent community needs in governmental spheres, obtain credit and to create a forum for discussing local issues. In extractivist communities, associations have also served to create local-level governance systems to regulate extractivist activities, forest clearing and timber sales. Local associations represent channels through which to obtain credit, commercialize agricultural and extractive products, and pressure local government into providing both road infrastructure as well as health and education services. They also serve as arenas for debate and decision-making on local issues of general community concern (Brown and Rosendo, 2000; personal observation). In the field site, associations served as the governance institution operating closest in scale to the household. In most cases, the association overlaps with tightly-knit family networks, with most associations representing several (often inter-marrying) extended families.

Associations play a critical role in assisting households to process and market agricultural production. Most associations have communal rice husking machines—where members of the association can husk rice at a reduced cost prior to either saving for later consumption or selling in town. Many associations serve to secure purchasing contracts for farm production for all association members. For instance, AMPAESQ negotiates annual contracts with Brazil nut purchasers who offer an agreed upon price in exchange for being the sole purchaser of Brazil nuts from association members. Another key purpose of associations is the collective pursuit of agricultural credit. Members of an association can request credit collectively through the association, assuming collective responsibility for repayment while obtaining more favorable interest and repayment conditions.

Land Tenure and Forest Conservation

Another question addressed is the relationship between land tenure and forest conservation in the research site. That is, “what is the relationship between land tenure and forest conservation attitudes and practices in the research site?” By shaping the land tenure system—particularly property size and land tenure security—specific administrative systems shape household livelihood strategies, leading to sometimes paradoxical land uses and attitudes toward forest conservation among the families residing within them. Numerous studies have documented the complex relationship between land tenure and land use in the Amazon (e.g., Schmink and Wood, 1992; Alston and Liebcap, 1999). On one hand, especially in areas of competing land claims, occupants have been reported to clear forest to demonstrate “productive use” of the land—and hence solidify their tenure claims (e.g., Hecht and Cockburn, 1990; Schmink and Wood, 1992; Kirby et al., 2006). On the other hand, using an opposing (but often effective) logic, from the time of Chico Mendes to the present, extractivists (and increasingly agriculturally-oriented populations) have used the need for forest conservation as a means of strengthening their claims to large forest land holdings.

In limited instances in the field site, the prior scenario of forest clearing as a means of establishing land tenure has occurred. For example, in a particularly densely populated region of PAE Santa Quitéria in which residents are officially entitled to lot-sized (80 hectare) properties but (unlike PAD residents) do not have formally-demarcated boundaries, a land conflict erupted in the mid-00’s between a resident and his neighbors. In order to solidify his land claim, the individual cleared and planted isolated swidden plots, in forest that his neighbors argued was theirs. While the clearings were only several hectares each, they effectively cut off the possibility of exploiting the more distant portions of their narrow properties. As of the time of

research, the matter had been brought before INCRA and it was as yet unclear if INCRA would be forced to change policy by formally demarcating lots within the PAE.

Aside from this and a handful of similar instances, forest clearing as a means of establishing land tenure appeared uncommon in the region³. In the colonization area, land conflicts were virtually non-existent due to the clearly demarcated property boundaries. In other areas with *colocação* property structures, approximate property boundaries (based on rubber trails) were generally known and respected. Furthermore, due to the large size of properties, even families with large land clearings tended to clear on their own property only⁴. Finally, as will be discussed below, due to the political importance of forest conservation at various levels, preserved forest often proves to be an asset, rather than a liability, for households concerned about tenure security.

Given the relative stability of land tenure and land claims in most of Alto Acre at the time of research (as opposed to other regions of the Amazon or the same region in the 1970's and 1980's), a different scenario, of forest conservation (in discourse and/or actions) as a means of establishing land tenure, appeared most common in the research site. As an example, in the fairly sparsely populated Seringal Porto Carlos, most residents, especially larger landholders, were in favor of the creation of a PDS rather than a colonization settlement. Furthermore, in this seringal, the ProAmbiente program seemed to be well-accepted. Ironically, this was despite the fact that mean per household deforestation rates had been fairly high (3 ha/year) and some of the largest ranches in the field site were located in the area. Of the four communities of the research

³ While still rare, land conflicts more commonly involved the ownership and exploitation of Brazil nuts rather than deforestation.

⁴ However, in light of both growing population density and deforestation, it is unclear how long this situation will persist, especially in administrative units such as the PAE and RESEX that lack clearly-demarcated property boundaries.

site that were enlisted in ProAmbiente, Porto Carlos stood out in the fact that its ProAmbiente members had on average deforested larger areas of their properties than the ProAmbiente members in other communities [52.7 hectares for Porto Carlos (n=7) versus 27.7 hectares for all sampled ProAmbiente members (n=25)].

This seeming paradox is fairly easily explained. Regarding the possibility of the area becoming a PDS, through conversations with both proponents and opponents, it became clear that larger landholders saw this as a means of gaining governmental recognition of the generous *colocação* property size, and preventing the appropriation of land for new INCRA settlements. Large cattle producers, while recognizing that the implementation of a PDS might severely limit future pasture expansion, believed it would also prevent INCRA from dividing their properties to settle landless strangers in the *seringal*. Smaller landholders, on the other hand, saw little reason to accept stricter environmental laws implied by a PDS when they faced little risk of losing land and could even benefit through its redistribution.

In the case of PAE Sta. Quitéria, the influence of land tenure security on land use was similarly strong. In reserve areas, especially the PAD, deforestation was widely recognized as not only an ecological threat, but as a threat to land tenure security as well. In INCRA areas dedicated to traditional land reform and settlement, property holdings usually did not exceed 100 hectares. Varying from this norm, due to the conservation component of PAEs, combined with the historical importance of the extractivist economy, their land holdings were much larger, generally several hundred hectares. However, as Santa Quitéria was facing on-going extensive deforestation, the environmental services of the PAE were becoming less evident and, as repeatedly noted in conversations with community leaders, should the area become perceived as a failed conservation unit, the justification for such large land holdings would become

increasingly untenable politically, especially given governmental desires to appease members of the vocal landless movement through land distribution. An INCRA official confirmed that the prospect of converting the PAE to a colonization area (implying the appropriation of *colocações* and distribution of smaller lots to residents and landless newcomers), while unlikely to occur in the near-future, in light of rampant deforestation in the PAE, had occasionally been proposed in discussions within the agency and remained a possibility at some future point should current trends continue.

These scenarios show both the strengths and limitations of land tenure policy, as embodied in administrative units, as a means of influencing land use. On one hand, the acceptance of large properties (*colocações*) in exchange for forest conservation, coupled with the threat of expropriation of deforested land, provided an incentive for forest conservation in both reserve areas and in areas in which reserves were being considered. However, on the other hand, this incentive alone has not proven sufficient to counter the lure of cattle ranching and pasture expansion among many reserve residents. In response to this conflict between the individual and collective good, many individuals elected to deforest illegally, finding the allure of wealth (or simply subsistence) from illegal land clearing to outweigh any collective danger imposed upon all members of the PAE by their illegal actions. Also, given the land conflicts that have occurred in more densely-populated areas of the PAE, it is unclear how resilient the *colocação* property structure commonly associated with reserves will remain under conditions of population growth.

Associations and Scale

A fourth question regarding governance and land use concerns the relative effectiveness of the three association structures common in the region: community-level associations and umbrella associations located locally and in regional urban centers. Specifically, “what are the

on-the-ground implications in terms of cross-scale trade-offs of these three distinctly-structured association types present in the field site?”

While associations themselves rarely assume roles in creating and enforcing desired land use policy, they play a fundamental role in connecting larger-scale structures of governance with the household. In addition to agricultural credit, this is also the scale at which most projects and courses are offered and implemented. Of the 16 associations included in the study (1 in Seringal Porto Carlos, 5 in the PAE, 3 in the RESEX, and 7 in PAD Quixadá), three distinct modalities of association structure were represented. Most associations operated directly at the level of the community. However, AMPAESQ and AMOREB served as umbrella associations for the smaller associations in the project/reserve, with an important distinction being that while the former was geographically located in the community, the latter was located in Brasília.

AMOREB

Local governance in the Chico Mendes Reserve was based upon an umbrella association structure, with local associations forming part of larger associations operating on a municipal level. Hence, for example, the portion of the reserve lying within the municipality of Brasília was represented by the Association of the Residents of the Chico Mendes Reserve, Brasília (AMOREB). As in other municipal-level associations of the RESEX, the main office of AMOREB was located in town. AMOREB is charged with, among other things, both implementing the management plan of the reserve and representing community interests in Brasília.

On one hand, having an urban base allowed AMOREB close access to government and NGO resources as well as high visibility in Brasília. Furthermore, the association headquarters serve as a sort of central gathering place for many of the association’s residents while in town. However, the distance from the actual reserve had some negative impacts upon participation in

the organization. In order to assume a leadership role, one had to have or find an urban residence and spend most days away from one's *colocação*. The spatial distance between the association's headquarters and its members may also have contributed to a fairly widespread concern among members interviewed about lack of accountability on the part of the association's directors. Some members of the association told me that he was concerned about the loyalty of the association's directory to its base, especially given its close collaboration with several governmental agencies. For example, one member of the association told me "They (AMOREB) don't want to let us work (our land). Those people in AMOREB, they work directly with IBAMA (in enforcing environmental regulations)."

AMPAESQ

The Association of the Residents of PAE Santa Quitéria (AMPAESQ) was founded in 1997 with the assistance of INCRA and CNS as an association to represent all of the PAEs residents. Like AMOREB, it served as an umbrella association representing the five local associations within the PAE. Yet it differed in that it was physically located within the PAE. However, it nonetheless suffered similar problems with participation and representation.

While the association was intended, on paper, to function as an umbrella association representing the local associations of the PAE, this was not always the case. Of the sampled households in the PAE, only 42.5% (17 of 40) had household members associated with AMPAESQ, the vast majority of whom lived in close proximity to the association. Furthermore, of the households associated with AMPAESQ, less than half (8 of 17) were members of local associations. Hence, due to various factors—including conflicts with local associations and the obstacle that sheer distance posed to many PAE residents who might otherwise participate—AMPAESQ, in practice, served less as an umbrella association than as a local association with a disproportionate amount of political power relative to its membership. Since most higher levels

of governance viewed and treated AMPAESQ as representative of the entire Project, many courses and projects reached only the fraction of the PAE's residents living in close proximity to the association, while completely missing those living in more outlying areas who may have had little if any idea of AMPAESQ's purpose or even existence.

Similarly, many decisions representing the entire Project—such as the creation of the project's management plan and the allocation of external funds—have been controlled by a small number of the PAE's residents, primarily those closely affiliated with the association. This led to one individual, an associated of both AMPAESQ and another local association, to complain “I think that the financial resources that they receive over there (in AMPAESQ) are being applied in the wrong way, that's not really looking out for the people of the region”.

AMPAESQ and Local Associations

AMPAESQ's relationship with three local associations illustrates the limitations of the association's effectiveness as a governing force for the entire reserve. In the case of Association AgroNorte—located in PAD Quixadá—a sizeable minority of the association's 50+ members resided within PAE Santa Quitéria, with a sense of community that spanned the boundary between PAD and PAE. While there seemed to be little antagonism between the two associations, due to the physical distance between them—approximately 25 kilometers from one association to the other—of the five AgroNorte families residing in the PAE included in the study, none were current members of AMPAESQ⁵. Not surprisingly, in this distant portion of the PAE, properties were commonly divided and sold without the required consent from AMPAESQ.

⁵ While some AgroNorte residents of the PAE attended occasional AMPAESQ meetings that they felt to be of special importance, local informants told me that no members of the association were actual members of AMPAESQ.

A very different scenario was presented by association Wilson Pinheiro, which, while lying a mere 15 minute walking distance from AMPAESQ had an antagonistic relationship with it. The Wilson Pinheiro association was established in the mid-1990's by an extended migrant family that had purchased land within the PAE. Upon the creation of AMPAESQ a few years later, the members of Wilson Pinheiro refused to cede precedence to the newly formed association. The situation was further complicated as many of the (locally-born) AMPAESQ members were suspicious of the migrants living in their midst.

As of 2006, while tensions had, at least superficially, cooled among individuals in both associations, neither recognized the legitimacy of the other. Members of Wilson Pinheiro complained about the undue power that AMPAESQ and the STR enjoyed, while the leadership of AMPAESQ expressed concern about the lack of collaboration from the association and that the lax attitude that some Wilson Pinheiro members had toward timber sales represented a violation of the PAE's environmental regulations and might jeopardize the collective well-being of the PAE's residents. When I stated to one of the directors of AMPAESQ that Wilson Pinheiro seemed very independent from AMPAESQ and STR, he corrected me by saying that they not only operated independently, but that they were the active enemies of AMPAESQ and STR.

The conflict between Wilson Pinheiro and AMPAESQ led to disillusionment among some Wilson Pinheiro members about the effectiveness and fairness of local level governance in the PAE. One informant, finding common cause with Brown and Purcell's (2005) caution against the "local trap", complained that INCRA and other government agencies were trying to "throw responsibility for the resolution of all these conflicts on us." While well-intentioned, he felt that devolution of responsibility for local conflicts to AMPAESQ had opened the door for local and inter-family conflicts to come into play. In contrast, he argued, external government agencies,

with little if any personal connections in the area, could make more objective decisions that could be better respected by all powers.

Yet another different scenario of AMPAESQ's relationship with local associations was the one it had with Vicente de Melo Association, located in the PAE approximately 9 kilometers east of AMPAESQ. The two associations tended to have very different attitudes toward conservation and the purpose of the PAE. AMPAESQ, in general, was guided by a very pro-conservation philosophy, its members tended to have relatively modest levels of household-level deforestation (mean 27.2 hectares), it tended to see IBAMA as an ally and it actively courted collaboration with environmental NGOs including PESACRE, Amigos da Terra, WWF and CNS. Vicente de Melo, on the other hand, was named for its founder Francisco "Macaxeira" Vicente de Melo, a former rubber tapper and leader of the *empate* movement who had become the largest rancher and likely the wealthiest individual in the PAE. Many other members of the association had followed Macaxeira's lead, looking to cattle as a means of escaping poverty while remaining on the land. Reflecting this fact, mean deforestation levels stood at 71.2 hectares among sampled households belonging to the association.

Interestingly, despite dissimilar philosophies and approaches toward conservation and development, significant overlap and dialogue existed between the two associations. While Macaxeira was renowned in the PAE and Alto Acre in general for being a perennial voice of dissent about the perceived emphasis upon forest conservation over economic development by AMPAESQ and its leaders, like many Vicente de Melo members, he did recognize the legitimacy of AMPAESQ and as of 2006, was considering a campaign to become its president. His complaint, he explained, was not against AMPAESQ per se, but against what he considered

irresponsible management of association finances and acceptance of environmental policies (e.g., 10% deforestation limits) that he found detrimental to the well-being of the PAEs residents.

Representation and Effectiveness in Association Models

For their part, local associations, on the whole seemed to have more satisfied members than the reserve-level AMOREB and AMPAESQ. This is likely due in part to the fact that most local associations have been constructed on top of existing kin networks and to the elective nature of participation in the associations (unlike AMPAESQ and AMOREB, the membership in which, on paper, was required of all residents within their jurisdiction). However, such associations, due to their smaller size, often tended to have less bargaining power and could easily be overlooked by government agencies and NGOs, especially when AMPAESQ or AMOREB were assumed to represent them. Local associations also tended to be less institutionalized and more personality-driven than the umbrella associations. That is, the most successful associations tended to have charismatic leaders who had proven themselves competent in working with both association members and governmental agencies in Brasília or Assis Brasil. Hence, it was not uncommon to find a once-active association disappear when a president had left office. Several local associations were defunct at the time of research; in one case, an association quickly fell apart when its popular and effective long-term president died. Fortunately, the reverse was also true, as in the example of an association in PAD Quixadá that had previously nearly disbanded under weak leadership later became one of the largest and most well-known associations in the region. Largely due to the influence of a particularly effective new association president, the association had become a recipient of various courses and projects, including ProAmbiente.

In some ways, the reserve-level associations like AMOREB and AMPAESQ, which spanned multiple local communities and associations, stood at an advantage to local community

associations. Such associations corresponded with governmentally-recognized administrative units (such as the PAE or RESEX) and were thus perceived as the legitimate representatives of the administrative unit in governmental decisions. Due to their institutionalization within the wider structure of governance, their power and persistence has arguably been greater than local associations. However, their larger scale has also brought some disadvantages to their members. The sheer question of distance often prevented the active participation of all members. Also, due to the fact that participation was often more compulsory than elective in nature and that membership was defined more by geographical location within an administrative unit rather than by kin networks, more opportunities for dissent and for inter-family conflicts tended to arise than in the local community associations.

Associations and Scale—Conclusions

This discussion of a locally-based umbrella association, an urban-based umbrella association and several local associations illustrates some of the important trade-offs that emerge due to the distinct scales at which each operates. Due to their high visibility and regular contact with governmental authorities, umbrella associations operating at administrative unit level, especially those located in urban areas, tend to be more effective in attracting external resources to their members and can also more effectively lobby government representatives on behalf of their constituents. However, due to the large variance in proximity, both social and spatial, between the directors of umbrella associations and their constituents, equal distribution of benefits in such associations tends to be more difficult than in local associations.

Differences in the legitimacy of the various associations can be traced to similar questions of scale. Due to their higher visibility, greater institutionalization in the wider political structure, and tendency to have better educated and more politically adept leaders, umbrella associations tend to be granted greater legitimacy than local associations by government agencies and NGOs.

However, local associations tend to enjoy greater legitimacy among their constituents due to day-to-day interaction and due to kin ties between members and between leadership and constituents.

Governance and Land Use

Given this understanding of both the structure and the specific policies of governance in the Alto Acre region, it is possible to operationalize the concept into a measurable variable for hypothesis testing. I measured two distinct forms of governance in this study—one centralized and the other participatory. By measuring these two forms of governance, it was possible to gain an understanding of the impacts of both traditional top-down environmental governance of the state and other governmental agencies and other more participatory forms of governance of civil society upon household-level land use decisions.

The first measure of governance reflects the actions of the state referred to by Soares-Filho et al. (2004) and refers to the governance system associated with the administrative unit in which a family resides. The administrative unit can be thought of as a “bundle” of legally-represented rights and obligations that have been directly or indirectly assembled through governmental action. Each administrative unit is associated with a distinct land tenure system, norms and regulations regarding land use, and access to NGO and government-sponsored environmental courses and projects (Table 4-1). In the research site, administrative units included three governmentally-sanctioned units: an extractive reserve, an extractive settlement project (PAE), and a colonization area (PAD), as well as two unofficial units: the Terra Solta and former Seringal Porto Carlos. While the PAE and RESEX were initially created with some degree of local input, the administrative unit, at the time of fieldwork, was largely a top-down structure created in government offices outlining the land tenure system and land use possibilities available to the households residing within them.

The second form of governance, which I have termed “participation in governance,” refers to the actions by civil society referred to by Soares-Filho et al. (2004) and is, by and large, participatory and elective in nature. This form of governance, in the research region, represents the multiple forms through which households may elect to participate in, challenge, and shape the wider structures of environmental governance. In my research project, I measured participation in governance through twelve household-level variables (Tables 4-2 and 4-3) which were then used to create a factor-weighted index of participation in governance (described below).

The average household had one male adult who was a member of the STR; the number was slightly smaller for women. The majority of households (60%) expressed satisfaction with the STR. 84% of households had at least one member who was a member of an association, though less than half of all households had a member who had assumed a leadership role in an association. In most households (60%), at least one member attended association meetings on at least a monthly basis. Satisfaction with the local association was somewhat lower (47%) than for the STR. Nearly half of all households had at least one member who had taken an environmentally-oriented course, though the average number of men and women who had participated in an environmentally-oriented project was much smaller. A considerable minority of households (27%) were involved in the ProAmbiente program. Nearly two-thirds were using credit.

In order to operationalize governance at the administrative unit level into a measurable variable, each administrative unit was assigned a governance score based on characteristics that I determined, through the course of fieldwork, to characterize the environmental governance

system in a given administrative unit. A four point index of governance was created by asking the following questions:

- Has the administrative unit been targeted by any environmentally-oriented courses or projects—sponsored by either the government and/or an NGO? (Yes=1, No=0)
- Is a specific governmental agency charged with the administration of the area? (Yes, IBAMA=2; Yes, INCRA=1; No=0)⁶
- Is the area subject to a 10% or 20% legal deforestation limit? (10%=1, 20%=0)

Using this system, the environmental governance scores for the five administrative units were as follows:

- RESEX Chico Mendes=4 (targeted by courses and projects, administered by IBAMA and subject to a 10% deforestation limit).
- PAE Santa Quitéria=3 (targeted by courses and projects, administered by INCRA and subject to a 10% deforestation limit).
- PAD Quixadá=2 (targeted by courses and projects, administered by INCRA and subject to a 20% deforestation limit)
- Seringal Porto Carlos=1 (targeted by courses and projects, no official governmental administration, 20% deforestation limit)
- Terra Solta=0 (not targeted by courses and projects, no official governmental administration and 20% deforestation limit).

Testing the Relationship between Governance (Administrative Unit) and Land Use

In order to test hypotheses 4.1, 4.2, and 4.3 about the impacts of governance at the level of the administrative unit on deforestation, cattle herd size, and frequency of pasture burning, I first conducted means analyses and F-tests to determine the direction, linearity and significance of the relationships.

Means tests of the impacts of governance and land use showed linear relationships in the case of deforestation (Table 4-4) cattle (Table 4-5) and fire (Table 4-6)⁷. Bivariate analyses of

⁶ While INCRA is charged with administration of issues like the inheritance of land and the illegal division of properties, unlike IBAMA, it is not charged with addressing explicitly environmental issues.

the relationship between governance and deforestation, while not significant, was suggestive that higher levels of governance might be associated with lower levels of deforestation, as was posited in hypothesis 4.1 ($F=.960$, $df=3$, $p=.416$)⁸. Similarly, bivariate analyses of the relationship between governance and cattle herd size, while not significant, was suggestive that higher levels of governance might be associated with smaller cattle herds, as posited in hypothesis 4.2 ($F=1.248$, $df=3$, $p=.298$). Finally, bivariate analyses of the relationship between governance and years since pasture burning, while not significant, was suggestive of a relationship directly contradicting hypothesis 4.3 that higher levels of governance are associated with more years since burning pasture ($f=.156$, $df=3$, $p=.926$).

Modeling the Effect of Governance at the Administrative Unit Level Upon Land Use

Due to the possibility of suppression effects from covariates, and given the linearity in each relationship, I conducted multiple regression analysis of the effects of governance and deforestation, cattle herd size and years since burning pasture, despite the lack of significant relationships in bivariate analysis. In these models, I controlled for years of residence and property size.

Governance and deforestation

I tested the first relationship between governance and household deforestation using multiple regression to control for the effect of years of residence and property size (Table 4-6, column 1). In the model, years of residence was significantly related with deforestation. For

⁷ In each analysis, the Terra Solta (governance value=0) violated the otherwise linear tendency between governance and the three dependent variables. As the sample for the Terra Solta was small ($n=4$) and may not in fact be representative of the entire population, I elected to remove it from the analysis.

⁸ When substituting “area in hectares in pasture” for “area in hectares deforested”, the relationship with the independent variable “administrative unit governance” becomes somewhat stronger ($F=1.264$, $df=3$, $p=.293$). This suggests that governance is more effective in controlling deforestation for cattle ranching as opposed to deforestation in general—which includes other ends including annuals and perennials.

every additional year of residence, the household is predicted to have cleared an additional 1.14 hectares of forest. Of special concern to hypothesis 4.1, after controlling for years of residence and property size, area deforested was significantly related with deforestation. Governance accounted for 3.4% of the variation in household deforestation. For every additional increment on the index of governance, deforestation is predicted to decrease by 8.76 hectares.

Governance and cattle herd size

I tested the first relationship between governance and cattle herd size using multiple regression to control for the effect of years of residence and property size (Table 4-6, column 2). In the model, years of residence was significantly related with cattle herd size. For every additional year of residence, the household is expected to own an additional 2.659 head of cattle. Of special concern to hypothesis 4.2, after controlling for years of residence and property size, cattle herd size was significantly related with governance. Governance accounted for 4.4% of the variance in cattle herd size. For every additional increment on the index of governance, cattle herd size is predicted to decrease by 31.155 head.

Governance and years since burning pasture

In the third model, I tested the relationship between governance and years since burning pasture, controlling for years of residence and property size (Table 4-6, column 3). The model did not show a significant relationship between governance and years since burning pasture. Hence, the model failed to prove hypothesis 4.3 that higher levels of administrative unit governance correspond to less frequent burning.

Testing the Relationship Between Participation in Governance and Land Use

In addition to governance as a product of actions by governmental agencies, I also considered governance as a household's elective decision to participate in environmental governance, whether instigated by the government or the local community. In order to test

hypotheses 4.4, 4.5 and 4.6 regarding the relationship between participation in governance and land use, I created an index based on the 12 measures of participation in governance that were presented in Tables 4-2 and 4-3. The first objective in testing the relationship between participation in governance and land use was to determine to what degree an operationalizable concept of “participation in governance” existed at the household level. Participation in governance is a factor-weighted index that accounts for the various commonly-available forms through which households in the study region may participate in, contest or shape the wider system of environmental governance⁹. Principle components analysis generated factor loadings that I used to weight the relative importance of z-scores of these 12 indicators. A second principle component analysis generated factor loadings of the seven variables that had yielded the highest scores (>.450) in the initial principle component analysis (Table 4-8). The factor loadings from this second analysis were then summed to create a new continuous variable representing “participation in governance”

I then used bivariate analysis to test the relationships between the new participation in governance independent variable and deforestation, cattle herd size and years since burning pasture that were posited in hypotheses 4.4, 4.5 and 4.6. As participation in governance and the three dependent variables are all continuous, I used Pearson correlation analysis for each relationship (Table 4-9). Bivariate analysis failed to find a significant relationship between participation in governance and the dependent variables. Hence, bivariate analysis failed to support hypotheses 4.4, 4.5 and 4.6¹⁰

⁹ The eigenvalue threshold for including a component was set at 2 (which yielded one index of participation in governance). The factor loading threshold for including a variable in the index was set at .450.

¹⁰ As with governance at the level of the administrative unit, I further tested these relationships with multiple regression analysis to determine if years of residence or property size had a suppressing effect on the relationship between participation in governance and the three land use practices. As this did not yield any significant relationships, results are not reported.

Discussion

In this chapter, I have explored the complex nature of environmental governance in Alto Acre. While environmental governance in this region is often represented by regulations imposed by governmental authorities, it is also a product of the actions of individuals, communities and other components of civil society (e.g., the STR). The history of Alto Acre shows the ways in which a social movement and a governmental apparatus, which were once in opposition, have co-evolved to the point that clear boundaries between the two are not always obvious. The close connection between the STR and Brazil's Workers Party is a case in point. Similarly, many environmental regulations, such as deforestation limits in extractive reserves, which are largely enforced by the government, have grown from the actions of civil society as they contested earlier policies that they saw as threatening their livelihoods (e.g., governmental incentives to clear land for pasture). A political ecological perspective shows the ways in which households not only are affected by environmental policy, but how they in turn shape the nature of governance as they pursue their individual or collective goals. For example, the crucial support that the extractive reserve model and the ProAmbiente program have enjoyed among Seringal Porto Carlos' powerful ranching families derives, at least in part, from their perception that the benefits of such policies—by buttressing their land tenure claims—outweighs the costs of stricter environmental regulation.

Finally, concerning the effectiveness of governance to control land use, the analysis of governance at the level of the administrative unit level and land use is encouraging. The relationship between stronger “bundles of governance” and reduced deforestation and smaller cattle herds suggests that, as argued by Nepstad et al. (2001), governance can be an effective means of moderating the environmental degradation that has so often occurred in the Amazon's roadways. At the same time, the lack of a clear relationship between participation in governance

and land use shows certain limitations in the use of governance as a tool to shape land use, especially when the desire exists to transform “command and control” forms of governance to more participatory forms that positively shape land use without relying upon coercion. As will be seen in the following chapter, the root of this disjuncture between participation in governance and land use can be found through careful attention to the relative costs and benefits of compliance with environmental regulations.

Table 4-1. Administrative Units in Field Site: Range of Environmental Governance

Unit	Tenure Type	Government Agency Responsible	Legal Deforestation Limit	Targeted by Courses or Projects?	Governance Index Score
RESEX Chico Mendes	Long-term use rights; collective management plan	IBAMA	10%	Yes	4
PAE Santa Quitéria	Long-term use rights; collective management plan	INCRA	10%	Yes	3
PAD Quixadá, Gleba 6	Long-term use rights; transitioning to private with individual titles.	INCRA	20%	Yes	2
Seringal Porto Carlos	Private with squatters' rights for residents; transitioning to long-term use rights or private property with titles.	INCRA ¹¹	20%	Yes	1
Terra Solta	De facto private, no titles.	None	20%	No	0
Fazenda Sta. Rita ¹²	Private, with title	None	20%	No	N/A

¹¹ As of the time of research, INCRA had completed a diagnostic study of Seringal Porto Carlos in anticipation of assuming responsibility for the administration of the region as a colonization area and/or Sustainable Development Project (PDS).

¹² While Fazenda Santa Rita, like all private property in Amazônia, is subject to a 20% deforestation limit, most portions of the project were already cleared by the mid-1980's, ahead of the implementation of contemporary deforestation limits. Due to its fairly static LULCC trajectory and lack of permanent households, it was not included in the analysis of governance and land use.

Table 4-2. Descriptive Statistics for Bivariate and Continuous Measures of Participation in Governance

Test Variables	Min	Max	Mean	Standard Deviation	Skewness	Valid n (n=92)
Male STR members	0	3	1.03	0.64	0.79	86
Female STR members	0	2	0.74	0.49	-0.49	85
Association Member (0=no, 1=yes)	0	1	0.84	0.37	-1.86	92
Association Cargo (0=no, 1=yes)	0	1	0.47	0.5	0.11	91
Environmental Course (0=no, 1=yes)	0	1	0.48	0.5	0.07	87
Male Participation in Project (0=no, 1=yes)	0	1	0.27	0.45	1.05	85
Female Participation in Projects (0=no, 1=yes)	0	1	0.07	0.25	3.51	89
Participation in ProAmbiente Program	0	1	0.27	0.45	1.04	92
Use of Credit (0=no, 1=yes)	0	1	0.59	0.49	-0.39	86

Table 4-3. Frequencies for Categorical Measures of Governance Satisfaction with STR (0=no, 1=somewhat, 2=yes; 999=missing)

		Frequency	Percent
Valid	0	19	20.65
	1	14	15.22
	2	55	59.78
	999	4	4.35
Total		92	100

Satisfaction with Local Association (0=no, 1=somewhat, 2=yes; 999=missing)			
		Frequency	Percent
Valid	1	13	14.13
	2	24	26.09
	3	43	46.74
	Total	80	86.96
Missing	999	12	13.04
Total		92	100

Frequency of Association Participation (0=never, 1=yearly, 2=alternating Months, 3=Monthly or More; 999=missing)			
		Frequency	Percent
Valid	0	27	29.35
	1	2	2.17
	2	6	6.52
	3	55	59.78
	Total	90	97.83
Missing	999	2	2.17
Total		92	100

Table 4-4. Means Test for Effects of Governance (Administrative Unit) for Household Deforestation

Governance	Mean	N	Standard Deviation
1 (Porto Carlos)	37.8333	15	35.49
2 (PAD Quixadá)	25.6957	23	19.26
3 (PAE Santa Quitéria)	20.3947	38	47.98
4 (RESEX Chico Mendes)	13.1667	6	8.73
Total	24.5427	82	37.76

Table 4-5. Means Test for Effects of Governance (Administrative Unit) for Herd Size

Governance	Mean	N	Standard
			Deviation
1 (Porto Carlos)	102.40	15	155.89
2 (PAD Quixadá)	69.36	25	76.01
3 (PAE Santa Quitéria)	43.85	41	123.9
4 (RESEX Chico Mendes)	20.17	6	14.68
Total	59.64	87	115.3

Table 4-6. Means Test for Effects of Governance (Administrative Unit) for Pasture Burning

Governance	Mean	N	Standard
			Deviation
1 (Porto Carlos)	3.42	12	2.47
2 (PAD Quixadá)	3.21	24	2.21
3 (PAE Santa Quitéria)	3.00	35	2.07
4 (RESEX Chico Mendes)	2.83	6	2.23
Total	3.12	77	2.15

Table 4-7. Governance (Administrative Unit) and Land Use (OLS Regression Coefficients)

Independent variable	Dependent Variable		
	Deforestation (ha)	Cattle (head)	Pasture Burning (years)
	1	2	3
Constant	16.362	62.831	3.541
Yrs of residence	1.140**	2.659**	0.005
Property Size (ha)	0.021	0.069	0.002
Governance (Ad. Unit)	-8.760+	-31.155*	-0.398
R square	0.265	0.191	0.043

+p<.1, *p<.05, **<.01

Table 4-8. Factor Weightings—Participation in Governance Index

Component Matrix(a)	Component
Male STR Members	--
Female STR Members	--
Satisfaction with STR	--
Association Membership	0.626
Association Satisfaction	0.661
Association Frequency	0.813
Association Cargo	0.468
Environmental Course	0.595
Environmental Project (Male)	--
Environmental Project (Female)	--
ProAmbiente	0.5
Credit	0.589

Extraction Method: Principal Component Analysis
Initial Eigenvalue=3.005

Table 4-9. Correlations among Participation in Governance, Household Deforestation, Cattle Herd Size and Years since Burning Pasture

Variable	Participation In Governance	Household Deforestation (ha)	Cattle Herd Size (head)	Years Since Burning Pasture
Participation in Governance	1			
Household Deforestation	0.082	1		
Cattle Herd Size	0.021	.903**	1	
Years Since Burning Pasture	0.055	.278**	.322**	1

CHAPTER 5
RECONCILING POLITICAL AND ECONOMIC REALITIES IN ALTO ACRE'S BR-317
CORRIDOR

The Political Ecology of Land Use in Alto Acre

A political-ecological perspective is useful in understanding the ways in which households make land use decisions in Alto Acre's BR-317 highway corridor. Such a perspective situates the household within a conceptual framework that addresses multi-scaled political, economic and ecological factors affecting and affected by the household. Political ecology focuses on local-scale land users, contextualizing them within their immediate social, ecological and economic environment, and then approaching these relationships within higher levels of decision-making power (Cumming et al., 2005, Schmink and Wood, 1987, Blaikie and Brookfield, 1987). Households make land use decisions in a dialectical relationship with the political, economic and ecological environment. In this relationship, the household both shapes and is shaped by the wider political-economic context as it makes land use decisions. For instance, many administrative units such as extractive reserves which now shape the land use possibilities available to residents are themselves largely a product of the grass-roots social movements of the 1980's, of which many current residents were part.

Analysis of field data revealed few lingering impacts of the cultural differences between migrants and native-born Acreanos interviewed in terms of land use, as they responded to similar ecological, social and economic forces. An exception, however, was the use of forest products such as Brazil nuts. The migrants who settled in the region in the 1970's and 1980's had a profound impact upon the region by bringing land use practices which often implied a new linear land use trajectory from forest to crops to pasture, replacing the shifting agricultural system which had previously left the vast majority of the region's forest cover intact, as was evident in Figure 1-2. This in turn resulted in ecological and economic changes; a region that was once

dominated by forest cover and had a forest-based economy had been transformed into a heavily deforested region in which cattle provide the mainstay of the rural economy. Despite their initial differences, in most ways, both Acre-born and migrant families included in the study have responded similarly to these transformed ecological and economic conditions, with Brazil nut production being the only land use in which a significant difference between the two populations appeared.

As of the mid 2000's, road paving had had greater implications for intra-regional migration than for inter-regional migration. That is, the vast majority of the movement of peoples in the region was occurring at a regional scale between rural and urban areas whereas migration between the region and other areas of the country, while still existent, was both multi-directional and much less common. Intra-regional migration tended to especially affect women in interviewed households, as evidenced by the disproportionate number of men present in rural areas and the larger mean number per household of women who had left for town than men in the previous four years. This pattern may have surprising implications. A clear correlation was found between greater presence of adult females and larger cattle herds. During interviews and informal discussions with informants, a likely explanation emerged that women tended to have a different approach to cattle production than men. Whereas men tended to see cattle as a readily available "bank account" for meeting short term expenses, women more often treated their herds as long-term capital investments to be used in cases of emergency or to meet long-term goals. Hence, the disproportionate migration of women to the city, by lowering mean household herd sizes, may be slowing the pressure toward deforestation in the countryside. However, it is unclear, from the perspective of a household's economic well-being, whether the benefits from

women's urban economic pursuits out-weigh the loss of their labor and influence in on-farm decision making.

As of the time of my research project, it was clear that cattle production was increasing among most families. A promising finding was the tendency of larger-scale cattle producers to use fire less frequently as a pasture maintenance tool. Hence, while the trend toward cattle herd expansion clearly had negative implications in terms of out-right deforestation, the possibility existed that herd expansion was accompanied by reductions in wildfire in nearby standing forest.

I considered two distinct forms of governance in terms of their impacts upon land use: governance in terms of the "bundle" of policies embodied by the administrative unit and in terms of a household's participation in governance, including, for instance, associations and environmentally-oriented courses and projects. Participation in governance, while not affecting land use, did have a very strong relationship with attitudes toward environmental rules among those interviewed. While household-level participation in governance did not show significant implications for land use, governance at the level of the administrative unit did. This was especially true in the case of deforestation and herd size.

Taken generally, despite numerous obstacles such as the limited budgets of local offices of IBAMA and INCRA, governance seemed to be having an increasingly positive impact among those interviewed in the Alto Acre region. While many landowners continued to deforest 2-3 hectares per year, large-scale deforestation events like the ones that created Fazenda Sta. Rita in the 1980's had become rare in the area, especially compared to recent decades. The paving of BR-317 improved the capacity for environmental governance, facilitating the oversight of the area by government agencies and also the entry of new projects like ProAmbiente, which would be difficult to carry-out in conditions of more difficult access.

Largely due to widespread environmental education targeting rural residents, such as classes, projects, radio announcements, and STR meetings, the dangers of deforestation and climate change were widely known among the region's rural residents. A virtual consensus existed that environmental regulation of some form was necessary and a majority (61%) of informants agreed that existing environmental regulations should be maintained or strengthened. This was often true even among households that had cleared large areas for pasture. For example, one informant, when asked if he approved of deforestation limits, replied that, despite his desire to clear more forest to expand his agricultural operations, regulations on forest clearing were necessary. With ironic humor, he stated that regulations on forest clearing were important; if there were no legal limits, he would probably clear every last hectare of forest that he owned. However, due to contradictions inherent in the contemporary political-economy of Alto Acre, such attitudes, while facilitating the tasks of politicians and governmental regulators in their efforts to preserve the forest, have not necessarily translated into forest-conserving land use practices among households.

The “Alto Acre Paradox”—Weighing the Costs and Benefits of Environmental Compliance

The recent history of Alto Acre demonstrates the multiple scales at which multi-scale political and economic forces affect household land use and also the ways in which households and individuals, through their actions, in turn change the wider political-economic system in which they live. Attention to the life stories of two influential individuals living in the research site shows the ways in which they have been able to successfully adapt to the rapidly changing political-economic context in which they live. It also shows the struggles that more typical families face as they must negotiate the often contradictory political and economic changes through which Alto Acre has passed in recent decades.

As they make land use decisions, rural households in Alto Acre's Inter-Oceanic highway corridor are influenced by the often contradictory forces of markets and a system of environmental governance that many of these same households helped create during the era of rubber tapper resistance to land invasions in the 1970's and 1980's. This has led to what I term the "Alto Acre Paradox." In Alto Acre, despite the large successes of the social movement to create policies designed to promote forest conservation, in the wake of the road's construction and paving, many of the region's residents, by following changing market forces, have adopted the cattle based livelihoods that many of them had once risked their lives to fight. On an ideological level, forest conservation has made great advances, with many of the region's rural and urban residents seeing it as an important priority. However, despite these pro-forest policies, cattle production has become the backbone of the region's private sector. Hence, paradoxically, even the largest ranchers in the region expressed at least some degree of concern about the ecological impacts of deforestation, yet even the most out-spoken advocates of conservation in the region owned at least some cattle.

Two individuals, Zé da Silva and Maria de Souza,¹ both residents of PAE Santa Quitéria, represent two examples of ways in which the area's residents have responded to the changing political, economic and social contexts of Alto Acre. Both are household heads who have chosen very different means to negotiate a path to success for themselves and their families despite, or perhaps because of, the Alto Acre paradox. They are also, arguably, the two most powerful and controversial people living in the PAE, as they represent two competing models for the future of the PAE. The experiences of these two individuals give insights into the strengths and limitations of various institutions of governance represented in this administrative unit.

¹ While the information about these two individuals is generally known in the region, pseudonyms are used.

Maria, a woman in her late 30's who, as of 2006 was preparing to begin study at a local university, followed the politics of forest conservation which led her from rural housewife with a fourth grade education to AMPAESQ vice-president, local CNS representative, STR officer and, ultimately, to become Brasília's Municipal Secretary of the Environment. Her successes came with some sacrifices in terms of land use on her family's *colocação* as well as in terms of pushing local social norms in which women rarely assume such a conspicuously dominant role in the household. Prior to entering politics, she and her husband sold off a large part of their cattle herd in order to become compliant with the 30 head limit mandated in the PAE's management plan. They also drained their pond, which was built prior to the implementation of clear governmental guidelines, and built another in compliance with IMAC guidelines. In addition to adding to her moral authority as an environmental advocate and government employee, these compromises may have long-term economic benefits as the surplus cattle were sold during a time of high beef prices and the well-designed pond provided a dependable source of protein in the form of fish, a product that might be commercialized in the near future.² She and her husband also entered the ProAmbiente program, which would serve as another means of both increasing the family's environmental credentials while possibly increasing household income.

In my discussions with her, Maria frequently mentioned the threats of deforestation in the PAE and in Alto Acre. These threats included loss of water, loss of livelihoods and, in the case of Santa Quitéria, a threat to the PAE itself and the *colocação* land tenure system it guaranteed. Furthermore, it was also clear that, due to her decision to build her career within the governmental hierarchy of Alto Acre, sustained deforestation could also jeopardize her

² As of 2006, given falling cattle prices, increased restrictions on land clearing and fire use and subsidies from the local government to build ponds (usually in the form of free bulldozer use and man hours, with the landowner only responsible for fuel costs), many people had begun to express interest in aquaculture as a means of generating both cash income and readily-available protein for household consumption.

environmentally-oriented career in the municipal government and, should the PAE be dissolved, she would also lose her influential behind-the-scenes role in AMPAESQ. However, should the municipality of Brasília, a pilot project for ZEE, become a show-case of environmental conservation, she might likely attain even higher levels of political influence, especially given her collaboration with representatives of the state government and GTZ in the implementation of OTL in Brasília.

Responding very differently to the changing political, economic and ecological realities of Alto Acre, Zé was the PAE's largest cattle rancher and was among its most influential residents. In his mid-60's at the time of research, Zé had lived a life of seeming contradictions. In the late 1970's and early 1980's, he was part of the early STR, actively engaging in the peaceful and violent resistance to the expropriation of *colocações* by in-coming ranchers. He was also among the early proponents of the PAE land tenure model, having argued that, instead of dividing the area into lots as INCRA had planned, the area's residents were entitled to recognition of the *colocação* land tenure system in which residents could continue their traditional livelihood system of rubber tapping. However, beginning in the early 1990's, as a response to falling prices for rubber and the growing market for beef, he and his family began to shift their resources toward cattle rearing. As he only reluctantly sold female calves, his herd rapidly grew, leading him to become the largest rancher in the PAE and among the largest ranchers in Alto Acre.

Zé had clearly been able to benefit from the various changes occurring in the region over recent decades, having taken advantage of social and economic conditions to both secure a large land holding and to become wealthy through cattle ranching, the former made possible due to the successful rubber tapper social movement and the collapse of earlier development models and

the latter arising from the construction and paving of the road and the development of local and regional beef markets, both of which have bolstered the profitability of cattle ranching in Alto Acre.

Zé was a perennial source of dissent at AMPAESQ meetings, especially when INCRA or IBAMA agents were present. In his disagreement with the environmental policies of the PAE, he drew upon a discourse of economic progress, social justice and attachment to place. In sum, his arguments emphasized that cattle ranching was the only means in the PAE at that time for the generally poor residents to reach a point not necessarily of affluence but of being “*mais ou menos*” (more or less) in terms of their living standards (a viewpoint that Maria considered an out-dated discourse from “another era”). Like many other PAE residents, he had been born and raised on the *colocação* on which he continued to live. Consequently, he resented the legal possibility that he could be evicted from his *colocação* and the PAE for violation of the management plan. He frequently made mention, however, of the value of forest preservation and his desire to see it preserved. But doing so, he argued, required greater assistance from the government, either through the subsidization of forest-based activities or, preferably, through assistance for intensified pasture management. He pointed to his passive reforestation of the streams crossing his pastures as proof of this conviction. He further argued that the PAE’s residents, by occupying large land areas, were in effect preserving the forest by preventing its occupation and clearing by outsiders, hence meriting compensation from the government.

Like Maria, Zé was also concerned about the possible dissolution of the PAE and the *colocação* land tenure system given current levels of deforestation. However, rather than finding it necessary for the PAE’s residents to take urgent efforts to remain within legal limits, he saw the need to redefine the laws of the PAE to reflect the new economic reality in which its

residents lived. Also, like other large cattle producers, he also faced the threat of falling beef prices, especially given his decision to focus nearly exclusively upon cattle ranching as an economic activity. However, assuming the recent dip in beef prices is temporary, the large herd size should provide a buffer for him and other large-scale producers to ride out the slowdown. While the specific aspects of their feelings about the value of forest conservation differed—in some cases widely—it was clear that both saw this is a worthwhile goal. Both had played a role in the rubber tapper movement and had fought for forest conservation (though in very different time periods). As of the time of research, both were concerned about the destruction of the PAE's forest cover, had taken some actions to mitigate their impact upon the environment (including minimized use of fire) and were advocates for governmental action to help preserve the forest while supporting local livelihoods. However, while Maria's *colocação* remained well within legal deforestation and cattle herd size limits, Zé continued to clear land for his growing herd, despite the fines he continually received.

In the case of Maria, we see that the environmental attitudes arising from her experiences in the region's social movement have translated into clear action. In Zé's case, his environmental attitudes and past experience in the rubber tapper movement have had little impact upon his land use decisions. His decision not to use fire in his pastures and to reforest riparian areas, while signaling cooperation with the PAE's management plan, also reflected his economic self-interest given the scale of his cattle operation³. A fundamental difference, I argue, lies in the different sectors in which the two have sought to build their livelihoods, social status and power within their communities.

³ Given the large size of his herd, he had capital necessary to invest in fire alternatives such as fences (for rotational stocking) and the practical experience to learn of the negative impacts of fire misuse upon forage quality and animal performance. Also, unlike smaller producers, he could maintain a more constant stocking intensity, further reducing weedy growth and the need for fire.

Rising through the ranks of the grassroots social movement, Maria ultimately obtained a position in the municipal government. Given the close ties between the Workers' Party and the rural social movement, the boundaries between the two have blurred, with STR officers commonly running as PT candidates or assuming appointed positions in the PT government. Of further significance, both the rural social movement (including the STR) and the PT have long histories of pro-forest stances that have continued into the mid-00's. While entailing some political and economic costs, such a stance has proven effective in attracting external funds and programs to the region. Examples include the ProAmbiente program, the selection of Brasília as a pilot area for regional zoning, and funding for the development of forest-based economic activities like sustainable timber extraction and rubber processing.

Zé's life-history stands in contrast to Maria's. While he gained much of his local prestige as an advocate for the PAE, then for rubber subsidies, he ultimately secured a livelihood outside of the public sector. Rather, he followed market forces developing in the road's presence that have made cattle production in the region lucrative. Hence, the livelihood which he built for himself and his family was founded in an economic system that rewards forest conversion and hence is directly contradictory to the philosophy of the region's environmental governance system. His economic success through cattle has given him both the motivation and the means to openly criticize and violate environmental regulations. This has given him the opportunity to make land use decisions as a form of political resistance to institutions of land use (e.g. 10% deforestation limits) that he felt had been co-opted by governmental authorities and no longer served the needs of the PAE's residents. In private discussions and in speeches in association meetings, he emphasized that he was trying to promote a vision for development in the PAE in

which local needs took precedence over the concerns of Rio Branco, Brasilia, the United States and Europe.

Unfortunately, most people, in the PAE and in other parts of the research site, have been caught uncomfortably between these two extremes and have been less able to harness one of the current trends to their advantage. Like Zé and Maria, most people were reluctant to clear the forest and agreed that forest conservation was a worthy goal. Yet most were also in a trajectory toward increased deforestation, and when they reached the limit, would be poorly able to either pay the fine to deforest illegally or to adopt other land use practices that did not require further deforestation. Unlike Zé and Maria, land use decisions of most individuals were driven less by calculated political strategy than by sheer necessity. While the growing public sector and the field of forest conservation provided an opportunity for some people, like Maria, to improve their livelihoods, such positions were nonetheless limited in number and only accessible to the well-connected and those who managed to obtain more than the rudimentary education generally available in rural areas of Alto Acre. Similarly, while cattle production had improved the economic lot of many households, the prospect of reaching the level of Zé appeared unlikely for many. Zé was an early adopter of cattle ranching and was consequently able to build a large herd ahead of the implementation of tightened environmental governance. The typical household in the region neither had sufficient alternative income to shift away from cattle as Maria had done, nor did they have enough cattle to pay the short-term cost of environmental fines for long-term gain from increased pasture and herd size as Zé had done.

Most people in the study region were also more vulnerable to environmental and social risks than were Zé and Maria. In dry years, the prospect of losing their crops or Brazil nut trees through wildfire would have much more devastating implications than for those like Maria and

Zé for whom subsistence crops and Brazil nuts formed a much smaller part of their livelihood system. Likewise, while cattle investments can always be liquidated and reinvested in the event of lost land (e.g., if the PAE were to be dissolved to create a colonization area), the same cannot be done with the annual subsistence crops and Brazil nut trees upon which poorer families usually depend. Additionally, as poorer families were more likely to obtain their drinking water from streams (as opposed to wells and springs upon which families of greater means tended to rely), poorer families would be at greater risk if climate change, deforestation or pollution from animal waste reduced the availability of clean water in the area's streams.

An example of this contradiction households often face when trying to balance the imperatives of forest conservation and economic development can be found in the attempts of an association in the field site to begin producing and marketing copaiba, a tree resin that has been actively promoted by environmentally-oriented NGOs in the region as a product that can be extracted from the region's forests. Some years after the project was implemented, the association was storing large quantities of the resin in a shed adjacent to the association meeting place in the hope that market prices would increase sufficiently to compensate the effort of extracting it. An informant, commenting on the project and the unsold product, told me he had become discouraged with copaiba, especially when neighbors who had remained outside the program good-humoredly reminded him that if he had dedicated the same amount of effort to raising cattle, he wouldn't be waiting for a buyer for his calves.

The Alto Acre Paradox and Institutional Design

Attention to issues of institutional design lends insights into the Alto Acre paradox, as it has played out in the lives of Zé and Maria. Several characteristics of robust institutions, as outlined by Ostrom (2005), are of particular relevance to the experiences of Zé and Maria and to

others within the PAE and in the larger Alto Acre region. I will draw attention to two characteristics in particular: costs and benefits of compliance, and graduated sanctions.

Regarding proportionality between costs and benefits of compliance with environmental regulations, Maria is an exception to the rule in Alto Acre. She has parlayed environmental compliance (combined with a large amount of personal effort) into a rising career first in the social movement, then the municipal government. For most people, the benefits of compliance with environmental regulations are less clear and certainly less immediate. Many people are aware of and concerned about the implications of deforestation for regional climate change and water availability. In the case of PAE Santa Quitéria, most people are also aware of the jeopardy that deforestation and the shift from extractivism to cattle ranching is placing on their ability to justify their right to large *colocações* to INCRA, a government agency that has faced increasing difficulty in finding sufficient land to settle the continuing tide of landless families in search of a *colônia*. However, while these threats are generally perceived to be very real, they present themselves in a much longer time horizon than the much more immediate benefits of illegal deforestation—including increased food security (through crops) and increased household savings (through cattle). If fully funded, the ProAmbiente program, with its promise of environmental service payments, would address this problem.

The existence of substantial monetary penalties, while helping to balance the costs and benefits of compliance with environmental regulations, is far from perfect. An important factor limiting the effectiveness of environmental penalties is the lack of a clearly defined system of graduated sanctions, with repeated offenses receiving more severe penalties than first-time offenses. In fact, the opposite often occurs. Several informants told me that after repeated interactions with IBAMA or IMAC officials, farmers become more sophisticated in their ability

to negotiate a fine than a first time offender. This is compounded by two further factors. First, at the time of research, IBAMA and IMAC generally offered reduced fines to those who could pay in a single payment, as opposed to a full fine for paying in parcels. This, combined with the fact that most repeat offenders, like Zé de Souza, have significantly larger herds (that can be sold off to pay emergency expenses like fines) than first-time offenders, creates a system of sanctions that is actually regressive in nature—penalizing the first-time offender more severely than the generally wealthier repeat offender. Hence, the only hope a household that is unwilling or unable to emulate the conservation-oriented model set by Maria, is to grow their herd while avoiding or at least weathering fines until they, like Zé, can afford to pay the fines as a part of their operating costs.

Reconciling Centralized and Participatory Forms of Governance

The failure of household participation in governance to significantly affect land use among those interviewed does not imply a rejection of the decentralization of governance or an argument that centralized governance is a preferable means of forest conservation. By being active participants in the governance process, many households come to identify with environmental conservation as an important goal for the well-being of themselves and the wider community. Participation in governance may also lead them to more readily consider alternative technologies and land uses that do not imply the destruction of the forest ecosystem. However the increased awareness of environmental issues and sense of empowerment to affect them that participation in governance brings may only translate into concrete action if households see any trade-offs implied by these actions as being out-weighed by the benefits. While some households may in fact differ from this tendency and act in purely altruistic form, this is an unrealistic expectation for most of the region's residents, especially those living at or below the poverty line.

Until the economic costs of environmental conservation by a household are out-weighed by the benefits, it may be difficult to translate environmental attitudes into environmental actions. Despite these obstacles, decentralized participatory governance is still a desirable goal in the region. Rather than placing the onus of enforcement upon governmental agencies, the pro-conservation attitudes common in the region have the potential to contribute to a governance system in which local institutions and individuals assume a complementary role in promoting sustainable land use. Both the economic and non-economic costs versus benefits of land use decisions appear to play a fundamental role in the link between participation in governance and land use changes on the ground.

For example, in associations such as AMPAESQ in PAE Santa Quitéria, which brought together families that had not yet inter-married and with distinct backgrounds (including native-born residents and indigenous and migrant families who had relocated to the region, from elsewhere in Acre and southern Brazil respectively), several informants expressed concern about the undue influence they felt certain families had gained in the association.⁴ Hence, it is important to recognize that, while removing economic obstacles is an important step in translating local governance into environmental action, other non-economic factors such as ethnicity, family identity and imagined histories will also play important roles, whether positive or negative, in this process.

Implications of Findings for Forest and Agrarian Policy in Alto Acre

Urban and Rural Connections

The shift that the highway has brought from low to intermediate levels of rural-urban social and economic connectivity has inevitable implications for rural land use and

⁴ Such sentiments were much less common in more homogeneous associations such as Association Porto Carlos—in which nearly all members were native born Acreanos and were inter-related through blood or marriage.

environmental policy. In regions such as Alto Acre, environmental degradation and deforestation cannot be considered solely as rural issues with rural implications and rural solutions. On one hand, rural land use change has increasingly significant urban implications as the region's growing urban favelas fill with ex-rubber tappers and ex-colonists, as urban water supplies are threatened by regional climate change and as smoke from forest fires threatens the health of the growing populations of young and elderly urbanites, closes airports and causes deadly accidents on the region's increasingly trafficked roads. On the other hand, urban public policy has increasingly large implications for rural land use; policies affecting the urban economy will have implications in the rural economy as well.

In light of increased urban-rural connectivity, state and municipal governments can utilize urban policy as an indirect means of rural forest governance. For instance, by incorporating larger proportions of forest-based products in foods provided to school children and the needy, the local government can provide a larger incentive for rural producers to focus upon these products. And, by subsidizing the creation of forest-based industries in the region's towns, not only can the burgeoning urban workforce find increased job opportunities, but the rural landholder can find an added market for forest-based goods. Recent government-sponsored initiatives in Alto Acre such as urban-based operations processing fruit pulp, timber and non-timber forest products are important steps in this direction.

Environmental Infraction Penalties

Another way in which environmental policy could better integrate with local economic and social realities of rural livelihoods would be through a careful review of the ways in which fines for illegal land use are levied. As mentioned in the discussion of the Alto Acre paradox, fines for illegal land use (1000 reais or US\$455 per hectare of illegal clearing or burning of forest) tend to strike smallholders hardest, given that larger cattle owners generally have enough reserve capital

to pay the fine as a short-term production cost. Such a fine can have a devastating impact on a smallholder without sufficient savings (usually implying cattle) to cover the cost. Possible solutions would be to eliminate the reduction of fines for early payment and to find alternative non-monetary means of paying fines.

An opportunity exists to transform fines from strictly punitive measures into mechanisms to economically compensate environmental services. That is, environmental fines could be made payable, in part or in whole, through environmental services. An example would be the option of reducing a 1000 real fine by 5 reais for each tree seedling successfully planted on a property. Not only would this give smallholders the opportunity to pay fines through labor rather than cash, it could also have the effect of ameliorating the environmental damage incurred through the infraction while improving the long-term economic security of the household as seedlings develop into marketable trees.

Cattle

Another means of reconciling policy with economic realities would be through careful attention to policies directed toward cattle production in order to ensure the sustainability of this lucrative industry while compromising neither the ecological integrity of the region nor other economic activities such as Brazil nuts. An example would be the effective enforcement and promotion of best pasture management practices, such as the protection of waterways, enforcement of overall land conversion limits, and increased funding for programs such as ProAmbiente that consider the entire household livelihood strategy, including cattle. Carpenter et al., (2001) assert that “the greater the number and equitability of potential uses of ecosystem goods and services, the higher the resilience of the SES” (Carpenter et al., 2001: 776). This argument lends support to an integrated model which sees cattle, by providing a capital investment to numerous smallholders, as enhancing rural livelihoods, as long as it is contained

and operates at a level that does not push other socio-ecological systems (e.g., forest cover and water quality) over critical thresholds.

ProAmbiente and Environmental Service Payments

The ProAmbiente program has emerged as an innovative means for average households to successfully navigate through the often contradictory economic, social, and ecological realities of contemporary Alto Acre. ProAmbiente offers technological assistance and credit for various perennial crops that have the potential to mimic the income generating and capital investment qualities of cattle while capitalizing upon the region's transportation infrastructure and avoiding the predatory trajectory that tends to be associated with the production of annuals and, especially, cattle. Importantly, the program also attempts to give greater economic value to forest conservation, providing cash payments in exchange for the environmental services rendered through maintained forest cover and avoided deforestation. Doing so creates a market mechanism to transform clean water, biodiversity conservation and carbon sequestration into farm products capable of competing with beef as part of the household's livelihood strategy. Furthermore, cash payments serve to boost the household's resilience to shocks that could occur as they experiment with more environmentally benign, but economically risky, land use practices. Unfortunately, funding issues have placed the program in jeopardy. However, should the program be fully implemented in the long-term, it will serve as a novel experiment in helping households navigate beyond the political-economic contradictions of the Alto Acre Paradox.

Fire

Acre's state government took an enormous step in late 2005 toward promoting economic, ecological and economic resilience at all scales from the household farm to the entire state when it strengthened environmental policies oriented toward diminishing the use of fire. As of 2006, fines for illegal pasture burning had been increased from 1000 to 5000 *reais* per hectare (that is,

approximately US\$450 and US \$2275, respectively), rightly reflecting the negative consequences of this activity. Fire, while necessary for some activities such as clearing forest for annuals and perennials, has frequently been misused, with disastrous implications not only for the region's forests, but for crops, air quality and even for cattle production. Unlike deforestation, which could be argued to be a "necessary evil" given current livelihood strategies, fire, especially in pastures, has little if any positive aspects. This is evidenced by the fact that the region's most successful ranchers have by and large eliminated fire as a strategy for pasture maintenance. By singling out this "lose-lose" land use, Acre's government has taken an important step in simultaneously protecting the state's forests and improving rural livelihoods. Other Amazonian states should consider following this example.

Directions for Future Research

Gender and Migration

One impact of the Inter-Oceanic Highway that deserves further attention is the phenomenon of bi-localism and its implications for land use. In the case of Alto Acre, by disproportionately affecting women, rural-urban migration has distinct implications for land use, especially of Brazil nuts and cattle. Further studies are needed, both in the Inter-Oceanic highway corridor and in other areas of the Amazon that have been recently impacted by road construction and paving. Such research will help determine to what degree these findings can be generalized beyond the context of these respondents in Alto Acre. Of special importance for future research is the relationship found in the dissertation between the presence of adult females in the household and higher cattle production. Based upon qualitative data, I have explained this relationship as likely being caused by gendered differences in approaches to cattle ranching, with women being more hesitant to sell calves than men. More research, both quantitative and qualitative, is needed to further evaluate this premise—both in Alto Acre and in other regions of

the Amazon in which the expansion of cattle ranching is threatening conservation efforts. Also, more research is needed to understand the full range of factors, and their relative importance, that influence a family's decision to expand, maintain, or decrease its cattle herd.

Land Use Governance

The findings in this dissertation indicate several important areas for future research. Based on this case study, the dissertation provides evidence supporting the capacity of governance to stem the deforestation and spread of cattle ranching that have traditionally followed Brazil's road network as it expands into previously isolated regions of the Amazon Basin. However, more research is needed in other regions of the Amazon, especially in areas of the Amazon with other LULCC dynamics (e.g. large-scale logging, soybean farming) and in regions with other types of administrative units (e.g. indigenous reserves, Sustainable Development Projects).

In Alto Acre itself, at least two governance interventions, which were nascent at the time of research, will likely prove fertile ground for evaluating the implications of governance for land use in the region. At the time of fieldwork, the ProAmbiente program was in the process of implementation and families had yet to receive their first payment for environmental services. As the program matures and becomes an established part of Alto Acre's environmental governance landscape, more research will be needed to determine the effectiveness of this program in changing the cost and benefit equation for small farmers as they decide among a variety of land use options—some of which being more environmentally sustainable than others.

The use of fire is another important area of research in regions of the Amazon such as Acre that have recently placed strict restrictions on its use. This dissertation has made the argument that effective environmental governance must bridge the gap between the costs and benefits of compliance. It has also demonstrated that many households, through experimentation, have found that reducing or eliminating the use of fire, especially in pastures, has yielded beneficial

results. Should these premises be true, recent restrictions on the use of fire should have much greater compliance than regulations, such as deforestation limits, that have a much less clear link to the household's economic well-being.

APPENDIX A
HOUSEHOLD SURVEY

Formulário Entrevista Familiar

1. Nome do entrevistador(s):

2. Data ___/___/___

3. Nome do(s) entrevistado(s):

4. Localização da propriedade

UTM da casa: Leste: _____ Norte _____

Latitude _____ Longitude _____

5. Localização de fronteiras da propriedade

UTM: Leste _____ Norte _____

6. Apelido (s): _____

7. Identificação da Colocação / Lote:

Município:

Unit:

Seringal:

Colocação:

Ramal:

Numero de hectares na propriedade:

Pode fazer um mapa de sua colocação / lote?

8. Propriedade da Terra

Vocês têm o documento de sua terra? Sim____Não

Qual (caso que sim)? _____

Porque (caso que não)? _____

Em nome de quem está a terra de vocês (casa que sim)? Esposo_____ Esposa_____

Outro (quem) :

12. Vocês estão procurando outro tipo de documento agora? Sim_____ Não_____ Caso que sim, qual?_____

Historia Migratória

Migração

13. Onde a senhora nasceu?

14. E o senhor?

15. Quanto tempo vocês moram no Acre (anos)?_____ (se o local de nascimento for outro)

16. Ano em que chegaram neste lote / colocação_____

17. Como vocês chegaram até essa colocação (estória migratória)?

18. E vocês se conheceram como?

19. Vocês sabem quando este lote / colocação foi criada? E quem era o dono antes de vocês?_____

20. Nos últimos 4 anos, alguém de sua família saiu da reserva?

Quem?

Caso que sim, para onde? _____

Porque? _____

21. Vocês tiveram que dividir sua colocação com alguém? Sim ____ Não ____

Com quem? _____

Porque? _____

22. E fizeram algum documento para isso? Sim ____ Não ____

Qual (caso que sim)? _____

Porque (caso que não) _____

23. Vocês estão satisfeitos de morar no PAE/PC? (H) Sim ____ Não ____

(M) Sim ____ Nao ____

Por que?

(Homem) _____

(Mulher) _____

24. Vocês pretendem ficar morando no PAE/PC? Sim ____ Não ____

25. Quanto tempo, por mês, vocês ficam na rua?

Homem _____

Mulher _____

26. Quando vão para rua, onde ficam?

Própria casa _____

Com família _____

Outro (que) _____

27. Vamos fazer um pensamento: O que vocês pensam para o futuro? Como vocês querem estar daqui a 4 anos?

Demografia, Educação, Religião, Saúde e Comunicação

28. Pessoas na família

Nome	Parentesco	Idade	Nível de Estudo	Estudando Agora?	Onde mora?

29. Vocês têm alguma religião?

Caso que sim, qual?

Onde fica?

30. No último mês, quantas vezes a senhora foi?

E o senhor? _____

31. Tem um posto de saúde aqui dentro? Sim _____ Não _____

Caso que sim, quem fez? _____

32. De que forma vocês decidem sobre produção, saúde, educação, coisas relacionadas para os filhos?

33. Vocês alguma vez já saíram daqui para morar na cidade? Sim _____ Não _____

Porque? _____

Recursos Financeiros

Quais desses itens vocês possuem?

Itens	Tipo/ Conservação	Unidade
Rádio		
Luz		
Fogão		
Curral para gado		
Cavalo		
Moto		
Carro/caminhão		
Casa (tamanho, vedação, tijolo ou madeira - conservação da madeira e tipo de madeira – torta ou não, fabricação própria ou não ..)		

Vocês estão usando credito? Sim _____ Não _____

Qual tipo (caso que sim)? _____

Para fazer o que (caso que sim)? _____

No media, quanto vocês ganham por mês? _____

De onde (e.g produção, diário, bolsa familiar, etc)?

Tipo	Fonte	Quanto (por mês)

Tipo	Fonte	Quanto (por mês)

Aceso a Estrada e LULCC

Vocês lembram quando este ramal saiu? _____

E entra carro durante quais meses por ano? _____

Como vocês fazem para sair daqui para o asfalto?

Tipo	De quem é?
Carro / caminhão	
Moto	
Bicicleta	
Cavalo / burro	
A pe	
Barco	
Outro	

Quantas horas vocês demoram para chegar ate a estrada no verão, saindo da porta da sua casa? _____

O que mudaria em relação à produção de vocês se o ramal fosse melhor? _____

Quem vocês acham que é responsável pelo melhoramento dos ramais? _____

A vida de vocês mudou por causa do asfaltamento da estrada? Sim _____ Não _____

Caso que sim, como (saúde, educação, lazer)? _____

E o tipo de produção, depois do asfaltamento da estrada? Sim _____ Não _____

Caso que sim, Por que? _____

Governância e Organização Social:

Vocês fazem mutirão por aqui? Sim _____ Não _____ (com quem?)

Vizinhos _____

Família _____

associados da mesma associação _____

outro (quem?) _____

Quais são as pessoas mais poderosas aqui nesta comunidade? _____

Organização	Associado? (quem?)	Desde Quando	Para que serve esta organização?	E sua família, com que frequência assistem as reuniões? **	Alguém desta colocação teve cargo? (S/N)	Qual função? Quando?	Você está satisfeito com essa organização? **
AMPAESQ							
Associação local							
Cooperativa (qual?) _____							
Sindicato (qual?) _____							
AMOREB							
Outro (qual)							

Instituição	Para que serve este órgão?	Vocês estão satisfeitos com essa organização?*
INCRA		
IMAC		
IBAMA		
Prefeitura		

Para que vocês acham que serve uma associação de mulheres?

Homem:

Mulher:

* (1) 01 por mês, (2) 01 cada 03 meses (3) 01 cada 06 meses (4) 01 cada ano

** (1) Ótimo (2) Bom (3) Ruim

Quais são as regras ambientais que todo mundo segue? _____

Por que?

Quais são as regras ambientais que devem ser mudadas?

Por que? _____

No ultimo ano, quantos vezes o senhor viu alguma pessoa do governo vindo fiscalizar na reserva? _____ Se viu, de que órgão era ele (a)?

O senhor já recebeu um multa do IBAMA/IMAC? Sim _____ Não _____

Qual foi a ultima vez? _____

Caso que sim, por que? _____

Qual foi a ultima vez (conduzir para últimos 4 anos) que o senhor soube de alguém aqui da reserva que recebeu uma multa do IBAMA/IMAC? _____

E lembra por que (caso que sim)? _____

Lembra se na sua associação quando a associação mesmo fiscalizou o uso da terra dum sócio?

Sim _____ Não _____

Caso que sim, quando? _____ Por quê? _____

Cursos

Alguma vez participou em algum curso (e.g. fogo, manejo, artesanato, etc)?

Homem: Sim__ Não__

Mulher: Sim Não__

Caso que sim, quais?

Nome do projeto _____

Quando? _____

Organizado por quem? _____

Valeu a pena? _____

Por que? _____

Projetos

Vocês já participarem em algum projeto do governo ou outra organização?

Homem: Sim__ Não__

Mulher: Sim___ Não___

Caso que sim, quais? _____

Nome do projeto 1 _____

E ainda está participando? Sim_____ Não_____

Mudou alguma coisa para sua família depois que o senhor participou deste programa?

Nome do projeto 2 _____

Está participando ainda? Sim_____ Não_____

Mudou alguma coisa para sua família depois que vocês participaram deste programa?

ProAmbiente

Conhece o programa ProAmbiente?

Caso que não, omite o resto das perguntas sobre ProAmbiente Sim_____ Não_____

Caso que sim, como conheceu este programa? _____

O que este programa significa para vocês?

Vocês estão participando no programa? (Caso que não, omite o resto das perguntas sobre ProAmbiente) Sim_____ Não_____

Por que? _____

Quais são as mudanças que vocês acham que podem acontecer na sua produção e na sua renda com sua participação neste programa?

Vocês já fizeram o plano de uso do programa? Sim_____ Não_____

Ele saírem como vocês queriam (caso que sim)? Sim_____ Não_____

Por que? _____

Vocês já conversarem com outros moradores sobre o programa? Sim _____ Não _____
Com quem (caso que sim)? _____
E o que vocês conversaram? _____

Uso do da Terra e Desmatamento

O que o senhor faz quando uma área de terra não produz mais? _____

E como faz a decisão de plantar capim ou deixar vira capoeira? _____

Para que tipo de produção o senhor acha que sua terra dá? _____

Quais os tipos de terra que sua área possui hoje e quando chegaram nessa colônia/colocacao? (em hectares)

Tipo	atualmente	quando chegaram
Capoeira		
Pasto		
Roçado		
Mata bruta		

Vocês botaram roçado esse ano? Sim Não _____ Quanto (caso que sim)? _____

E vocês conseguiram tirar a licença no IBAMA? Deu tempo? Sim _____
Não _____

E ano passado? _____

No ultimo ano, vocês plantaram arvores em seu terreno?

Quantas (caso que sim)? _____

De qual tipo? _____

Por que? _____

Onde? _____

Já plantou algum tipo de leguminosa aqui? Qual (caso que sim)? _____

E deu certo? _____

Como chegaram à decisão plantar isso?

O que o senhor faz para colocar fogo em seu lote e ele não entrar no lote do seu vizinho?

Existe alguns problemas na sua área com fogos acidentais? Sim_____ Não

Em sua propriedade, já tem algum tipo de produção agroflorestal? Sim_____ Não

Caso que sim, o que produz?_____

Caso que sim, onde colocou? (mata bruta, capoeira, etc)_____

E deu certo?

Comercialização de produtos extrativistas não-madeireiros

Qual a importância destes produtos para sua renda

Produto	2000*	2004**	2008*
PRINCIPAIS			
Castanha			
Borracha (qual forma)			
Madeira			
FRUTOS			
Açaí			
Patoá (fruto)			
Bacaba			
Buriti			
Ouricuri			
Murmurú (fruto)			
Tucumã (fruto)			

Jatobá (fruto)			
Jutaí (fruto)			
Bacuri			
PALMITOS			
ÖLEOS/DERIVADOS			
Patoá (óleo)			
Copaíba (óleo)			
Jatobá (óleo)			

*1=mais, 2=mesmo, 3=menos

**% de renda familiar

Vocês têm gado? Sim Não_____

Quanto?_____

Desde quando?_____

Por que vocês criam gado (caso que sim)?

Por que vocês não criam gado (caso que não)?_____

E quanto pretende ter daqui a 4 anos?

Sua vida mudou depois que vocês começaram a criar gado? Sim Não_____ Por que?

Que tipo de pasto o senhor tem?

Como limpa seu pasto?

Com que frequência usa fogo para limpar o seu pasto (depois de ser formado)?

Quando foi a ultima vez que usou fogo para limpar o seu pasto (depois de ser formado)?

Comentários sobre técnica e frequência de limpar pasto

Tem algumas questões, duvidas ou sugestões sobre esta pesquisa?

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BIOGRAPHICAL SKETCH

Growing up in a partially-forested rural area of the state of Indiana, I have long had a love for the outdoors and for forests and have been intrigued by the interface of human activity with the natural environment. During subsequent travel, especially in the western United States and South Asia, I became fascinated by the role that land management policy has had both for forest ecosystems and for the local communities that depend upon them. These combined experiences have been instrumental in directing my academic and career goals toward environmentally and socially sustainable forest management. Master's fieldwork in the Peruvian Andes, including a brief visit to the Peruvian Amazon, has further refined my interests toward natural resource policy in Latin America.

In 1998, I received a B.A. in Anthropology from Indiana University. Subsequently, I began a Master's program in the Anthropology program at the University of Kentucky. As a part of my Master's program, I conducted ethnographic fieldwork in the Department of Cusco in the southern Peruvian Andes on the social and economic implications of community eucalyptus forestry. Subsequent to receiving my M.A., in 2002, I began a Ph.D. program in the School of Natural Resources and the Environment (SNRE) at the University of Florida. As part of my academic program, I concentrated in Tropical Conservation and Development (TCD). I spent a year and a half as a research assistant with UF's Gender, Environment, Agriculture and Participation program (GEAP). Subsequently, I spent two and a half years as a fellow in UF's NSF-funded Working Forests in the Tropics Program, a program that has been instrumental in my graduate training. While at UF, I have served as co-president of the SNRE Graduate Council and coordinator of the interdisciplinary Roadies Group.

I traveled to Acre in the summer of 2002 and again in the summer of 2003 to conduct preliminary fieldwork. I returned to Acre in June of 2004, beginning fieldwork research in the

Alto Acre region that would continue through July of 2005. In the summer of 2006, I again returned to Acre to return research results. This experience included presentations in association meetings, rural schools and in homes in the field site.