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Robert Walker
Major Professor's Signature

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SETTLEMENT FORMATION AND LAND COVER AND LAND USE CHANGE: A CASE STUDY IN THE BRAZILIAN AMAZON

By

Marcellus Marques Caldas

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ABSTRACT

SETTLEMENT FORMATION AND LAND USE AND LAND COVER CHANGE: A CASE STUDY IN THE BRAZILIAN AMAZON

By

Marcellus Marques Caldas

Land reform in Brazil has moved into the reaches of the Amazon, affecting the environment in colonization areas throughout the basin. Research addressing the causes of Amazonian deforestation has implicated many factors, ranging from the role of markets in the south of Brazil to the size of individual farming households. Much remains to be learned, however, about the impact of land reform on this massive process of environmental degradation. This dissertation seeks to comprehend land cover and land use change in Amazônia by direct reference to the underlying social and institutional circumstances that have contributed to it. Specifically, poor farmers, who have grown disillusioned with the Brazilian government's promise of land redistribution, have taken it upon themselves to form settlements, or *assentamentos*, in what has been referred to as *direct action land reform*, or DALR.

The main objective of this research is to comprehend the social processes leading to spontaneously-formed *assentamentos*, and to assess associated impacts on Amazonian deforestation. Three hypotheses were tested about

spontaneous DALR and developed with the support of anecdotal field evidence. Two were related to factors driving the appearance of these settlements, and one related to the environmental impacts on the landscape. More specifically, the first one states that spontaneous DALR occurs on unclaimed public lands beyond the frontier, given the low land value of primary forest areas. The second hypothesizes that spontaneous DALR is a consequence of early land reform policies that stimulated in-migration to the region as well as from demographic household life cycles. The last hypothesis states that spontaneous DALR increases deforestation and fragmentation. Also, I argue that the underlying/proximate causation (UPC) framework of land use and land cover change to date has tended to provide considerable generalization across highly aggregate factors, which complicates applications to specific processes of possible interest. To achieve my goals, I conducted key informant interviews with community leaders and government officials about the settlement location selection process, and undertook a case study of five fully – or near fully - formed settlements. In addition, I conducted a remote sensing analysis of deforestation and fragmentation occurring in nine *assentamentos* found in the Transamazon Highway region with the objective of evaluating their impacts on the landscape.

The results support my hypotheses, although fragmentation and deforestation magnitudes vary among different settlements. Also, this dissertation calls attention to the role of land law in facilitating settlement formation.

To Martha,

A Martha, que mais do que ninguem me deu amor, carinho e suporte na elaboracao desse trabalho. Sem ela jamais teria realizado esse sonho.

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LIST OF ABBREVIATIONS

CPT: Comissão Pastoral da Terra

DALR: Direct Action land reform

DN: Digital Number

ERDAS: Raster Graphic Editor

ETM+: Enhanced Thematic Mapper Plus

FAO: Food Agriculture Organization

FETAGRI: Federação dos Trabalhadores da Agricultura

GPD: Gross Domestic Product

GIS: Geographic Information System

GOES: Global Observatory for Ecosystem Services

GPS: Global Position System

IBGE: Instituto Brasileiro de Geografia e Estatística

INCRA: Instituto Nacional de Colonização e Reforma Agrária

ITR: Imposto Territorial Rural

LCLUC: Land Cover and Land Use Change

MLPT: Movimento de Luta Pela Terra

MST: Movimento dos Sem-Terra

PA: Projeto de Assentamento

PCB: Partido Comunista do Brasil

PDA: Plano de Desenvolvimento do Assentamento

PIC: Programa Integrado de Colonização

PIN: Programa de Integração Nacional

POLOAMAZONIA: Programa de Polós Agropecuários e Agrominerais da Amazônia

PNRA: Plano Nacional de Reforma Agrária

PROTERRA: Programa de Redistribuicão de Terras e Estímulo a Agroindustria do Norte e Nordeste

RMSE: Root-Mean Square Error

SMO: Social Movement Organization

TM: Thematic mapper

UPC: Underlying Proximate Causation

UDR: União Democratica Ruralista

ULTAB: União dos Lavradores e Trabalhores Rurais do Brasil

CHAPTER 1: INTRODUCTION

Concern about loss of the Amazon forest has mounted over the past few decades, given its significance as a reservoir of biodiversity and carbon, and what appears to be an inexorable process of forest destruction. These concerns have spawned a great deal of research and even international research programs attempting to elucidate the role of Amazônia in the global climate system (e.g., NASA's Large Biosphere Atmosphere program). Research addressing the causes of forest loss (to which this dissertation seeks to contribute) has implicated many factors, ranging from the role of markets in the south of Brazil to the size of individual farming households. Much remains to be learned, however, about the social and institutional conditions underlying this massive process of environmental degradation.

Land cover and land use change has been pronounced in the Amazon basin, and Brazil continues to experience the highest rates of forest loss in the world.[1] Although many factors have been identified as drivers of deforestation (e.g., agricultural expansion, infrastructure expansion, technological factors, policy and institutional factors), an increasingly important impact is associated with colonization by smallholders and spontaneous appropriation of unclaimed public land in the process of *assentamento* (settlement) formation. Between 2003 and 2005, colonist households organized 552 *assentamentos* in the Amazon region, covering an area of about 15,984 ha (INCRA 2007a). These

[1] It is important to remember that recent studies have produced different estimates of deforestation, raising questions about the accuracy of the rate of deforestation in the Brazilian Amazon.

assentamentos represented one-third of all new settlements formed during 2003-2005 throughout Brazil, which points to the significance of Amazônia to Brazil's colonist-led *direction action land reform*, or DALR (INCRA 2007a). Brazilian Law forbids *assentamento* formation in forestlands, but such areas are often selected for occupation in the Amazon basin, especially the states of Pará and Rondônia, which have borne the brunt of spontaneous migration and colonization (Fernandes 2000). Research on Amazonian deforestation — and development — has addressed the farming systems of smallholder households (e.g., Walker and Homma 1996; Pichón 1997; McCracken et al. 1999; Perz and Walker 2002; Walker 2003; Pan et al. 2004; Aldrich et al. 2006; Caldas et al. 2007), the political economy of opening the region to colonization (e.g., Schimink and Wood 1984,1992; Bunker 1985; Hecht 1985; Browder 1988,1994), and the motivations driving colonist migration decisions (e.g., Skole et al. 1994). However, the *assentamento* formation process is not well understood, given its relative newness, as many of the *assentamentos* date from the middle 1990s and are still in phases of active development. Although their landcover impacts are necessarily linked to the farming decisions of small holders, and stem from colonization and migration decisions, which together put potential deforesters into the midst of forest, the specific factors leading to the spontaneous formation of *assentamentos* remain unknown.

This dissertation seeks to comprehend land cover and land use change in Amazônia by direct reference to the underlying social and institutional circumstances that have contributed to a source of deforestation in the Amazon

basin that has grown in significance in recent years and shows no signs of abating. Specifically, poor farmers, who have grown disillusioned with the Brazilian government's promise of land redistribution, have taken it upon themselves to form settlements, or *assentamentos*, in what has been referred to as *direct action land reform*, or DALR (Simmons 2006). This study addresses a particular type of DALR, which I call *spontaneous* DALR. The goal of this dissertation is to comprehend the social processes leading to such organically formed *assentamentos* and to evaluate any associated impacts on Amazonian deforestation.

My dissertation is divided into six chapters. In chapter 1, I consider land cover and land use research in the Amazon basin. I include this in order to provide the necessary context for my subsequent focus on agrarian reform. In chapter 2, I analyze the evolution of land law in Brazil and its effects on land concentration. In chapter 3, I focus briefly on social movement theories (seeking to identify the historical roots, main points, strengths, and weaknesses of the major theoretical perspectives) and their influence in Latin America. In addition, I approach the social movement organizations of rural workers and the DALR. In chapter 4, I analyze social contention, land occupation, and *assentamento* formation along the Transamazon region. In this chapter, I describe the contentious process of *assentamento* formation and place this within a land cover and land use change framework by describing the underlying processes that lead to spontaneous *assentamento* formation. In chapter 5, I present a discussion of the research and sample design, the study area, and data

collection. In chapter 6, I present the results and discussion. This includes descriptive statistics and a regression model of *assentamento* formation. Also, I analyze the effects of settlement formation in the landscape through land cover changes and fragmentation metrics. The final chapter is a presentation of my concluding remarks.

1.1 Land Cover and Land Use Research in the Amazon

The causes and processes that drive deforestation in tropical countries have attracted the attention of social scientists for a long time. In reality, since the beginning of the 1980s, many attempts have been made to explain tropical deforestation throughout the world (e.g., Tucker and Richards 1983; Allen and Barnes 1985; Walker 1987; Richards and Tucker 1988; Rudel 1989; Burns et al. 1994; Williams 1990, 1994; Kimsey 1991; Stern et al. 1992; Brown and Pearce 1994; Bilsborrow 1994; European Space Agency 1994; Lambin 1994, 1997; Krutilla et al. 1995; Capistrano and Kiker 1995; Painter and Durham 1995; Bernard and Koninck 1996; Sponsel et al. 1996; Rudel and Roper 1996, 1997; Kant and Redantz 1997; Murali and Hedge 1997; Bawa and Dayanandan 1997, 1998; Amsberg 1998; Ehrhardt-Martinez 1998; Kaimowitz and Angelsen 1998; Angelsen and Kaimowitz 1999; Wunder 2000; Irwin and Geoghegan 2001; Lambin et al. 2001; Geist and Lambin, 2001, 2002; Lambin et al. 2003; among others). These studies represent an inexhaustible account of the subject and have produced many arguments about what drives deforestation. In considering the specific case of the Brazilian Amazon, the topic of this Ph.D. dissertation, previous studies have pointed out that government policies, logging, mining,

agricultural development, and migration (among other factors) are major drivers of deforestation (Browder 1988; Mahar 1989; Serrão and Homma 1993; Serrão et al. 1996; McCraken et al. 1999). In general, these studies have used different conceptual frameworks, primarily from economics or political economy. If, on the one hand, studies using economic frameworks are more concerned with the role of market over deforestation and are centered in quantitative models; on the other hand, political economy is more a commentary on the likelihood of social welfare impacts of Amazon development (e.g., Forewaker 1981; Sawyer 1984; Schimink and Wood 1992). Although it is possible to note that approaches based on political economy are not very common in explaining the causes of deforestation in the Brazilian Amazon, there are some exceptions (Schimink and Wood 1984; Hecht 1985; Browder 1988). Consequently, whatever approach is used, the causes of deforestation continue to be an intriguing question. For instance, recent land occupations in the Amazon region by landless workers have lead to the appearance of new land reform settlements; and little attention has been paid to either the creation of these settlements or their possible impacts on land cover. Taking this in consideration, I now undertake a review of the deforestation literature in the Amazon, with the specific goal of demonstrating that land reform in the Amazon region is a new and important cause of deforestation and, as such, has not yet received enough attention.[2]

I would like to start by highlighting that the first deforestation studies were based on analyses at aggregate scale, and the data used were collected for

[2] For general reviews addressing deforestation studies that have been undertaken, see Kaimowitz and Angelsen (1998), Geist and Lambin (2001, 2002).

geographic units. In general, these first efforts to understand deforestation sought to explain land cover change at aggregate scale, calculating deforestation occurring over some time period as a function of socioeconomic and physical variables. Also, the data used in this type of analysis were acquired for jurisdictional units using government censuses on forest area and socioeconomic indicators (Allen and Barnes 1985; Rudel 1989; Barbier 2001). Later, models based on the behavioral theory of individual agents implemented analyses using disaggregate data. Thus, in light of these two basic approaches, this literature review is divided into two parts: the first considers studies of deforestation that used aggregate data (Appendix A). The second part focuses on studies of individual agents and shows in Appendix A the diversity of variables used in this type of analysis.

1.1.1 Aggregate Studies

The literature often partitions the causes of deforestation into two types: indirect or underlying causes and immediate or proximate causes (Kaimowitz and Angelsen 1998; Geist and Lambin 2002). Proximate causes are defined as those human activities that directly affect the environment (Geist and Lambin 2002). The underlying causes can be conceptualized as broader economic, cultural, political, technological, and demographic forces that underpin proximate causes (Kaimowitz and Angelsen 1998). The empirical research on deforestation that uses geographically aggregate data generally approaches the issue of land cover change through proximate causation frameworks, where the variables used can be seen as immediate (or direct) factors in a land use decision and,

consequently, on land cover change. In general, the data are grouped in different categories. For instance, Geist and Lambin (2001) grouped proximate causes of deforestation in three categories: agricultural expansion (e.g., shifting cultivation, cattle ranching, permanent cultivation), logging (e.g., fuelwood extraction, charcoal production, commercial wood extraction), and infrastructure expansion (e.g., transportation infrastructure, settlement expansion, market infrastructure). Despite the fact that no general rule exists about how to group the variables, in this dissertation I group the causes of deforestation using five general categories: market factors, socioeconomic and demographic factors, institutional factors, environmental factors, and control variables (see Appendix A). The variables grouped as market factors are described as the ones that affect production costs directly or indirectly. In this context, transportation costs and land prices are, in general, the most commonly used. The influence of market factors on deforestation in the Amazon region associate the land use decision with transportation costs or to a proxy (e.g., distance). Nelson and Hellerstein (1997) discussed the development of new roads as intensifying the pace of deforestation by making access to forested lands less costly. Empirical models that use this approach show that easy access to forest lands, and to the market, increase deforestation (Reis and Gúzman 1994; Andersen 1996; Pfaff 1999). However, proximity to market is not the only opportunity that creates land cover change. For instance, a given tract of land has many possible useful resources linked with it; consequently, these resources will (assumably) be used if it is lucrative (Nelson and Hellerstein 1997). According to this assumption, the choice

of a particular land use is made by comparing the net present value of the profitability of all possible land uses. Chomitz and Gray (1996), Nelson et al. (2001), and Walker (2004) hypothesized that a set of ***h*** land uses generates rents, or net present values, R_h, where $h \in \boldsymbol{h}$ and rents are defined on prices for inputs and outputs and production magnitudes. The observed land use on a tract of land is given as h, when $R_h > R_{h'}$, for all $h \neq h'$ (Walker 2004). Consequently, these rents can be acknowledged as functions of distance. Thus, following Walker (2004), Nelson et al. (2001), and Nelson and Hellerstein (1997), the net present value for land use h at location i and time period T can be defined as

$$R_{hlT} = \max_{X_{hlT+t}} \int_{t=0}^{\infty} (P_{hlT+t} Q_{hlT+t} - Z_{hlT+t} X_{hlT+t}) e^{-it} dt$$

where P is the output price, Q is the quantity of output, Z is a vector of input prices, X is a vector of inputs under the land manager control, and i is a discount rate, all for each land use ***h*** at location i and time t. Walker (2004) argues that time invariance in prices converts this static maximization problem such that

$$R_{hl} = \max_{X_{hl}} (P_{hl} Q_{hl} - Z_{hl} X_{hl}) \int_{t=0}^{\infty} e^{-it} dt$$

Consequently, the land use chosen for the tract of land has the highest R_{hl} value. However, access to a road is clearly not the only variable that increases deforestation. The simple existence of roads has different effects on land cover,

facilitating or constraining the access to primary forest areas (Southgate et al. 1991a; Reis and Guzman 1994; Andersen et al. 2002). The correlation between distance to roads and deforestation assumes that roads cause deforestation. However, deforestation can be an important factor in attracting the development of a road system. In other words, deforestation and progress of local economies can cause new infrastructure creation, such as roads, by stimulating a socioeconomic and political momentum for advancing road creation (Chomitz and Gray 1996). In addition, deforested areas and roads can simultaneously be influenced by other factors, such as soil quality or population density (Southgate et al. 1991b; Wood and Skole 1998; Pfaff 1999). Moreover, considering this market perspective, other factors can influence land cover change; for instance, land price. Besides the lack of research with aggregate data using this type of variable, there is an exception (Andersen et al. 2002).

Market factors are not the only factors influencing land cover change. Socioeconomic and demographic variables are also used in deforestation models. The argument commonly used states that deforestation can also increase because an increasing population needs more land and derivative products. In this context, demographic factors make the list of variables much larger; and these variables, in the majority, are related to population factors, such as population size. These studies argue that a large population size has a positive effect on deforested areas (Southgate et al. 1991a; Andersen 1996). This result is not surprising as other authors found similar results for other Latin American countries, such as Mexico (Barbier and Burgess 1996). However,

when this analyzes combines many countries simultaneously, and additional independent variables are used, the correlation between deforestation and population density disappears. In this context, the population variable could be acting as a proxy for others (Harrison 1991; Deacon 1994). Moreover, in some models, population growth has no effect on deforestation (Palo 1994). However, demographic factors are not restricted to population size. Many studies have used population density and migration. According to these studies, the higher the population density, the greater the amount of deforestation (Wood and Skole 1998; Pfaff 1999). In addition, these studies noted that rural migration has a positive influence on deforestation (Wood and Skole 1998).

Another important group of variables used in land cover models is related to environmental factors. In other words, considering the important role that natural resources have on economic activity, many authors have already described their effects on the forest. For instance, Southgate et al. (1991a) and Pfaff (1999) showed that soil type affects the size and proportion of area deforested for agricultural use. Also, Wood and Skole (1998) argued that deforestation is less in municipalities that have a large proportion of land in savanna; and Chomitz and Thomas (2003) stated that precipitation has a negative effect on the proportion of land used for agricultural purposes. In addition to the variables discussed above, there is a group of variables that attempts to capture the effect of institutional factors on land cover change. In general, these variables seek to evaluate the influence that land security, credit, and fiscal incentives have on land use decisions (Southgate et al. 1991a; Pfaff

1999; Andersen et al. 2002). In the absence of well-defined property rights deforestation becomes the most common way to acquire land rights. Besides, property rights stimulate investments; and if the investment involves land cover change, deforestation can increase as a result. Despite important analyses in land cover change, these factors are difficult to evaluate with aggregate data as it is very complicated to acquire precise information. Consequently, few studies with aggregate data have analyzed the effect of property rights on land cover change. However, institutional factors are not constrained to property rights. Many government institutions have given credit and fiscal incentives in the Amazon that have been pointed out as primary drivers of deforestation (Pfaff 1999; Andersen et al. 2002). Finally, a group of variables have been used as control variables. These variables are used to control, or isolate, the effects of development. Among these variables are the previous amount of deforestation, property density, number of bank agencies, and land conflict. No doubt that In the last century, land conflict was an important driver of sociopolitical and environmental change (Homer and Dixon 1999); and considering that property rights in the Amazon region are strongly related to conflicts, Wood and Skole (1998) argued that there is a positive relationship between conflict and deforestation.

Clearly, aggregate studies have identified many important factors driving deforestation. Nevertheless, the research framework has changed over time and now considers deforestation as a discrete event affecting individual parcels of land where potential uses are evaluated economically (Walker 2004). Thus, the

decision unit involves individual parcels of land and discrete changes between land cover change categories. In addition, the availability of remotely sensed information, and the functionality of geographic information systems, has largely facilitated these types of analyses because they allow an accurate gathering of information on land cover change and enable spatial projections at pixel levels (Walker 2004). Consequently, the analysis of land cover change is adapted to include the analysis of the behavior of individual agents (Bockstael 1996; Chomitz and Gray 1996; Nelson et al. 2001; Walker et al. 2002; Walker 2004).

1.1.2 Studies Addressing Individual Agents

The types of individual agents involved in deforestation in tropical countries varies from region to region and generally includes loggers, shifting cultivators, farmers, ranchers, and colonists, among others. These agents act interdependently, and deforestation is a result of their complex interactions (Walker 2004; Geist and Lambin 2001).

Similar to aggregate studies, the variables that affect the decisions of individual agents can be divided into market factors, environmental factors, socioeconomic and demographic factors, and institutional factors (see Appendix A). The importance of market factors is observed in both approaches, and transportation costs affect deforestation in both cases. According to individual agent studies, distance to market has a negative impact on deforestation (Caldas et al. 2007; Walker et al. 2002; Pichón 1997). Also, the use of variables that measure the effects of natural resources on the landscape are not so common in models of individual agents because this type of data is difficult to acquire.

However, a few authors that have used this type of information (Caldas et al. 2007; Pan et al. 2004; McCraken et al. 1999; Pichón 1997). Pichón (1997), for instance, argued that a relationship exists between land quality and deforestation. According to this author, better soil quality can lead to greater deforestation. In addition, he showed that topography is also an important factor in land use decisions, where properties with hilly land and steep slopes have more area in forests. On the other hand, Pan et al. (2004) stated that flat land is important to annual crops and pastures and, by extension, to deforestation. McCraken et al. (1999) argued that previously deforested areas have a significant impact on the amount of land deforested annually. Caldas et al. (2007) showed that soils suitable for pasture (and with water) can positively affect the total area deforested. However, their results are not sustained when spatial autocorrelation analysis is implemented.

Considering the effects of demographic factors on individual agent models, one can observe that migration is an important factor in the development of the Amazon frontier. Consequently, many studies have used a set of demographic variables to explain deforestation. Most of this research has shown that family size (Rudel and Horowitz 1993; Pichón 1997; Coomes et al. 2000; Coomes 2004), number of men in the household (Sydenstricker and Vosti 1993; Walker et al. 2002; Pan and Bilsborrow 2005), and dependency (Walker et al. 2002) have an impact on agricultural systems or on the amount of land to be deforested. However, other attributes are also important, such as level of wealth (Alston et al. 1993; Jones et al. 1995; Pichón 1997; Murphy et al. 1997; Walker

et al. 2002) and length of residence on the property (Pichón 1997; Walker et al. 2002). Clearly, the analysis shows that variables that seek to measure the effects of family structure (e.g., number of men, women, children, and elderly) are, in general, associated with labor availability. Consequently, large deforested areas appear on properties that have families with substantial family labor resources, including hired labor (Rudel and Horowitz 1993; Godoy et al. 1997, 1998a,b; Pichón 1997; Walker et al. 2000; Pan et al. 2004). In addition, deforestation also relates to the length of residence on the property, education level, and age of the household head (Alston et al. 1993; Godoy et al. 1997, Pichón 1997, Godoy et al. 1998b). Families with longer periods of residency have deforested larger areas. However, Pichón (1997) called attention to the difficulty of isolating the effects of length of residency from the overall effects of soil degradation.

Even though demographic and environmental factors are indicated as drivers of deforestation, institutional factors (such as credit and land security) are also important. In other words, forest conservation is positively associated with land security (Alston et al. 2000; Pichón 1997; Muller et al. 1994). Nevertheless, disagreements regarding this view emerged. Pan et al. (2004) argued that land security is also associated with large areas of pasture and less area in perennial crops. These contradictory views can be related to credit acquisition or land speculation. Walker et al. (2000) agreed with the statement above and argued that land security can be a facilitator in credit acquisition and, consequently, can be used for pasture formation.

The above literature review has demonstrated that plentiful research and systematical methods have focused human-environment studies on clearing patterns, which have identified small and large producers as a primary proximate cause of land cover change (Geist and Lambin 2001, Walker et al. 2000). However, Pan and Bilsborrow (2005) argued that as the compilation of data to predict changes in clearing have become complex, operating at multiple temporal and spatial scales, the statistical models applied to test theoretical relationships have not been developed. These authors argue that many theories of land use follow a structural approach in which the conceptualization of land use by households is seen to occur within a larger institutional context and that existing models fail to adequately capture the effects of either household or community-level socioeconomic factors that may influence land cover and land use change (LCLUC). In addition, they argued that previous research neglected to incorporate factors influencing land use at higher institutional levels or did not account for the clustering of observations (e.g., farms) within higher level units (e.g., communities) resulting in inefficient estimates of factors influencing land use. Thus, to accomplish this task, they incorporated a theoretical model of land use with applied statistical technology because theoretical land use models often combine factors at multiple temporal and spatial scales to illustrate land use and land cover change. Their results can be divided in two parts. The first part approaches the traditional variables used in household models (e.g., demography variables) and in the second approach community variables (e.g., civil registration office) are used. Pan and Bilsborrow (2005) showed that higher

population pressures are associated with less forest and more land allocated to all other uses. Hiring labor and holding title to land, which indicates higher socioeconomic status of the household on the farm, appears to be strongly related to less forest and more pasture. Also, better land quality is associated with less land in forest. The presence of a civil registration office indicates communities that are political centers (e.g., proxy to community development), and the presence of a civil registrar was significantly associated with more pasture and less fallow land because farms located near major cities were less likely to have fallow land when there is a ready local market. Their results demonstrate the need to more comprehensively explore various community and structural effects on land use.

The above literature review calls attention to potential problems in using survey data in land cover change analysis, leading some authors to suggest the use of independent sources of information, such as the ones generated by remotely sensed data (Walker et al. 2000). The existence of potential bias and the difficulty in obtaining accurate information on land cover change creates a greater interest in georeferenced data, such as remotely sensed data. However, high-resolution satellite data provide an empirical basis for measuring the amount and the spatial configuration of forest clearing, but satellite data do not explain the causes of deforestation (Wood and Skole 1998). Thus, concern over the limited ability to explain the social causes of deforestation have increased the attention of social scientists. In this context, Rindfuss and Stern (1998) argued that there is increased interest in making scientific progress through the use of

remotely sensed data in social science research, and Geoghegan et al. (1998) stated that the impacts of Remote Sensing and Geographic Information System (GIS) to date have been greatest within the environmental and policy arenas because space-based and other imagery is used primarily to determine the physical attributes of the biosphere and the earth's surface (such as forest cover) that is needed in spatially explicit form by various decision makers. Consequently, many studies have used this approach (Walsh and Crews-Meyer 2002; Fox et al. 2003; Boucek and Moran 2004; Gutman et al. 2004; Entwisle and Stern 2005). However, in the case of the Brazilian Amazon region, only a few researchers have combined georeferenced information with data collected at the household level (Moran and Brondizio 1998; McCracken et al. 1999; Walker et al. 2000; Aldrich et al. 2006; Caldas et al. 2007).

Moran and Brondizio (1998), for instance, link social science and biological field methods with remotely sensed data to advance understanding of how human decisions about land use have influenced both rates of deforestation and secondary regrowth in Amazônia. McCracken et al. (1999) looked at the influence of environmental and market factors on deforestation at the property level and demonstrated that distance has a negative effect on land cover change. Their results also affirmed that a given property with less pasture has more areas in secondary and primary forest. Walker et al. (2000) used satellite imagery to measure deforestation to discuss the relationship between ranching and deforestation in the Amazon, and they argued that large ranchers can be responsible for a greater share. But they also reinforced the idea that small

farmers, through proximate causation, are also responsible for a substantial portion of deforestation. Aldrich et al. (2006) presented analyses based on cadastral information, a panel of smallholders collected in 1996 and 2002, and satellite image analysis of land cover change of the Transamazon region from 1986 to 1999. These authors sought to analyze the structural processes of land aggregation by ranchers along the Transamazon highway. The panel data analyses demonstrated that property aggregation is largely compensated for by disaggregation in the study area; and when it occurs, it does not appear to result in the formation of large, well-capitalized ranches. Instead, the aggregation process that does exist arises from the acquisitive interests of the local smallholders themselves and may be regarded as endogenous to the colonization process: In other words, wealthy outsiders do not appear to be penetrating the region and appropriating the land of subsistence farmers (Aldrich et al. 2006). Colonization is also approached by Caldas et al. (2007). These authors seek to understand the land cover impacts of an important agent in the Amazonian landscape, the household colonist. The main objective of their research was to develop a peasant economy perspective on deforestation in tropical forest frontiers and to apply it in a study of colonist households living in the Brazilian Amazon along or near the Transamazon highway. The information used in their study was generated by a GIS linking household survey data and classified satellite images. They paid particular attention to statistical issues affecting regression-based, land cover change studies, including endogenous relations between key variables and spatial autocorrelation. Their results

demonstrate that deforestation is a spatially auto-correlated process. In addition, their statistical findings point to the importance of household structure and expected land values (reflecting market access) on deforestation. In this regard, they drew two conclusions. First, household labor endowment is the most important demographic variable in the deforestation process. Their results showed that among the household life-cycle variables age of household head had no impact on the magnitude of deforestation (Walker et al. 2002). Also, they stated that length of residence was statistically insignificant, thus, confirming the results of previous studies (Alston et al. 1993; Almeida and Campari 1995). Their second conclusion was that the simultaneous significance of household and market variables illustrates the duality of the peasant household, reliant as it is on family resources but hopeful of market success (Turner and Brush 1987; Walker 2003). Besides the fact that satellite imagery has been used to measure deforestation in the Amazon region, new studies are analyzing changes in the landscape through the use of pattern metrics, such as patch, density, contagion, and landscape shape index. For instance, Pan et al. (2004) demonstrated the integration of spatial information (i.e., remote sensed images) with household survey data to statistically explore different models of landscape complexity in two different time periods. More specifically, they explored the relevance of spatial patterns of LCLUC at the farm level and how socioeconomic, demographic, biophysical, and geographical variables explain the observed variation in land cover and land use patterns using a set of landscape metrics. Their results showed that rapid population growth is causing substantial

subdivision of plots, which in turn has developed a more intricate and fragmented landscape (e.g., patch density increase). Key factors forecasting landscape complexity are population size and composition, plot fragmentation through subdivision, expansion of roads, and topography.

As indicated, many researchers have studied LCLUC in the Amazon basin. These studies have included econometric estimation, spatially explicit models, and household level research; they have ranged from basin-scale analyses to highly circumscribed locality studies. The factors that have been used in a statistical modeling framework cover a very wide range and include variables that can be grouped under those reflecting market factors (e.g., distance), environmental factors (e.g., soil quality, vegetation), socioeconomic and demographic factors (e.g., GDP, poverty, population density), and institutional factors (e.g., credit, land security). However, much of the research to date overlooks underlying social and institutional factors affecting land cover change. This can be a serious omission, particularly in Brazil where the federal government's role in Amazonian deforestation processes has involved geopolitical considerations, the provision of sweetheart subsidy deals for wealthy landowners, and efforts to mitigate rising populism directed at poverty and land reform.

In sum, the research on deforestation in the Amazon basin is helping to explain the effects of anthropogenic change in the landscape. However, the literature shows a lack in an important social phenomenon that today affects the Amazon landscape: the formation of land reform settlements. Brazil is well known

as a relatively rich country, and its GDP is one of the largest in the world. However, today most Brazilians are living in poverty, and Brazil is among the countries with the highest income inequality worldwide (Rangel et al. 2007). No doubt that there are many causes for poverty in Brazil, and land concentration has been pointed out as a very important one (Cline 1970; Roumani and Coirolo 2005). Brazil has a landless population of 5 million families that are looking for land in every part of Brazil, and the Amazon region is no exception. The importance of this phenomenon can be demonstrated by the number of new settlements in the northern region of Brazil where it is estimated that 1,916 new settlements occupy an area of 5.4 million ha (INCRA 2007a). These new settlements represent almost one fourth of the total in the whole country, which is estimated at more than 7,694 settlements (Table 1).

The creation of land reform settlements is an important form of land redistribution, and it has already benefited many poor people in Brazil. In the case of the Legal Amazon, in just eight years (from 1994 to 2002), the number of families living in land reform settlements went from 161,000 to 528,000 families (INCRA 2003). However, land use and its consequences on land cover can generate serious problems for the environment. Despite the importance of the problem, few authors have addressed the subject; and those that have addressed it have done so only superficially. Van de Steeg et al. (2006), Brandão and Souza (2006), Simmons et al. (2002), and Fearnside (2001) have brought attention to the effects of social processes on the landscape and the potential impacts that land reform settlements can have on the forest. Brandão and Souza

(2006) combining deforestation data with the map of settlements created from 1970 to 2002 by the Brazilian Institute of Colonization and Land Reform (INCRA – Instituto Nacional de Colonização e Reforma Agrária) affirm that around 106,000 km^2 (49% of the area of settlements mapped) were deforested up to 2004, representing 15% of all Amazon deforestation. In addition, these authors argued that from 1997 to 2004, the rate of deforestation in these settlements was 1.8% per year. Besides that, these authors stated that the rate of deforestation in land reform settlements is four times greater when compared to the mean rate of deforestation in the Amazon as a whole.

Table 1. Land Reform Settlements in Brazil from 1960-2007

States	Area (Ha)	Settlement Capacity (# Families)	# Families Settled	# Settlements
Pará	18,532,161.49	255,534	191,954	893
Mato Grosso	5,669,978.80	91,174	75,151	542
Acre	5,645,299.07	30,709	35,590	131
Amazonas	17,934,105.58	41,518	34,661	90
Rondônia	5,679,956.96	73,879	40,275	151
Amapá	2,095,394.61	12,190	10,598	37
Roraima	1,543,063.00	19,790	16,755	48
Tocantins	1,153,576.06	22,619	26,444	338
Sum	58,253,535.57	547,413	431,428	2,230
Rest of the Country	13,051,295.43	443,772	390,856	5,464
Brazil	71,304,831.00	991,185	822,284	7,694

Source: INCRA (2007a)
Note: These numbers include colonization settlements created between 1960 and 1970

Fearnside (2001) is more dramatic and has suggested that 30% of deforestation in the Amazon can be attributed to land reform programs. In addition, he argued that the continuing migration of the landless population to the Amazon region makes unviable any plan to support the region's present rural population through agrarian reform. Simmons et al. (2002) expressed that it was surprising that little attention has been given to the role of social and political movements as agents of land cover change and the impact of land reform on the

landscape. Van de Steeg et al. (2006) argued that the cultivation of legal reserves (and deforestation) are the main issues related to environmental impacts of settlement formation. However, none of them explained how settlements appear, which factors influenced their formation, and what impacts they had on the landscape.

The above review demonstrates that land reform is a potentially significant driver of Amazon deforestation. However, land reform is a consequence of land concentration in Brazil. From the very beginning of Brazil's colonization, wealth has been largely associated with land; and as such, to understand settlement formation it is first necessary to have an historical perspective on land concentration and land law in Brazil, a topic that I will develop in the next chapter.

CHAPTER 2: THE HISTORIC EVOLUTION OF LAND LAW IN BRAZIL AND ITS EFFECTS ON LAND CONCENTRATION

Land concentration in Brazil has many reasons for its existence. Since the start of the Brazilian colonization, many land laws were created with specific objectives. In the beginning, the land laws were created to protect the Portuguese land claims in the New World. Later, the land laws were created to explore the colony. As the World economy developed, so did the interests of the Portuguese Crown. Thus, the necessity to expand the colony economy stimulated a disorganized territorial expansion and land acquisition in Brazil. This problem of unauthorized land occupation generated a land concentration that was never fully resolved. On the contrary, the land laws created to solve this problem just aggravated land concentration.

This chapter reviews the historical evolution of land law in Brazil and its effects on land concentration. The main objective of this chapter is to demonstrate how land laws elaborated since the colonial times favored a property system that is based on land concentration.

2.1 The Sesmaria System in Brazil

Historically, land concentration in Brazil has many reasons. Land law in Brazil is derived from the system of *Sesmarias,* created in Portugal at the end of the fourteenth century. During this period, land that was part of the dominion of the Portuguese Crown was governed by the feudal system, leading much of it to remain uncultivated (Rau 1982). The basic objective of the *Sesmaria* system was

to do away with unused lands by making it obligatory to cultivate the land or risk losing control over it. As part of this system, landlords who did not cultivate or sublease their land would lose their land rights, and the land would be returned to the Crown to be redistributed to someone who would make it productive and respect the collective interest.

The need to explore and defend Portuguese land claims in the New World led the Portuguese to apply the *Sesmaria* system in Brazil, beginning in 1530. To do so, the King of Portugal granted land to Portuguese nobles who were deemed capable of developing and defending these lands with their own resources. These land grants were called *Capitanias Hereditárias.*[3] Further, because of the importance of trade to the Portuguese, the king authorized these nobles to subdivide their granted lands among other nobles. The new grants were called *Sesmarias*. However, the *Sesmaria* system did not operate as planned.

In Portugal, land structure of the sixteenth century allowed the *Sesmaria* system to create smaller properties than was possible under the older feudal system. In Brazil, the *Sesmaria* system was the primary impetus for the appearance of *latifúndio* (latifundia)[4] (Costa Porto 1978). However, the *Sesmaria* system cannot be solely blamed for the growth of *latifúndio* in Brazil. Silva (1996) argued that the historical conditions were different in colonial Brazil than in Portugal. According to Silva, the primary characteristic that differentiated colonial

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[3] The Crown divided Brazil into 14 sections every 50 leagues (a league was a measure of distance that varied from country to country) along the Atlantic coast with boundaries extending westward. Each section (*capitanias*) was given to a captain who had complete authority over his land and who responded only to the Crown.

[4] *Latifúndio* means a very large property. It comes from the Latin *Latifundium* where *Lātum* means large, spacious, and *fundus* means farm, estate.

lands from lands in Portugal was that colonial land was, more or less, empty. In other words, these lands were without a landlord, inhabited only by indigenous peoples with no concept of Portuguese land rights.

The lack of settlement in the New World was responsible for an unintended interpretation of one of the central terms of the *Sesmaria* system: the expression *terras devolutas* (Silva 1996). The original meaning of the term *devoluto* was "to be returned to the original owner [*devolvido ao senhor original*]" or, more simply, to be returned to the Crown. Land granted or appropriated that was not productive would be returned to the Portuguese King. According to this notion, even those *sesmarias* in the colonies that were unproductive would be returned to the Crown. However, over time, *terra devoluta* came to be used to represent all unoccupied or unused land, or land considered vacant (Silva 1996). The consequence was that lands termed *devoluta* were redistributed among the subjects of the *capitanias* instead of being returned to the dominion of the Portuguese Crown. The Crown, wishing the productive use and occupation of the colony, sought to grant lands to nobles with resources. However, the financial difficulties of the Crown in the middle of the seventeenth century and the possibility of the commercial exploitation of the colony through sugarcane plantations (which demanded large extensions of land) led the Crown to "close its eyes" to the way that land was granted in the colony.

The redistribution of unused lands in the middle of the seventeenth century among the lesser nobility in Brazil (e.g., friends of the Crown or anyone who claimed to have the means and desire to make use of the land) gradually

caused land concentration. In the beginning, besides the Crown recommendations, the *Sesmaria* system did not have any set of property size limits, at least not until the middle of the seventeenth century. Also, the methods used to demarcate land were rudimentary. The delineation and description of properties was largely based on natural features (and remained used until the nineteenth century), and the practice to petition many *sesmarias* by the same noble (or friend of the Crown) was not uncommon. Thus, there were cases of many *sesmarias* granted to the same individual (called *sesmeiro*), and cases where the individual's petitioned *sesmarias* in the name of their sons or daughters (Mendonça 1976). The *sesmarias* were clearly not homestead properties, and a labor force would have to be introduced. The solution to this labor need was found first through the use of indigenous people and, later, in the introduction of slave labor from Africa. However, by the end of the seventeenth century and the beginning of the eighteenth century, the colony of Brazil experienced some modification that had repercussions over the way land had been granted. One factor that contributed to the modification of the colony was its own growth. This growth was not restricted to population size, but was also an economic and territorial growth. In other words, migration flux increased from Portugal to the colony, the importance of the colony increased in the world market, and the frontier area that was formerly restricted to the coastal area of the colony expanded. The expansion of the new frontier led to the discovery of gold in the south-central area of the colony, thus redesigning the initial occupation. The combined increase in the slave population coupled with colonial

growth (population, economy, and territorial) stimulated and forced a large part of the population of the colony to migrate to regions of the country where land could be had and mines could be established. The territorial expansion of the colony in the eighteenth century highlighted the most important modification that occurred since the beginning of colonization: the dissemination of another form of land appropriation, the *posse* system.

In the first two centuries of colonization, *posse* represented a form of occupation by small farmers without the necessary conditions to maintain a *sesmaria*. In other words, the *posse* system involved informal rights to use land by squatting on it and enforcing land claims through social norms (e.g., by showing the use of land). In a supposed *latifundiário* regime, poor colonists were so economically constrained that migration to distant areas with available land (often with absent landlords) began to occur. As described before, with the evolution of world commerce, the Portuguese Crown developed a keen interest in the cultivation of sugarcane, which demanded grand expanses of colonial land. This led the king of Portugal to ignore the irregularities of the *sesmaria* system and, in particular, the extensive land grants under the system that remained unused. These unused areas were the overwhelming recipients of those forced to migrate because of land concentration in coastal areas. This occupation of unused *sesmaria* land by poor colonists created a problem for colonial authorities who sought to use this land for the cultivation of sugarcane. Thus, the poor colonists who had occupied the previously unused portions of the *sesmarias* were considered to be in the way of the Portuguese Crown.

This problem of unauthorized land occupation persists today and is related to the imprecision of property boundaries. The delineation and description of properties was largely based on natural features, a process that was common in the colonial era. Complicating the problem, the registration of property at that time was imprecise, creating many conflicts between smallholders and landlords. The *Alvará* of 5 January 1785 states that the *Sesmaria* system should have to conform to three explicit basic conditions: agricultural production, measurement, and confirmation (Alvarenga 1985). This means that the *sesmeiro* had to cultivate, demarcate, and obtain from the authorities recognition of the measurement of the land. However, people specialized in this type of work were very difficult to come by and the land was very hard to penetrate. Thus, measurement was not effective, and the use of natural features was used to demarcate the boundaries of a property.

By the end of the seventeenth and the beginning of the eighteenth century, the *posse* system increased in its impact, acting outside of the control of the Portuguese Crown. One important characteristic of the *posse* system was that, like the *sesmarias* themselves, the boundaries of a *posseiro* (the "owner" of a *posse*) were defined by the *posseiros* themselves. Following the *posse* system, large and small areas were demarcated throughout Brazil. Although in principle *posseiros* began as small producers, they frequently became large landholders (Rios 1950).

As a result of these developments, the *posse* system (which had always existed in the colony) began to cause severe problems. The colony already had

issues related to irregularly defined land grants (*sesmarias*), and the *posse* system added to these problems. Under the *sesmaria* system, the colony needed to grant new lands for sugar production. Thus, a significant risk that the boundaries of newly granted lands would overlap with the boundaries of the lands already claimed by a *posseiro*, or even areas of *sesmaria* started to appear.

In sum, this history suggests that the distance of the colony from Portugal led to a lack of enforcement by the Crown regarding the size of *sesmarias*. In addition, the economic development of world commerce led the Portuguese Crown to "close its eyes" to the way that land was being accumulated in the colony in the hope that it would stimulate sugarcane plantations. This land accumulation, either under the *sesmaria* or *posse* system, contributed to the formation of *latifúndio* in the colonial period. However, by the time of Brazil's independence in 1822, the difficulty in monitoring *sesmarias* and the conflicts between *posseiros* and landlords led to the suspension of the *sesmaria* system (Vasconcellos 1860).

2.2 The End of the *Sesmaria* System and the Reaffirmation of the *Posse* System

With the abolition of the *sesmaria* system, the *posse* system became the most common means of acquiring land in colonial Brazil (Lima 2002). On the one hand, the *sesmaria* was *latifúndio*, a large landholding inaccessible to colonists without resources. On the other hand, *posse* (at least in the beginning) was a small landholding created by necessity. Once *posseiros* marked their lands with

the "naked eye" to match their desires, the lands under their control became as extensive as the *sesmarias* (Lima 2002). Because of their extensive landholdings, the colony sought to remedy land acquisition and regularization by changing the agrarian policy.

Brazil's newly achieved independence in 1822, the accompanying changes in political power, and an economic expansion largely driven by coffee cultivation created conditions favorable to address the issues surrounding landholdings that Brazil had inherited. The expansion of the coffee industry in the first half of the nineteenth century had immediate repercussions for land appropriation. The most important issues were the spatial location of the new economic cycle and the availability of land in the south-central area of Brazil that benefited from the decadence of the mining regions (Furtado 1959). Thus, the new economic cycle (the coffee cycle) was a result of the reorientation of unused resources and the use of available land.

Nevertheless, the amount of land that could be economically exploited was limited. In addition, depending on the location, the characteristics of some land resources made their use uneconomical. Further, other areas were located too far from transport or roads, making the cultivation of coffee unprofitable. In addition, the land in the coastal regions of Rio de Janeiro and São Paulo, as well as farther inland in Minas Gerais was concentrated. The prosperity brought about by the coffee industry in these regions also increased population density. Thus, the concentration of agricultural interests and population would generate conflict over the agrarian question, creating land insecurity that only land regularization

could minimize. The development of the coffee economy that began to alter Brazil did not change the use of slave labor or the continuing incorporation of new lands (Silva 1996). As I have tried to demonstrate, landownership in Brazil was problematic. The landowner that had developed in the colony could not be called a landowner in its *strict sense* because the large majority of landowners (either *sesmeiro* or *posseiro*) did not have a land title. But this was not important; the most important goal was to keep the economic system based in the *latifúndio* and in slavery. In other words, the interpretation of the resolution ending the *sesmaria* system was that it was not applicable to the *posse* system (Silva 1996). Consequently, by keeping the possibility of land acquisition and the use of slave labor, landowners did not see any reason for land regularization. Finally, in 1850 after 28 years without land titles this situation changed. The Land Law of 1850 prohibited the acquisition of *terras devolutas* in any way, except by purchase, and established a new definition of the concept of *terras devolutas.* Specifically, the Land Law of 1850 determined that *sesmarias*, or other government land concessions that were cultivated or used under the principles of *"cultura e morada habital"* (i.e., the basic principles of *usocapião*[5]), would be recognized. In addition, this law stated that in the case of conflicts between *posseiros* and *sesmeiros,* the most important criterion for determining who would control the land was the present cultivation of it. Finally, the law allowed the government to reserve *terras devolutas* for colonization and military use.

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[5] *Usocapião* is a form of land acquisition of a property by using the land for many years without interruption.

The Land Law of 1850, although recognizing the acquisition of land by *posse* through cultivation, allowed for the correction of some land problems but avoided massive expropriations. Eventually, the law brought an end to the *posse* system in Brazil by establishing a system of private property that recognized the holdings of *posseiros* under the concept of effective cultivation (article 8 of the 1850 Land Law). In addition, the Land Law of 1850 defined *terras devolutas* as: (a) lands that were not private; (b) lands that were not in *sesmarias* or other government concessions; (c) lands that were not occupied by *posseiros* and were not regularized under the law (see above); and (d) lands that were not reserved for public use at the municipal or state level (article 3 of the 1850 Land Law).

Silva (1996) argued that this redefinition of *terra devoluta* changed the legal meaning of the term *devoluto,* which came to be applied (after the colonial period) to signify vacant land. The original meaning of *devoluto* was land in a concession that, if the landholder did not put in production, would be returned to the Portuguese Crown. Eventually, the new meaning of *devoluto* became commonly used in Brazil. However, the Land Law waited 4 years to be promulgated, and the land competence was attributed to the *Repartição Geral de Terras Públicas* (General Public Land Agency) through the Imperial Decree 1.318 of January 1854. According to this decree, this agency was supposed to drive and organize the measurement, description, and division of *terras devolutas* and to recommend to the government the lands that should be reserved for colonization, put up for sale, or put to military use. However, the

government did not achieve its objective of demarcating land for sale. Thus, the government concentrated its action in demarcating *terras devolutas* which could be used for colonization by migrants. But these actions were not enough to regulate and stop land acquisition. The Brazilian government was unable to implement the Law of 1850, and consequently, *terras devolutas* continued to be illegitimately occupied.[6] The failure of the 1850 Land Law would lead to a new legislative change. The 1891 constitution would remove the recognition of land concessions in areas labeled as *terras devolutas*, would reaffirm the concept of private property, and perhaps most importantly, transfer all unoccupied lands to the states, except in the case of frontier areas. In other words, the Brazilian government put the organization and administration of *terra devoluta* in the hands of the regional oligarchy. Thus, the history of the territorial appropriation would be linked from this point on to the history of each old province (now states). Consequently, with this legislation, the states began to develop their own laws governing the occupation of lands under state control. Among the larger states was Pará State in the Amazon region. This state, after Decree 410 of 1891, defined its own rules for mediation, buying, selling, obtaining title, and validation of land holdings. This law would recognize all landholders up until the date of its enactment, including the possessions of small landholders as well as those of *sesmeiros* and their descendents. However, the *sesmarias* were subjected to revalidation and existing *posses* to regularization. Because of this, in both cases, it was necessary to prove that the land was effectively being

[6] This illegal occupation of land would come to be recognized as *grilagem* (Silva 1996). *Grilagem* is a complex form of fraudulent land titling by which lands are seized with forged documents.

cultivated or that the landholder was a permanent resident of the property (Lamarão 1977).

In this period, rubber extraction was not a small landholder activity. The owners of the *seringais* (extensive rubber extraction areas) and rubber buyers involved in the activity of extraction were already members of the elite in Amazônia (Weinstein 1980). The areas of the *seringais*, as well as natural pastures used for cattle ranching, were not required to be cultivated. Therefore, Decree 410 defined forest conservation for extractive industries as a form of cultivation (Monteiro 1980). This definition was yet another step whose purpose was the preservation of *latifúndio* and the concentration of land. During this period it would have been ideal to regularize all existing properties, thereby demarcating all unoccupied public lands that could then be sold or reserved for specific uses such as colonization projects.

The collapse of the rubber boom would change this situation. To avoid the migration of small landholders who were associated with rubber extraction and food production, the State of Pará established public land concessions for everyone who needed land, with a maximum concession of 100 ha (Law 1.432 of 1914). In addition, provisional titles could be acquired, permitting the occupant to obtain definitive title after two years (State Law 1.584 of 1914). Despite the decline of the rubber economy, other activity expanded in the region, such as Brazil nut extraction, which was organized in the same way as rubber and therefore a legitimate extractive activity. Extractive activities became the most important factor in agrarian politics before 1930. Local political elites interested in

Brazil nut extraction were able to establish long-term leases (e.g., *aforamento perpétuo*) that allowed them to control enormous expanses of land in the region (Simmons et al. 2007). These leases (made possible to obtain complete control over Brazil nut reserves) were inexpensive for the lessees (Santos 1984; Emmi 1999). Ultimately, the state government approved a law that would allow the lease terms to be of undetermined length and would allow the acquisition of expansive landholdings for agro-industrial groups (Coimbra 1981), a fact that would cause substantial public protest in Pará State.

2.3 Agrarian Polices between 1930 and 1970

Public protest at the end of the 1920s and the Great Depression of the early 1930s aggravated the political and economic situation of the "old republic."[7] This crisis would lead to the increasing visibility of labor mobilization and would threaten the traditional political alliances between states in southeastern Brazil, principally between São Paulo and Minas Gerais [often called "Coffee and Cream" politics (*Política do Café com Leite*)]. This political and economic instability would lead to the 1930 revolution. To avoid possible popular revolt to the detriment of the economic gains of the oligarchy at the time, the leaders of the 1930 revolution did not look upon state government decisions favorably. Revolutionary Decree II of 7 November 1930 required the immediate return to the Union of all areas granted by the state, including long-term leases for Brazil nut extraction. In addition, the revolutionary government started to review every land

[7] The First Republic, or "Old Republic," was a period of Brazil's history that begins with the proclamation of the republic in 1889 and ends with the 1930 revolution.

title granted by the state through concession. However, the new state (*Estado Novo*) did not express its opinion over an issue of great importance for the agrarian situation in Brazil: the issue of *usucapião*, a principal according to which property could be obtained by anyone who effectively cultivated it for a minimum period of time. To the contrary, the Brazilian constitution of 1934 (article 125) officially instituted *usucapião* (called *usucapião pró-labore*) in which a property of 10 ha could be obtained if cultivated for a minimum period of 10 years. This decision was reaffirmed in the Brazilian constitution of 1937 (article 148) which maintained the minimum period of 10 continuous years of cultivation for an area of 10 ha.[8] Once again, the law was not enforced and the *aforamento perpétuo* did not come to an end; although this decree allowed, during a set period of time, the Union control of the conflict between large and small landholders.

By the end of 1947, a communist wage was striking many countries in the world. Brazilian communist sympathizers found supporters in the countryside and helped the peasantry work toward the organization of *Ligas Camponesas*. For theorists helping to organize the *Ligas Camponesas*, Brazil was being used by imperialist countries, such as the United States. According to these theorists, imperialist countries and the Brazilian collaborators (e.g., big coffee planters, beef exporters) were interested only in the production of export commodities; and in order to protect their interests, they conspired to hold the agricultural sector in a backward state of development (Welch 2006). To avoid popular adherence to

[8] The Brazilian constitution of 1946 (article 156, § 3) kept the minimum period but changed the size to 25 ha, and the Brazilian constitutional amendment number 10 of 1964 (article 156) changed the size again to limit it to 100 ha and a minimum period of 10 years.

the communists' ideas, the Brazilian government decided to ban the Brazilian Communist Party (PCB). Going underground, communists started to guide their militants through the beginning of the 1950s with ideas that it was necessary for the peasantry to rise up and fight for land seizures without compensation to *latifúndios*. Also, the communists felt it was necessary to confiscate the *latifúndios*, which then should be given freely to those who work and live on the properties (Welch 2006). With elections approaching, the populist candidate Getúlio Vargas decided to stand up against the "imperialists" in 1951. As part of his economic plan, Vargas exploited coffee export earnings through taxation and the manipulation of foreign exchange rates (Welch 2006). Consequently, this policy irritated coffee producers; but they were able to protect their profits by reducing labor costs through increased exploitation and the withdrawal of privileges such as free worker housing (Welch 2006). Overwhelmed by scandal, Vargas committed suicide in 1954. The communists took advantage of Vargas' death to host a congress of rural worker and peasant delegates from associations throughout the country. In this congress, the Farmer's and Agricultural Laborers' Union of Brazil (ULTAB, *União dos Lavradores e Trabalhadores Rurais do Brasil*) was founded, which shortly became the main tool used to advance the rural labor struggle in Brazil.

The pressure for land reform in many parts of the country would lead the Brazilian president to construct the Belém-Brasília Highway in 1960 as a way to release the pressure for land reform in southern Brazil. This action would attract new migrants to the Amazon region. Small and large producers would be

attracted by the perspective of potential benefits offered by the presence of mineral deposits, such as gold and diamonds, as well as soils fit for agriculture. This migration opened the way for land speculation and intensified the demand for land in the region (Santos 1979). To provide a picture of the volume of land transactions between 1959 and 1963, the height of this rampant speculation, the State of Pará sold more than five million hectares of land, the majority granted to large capitalist interests headquartered in southern Brazil (Santos 1979). Between the construction of the Belém-Brasília highway and the revolution of 1964, the economic growth of Brazil was attributed to import substitution through increases in tax and favorable exchange rates. This growth continued through the 1960s with increased foreign, government, and private investment. However, by 1964, the country had a record budget deficit and an annual inflation rate of 52% (Wynia 1990). The aggravation of this new economic crisis and increasing benefits to capitalists brought a spike in the number of small producer and rural worker associations, nearly all of which favored agrarian reform. This fight for agrarian reform would become part of the daily life of the Brazilian population and would stimulate increasing pressure for change in the countryside. Thus, much like examples in other countries (e.g., Cuba, Mexico, Bolivia), the *Ligas Camponesas* started to organize again; and a movement in favor of social justice and agrarian reform in the countryside spread throughout the nation, assuming grand proportions in the mid 1960s.

Popular dissatisfaction throughout the Brazilian countryside would lead to the military coup of 1964 and the establishment of the Land Statute of April 1964.

For the first time in Brazil's history land reform had been defined as a set of measures that could promote a better land distribution by modifying the land use regime and landownership based upon the idea that the Land Statute was to promote social justice and productivity. This statute would drive agrarian politics and agricultural policies in Brazil. The Land Statute had two principal objectives for the military government: (a) the implementation of a land reform program and (b) the development of agriculture. In addition, the statute would create opportunities for access to proper titles for private land, with the condition that it would be used to serve a "social function". In article 2, the Land Statute of 1964 established that the "social function" of land would involve the well-being of the landholder and the rural workers who worked on it, coupled with satisfactory levels of productivity and the conservation of natural resources. However, should lands not meet their "social function" as elaborated by the Land Statute, they would be subject to expropriation as if they were unused (*terras devolutas*). In addition, the Land Statute of 1964 would establish that (a) any rural worker that had occupied *terra devoluta* for one year would have preference in acquiring that land up to the size of one rural module[9] in the region (article 97, § II); and (b) everyone that had occupied a land in *terra devoluta* for 10 uninterrupted years would have rights to that land (article 98).

The main contrast of the Land Statute of 1964 with earlier laws was the clear wish to terminate *latifúndio* through the use of expropriation. However, on the one hand, the Land Statute provided a way to decrease land concentration;

[9] A rural module is defined regionally and considers the quality of the land and the climatic conditions of each region.

on the other hand, it emphasized the need to develop agriculture through agricultural credits and subsidies. At that time, an increased public debate on agricultural policies was arguing that the agricultural sector was backward, traditional, and generally exhibited nonmarket behavior in its alleged lack of supply response to price incentives (Silva 1981). Thus, Law 4.829 of 5 November 1965, following the Land Statute, would allow the modernization of Brazilian agriculture through mechanization. The principal idea of this policy was to lower the cost of capital for the agricultural sector. However, the combination of these two policies (land reform and agricultural credit) distorted the underlying objective of each on their own. In other words, this combination of policies made unskilled labor much more expensive and lessened agricultural capital (Rezende 2006). As a result of this price factor distortion, a rapid change in agricultural technology with the mechanization of production on a grand scale occurred but it came without a solution to the problem of land concentration in Brazil (Figures 1, 2, & 3).

This was a period of the technological modernization of Brazilian agriculture. However, this modernization was only partial and affected only some products (e.g., sugarcane, cotton, cocoa, coffee, soybeans) and regions (south-central and northeast). Another impact was an increased dependency of agriculture on other economic sectors, principally industry and finance. Consequently, the technical progress of Brazilian agriculture was not uniformly distributed and would contribute to the maintenance of land concentration.

2.4 The Modern Determinants of Land Concentration in Brazil

With the modernization[10] of agriculture, agricultural specialization occurred on a national scale. In some regions, crops outside of the family economy were considered commercial and, hence, were developed and modernized. This was the case with sugarcane, cotton, tobacco, and cocoa in the northeast; coffee, cotton, and sugarcane in the southeast; and rice, wheat, soybeans, and grapes in the south (Soares 2000). In southern Brazil, the substitution of extensive cattle-raising occurred, and agriculture concentrated in the growth of export products (i.e., coffee and soybeans). In contrast, west-central Brazil became an area of agricultural occupation centered on large-scale soybean, corn, rice, and beef-cattle operations, largely supported by special government programs and financial incentives (Silva and Kohl 1984). Different from other regions of the country, where intensive modernization occurred through the use of fertilizer, the northern region saw an increase in cultivated area by bringing land into production. The use of agricultural machinery and modern inputs shows practically no change from 1960 to 1975 (Silva and Kohl 1984). This agrarian structure evolved to be more concentrated and exclusive, making access to land for rural workers in Brazil difficult. Not only did land become more concentrated, but access to the land that remained was practically eliminated (Rezende 2006).

[10] For some authors, such as Silva (1981), modernization was a transformation of the natural form of the rural production process to industrialized farming.

This agricultural modernization also had strong effects on the rural exodus, increasing the number of workers who left rural areas looking for jobs in urban centers. Brazil shifted from an agrarian rural society to an urban society in only few decades. In 1940, 28 million people (68.8%) of the population lived in rural areas. By 1950, 18.7 million people were classified as urban inhabitants, which was 36.2% of the total population. The 1960 census recorded an urban population of 31 million; this was 44.7% of the total population of Brazil. The estimated urban population of Brazil in 1970 was 52 million, which was 55.9% of the country's total population (Table 2). This migration involved both movements of people from rural areas to the more urbanized areas of the same state as well as a shift from more rural states to the more urban states.

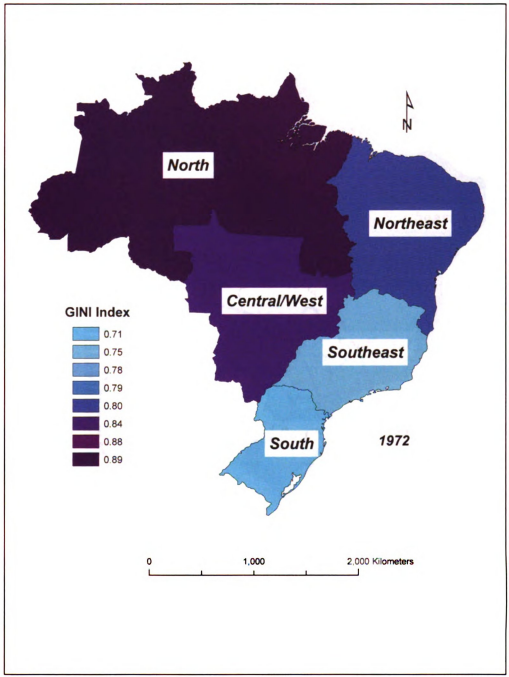

Figure 1. Brazil Land Concentration Indices by Region, 1972. Source: INCRA (2007b)

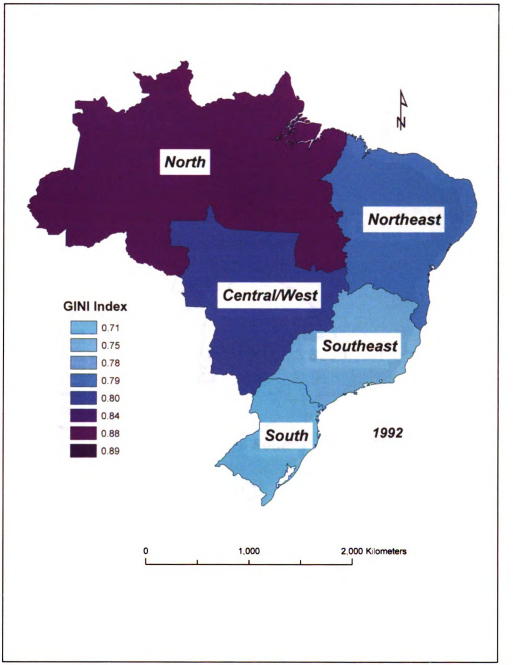

Figure 2. Brazil Land Concentration Indices by Region, 1992. Source: INCRA (2007b)

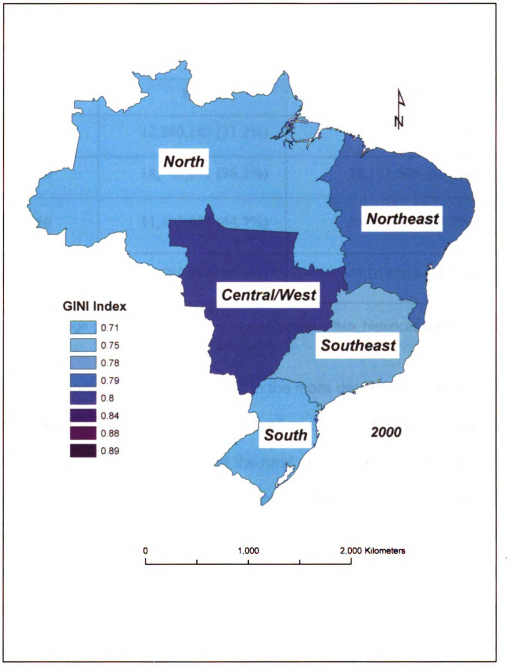

Figure 3. Brazil Land Concentration Indices by Region, 2000. Source: INCRA (2007b)

Table 2. Resident Population, 1940 – 1970

Years	Total	
	Urban	Rural
1940	12,880,182 (31.2%)	28,356,133 (68.8%)
1950	18,782,891 (36.2%)	33,161,506 (63.8%)
1960	31,303,034 (44.7%)	38,767,423 (55.3%)
1970	52,084,984 (55.9%)	41,054,053 (44.1%)

Source: Séries Históricas do Brasíl. IBGE 2007a.
(http://www.ibge.gov.br/home/estatistica/populacao/defaulttab_historicas.shtm)

This urbanization process began in the more developed regions of the country where capitalization and mechanization of agriculture first occurred and became most intensive. The result of the rural exodus was burgeoning urban zones and the creation of a marginalized population without jobs and living in subhuman conditions. This marginalized population would continue to apply pressure for land reform. Thus, the military government, in the search for a plan of action to resolve this "new" pressure for agrarian reform, decided to stimulate the opening of new agricultural frontiers. This strategy focused on the occupation of the Amazon, a region with immense areas of *terra devoluta* with low population densities.

The Revolution of 1930, through revolutionary Decree II, had already returned all unclaimed land to the Union. Thus, to achieve its plan, the military

regime created two important laws: Law 5.174 of October 1966 and Law 5.374 of October 1967, which would emphasize the importance of private enterprise in regional development. According to these laws, the government would provide the infrastructure and general funding for development; and in addition, it would also create many programs. For instance, the federal government created the National Institute of Land Reform (INCRA - *Instituto Nacional de Colonização e Reforma Agrária)* in 1970, as well as various special programs for regional development. Among these special programs were the National Integration Program (PIN - *Programa de Integração Nacional*, or PIN -1970), the PROTERRA program (*Programa de Redistribuição de Terras e Estímulo a Agroindustria do Norte e Nordeste*), and the POLOAMAZONIA program (*Programa de Polós Agropecuários e Agrominerais da Amazônia*). Of these, POLOAMAZONIA was designed to attract national and international companies to the Amazon region through fiscal incentives and credit programs. In addition, the military regime also had concerns with the security of the region. To protect the region, the military regime would declare the *terras devolutas* located in 100-km strips along both sides of all federal roads in the Legal Amazon (Decree number 1.164 of April 1971)[11] and *Faixas de Fronteiras* (Frontier Strips)[12] as

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[11] Decree number 2.375 of November 1987 removed the clause that made the *terras devolutas* located in 100 strips along both sides of all federal roads indispensable to national security.

[12] The utilization of property in areas close to national borders was subject to special conditions since the Old Republic. Law 601 of September 1890 had reserved a strip of 66 km (10 leagues) along the national border that could be freely given. The constitution of 1891 established in its article 64 that the *terras devolutas* would belong to the States and the Union would stay with a portion of the territory that was indispensable for defending national borders, military fortification, and federal railroads construction. Article 166 of the constitution of 1934 advanced the limits of *Faixa de Fronteira* to 100 km, and the constitution of 1937 changed the limits to 150 km, the extent that remains to today.

indispensable for national security. However, aside from these efforts, not many changes in the agrarian structure of the country occurred. To the contrary, in the Amazon region, this period was characterized by the development of rural capitalist enterprises, as well as the continuation of traditional *latifúndio* (Hoffman 1998).

In terms of land issues, the 1980s were no different than the decades that preceded them. In other words, struggles for land reform and increased mobilization for democratization occurred in the whole country, principally in the more industrialized cities. This increased mobilization was again responsible for changes to land law in Brazil. Congressional law 6,969 of December 1981 (article 1) would reduce the *usucapião* time period to 5 years for anyone continuously using an area of no more than 25 ha.

The democratization of Brazil after 1985 opened the door for the Brazilian population to reaffirm the necessity of agrarian reform because of the great masses of landless workers throughout the country. Many social movements, which were under the oppression of the military regime and functioning only clandestinely, began to operate with more liberty. Then, in 1985, the government of José Sarney implemented the first National Plan for Agrarian Reform (PNRA, *Primeiro Plano National de Reforma Agrária*). The objective of this plan was the rapid application of the Land Statute of 1964 and the enabling of agrarian reform until the end of Sarney's term in office.

The first National Plan for Agrarian Reform (PNRA) stated that the principal method to obtain land for agrarian reform purposes was through the

expropriation of land for the social interest. In addition, the first PNRA also stated that the owners of expropriated lands must be compensated in the amount of the land's declared value according to the Rural Territory Tax (ITR). However, the declared value of lands on ITR paperwork was generally much lower than the land's true market value. Consequently, this proposal assumed that expropriations would penalize landowners for not using their land (Medeiros 2002).

As a result, the PNRA generated a conflict of interest between the rural elites and emerging social movements. For instance, the UDR *(União Democrática Ruralista)* was created in 1985 to resist agrarian reform efforts undertaken through land occupations that were occurring throughout the country (Fernandes 1999). The UDR would defend the rights of landholders in negotiating the sale of land to the state as an alternative to land expropriation. In addition, the political power of rural elites led to the inclusion of a clause in the final version of the first PNRA that prohibited the expropriation of productive properties, regardless of their size or use. In its final version, the first PNRA took as its objective the settlement of 1.4 million families in the whole country. However, once more meaningful land reform only existed on paper. The Sarney government, at the end of its term, settled only 90,000 families, representing just 6% of the original goal of the PNRA (INCRA 1995).

The convocation of the 1987 Constitutional Assembly was the next phase in the struggle against land concentration. A strong popular interest in favor of increasing agrarian reform efforts emerged, but rural elites represented by

traditional rural organizations (e.g., *Confederação Nacional da Agricultura, Sociedade Rural Brasileira*) once again impeded the implementation of constitutional articles that benefited agrarian reform efforts (Fernandes 1999). Even so, the new constitution advanced, principally with respect to social rights. The Constitution of 1988, as in the Land Statute of 1964, established that land must serve a social function, where social function was defined as (a) the well-being of landowners and those working for them; (b) the maintenance of satisfactory levels of productivity; and (c) the rational use and conservation of natural resources. However, introduced by the Land Act, the land expropriation legislation was significantly changed by Brazil's 1988 Constitution. Since then, only unproductive land was under the risk of expropriation for which the state needed to pay a price. In other words, the constitution defined how the compensation for the expropriation of land for reasons of social interest would be awarded. Consequently, landowners would be paid in agrarian bonds over a period of 20 years. Ultimately, the constitution exempted the expropriation of lands < 15 "rural modules" (*módulos rurais*), as well as those properties that were productive. In addition, article 189 made any rural land acquired through land reform programs non-negotiable for a period of 10 years. This legislation took 5 years to be ratified in the Brazilian Congress — a delay that only served to increase tensions between landless people and large farmers. In 1992, the National Institute of Colonization and Land Reform was authorized to acquire land for land reform purposes in areas of social tension to satisfy the requirements of the National Program of Land Reform. But even with all these

arrangements, the tension between landless people and large farmers did not end. The federal government, concerned with putting an end to land invasions, established in 1993 the agrarian Law 8.629, which would simultaneously allow deeper agrarian reform legislation but would eliminate many other opportunities. For instance, two impacts of this law were that public lands could be used for land reform purposes, but that the definitions of "social function" and "productive" land remained unclear. This created opportunities for the use of both terms to conform to the needs of interested parties (i.e., rural elites and the landless). In addition, the law stated that any rural property that was invaded would not be evaluated or disappropriated for a period of time of 2 years following its disoccupation. Also, the period of time would double if the same property were invaded again. Finally, the law would penalize with exclusion any individual that had been enrolled to receive a parcel of land (or had already received land in a settlement) if it was proved that he/she had participated in an invasion of public or private properties.

Despite these efforts, the land reform problem did not change much in the 1990s compared to the 1980s. To the contrary, land invasions did not cease, and the concentration and the underuse of land increased in the 1990s. Between 1992 and 1998, the area devoted to large properties (more than 2,000 ha) increased by 56.2 million hectares, an area the size of France (INCRA 1996). Further, the *Atlas Fundiário do Instituto Nacional de Colonização* of 1996 shows that *latifúndios* (2.8% of rural establishments) occupied 56.7% of the country,

while *minifúndios*[13] (62.2% of rural establishments) occupied only 7.9% of the total area of the country. In addition, the *Atlas Fundiário* provides an account of the amount of unused land in Brazil — 185 million hectares, or 40% of all usable area, had a landholder but was not considered productive (i.e., was *latifúndio*). Although many elected presidents had developed various agrarian reform plans, the concentration of land did not diminish as expected in Brazil (Figures 1, 2, & 3). Consequently, throughout Brazil, social movements of rural landless workers emerged, tired of waiting for concrete action by the federal government. These people initiated their own land reform movement by increasing the number of occupations of private land and *terras devolutas.*

The main objective of this chapter was to provide an account of the evolution of agrarian law in Brazil, from the initial domination of the Portuguese through the present day. Throughout this complicated 500-year history, the changes in agrarian law did not bring about a deconcentration of land in Brazil. To the contrary, these changes maintained the same historical patterns of land concentration. However, sociopolitical shifts that occurred in Brazil made possible the mobilization and collective action of the population at large, through the emergence of social movements favoring substantial changes in land reform policies. Thus, considering the appearance of social movements and the importance of these movements to agrarian reform, in the next chapter I will

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[13] *Minifúndios* were properties of less than one rural module. In general, *Latifúndios* could be classified according to *utilização* e *tamanho. Latifúndios de Utilização* (use) were properties between 1 and 600 rural modules in size in which the level of productivity was less than the regional average. *Latifúndios de tamanho* (size) were properties with areas larger than 600 rural modules without any consideration of the type or characteristics of production (Campanhole 1969).

outline the trajectory of social movements and identify their historical origins and their role in direct action land reform (DALR) in Brazil.

CHAPTER 3: THEORIES OF SOCIAL MOVEMENTS AND THE DIRECT ACTION LAND REFORM IN BRAZIL

The 1960s had a profound influence on societies around the world. Among those affected, American societies perhaps saw the greatest number of protests and collective actions. This period was marked by substantial public dissatisfaction, organized in protests, social movements, "political" organizations independent of political parties (e.g., workers' unions), among other forms of public manifestations. These collective actions became very important in the U.S., as in Europe. However, the explanations of the causes of the rise of collective action and social movements diverged in both places.

In this chapter, I present the trajectory of the study of social movements, with emphasis on a number of principle theories explaining their emergence. First, I will review the theories that dominate the initial studies of social movements in the 1960s, often referred to as the "classical model of social movements." Following this review, I will approach the two theories that challenge the classical view: resource mobilization and collective process. Next, I discuss how those who studied social movements in Latin America viewed these theories. To conclude this chapter, I present the role of social movements in the struggle for agrarian reform in Brazil.

3.1 The Classical View of Social Movements

The classical approach dominated initial studies of social movements until the middle of the 1970s. Led by the "Chicago School," these studies viewed

social movements as a result of a behavior crisis or, in other words, as a consequence of "social strains" (Merton 1938, 1968). According to this theory, social movements emerge from general and profound dissatisfaction, which could be a result of social change that modifies existing social relations, which are considered inadequate (Jenkins and Perrow 1977). Consequently, this "social strain" would create dissatisfaction, and collective action rises with the intent of alleviating these "strains." The existence of social frustration and crisis automatically produces revolt. This type of collective behavior was described as irrational or nonconventional. In other words, the classical theory viewed collective behavior as "deviant" (Smelser 1962). Following this view, it was argued that, in democratic societies, it would be rational to use conventional means to enact social change through institutionalized channels instead of rebellion, strike, or other forms of collective action.

The classical theory is not a theory comprised of a single argument. Some variations of the theory could be classified as (a) mass theory, (b) status inconsistency theory, (c) collective behavior theory, and (d) relative deprivation and its variation (Davis' so-called "J curve").

McAdam (1982) argued that every variation of the classical model has unique characteristics. However, the most important aspect of these variations is the consistency with which each name identifies the same general cause as responsible for the emergence of social movements. In other words, all the variations identify a structural problem in society that leads to a psychological effect, which disrupts the existing *status quo*, resulting in the production of social

movements (McAdams 1982). Every version of the classical model has as its central point the identification of a structural fault of a problem and differs only with respect to the conceptualization of the structural problem itself. With the object of comparing the similarities of each model, I will briefly describe each of them in the following sections.

3.1.1 Mass Society Theory

Mass society theory refers to the lack of an intermediate structure through which individuals can be integrated with society (Kornhauser 1959). Through this view, social isolation is a fundamental prerequisite for social protest, and feelings of isolation and anxiety cause a disposition to become involved in collective action. Kornhauser (1959) argued that one of the principal causes of "structural strain" is the disappearance of a sense of community. According to this author, the collapse of a stable community creates a feeling of isolation and anxiety among individuals. Hamilton (2001) argued that in mass society individuals are atomized, leading them to isolation and solitude. According to this theory, social movements emerge when society's intermediary organizations are lost (e.g., workers' unions, churches, associations) causing dissatisfied individuals to join these movements (Kornhauser 1959). These organizations function as intermediaries between individuals and the new social structure, aggregating individual preferences and serving to relieve the pressures of social life.

3.1.2 Status Inconsistency Theory

Another variation of the classical model is "status inconsistency." This theory argues that an individual with an inconsistent social status can become more frustrated than an individual with a more consistent social status[14] (Lenski 1954). Nevertheless, this type of approach only proliferated between the 1960s and 1970s, with the intent to explain the relationship between inconsistency and political responses. The theory of status inconsistency argues that there exists a set of conflictive expectations that produce anxiety and social tension.

McAdam (1982) stated that status inconsistency refers to the discrepancy between the ranking of an individual according to a number of status dimensions (e.g., education, income, occupation). According to McAdam, if the discrepancy is severe, an individual can begin to feel tension similar to that of individuals afflicted with feelings of atomization as described by mass society theory. Thus, status inconsistency is another variation of the classical model, in that severe discrepancies in social status produce a "strain," a dissatisfaction that generates collective protest and results in the appearance of social movements.

3.1.3 Collective Behavior Theory

Differing from the two theories presented above, the theory of collective behavior does not highlight a specific condition, such as status inconsistency or atomization, as a primary cause of the appearance of social movements. To the contrary, this model, similar to the one proposed by Lang and Lang (1961) and

[14] Social status can be interpreted as the social position of an individual in society.

Smelser (1962), argues that any type of severe "strain" may contain the necessary components to stimulate the emergence of social movements. Consequently, this approach became one of the more general classical models.

Following Smelser (1962), a form of "strain" must be present for an episode of collective action to occur. Therefore, collective behavior assumes that individuals enter into episodes of collective action because something is wrong with the social environment in which they exist. For example, a rapid economic crisis that may lead to significant economic depression and unemployment may generate a "strain" that brings about social insurgency. Gusfield (1970), for instance, argued that social movements are a response to social change that follows new ideas that break down existing social structures. This line of thought sees social change as a source of structural "strain." In this context, social change has been seen as a stressor because it causes a breakdown in the normative order to which individuals are accustomed.

3.1.4 Relative Deprivation Theory and the Davis J Curve

Relative deprivation theory is associated with the existing links between depravation, frustration, and aggression. Following this theory, the dispossession of goods and services may lead to frustration, which may produce aggression when frustration is released. This theory is based on the hypothesis that social movements are made up of individuals who feel deprived of the ability to obtain resources or goods (Morrison 1978). This approach considers the fact that individuals who lack the conditions to obtain these types of goods (or services) are the most favorable individuals to organize social movements with intent to

improve their conditions. In other words, these individuals feel frustrated with their conditions in relation to others. However, relative deprivation theory presents a problem. The majority of people feel deprived at some moment in their life of some goods or services (Morrison 1978). Consequently, this theory is unable to explain why individuals join together to form a social movement while others similarly deprived of goods and services do not.

The Davis J Curve is a variation of relative depravation theory. This theory results from an attempt by James C. Davis[15] to reconcile two explanations for revolutionary phenomena. According to Davis (1969), Karl Marx and Alexis de Tocqueville (two important scholars of revolution) arrived at opposite conclusions about it. Davis (1969) argued that for Marx revolutions probably occurred when the situation became critical. In other words, revolution occurs when proletarian misery increases in relation to the economic power of the bourgeoisie. In contrast, Davis (1969) saw in Tocqueville's work that revolutions were the result of the liberation of oppressive conditions.

Davis (1969) attempted to reconcile these two contrary explanations through the argument that both were incomplete. He argued that revolutions occur when a period of progress is follow by a period of profound decline (Davis 1969: 86):

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[15] James C. Davis (1969). "Toward a Theory of Revolution" in Studies in Social Movements, ed. Barry McLaughlin.

Revolutions are most likely to occur when a prolonged period of objective economic and social development is followed by short period of sharp reversal. The all-important effect on the minds of people in a particular society is to produce, during the former period, an expectation of continued ability to satisfy needs...

The brief explanation above demonstrates that the various versions of the classical model, despite their differences, have a number of points in common. In all of the models presented here, structural "strains" create tensions and frustrations that, when they reach a certain threshold, cause social insurgency to appear. In addition, though taking as its goal the description of the rise of collective action, classical models are in reality more preoccupied with the psychological effects of "strain" on individuals. In other words, individual dissatisfaction, anxiety, and frustration are the principle drivers of the emergence of collective action. Ultimately, in all the classical models discussed above, the appearance of collective action is associated with a basic preoccupation with the search for a solution to the problems of frustration and anxiety — not a search for political objectives.

During the 1960s and 1970s, as with many other aspects of society, social movements underwent a number of grand transformations. In the 1960s, the majority of scholars avoided addressing social movements. In their estimation social movements were viewed as groups of individuals that were the irrational product of "social strain." This presupposition was subsequently considered

problematic during the 1970s because it assumed that the emergence of social movements was a consequence of a certain level of "strain" in a society. Consequently, this approach indirectly assumed that society was always in equilibrium and without "social strain." However, for Wilson (1973) this perception was problematic. He argued that society was rarely in equilibrium and was always showing social "strain" because it was always mutating. Therefore, social movements always had stimulus to emerge.

The idea that social movements is a consequence of frustration, deprivation, and social strain started to change in the end of the 1970s and the beginning of the 1980s with the inclusion of the political context argument. For instance, McAdam (1982) argued that the classical model lacked a discussion of the political context in which social movements appear. For this author, social movements do not appear instantaneously. Much to the contrary, social movements are modeled by a large variety of social-environmental factors. In this context, the appearance and development of social movements occur as a product of individuals involved in organized and dynamic interactions within an environment constantly undergoing political and socioeconomic mutation.

Jenkins and Perrow (1977) argued that the success of rural works in the United States during the final years of the 1960s can be explained by changes in the political environment of the period, as well as the internal organizational characteristics of the movement. Cohen (1985) demonstrated that the appearance of well-organized social movements was not a symptom of irrationality. To the contrary, the individuals involved in protests and mobilizations

have a clear objective and strategy. Therefore, McAdam (1982) noted that "strain" could be necessary to generate social movements, but is not a sufficient cause on its own.

Another criticism of the classical theory of social movements is centered on the hypothesis that social insurgency is a function of individual discontent and that it is necessary to arrive at a maximum limit of discontent or "social strain" to produce a social movement. However, according to McAdam (1982) the classical theorist has not stipulated a threshold at which this level of discontent or "strain" is able to produce a social movement. In addition, classical theories ignore the fact that social movements are a collective phenomenon. Thus, these scholars are not able to explain how discontent or unsatisfied individuals are transformed into an organized movement. In the end, the argument that the appearance of social movements is the consequence of the psychological irrationality of individuals seeking an escape valve does not consider the possibility that these same individuals may be involved in rational collective action. In other words, the classical theory does not consider that social movements may have well-defined political objectives and power.

Bachrach and Baratz (1973) and Prewitt and Stone (1973) argued that social groups differ based upon the political power that they have. Those groups with sufficient political power are able to bargain and advance their interests. As a result, these groups control the political environment, excluding those groups that are without political power. Keeping in mind this perspective, the above authors argued that it is possible to observe that social movements are not a

form of irrational behavior but are instead a planned response against a repressive political system.

In sum, the classical approach assumed that the increase of individual complaints generates "social strain" that enables the appearance of social movements. While the specific hypotheses of the classical approach vary between different currents of thinking, each of these versions agrees that the individuals involved in social movements act irrationally as a consequence of "social strain." The diversity of social movements in this period (1960s and 1970s) helped change this way of thinking and contributed to the development of alternative hypotheses. The fact that different social groups with varying levels of political power exist helped the development of the hypothesis that social movements act rationally and in an organized manner. This new idea gave rise to the approach of resource mobilization theory.

3.2 Resource Mobilization Theory

The social movements that appeared between the 1960s and 1970s stimulated new hypotheses about the rise of organized social protest. This new way of thinking would be known as resource mobilization theory (McCarthy and Zald 1973, 1977; Oberschall 1973; Gamson 1975; Tilly 1978, among others). The central hypothesis of this theory states that social movements generally consist of formal organizations, thus leading the above authors to argue that (a) any organization requires a certain level of resources, especially money, to sustain it; and (b) in society there are always dissatisfied individuals who are ready to create a movement of protest. However, according to these authors, the

change that has occurred over time has been that social movements use the resources available to them, such as financial support and the individual skills of movement participants. Following this realization, studies of social movement changed their focus from addressing the type of individual that joins social movements to studies of the infrastructure necessary to sustain a movement.

In general, resource mobilization theory could be seen as a reaction to the deficiencies of the classical model. These theories viewed social movements through two distinct conceptualizations. On the one hand, the traditional form viewed social movements as extensions of elementary forms of collective behavior (Jenkins 1983). On the other hand, resource mobilization theory viewed social movements as extensions of institutional actions and constrained the focus on movements that sought institutional change (McCarthy and Zald 1977). In other words, the view of resource mobilization theory argued that social movements were composed of political actors dedicated to achieving their objectives, which in some cases could be political. This vision of clearly delineated objectives attributed to the participants within social movements a perspective of rationality.

Eyerman and Jamison (1991) argued that resource mobilization theory studied the mechanisms through which social movements recruit their members as well as the organizational forms through which resources and movement participants are mobilized. Contrary to the approach of collective behavior, the approach of resource mobilization centered its analysis on organizations instead of individuals. For some authors, the grievance used by theories of collective

behavior to justify the rise of social movements always remains relatively constant, and social movements form from long-term changes in the availability of existing resources, the organization of movements, and the opportunities for collective action (Jerkins and Perrow 1977; Tilly 1978). However, changes in society also could be caused by changes in interests and new opportunities that favor the mobilization of individuals. In other words, changes in society could be occurring by the opening of political opportunity that facilitates for individuals to organize and mobilize. This view was the starting point for the political process theory.

3.3 Political Process Theory

The concept of political opportunity also has its origins in the 1960s. During this period, changes in society were stimulating collective actions. The perspectives of Europeans and North Americans aided the understanding of the reasons for mobilization, but none of these ways of thinking were able to explain why individuals supported some movements during a period of time and why some Western countries experienced more collective actions during the 1960s than others. In reality, the importance of political context in the formation of collective actions did not rise instantly. According to Tarrow (1998), a brief analysis of modern history demonstrated that episodes of collective action cannot be explained only through the deprivation or disorganization of society. For this author, what varied in history were the opportunities that involved individuals had for experimentation. Agnew (1977) argued that opportunities for collective actions were sometimes greater in some places than in others. Consequently, individuals

saw in these opportunities a way to advance their causes. However, for political process theory, what was important were the reasons for the appearance of collective actions and not how they mobilized. Within this context, for the political process the most important task was to analyze the cause of structural change that created political opportunities in society. Following this, Tarrow (1998) identified five dimensions in political process theory (i.e., political opening, political alignment, appearance of allies, appearance of divisions, and decline in the capacity of repression). The process of political opening allows individuals excluded from the decision-making processes of movements to gain access to them. In nondemocratic systems, the individuals of less-favored classes do not possess rights and do not have representatives in the decision-making process. The process of political opening allows the opportunity for these individuals to organize and mobilize. The organization and mobilization allow new alliances to be formed, often creating conflicts within the dominant class, and thus generating divisions that serve as an incentive for collective actions. Political opportunity also favors the appearance of alliances within society that consequently act as another stimulus to collective action. Taking Brazil as an example, the division between hard-line militarists and moderates allowed the mobilization for collective action in favor of direct presidential elections and the support of society for social movements struggling for land reform.

McAdam (1982) argued that political arrangements change over time, allowing certain segments of society to benefit from these arrangements as well as advance their interests. This author also argues that isolated factors related to

the sociopolitical environment and internal factors within social movements are not sufficient to generate and develop collective action. In reality, the theory of political process is centered on the hypothesis that social movements are a product of the linkage between two connected factors. Thus, social movements vary in characteristics and organization according to the type of political authority that they challenge. In other words, the changes in social movement strategy are the result of changes in power structure. Consequently, the collective identity and the strategy of actions are determined by interactions with the political environment on the ground and, particularly, with state institutions (McAdams 1982).

Besides all of these theories of social movements, Meyer and Staggenborg (1996) argued that what is important is the recognition that the development of social movements, their tactics, and impacts are profoundly affected by changes in factors external to movements themselves. These external factors can be linked to the presence of the state as a facilitator or constrainer of political opportunities. Therefore, the strong presence of the state in Latin American politics has created specific political conditions for the rise of social movements in that part of the world.

3.4 Social Movements in Latin America

In the same way that social movements influenced social science in Europe and the United States, they also influenced Latin America. The European theory of social movements had been built in a social and historical context that included social-democratic consensus, the growth of state welfare, and a strong

corporatist tradition (Foweraker 1995). Consequently, the theory of social movements sought to explain social movements as a result of social changes. In the United States, to the contrary, there was not a strong corporatist tradition and the worker's movement was not as strong as in Europe. Therefore, the emergence of social movements was explained not by social changes but as a consequence of the ability of movements to organize and gain representation within the pluralist political system (Forewaker 1995).

In the beginning, Latin American scholars used the same type of frameworks developed by scholars in the United States and Europe, and little effort was put toward the development of alternative models sensitive to the political and social context of Latin America (Foweraker 1995). Nevertheless, at the time, scholars observed that resource mobilization theory, as applied in the United States, was not completely applicable to the reality of Latin America. The rejection of resource mobilization theory was based on the argument that there had been a crisis of the State in Latin America with the existence of nondemocratic regimes. Consequently, for Latin American scholars, the theory of a pluralist state did not apply to the Latin American context, where the state was authoritarian.[16] For Foweraker (1995), resource mobilization theory should not be completely discarded once the appearance of social movements with specific and well-elaborated strategies occurred in countries with nondemocratic regimes. As an alternative, Latin American scholars searched for a greater focus on the

[16] There are strong differences among Latin American countries; however, for the Latin American scholar, what was important to justify the rejection of the resource mobilization theory was the lack of nondemocratic regimes and a strong dictatorialship in many Latin American countries in the 1970s and 1980s.

theory of political process (Calderón et al. 1992; Escobar 1992; Escobar and Alvarez 1992). Ultimately, this approach also suffered criticism once the majority of Latin American scholars perceived that the political opportunity model was too centered on state actions and consequently had little utility in a region where the state was considered an opponent (Davis 1999).

In this context, for Latin American scholars, the political opportunity approach was over-preoccupied with the elite and the resources of individuals (Foweraker 1995). In other words, this approach was not seen to have any concern with society. Traditional approaches demonstrated inadequacies in the characterization of protests that grew in Latin America in the 1980s, principally in urban areas. These protests were characterized in a manner that differentiated them from those occurring in the 1960s and 1970s in the United States and Europe, leading scholars to call them "New Social Movements" (NSM) once scholars believed that these movements expressed new popular interests (Foweraker 1995).

In reality, the approach of New Social Movements stemmed from post-structuralist and post-Marxist frameworks coming from Europe in the 1970s and becoming popular among Latin American scholars. However, New Social Movements in Europe appeared as a response to post-industrial contradictions, while in Latin America these movements appeared as a response to material demands that sought to satisfy basic needs (Hellman 1992). Within this context, scholars believed that social movements had the power to transform civil society (Davis 1999). Thus, the theory of New Social Movements would be perceived as

focusing on civil society (Oxhorn 1995; Escobar and Alvarez 1992), as well as allowing questions relating to the meanings and identity of the movements themselves instead of resource mobilization strategies (Cohen 1985). Consequently, what made this theory applicable to the region was its autonomy and distance from the state and formal political process (Melucci 1980; Scott 1990).

Evers (1985) argued that social movements in Latin American rose where the "left" was suppressed. For example, the development of grassroots movements in Chile, Brazil, and Mexico are frequently seen as evidence that these social movements are the result of authoritarian regimes. Thus, these movements grew and spread in locales with a lack of democratic institutions or in areas with few opportunities for political expression. The existence of repression had a strong impact on the rise of social movements in some Latin American countries, principally in urban regions or areas with few opportunities for political expression. However, on the one hand, there is no dearth of studies focused on the role of the state in the strategies and formation of social movements in Latin America (e.g., Foweraker 1995, Alvarez et al. 1998; Eckstein 2001); on the other hand, there is a gap in the literature about the mobilization of rural workers (Starn 1992). It is well known that a rural social movement organization in Latin America is associated with the presence of unequal agrarian structures, lack of institutionalization, and poor legal and political channels through which rural workers can pursue their claims. However, the focus of studies about land reform

in many Latin American countries has typically been on impacts of land reform programs.

For this reason, the rise of social movements focused on agrarian reform in Latin America in general, and Brazil in particular, has recently called attention to their mobilization tactics (which include the occupation of private and public properties through encampments) and settlement formation, but never was the problem of land reform settlement formation explored. Thus, in the next section I will explore the role of social movement organizations of rural workers in Brazil and their role in direct action land reform.

3.4.1 The Social Movement Organization of Rural Workers and Direct Action Land Reform (DALR) in Brazil

Among Latin American countries, Brazil is without doubt one of the countries with the highest level of land concentration,[17] and remains a place where the struggle for the redistribution of land is not new. This struggle has existed since the 1940s and 1950s and was initially led by the *Ligas Camponesas* (Peasant Leagues) and the *União dos Lavradores e Trabalhadores Agrícolas do Brasil* (ULTAB, Union of Rural Workers). The post-war era was marked by significant conflicts between capitalist and communist nations, and the cold war dominated the international political scene. As a result, social movements were frequently associated with communist uprisings, and in the case of Brazil, social movements were associated with the Cuban revolution.

[17] Paraguay has the highest land concentration index (0.93) among Latin American countries, followed by Peru (0.86), and Brazil (0.85) (FAO 2007).

The example of communist revolution in many Latin American nations served as a model to strengthen social movements and increase popular protests that led the Brazilian government to act to constrain popular revolt. One of the first steps was the creation of the *Superintendência de Reforma Agrária (*SUPRA, Superintendence for Agrarian Reform) in 1962. This agency, among other activities, facilitated the unionization of rural workers that would serve as the base for the creation of the *Conferência Nacional dos Trabalhadores Rurais* (National Conference of Rural Workers) and the creation of the Rural Worker Statute in 1963. However, with the military coup in 1964, social movements and workers' unions became clandestine. Despite these conditions, these associations and movements did not cease their activities meant to stimulate the struggle for structural changes in the agrarian sector of the country. Preoccupied with potential popular revolt and attempting to ameliorate a tense situation in the countryside, the military government created the previously discussed Land Statute (*Estatuto da Terra*) in April 1964.

If, in the beginning, the main objective of the Land Statute was to calm and satisfy the anxieties of the general public, this law would also orient the future of agrarian politics during the following decades, persisting in its influence until today. In addition, this law allowed the possibility of land expropriation, with monetary compensation, in cases where social interest dictated the need. However, the definition of social interest was associated primarily with the question of land conflict. The legal benefits that the capitalist class received since the colonial period facilitated the concentration of land and had been the source

of conflicts in various regions of Brazil. The goal of the Land Statute was to eliminate a property that was a source of conflicts. In other words, the Land Statute of 1964 had as one of its objectives the elimination of properties of less than one rural module (*minifúndio*) and the end of *latifúndio*.

According to the Land Statute, *minifúndios* were incapable of generating adequate levels of production to meet subsistence needs. In addition, the Land Statute sought to end *latifúndio* that over centuries was seen as the principal factor leading to the underdevelopment of Brazilian agriculture. To accomplish this, the Land Statute sought to modernize agriculture. By addressing Brazil's problems of agricultural development while simultaneously attempting to resolve the existing conflicts between small and large producers, the Land Statute would create further conflicts. In other words, the modernization of agriculture would be accompanied by a massive mechanization that would bring about the dislocation of rural workers. The Brazilian literature covering these shifts is rich in examples of the mass of rural workers that had been dislocated to cities, joining the urban society already marginalized by a lack of formal employment (Chase 1999; Browder 1994; Silva 1982). The result of migration to these urban areas was an increase in protests for agrarian reform.

This period of agricultural modernization was also marked by struggles for the democratization of Brazil, principally in most industrialized cities. Tired of violence, economic crises, and repression by the military government, the Brazilian elite began to indirectly support social movements focused on the struggle for the democratization of Brazil. Taking advantage of the struggle for

democratization, many social movements, unions, and community associations began to emerge. Among these was the movement of rural landless workers (*Movimento dos Trabalhadores Rurais Sem-Terra*, or MST), which is one of the most important social movements for land reform in Latin American history. Tired of waiting for ample land reform, this movement was founded in 1984 and it recognized the necessity to use the occupation of land as an instrument in their struggle.

Thus, the democratization of Brazil in 1985 opened the doors for the Brazilian population and social movement organizations to reaffirm the necessity of land reform. Taking advantage of the end of the military regime, in 1985 the MST realized its first national congress under the slogan "occupation is the only solution (*"Ocupação é a única solução"*). The principal argument of the Landless Rural Movement, sustained by many rural social movements (e.g., FETAGRI - *Federação dos Trabalhadores da Agricultura*, CPT - *Comissão Pastoral da Terra*, MLPT - *Movimento de Luta Pela Terra*), is that land occupations are necessary in the venture to redistribute land and thus accomplish a more democratic agrarian structure.

Consequently, the pressure of social movements and the support of civil society led President José Sarney to approve the *Primeiro Plano National de Reforma Agrária* in 1985 (I PNRA, First National Agrarian Reform Plan), which had as its objective the rapid application of the Land Statute and the implementation of land reform. Once more, land reform remained on paper. Although various elected presidents have developed their own agrarian reform

plans, the concentration of land in Brazil has yet to decline. As a result, leading social movements (e.g., MST, FETAGRI, MLPT, CPT) rely on direct action land reform (DALR) (Simmons 2006), which has led to an explosion of encampments (*acampamentos*), land occupations, and the creation of settlements (*assentamentos*) throughout Brazil (Figure 4).

Between 1992 and 2000, the number of families participating in direct action land reform (DALR), with the support of the *Movimento do Trabalhadores Sem-Terra* (MST), increased from 100,000 to 560,000 families[18] (MST 2006). Solely in the Amazon region, nearly 705 *assentamentos* were created, encompassing 185,000 families and 12 million hectares between 1979 and 1999 (Fernandes 2000).

[18] Land reform numbers vary among government agencies and nongovernmental organizations, such as The Landless Movement of Rural Workers.

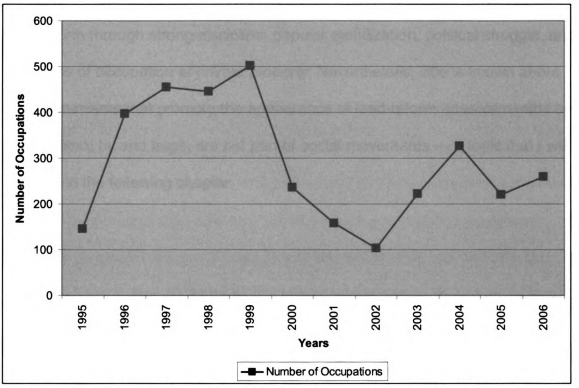

Figure 4. Evolution of Land Occupation in Brazil, 1995 – 2005. Source: INCRA 2005

Thus, the explosion of rural *assentamentos* in Brazil was called to the attention of researchers[19] (Simmons 2006; Brandão and Souza 2006; Fearnside 2001; Fernandes 2000). However, many of these studies have been focused more on the characteristics of *assentamentos* and the causes of their success or failure than on the factors that led to their appearance (Simmons 2006). Consequently, a significant gap in the literature exists, and the role of land reform *assentamentos* in the modification of land cover is only beginning to be questioned. For instance, Simmons (2006) suggested that new land reform *assentamentos* in the Amazon could be responsible for significant changes in

[19] Brazil has 7,694 settlements involving an area of 74 million hectares and 822,284 families (INCRA 2007a).

vegetative cover. However, her study focuses on the *settlements* led by social movement organizations (SMOs). These SMOs typically focus their struggle for land reform through strong discipline, popular mobilization, political struggle, and strategies of occupation of private property. Nevertheless, little is known about the mechanisms that promote the appearance of land reform *assentamentos* by settlers who, by and large, are not part of social movements — a topic that I will address in the following chapter.

CHAPTER 4: SOCIAL CONTENTION, LAND OCCUPATION, MIGRATION AND *ASSENTAMENTO* FORMATION

Up to this point in this dissertation I have argued that *assentamento* formation has important environmental impacts on the tropical forest. However, the spontaneous appropriation of unclaimed public land through *assentamento* formation is not well understood. The *assentamento* formation schema is a result of social processes that can be addressed through a conceptual framework called contentious politics. This conceptual framework is very common in the political sciences, though it has not been frequently used in geography with some exceptions (Simmons et al. 2002, 2007; Wolford 2003a, 2004; Simmons 2005). Wolford (2003a), for instance, applied contentious political concepts in describing why landless participants decide to join the landless movement in Brazil. She argued that Brazil has an unequal land distribution and that a few landowners control the vast majority of land. Thus, the potential benefits of joining social movement organizations (such as the Movement of Rural Landless Workers) are clear (see also Wolford 2004). Simmons et al. (2007), on the other hand, detailed the contentious mechanisms (environmental, cognitive, and relational) that have led to violent land conflict in southern Pará State. Their approach considered the link between violence, land distribution, and the institution of property as promulgated in the Brazilian constitution. However, violence in *assentamento* formation is not new or uncommon in the Amazon. Simmons et al. (2002) developed a hypothetical two-stage model of land conflict evolution in the

Amazon that acknowledges rural and urban dynamics. The first stage of their model involves a purely agricultural frontier[20] with individualized conflicts between small farmers and large holders clashing in a competition for land resources. The second stage of their model of land conflict approaches organized resistance emerging as a result of urbanization. In other words, urbanization in this stage facilitates the large-scale political mobilization of different groups on both sides of the land struggle. Nonetheless, I adopted the notion that *assentamento* formation can be nonviolent, and as such, it is different from the approach used by Simmons et al. (2002, 2007). Thus, the type of settlement I refer to in this dissertation is not social movement oriented. On the contrary, I argue that existing direct action land reform (DALR) appeared as a consequence of the first colonization policies that attracted colonists to the region, and continue to attract migrants, as early *agrovilas* grow into towns. In addition, I argue that as the sons and daughters of early colonists begin to establish their own properties, it consequently leads to new settlement formation. Thus, throughout this dissertation I will refer to this type of settlement as spontaneous.

This chapter seeks to describe the contentious process of *assentamento* formation, and places it within a land cover and land use change framework by describing the underlying processes that lead to *assentamento* formation, and it also details the resulting proximate land cover impacts.

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[20] "Frontier" is defined as a region of abundant resources and weak institutions (for more details Simmons et al. 2002; Mueller et al. 1994; Alston et al. 2000).

4.1 Social Contention in the Amazon

In the previous sections I highlighted the ambiguity of Brazil's land laws and the institutional policies that favor land concentration. In addition, I suggested that direct action land reform (DALR) uses this ambiguity as an institutional cover for targeting large holdings that have not fulfilled their social function in accordance with the Land Statute of 1964 (*Estatuto da Terra*) and the Brazilian Constitution of 1988 (Treccani 2001; Simmons et al. 2007). Also, I argued that *assentamento* formation can be addressed by a conceptual framework called contentious politics. But what is contentious politics? Contentious politics does not have a specific definition. For instance, McAdam et al. (2001, 5) referred to contentious politics as:

> *episodic, public, collective interaction among makers of claim and their objectives when (a) at least one government is a claimant, an object of claims, or a party to the claims and (b) the claims would, if realized, affect the interests of at least one of the claimants.*

These authors stated that this definition can be roughly translated as meaning collective political struggle (McAdam et al. 2001) because contentious politics, in their point of view, is episodic rather than routine. Also, they used the term public to eliminate claim making that happens within well-defined organizations, such as firms. Thus, they concentrate on claims that have political implications. Therefore, contentious politics in this dissertation will differ from

politics "as usual" by virtue of its innovative, often conflictive, tactics deployed in episodic efforts to redress a social wrong (McAdam et al. 2001; Sewell 2001). Thus, DALR may be regarded as contentious because it seeks to redress the maldistribution of land and because its premier tactic, land *occupation*, falls outside conventional societal grievance channels.

Contention in the struggle for land in Amazônia results from a convergence of political interests, social needs, and institutional opportunities. Political interests have been well described by research on Brazil's social movements; and these studies have demonstrated that political interest, such as the democratization of Brazil or the struggle for land reform, had put together different social movement organizations with different political agendas (Cardoso 1983; Mainwaring 1989; Assies 1994; Fernandes 2000). The social needs for land reform in Brazil verges on the obvious and has been the discussion of extensive commentary and much research (Muller et al. 1994; Alston et al. 2000, 2005; Fearnside 2001; Simmons et al. 2002; Simmons 2004; Wolford 2003a). On the other hand, institutional opportunities (a focus of the present discussion) are less apparent but no less important to the current situation in Amazônia and throughout Brazil more generally. I refer here to the structure of land law as well as to the status of certain lands in federal holdings, *terra devoluta*. The particular nature of the institutional opportunity results from a definition of property stemming from the earliest days of the colony and from a relatively novel statement of land rights found in the new (1988) republican constitution. Under this set of laws, individuals wanting land have clearly stated rights and may

possess land under constitutional stipulations. Private land can be expropriated if it does not meet its social use function (article 184 of the 1988 Brazilian Constitution), or it can be expropriated if occupied without contestation for an uninterrupted period of 5 years (article 191 of the 1988 Brazilian Constitution). *Terra devoluta*, which is vulnerable to actions of physical possession by land-desirous individuals, cannot be expropriated (article 191, §1 of the 1988 Brazilian Constitution). However, t*erra devoluta* in the Brazilian Amazon is presently the land most vulnerable to occupation because of its historical origins in the system of *sesmarias*.

Private holdings have their defenders, as do public lands dedicated to distinct social purposes, such as national parks. But no one champions the sanctity of *terra devoluta*. In fact, a sense of "free for all" often prevails, with people taking what they want and paying little or no attention to the legal niceties. Thus, this dissertation hypothesizes that current property institutions in Brazil, formal and informal, legal and extra-legal, constitute a primary underlying cause of land cover and land use change in the Amazon basin via the proximate causation of *assentamento* formation.

4.2 The Conceptual Framework

This dissertation deploys contentious politics theory within the land cover and land use change discourse, and specifically within the underlying/proximate causation (UPC) framework. I argue here that the UPC framework to date has tended to provide considerable generalizations across highly aggregate factors (e.g., demographic factors, economic factors, technological factors,

infrastructure, wood extraction, among others; see Geist and Lambin 2002), which complicates applications to specific processes of possible interest. Thus, I adapt the UPC conceptual framework to the purposes of the present dissertation by drawing attention to *assentamento* formation processes and land cover change in the Amazon basin, as depicted in Figure 5.

The conceptual framework is not a definitive model, and I base it in part on anecdotal information collected over the past few years of field visits to the region. Thus, the conceptual model developed here can be interpreted as a set of hypothetical statements regarding both *assentamento* creation and impact on the landscape. The framework in Figure 5 shows several "underlying" factors grouped in the upper panel. These underlying causes acting at macro- and microscales affect population. Thus, to understand how underlying causes affect population, it is first necessary to understand how macropolicies were developed and how they affected the Brazilian population, leading to social marginalization.

4.2.1 Macropolicies and Social Marginalization

Following the military takeover of 1964, the federal government pursued import-substitution industrialization by constraining imports of consumer goods and stimulating investments in industrialization. To accomplish their goal, the state invested in infrastructure in the country's largest urban centers (Howe and Goodman 1992). Brazilian agriculture in the 1970s was extremely underdeveloped, with very low yields for world standards. Policies to modernize agriculture were almost nonexistent, with some exceptions to improve coffee, cotton, and sugarcane production (Pastore et al. 1976). The expansion of

Brazilian agriculture in this period was due mainly to road building programs. In other words, the military regime enabled the construction of new roads that facilitated the efforts of farmers to bring more land into cultivation. Thus, the increase in production was from an increase in cultivated area and not from increases in productivity. Nonetheless, Brazil still had plenty of unused land in savanna (*Cerrado*) areas, but there were no technologies for their utilization (Mueller and Mueller 2006).

Facing pressures for agriculture development, the military regime took action to construct conditions for intensive exploitation of the lands. Thus, the state embarked on policies of "conservative modernization" (Martine 1993). Seeking to build a modern agriculture, the military regime created a rural credit system to provide sufficient amounts of financing to agribusiness at low interest rates (Mahar 1979; Hecht 1985; Browder 1988). Toward this goal, the state offered low-interest credit for purchasing land and modern inputs. The objective was to induce farmers to improve their production methods by purchasing modern technologies, such as tractors (Silva 1981). However, low interest rates favored large farmers or more capitalized landowners, permitting land concentration. Consequently, this macropolicy favored the creation of a *minifúnfio-latifúndio* complex that did not make sufficient land available for subsistence farming, thus forcing peasants to find work outside their farms in order to supplement their livelihood (Foweraker 1981). This type of macroeconomic policy favored agricultural expansion until the beginning of the 1980s; but in the mid 1980s, inflation was again more than 200% a year, and

Brazil suffered its worse recession in the twentieth century. Consequently, a range of orthodox restrictions was introduced. For instance, wages were controlled and credit was constrained. The real interest rates on farm loans became positive; and the incentives and subsidies of the credit policy ceased, increasing unemployment rates. Nevertheless, during this entire period land concentration did not decrease. Consequently, the 1980s were known as "the lost decade" (Weinmann 2007; Cohen and Portes 2003). The search for economic growth led the Brazilian government to develop and try many stabilization plans (e.g., *Plano Cruzado I and II, Plano Collor I and II*), but all failed. Between 1993 and 1994, the Real Stabilization Plan was successfully implemented. However, despite the changes meant to modernize agriculture and the Brazilian economy as a whole, the country still showed one of the worst patterns of income distribution in the world, with rural poverty levels still high (Barros et al. 2001). Consequently, rural poverty, unemployment, and land concentration continued to stimulate migration to urban settings. As a result, masses of rural workers were led to social marginalization. This process of social marginalization has streamed two distinct social processes of settlement formation in the Amazon basin that are described in the conceptual framework (Figure 5). On the left, the social marginalization lead to the formation of *assentamentos* with Social Movement Organization (SMO) leadership, such as the one lead by the Movement of Rural Landless Workers; while on the right, the social marginalization lead to the formation of Spontaneous Direct Action Land Reform settlement. Although the populations at risk are quite similar in both

cases, and step forward from the ranks of the rural landless and the urban unemployed, I argue that a sharp distinction exists between these two types of settlements. Here, I use the statement developed by Wolford (2003b) to support the link between contentious political and social movements and my hypothesis in my framework. In other words, the appearance of SMO-led settlements are politically motivated, with landless people being the ones with the weakest family ties and with the least to lose from violating social norms (Wolford 2003b). On the other hand, I argue that spontaneous settlements appear as a result of family networks that were developed as a consequence of early land reform policies that attracted thousands of people to the region and stimulated the appearance of towns that act as pull factors attracting migrants to the region. Clearly, whatever the type of settlement, the land law in Brazil favors both the *assentamento* formation by isolated individuals and *assentamento* formation by social movement organizations.

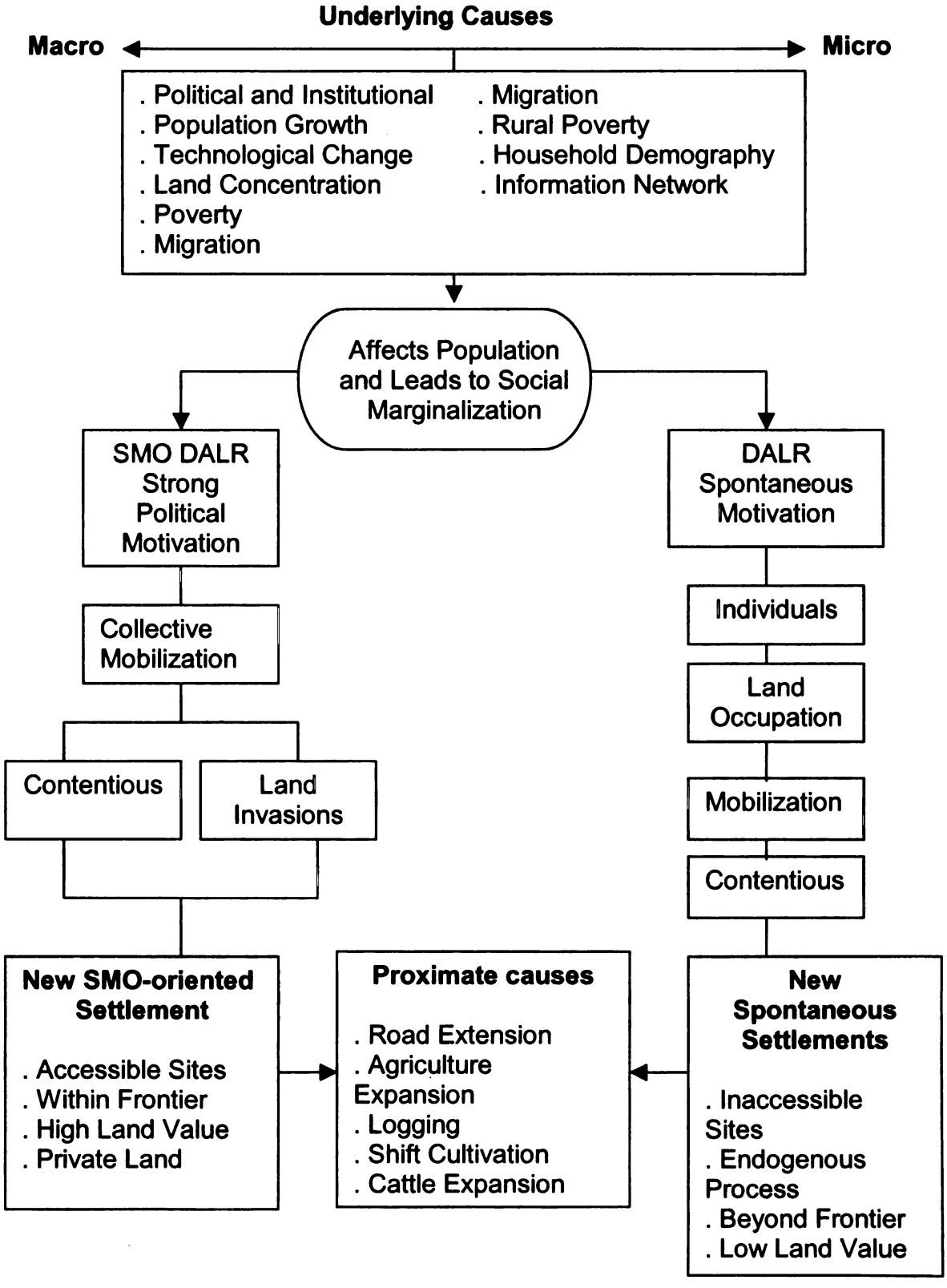

Figure 5. The conceptual framework of settlement formation.

4.2.2 Migration and Network Theory

Several studies around the world have shown that personal networks of friends and relatives are crucial supporters of migration (Mahmood 1991; Nair 1991, 1998; among others). No attempt is made here to fully review the body of migration and network chain theory. Rather than attempt to describe all research about migration and factors affecting migration, this section is restricted to highlighting the importance of urbanization and social networks in attracting people to settlement frontiers in the Brazilian Amazon.

4.2.2.1 Migration and Social Networks in Settlement Areas

Human migration is generally the movement of people across a specified boundary for the purpose of establishing a new or semipermanent residence, and migration has become an important livelihood strategy for many poor people across the world (Deshingkar and Grimm 2004). However, the decision to move can be attached to many factors. An individual's kinship ties, financial welfare, personal values, and survival itself may be important in deciding to migrate. Scholars have researched migration in Brazil from many different perspectives. Some have described interregional movement by analyzing data from government agencies (Dawsey 1983; Goodman 1989; Merrick 1989), while others have focused more on communities and based their findings on interviews with local residents (Muller 1986; Lisansky 1990). Many of these studies have elaborated hypotheses regarding mechanisms causing migration and the impact on destination and source area.

In general, the migration process can be a result of "pull and push" factors. The "push" factors are those related to life experience that gives an individual reasons to be dissatisfied with his present place (Shaw 1976; Dorigo and Tobler 1983). The "pull" factors are those characteristics of distant places that make them appear attractive. Economic crisis, low social welfare (poverty), and unemployment all generate dissatisfaction with an individual's present locale. Consequently, migration occurs if an individual's basic needs at a potential destination are perceived to be greater than at his present location. Investigation of migration in Brazil has focused on rural-urban migration, a characteristic of much of the underdeveloped countries. However, important differences exist between Brazil and other countries. For instance, a high level of industrial development in Brazil differentiates this country from African nations where urban population is also expanding (Berry 1986; Gugler 1986). In evaluating rural-to-urban migration in Brazil, the dominant motivator seems to be "push" conditions in rural areas. The increasing scarcity of rural labor opportunities, agricultural technological change, and land concentration (Shaw 1976; Saint and Goldsmith 1980; Goodman 1989; Michaels 1990) have forced many people off their lands. In addition, a better transportation system facilitates migration and provides farm workers with the option of living in urban centers rather than rural areas. However, the same "push" factors of land concentration, agricultural mechanization, industrialization, and unemployment in urban centers have also driven people back to rural areas (Lisansky 1990). The Brazilian development policy of the 1970s has arguably been the most important factor causing

migration to rural areas, mainly to the Amazon region (Schimink and Wood 1984; Moran 1981; Browder and Godfrey 1997). The military government of 1964 promoted programs to stimulate migration and integrate the Amazon region into the national economy. The efforts of the military government were heavily concentrated in road building and colonization settlements, mainly along the Transamazon highway; and many studies have focused on the characteristics of migrants to this area and on the impacts on the land (Walker et al. 2002; McCraken et al. 1999; Caldas et al. 2007). Undoubtedly, the Amazon region experienced rapid rural in-migration and state-led colonization schemes flourished in the basin. The wish of a better life motivated people to migrate to the frontier. However, the long-standing rural idea of agrovillages is part of the past, and urban centers started to proliferate in precarious conditions to become municipalities, attracting migrants to work in agriculture, cattle ranching, timber extraction, and other natural resource areas (Godfrey 1992). Browder and Godfrey (1997) stated that many new towns in the Amazon emerged spontaneously, especially at the intersection of national and state highways and at local feeder roads. These authors explained that many of these towns provide a limited range of functions associated with their strategic location, such as auto repair, restaurants, hotels, and other services; and they often support only a small resident population with a limited potential for growth or structural development. They also noted that other cities at network junctions have "taken off" and become important locations for extractive forest industries, regional commerce, and services. Thus, the urban growth idea feeds the imagination of

the colonists that passes this idea on through an informal social network. However, the role of informal social channels, consisting of friends and relatives, from colonization areas in the Brazilian Amazon is not well understood; but my anecdotal evidence recognizes them as an important factor for encouraging additional migration to the forest frontier. Families and friends with migration experience provide initial contacts and information and, in some cases, may sponsor the move by a subsequent kin or friend. MacDonald and McDonald (1964) describe this type of migration as chain migration, and it has alternatively been labeled "kin-mediated migration" (Lomnitz 1977) and "network migration," where the latter term comprehends a variety of social relationships in addition to kinship (Massey 1987; Mines and de Janvry 1982).

Network migration through friends and relatives in a settlement frontier can result in several favorable consequences for migrants because the social network can lower substantially the costs and risks associated with the move to an unknown area. Kin and friends may aid migrants in a forest frontier in a variety of ways: they inform migrants about land availability in *terra devoluta*, they can assist migrants in finding land, they orient migrants to life in the town, and often constitute the primary source of continuing social relationships and moral support once migrants have established themselves at their parcel of land. My anecdotal observations suggest that expansion of networks can lead to more migration, which can lead to the expansion of the network. Thus, network chain migration can be a very important mechanism for supporting migration and settlement formation in the Amazon region.

4.2.3 Settlement Formation and Land Cover Change

Since 1985, with the approval of the slogan *"Ocupação é a única solução"* ("Occupation is the only solution") by the Movement of the Rural Landless Workers (MST), the fundamental tactic of any SMO struggling for land reform in Brazil is land occupation and mobilization (Branford and Rocha 2002).[21] Small towns in the urban settings of the Amazon have limited urban opportunities for employment. This leads to migrant and urban worker discontent and harbors feelings of social injustice, thereby creating a group of people desiring a return to the countryside, as well as one that may be easily mobilized for land occupation (Wolford 2003a). However, not everyone affected by agricultural restructuring and political transition join SMOs, such as the MST. Wolford (2003b) argued that social relations are embedded in a particular spatial context and they are critically important to the decision to join an SMO. She argued that people who chose to join the MST during an economic crisis are the ones who have the weakest ties to family and community and, as a consequence, had the least to lose from violating social norms. Also, she stated that they were the ones where land represented tradition, subsistence, social reproduction, citizenship, and community (Wolford 2003a). Thus, in a country facing continuous economic deprivation as a consequence of constant unemployment, economic crises, and land concentration, the cities are transformed into places that provide inspiration for involvement in the landless movement (Simmons et al. 2002).

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[21] A crucial distinction between occupation and invasion exists. In the discourse of the landless militants, they occupy land that is not in fulfillment of a social function. However, for landowners, the landless movement is invading their properties. Thus, in this dissertation, occupation and invasion will be used as the same.

The concept of place has long been discussed by many authors as important in the understanding of political, economic, and cultural processes (see Massey 1984; Massey and Allen 1984; Cox 1997). In addition, this concept has facilitated the understanding of place as areas of resistance (Miller 1994; Staeheli 1994; McAdam et al. 2001; Wolford 2003b; Simmons 2005; Simmons et al. 2007). Simmons et al. (2007), for instance, argued that place is a site where economic, social, and political processes interact across spatial scale, consequently creating the conditions of daily life where meanings and values shape up, creating community identity and resistance (see also Agnew 1987; Woldford 2004). Thus, SMOs, taking advantage of places as source resistance and inspiration against social injustice, instruct their landless militants (*Frente de Massa*) to spend weeks or even months recruiting families in both urban and rural places. The objective of the landless militant is to target different groups of individuals, including small farmers and sharecroppers who have lost the right to use the land, rural wageworkers, *posseiros*[22], and unemployed urban people. All these impoverished recruits have in common a strong sense of social injustice that facilitates the identity formation that is critical to the understanding of membership in social movements, and especially those dedicated to land reform in Brazil, such as the MST (Wolford 2003a; Simmons et al. 2007). In fact, some SMOs such as the MST argued that the urban place is important for mobilization and is a fundamental objective of its national political struggle (Petras 1998). Consequently, identity formation among militants and the poor creates a

[22] *Posseiro* means squatter. However, *posseiro* in Portuguese does not have the negative meaning that squatter has in English.

conscious framework for contentious performances (Simmons et al. 2007). Thus, collective mobilization occurs in urban places, and land invasions happen simultaneously with contentious pressuring for land expropriation.

In general, the process of land occupation requires careful investigation, starting with the identification of a large property believed to be unproductive or eligible for agrarian reform for a failure to fulfill its social function. Here, the term social function can assume different forms. It can mean the use of slave labor in a farm, environmental problems, and so on. Thus, SMOs employ any kind of information that can be used to justify occupation. However, the identification of a property involves a complex network of rural workers, militants, lawyers, and even sympathizers of land reform in public offices. With the information of a property that is not fulfilling its social function, social movements start the logistical process of planning the occupation. In general, these SMOs often move in on targeted lands with military quickness and discipline, looking for areas with easy access (close to main roads and within the agricultural frontier), usually private land with high land value. In most cases, the process of occupation starts late at night when landless militants, wives and children, and their recruits (using cars, trucks, and buses) occupy the selected property with an encampment engaging several hundred families (Branford and Rocha 2002). However, this process is not an easy one. The decision to invade and settle a private property requires maturity, cohesion, discipline, optimism, and organization (Martins 2006).

The organization process for an occupation starts very early, with some basic precautions. For instance, movement militants contact the media with two purposes: (a) to make sure that the occupation will be broadcast to the public, and (b) to assure that they will have testimony and a public record in case of violence from the landowner (Branford and Rocha 2002). Once on the land, the families set up a large encampment made up of wooden huts covered with black plastic sheeting or palm fronds. The process of land expropriation can take months or years to occur. Normally, landowners ask for property reinstatement, and if that occurs, the landless workers are forced to leave the occupied land by the military police. One common approach used by SMOs to call attention to their problems is to shift their encampment to the margin of a public road. The main idea of moving to the margin is to be exposed to the public and media. They stay encamped and united until land is granted and to make use of the maximum amount of pressure on the system. Consequently, negotiation takes place; and the federal agency INCRA helps the encampment with food supplies (*cesta básica*). The tactic of occupation can lead to the occupation of the same property as many times as necessary to gain the land. While in the encampment, the landless workers develop an internal camp organization responsible for food production, education, health care, politics, and security, among other tasks. The objective of the organizational scheme is to develop a process of political-ideological formation through study groups of radical theory. In addition, landless workers learn that planning means democratic decision-making. In other words, landless workers participate in the organization and discussions by making

proposals (Martins 2006). The internal camp organization also plans and employs a variety of other pressure tactics, such as marches, road blockages, and the occupation of government buildings. The objective of all these tactics is typically to obligate the government to implement the constitutional clause mandating the expropriation of properties for agrarian reform. When triumphant, the landless workers receive parcels and provisionary titles in government-sponsored settlements, as well as investment in infrastructure such as schools, electricity, and roads. In addition, families can also benefit from credit through the program *Agricultura Familiar*. Last but not least, SMOs struggling for land reform try to keep the communities who have already received land politically mobilized to support further occupations by the still landless, as well as to keep fighting for social change (Martins 2006). Thus, SMOs struggling for land reform have, in their approach of land occupation, a complex combination of tactics and confidence on constitutional clauses that call for the Federal Government to expropriate uncultivated land and redistribute it to landless people, consequently creating new settlements.

This narrative stands in sharp contrast to my own anecdotal observations regarding spontaneous direct action land reform settlement, where *assentamentos* appear to be formed ex-post. In other words, land reform occurs after individuals acting in isolation, or disarticulated from each other, have occupied their lands. I argue here that spontaneous settlement formation is not only a consequence of democratization, but it also appears as a combination of a social process that started with social marginalization from macropolicies in

addition to early land reform policies that stimulated in-migration to the region (Moran 1981; Smith 1982; Simmons et al. 2002). It is important to remember that the first colonization policies of the military regime opened the Amazon frontier and attracted thousands of migrants to the region. These first wave migrants arrived with their families to live in *agrovilas* (agrovillages) along the Transamazon highway. After almost four decades, these *agrovilas* have grown into small-sized towns and, as such, act as a "pull" factor, attracting people from different regions through a network of information. In addition to this, through the demographic life cycle, old colonist families mature and their growing children start to search for land in order to begin a family (Chayanov 1966; Walker and Homma 1996; Wolford 2003a), generating new land demands outside old sites and consequently stimulating land occupation. Caldas et al. (2007), for instance, described how the household's agricultural economy shifted from subsistence to market production in colonization sites and consequently increased degradation through deforestation. These authors argued that, given initially low levels of capital and little farm experience, the first colonist families depended on shifting cultivation and annual crops and that this continued while the children were young and household dependency was high. With time, the children aged and their parents acquired agricultural experience, which mitigated risk aversion. With new family workers, the colonist household was now positioned to invest, through deferred consumption, in a farming system of greater commercial potential, typically a ranch, a perennials plantation, or some combination. Therefore, agricultural activities evolved in concert with deforestation. Thus, deforestation

increased in old *lotes*, increasing the amount of land for cultivation; but, depending on the agricultural system, environmental degradation can also rise. Consequently, the new land demand is also the result of worsening environmental conditions in the old colonization sites. As a result, forestlands in *terra devoluta* around old colonization sites are seen as unproductive and are targeted for occupation and settlement formation. Hence, the same legal structures, based in the Brazilian land law, that justify land invasion of private lands also are used to justify the occupation of public lands.

Nevertheless, I argue that the process of spontaneous settlement formation is different from the ones led by SMOs. Its dynamics start with the arrival of a young family in a parcel of land that contains primary forest. As the family matures along the household life cycle, many land use types are used (Walker and Homma 1996). As young children become adults, they begin their own demands for land. In other words, with the arrival of the adult phase, the new adults feel the necessity to start their own properties. Obviously, one way to solve this problem is through new land occupations. Different from earlier colonization when colonists did not have any type of family support, in this new process of spontaneous settlement formation family support is very important. Using the family's property in the old colonization site as a base for the new task, the new *posseiro* open trails (*picadas*) in the forest to choose a piece of land to be occupied (Perz et al. 2007). Two goals can be observed in this process. The first goal of the new *posseiro* is to make sure he/she is following the same road's trajectory (direction) of the old colonization sites. In other words, the *posseiro*

knows where the last colonist is living in the settlement road. Thus, he/she looks for the end of the colonization road and starts a new trail in the forest (Figure 6).

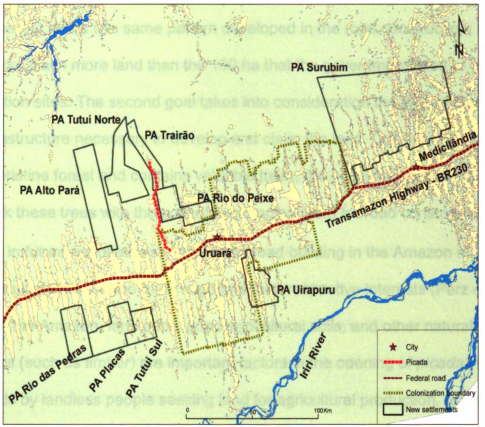


Figure 6. Road expansion and settlement formation in terra devoluta.

In sequence, he/she chooses a piece of land to make a *marcação* of the parcel that, in most cases, has the same size as the parcels in the old colonization zones. Here, the objective is to show to the land reform agency that he/she is just following the same pattern created by the federal government in the old colonization sites. In the beginning of the 1970s the land reform federal agency was responsible for building the official roads [also called primary roads or development roads (Perz et al. 2007), such as the Transamazon highway] and with demarcating 100-ha lots for colonists. To accomplish its task, INCRA also

built feeder roads running north-south, thus intersecting the Transamazon highway perpendicularly at 5-km intervals and extending 5 to 10 km from the Transamazon, called *travessões* or *vicinais* (Perz et al. 2007). In other words, *posseiros* just follow this same pattern developed in the road construction; also, they do not claim more land than the 100 ha that the government used to give in colonization sites. The second goal takes into consideration the lack of money and infrastructure necessary to develop and claim the land. Considering that the area is pristine forest and contains valuable trees, the *posseiro* starts to count and mark these trees with the goal of exchanging them for road construction services in future negotiations.[23] However, road building in the Amazon may involve multiple actors who must negotiate their respective interests (Perz et al. 2007). In the Amazon, land price, good agricultural soils, and other natural resources (such as timber) are important factors in the opening of *picadas* (trails) and roads by landless people seeking land for agricultural production. Equally, loggers are aware of the national and international timber market, paying close attention to prices of various timber species, and will build roads to acquire valuable trees. These two factors make *terra devoluta* in the Amazon very attractive. However, it is necessary to negotiate road building to reach this type of land, extract valuable trees, and gain land title to it by working it. As a result, the

[23] Arima et al. (2005) describing road building along the Transamazon highway stated that original federal road infrastructure, composed of the main highway and secondary roads, was extended in the area. These authors identified two main types of road extension. The first one comprises simple extension of the original secondary road following the government spur that they call destination-indeterminate, with this road just replicating the initial settlement geometry of the old colonization site. The second type of road they referred to as destination-determinate, as it achieves a discernible spatial objective. Both destination-indeterminate and destination-determinate roads are typically built by well-capitalized loggers with help from colonists and local government.

social actors involved visualize their preferred route for the road, or (in other words) the participating interest groups will act according to their own particular motivations, depending on the natural resources they seek to control. Therefore, roads can help to demonstrate investments toward productive use before the state (Perz et al. 2007). Consequently, the next step is the deforestation process, generally necessary to demonstrate productive use of the land. The initial deforestation will serve to pressure the Federal Government to demarcate the land as the land is in fulfillment of its social function, or in other words, it is in production. Also, land occupation close to the family's property has some advantages because forest frontier is, in general, an inhospitable area without roads or any kind of services, and proximity to the family's property facilitates the mobility to work in the new area. Thus, proximity facilitates the exchange of family labor necessary to consolidate the new property. Also, proximity can help the new *posseiro* to secure the new area. The Land Statute clause of *morada habitual* (article 11, chapter III) almost obligates the *posseiro* to show that he/she is using and living on the land, and his/her absence for a long period of time can lead another *posseiro* to claim the land. In addition, the location of the new parcel can facilitate the appearance of a family network that can be used in the future as a source of resources for mobilization. Obviously, the network can also appear among *posseiros* through time by solidarity and confidence. In this case, it can lead to creation of associations, communities, or another form of grouping, formal or informal.

In general, the mobilization and the appearance of an association in spontaneous settlements are led by the oldest *posseiros* in the area and assume two important roles. First, it is through mobilization that the new *posseiros* will negotiate with loggers the creation of roads[24] necessary for land consolidation. Normally, the *posseiro* opens trails in the forest and uses them for a long period of time with two main goals: to demarcate the land and to demarcate the valuable trees. In the process of land occupation, the *posseiro* demarcates valuable trees to exchange for road construction, making the area more attractive and valuable. Simmons (2005) argues that, on the frontier, land values are low, property rights are ill-defined, and investments are minimal. However, with mobilization of *posseiros*, enough trees can be joined to exchange for road construction, which can stimulate production and raise property values.

One should also note that mobilization is not only important for road construction. Brazil is going through an important political and socioeconomic process with pressures for land reform occurring in every part of the country. Obviously, *posseiros* have a perception that they can benefit from this process. But to achieve their goals they need to organize and to mobilize to struggle for their rights. Simmons (2006) stated that a cognitive mechanism that includes the processes or events that shape people's perception exists and sets the stage for actions and reactions to contention. Thus, the *posseiros*, using the same type of contentious politics that occurs in other parts of Brazil, bring people into collective

[24] For more details about roads creation in the Amazon, see Arima et al. (2005).

action through alliance. Clearly, the practice of building solidarity among them reinforces the collective commitments to pressure INCRA for land reform. However, alliances are not only present among themselves. Support from influential allies, such as local syndicates and local politicians, are also key contributions to the process. Local politicians can benefit from settlement consolidation through future votes in local elections, and local syndicates can strengthen their political power with new members (Toni 1999).

The process described above suggests that there exists an endogenous process that is occurring around old colonization sites. Unofficial roads (Perz et al. 2007) built by the interaction of landless people and loggers involve a sociospatial process that results in settlement formation. However, this process is not the only one affecting spontaneous settlement creation. Migration seems to be one of the main factors. Through family networks and social ties, the old colonization schemes work as an engine that attracts people to the region. That is, a family's network and social ties inside the old colonization schemes (agrovillages) serve as a source of information about new areas for land occupation. Information spreads out rapidly through community networks (Wolford 2003b) and many *posseiros* hear about a new area by talking to their friends or relatives.

Differing from settlements led by SMOs, spontaneous direct action land reform apparently seeks out unclaimed lands, beyond the agricultural frontier, where land is of low value, thus minimizing the personal risk of individuals who occupy land without organizational support or assistance from the state. On the

one hand, SMO-led efforts targeted properties pursuant to movement objectives (such as obtaining productive lands with some infrastructure for their membership or raising the organizational profile through confrontations with the state or select individuals); on the other hand, in the spontaneous settlement formation process, mobilization occurs after the land has been occupied. In addition, the contention that occurs is for land legalization and *assentamento* creation. In such a situation, *assentamento* creation evidently provides an institutional mechanism for obtaining land title, and perhaps the liberation of resources for road building and other social services useful to agricultural activity in remote areas (Laurance et al. 2001). Consequently, with time and the consolidation of the settlement, farming increases (or proceeds) and deforestation increases. In other words, the formation of the *assentamento* acts as a proximate cause of land cover change through the farming practices of project participants. Thus, given the additional resources available for *assentamento* formation and the security of land occupation in settlement areas, deforestation and forest fragmentation may be intensified in the settlements.

In sum, *assentamento* formation results from the interaction between broad national processes that operate across spatial scales and the specific local institutional opportunity afforded by the land law that creates the conditions for settlement formation.

CHAPTER 5: RESEARCH AND SAMPLE DESIGN, STUDY AREA, AND DATA COLLECTION

5.1 Research Design

My overarching goal is to study the institutional framework and social processes leading to spontaneous *assentamento* formation and to assess associated impacts on the Amazonian forest. This entailed three practical hypotheses and objectives. The first hypothesis, **H1**, argues that spontaneous DALR seeks out unclaimed pubic lands (*terra devoluta*) beyond the frontier, given the low land value of primary forest, thereby minimizing the risk of individuals who occupy land without organizational support or assistance from the state. The second hypothesis, **H2**, argues that spontaneous DALR is a consequence of early land reform policies that stimulated in-migration to the region. In addition, early migrants have created a local population pursuing DALR via a "demographic" life cycle, whereby the second generation of the original settlers now seeks its own land. The final hypothesis, **H3**, argues that land cover change and forest fragmentation increase after DALR settlement officialization by the federal government because of federal resources for infrastructure creation. To test my hypotheses, three objectives were developed. The objectives were to (1) interview key informants from the community, rural syndicates, and government agencies; (2) undertake a case study of newly formed *assentamentos*; and (3) conduct a remote sensing analysis of deforestation occurring in the *assentamentos* and others like it in the region. I

now consider each of the research activities in relation to stated hypotheses and design.

To address hypothesis **H1,** I undertook in the summers of 2004 and 2006 key informant interviews of INCRA officials and of community and syndicate leaders. In these unstructured interviews, I identified seven spontaneous settlements (four in the municipality of Uruará, one in the municipality of Medicilândia, one in the municipality of Marabá, and one in the municipality of São João do Araguaia), and I discussed at length the history of the settlements. I asked explicit questions in this regard, particularly about the legal issues involved in land occupation and any possible reactions by municipal, state, or federal government (as well as by other interested parties, such as loggers). In addition, a survey questionnaire was applied among *posseiros.* I argue that **H1** is upheld if my key informants describe the site as easy to occupy regarding legal issues and other possible risks associated with competition for land.

Objective two involves a case study of the settlements identified in the key informant interviews, and it is addressed through survey data. Since the idea is to test **H2** where spontaneous DALR is a consequence of early land reform policies and demographic life cycle, I identified and selected two different regions in the State of Pará where settlement formation is occurring (Figure 7). Five *assentamentos* were along the Transamazon highway: *PA*[25] *Trairão, PA Uirapuru, PA Rio do Peixe, PA Tutuí Norte,* and *PA Surubim*; and eight *assentamentos* were located in the southern Pará State: *PA 17 de Abril, PA*

[25] PA is the designation for *Projeto de Assentamento* (settlement project).

Canudos, PA Cabanos, PA Santa Maria do Pontal, PA 1º de Março, PA Araras, PA Palmares II, and *PA Alegria.*

The survey focused on household demography and, in particular, on familial linkages between *assentamento* residents and earlier colonists in the region. Questions addressed *household demography* (age cohorts, location of immediate family member, kinship ties in the *assentamento* and elsewhere in Uruará), *migration history* (place of birth, prior residence(s), year of all municipal moves), and *social capital* (organization memberships, church, syndicates, etc.). I also probed respondents about the land occupation process. Specifically, I wanted to know if the state or other agents (e.g., loggers, ranchers) offered resistance, whether land titles had been secured, and if not, how long they expected to wait. Finally, I asked whether *assentamento* creation had liberated any federal resources, especially for road building.

Although the survey has developed a great deal of contextual information and shed light on hypothesis **H1**, hypothesis **H2** is directly tested by a *Logit model.* Because the main idea of **H2** is to test if spontaneous DALR settlements are a consequence of early land reform policies that attracted migrants to *terra devoluta.* Thus, a dichotomous dependent variable was set equal to 1 (one) if an individual chose to create a spontaneous settlement, or 0 (zero) if he/she chose to create an SMO settlement. I expect the predicted value of the dependent variable to fall mainly within the interval between 0 and 1.

In specifying the *Logit model,* it assumed that the response probability is linear in a set of parameters, β_j, such that:

$$P(y=1 \mid x) = H(\beta_0 + \beta X_1 + \beta X_2 + \ldots\ldots + \beta_k X_K) = H(\beta_0 + X\beta)$$

where $(\beta_0 + X\beta)$ is equal to f, H being a function of f; thus, taking on values strictly between 0 and 1: $0\langle H(f)\langle 1$, for all real numbers f. This ensures that the estimated response probabilities are strictly between 0 and 1. Various nonlinear functions have been suggested for the function H in order to make sure that the probabilities are between 0 and 1. In the *Logit model*, H is assumed to be the logistic function, such that $H(f) = \exp(f)/[1+\exp(f)]$ which is between 0 and 1 for all real numbers, f.

This *Logit model* suggests that the predicted value of the dependent variable could be interpreted as the probability that some arbitrary individual will choose to create (and consequently live) in a spontaneous *assentamento* rather than to create (and live) in an SMO-led *assentamento* given a set of explanatory variables, such as individual length of residence in the area, type of land (*terra devoluta* or private land), settler political experience in contention activities, migration pattern, distance from cities, among other explanatory variables.

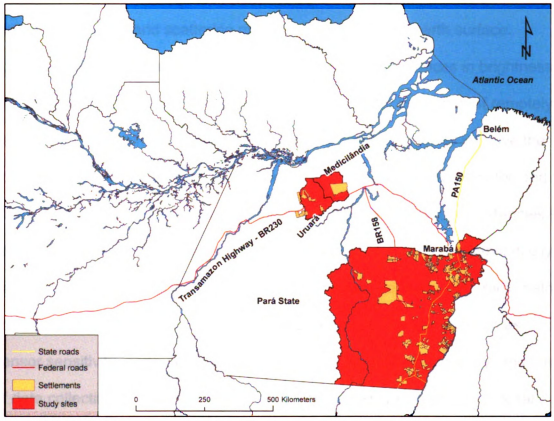


Figure 7. Two regions with assentamento formation in the Pará State.

Finally, the last objective seeks to analyze land cover changes occurring on *assentamentos* found around the municipality of Uruará on the Transamazon highway. The remote sensing analysis was undertaken using Landsat imagery (TM and ETM*, paths 227, 226 and rows 62, 63), covering a 3-year period (1986, 1991, and 1999). The satellite imagery used in this dissertation was obtained from the archives maintained by the Tropical Rain Forest Information Center (http://www.trfic.msu.edu) at the Global Observatory for Ecosystem Services (GOES), Michigan State University. Prior to classification, the images were geometrically registered, radiometrically and atmospherically corrected, and mosaiced (Markham 2003).

Images acquired by satellites can be affected by atmospheric particles through absorption and scattering of the radiation from the earth surface. Examination of any image depends upon detection of differences in brightness of objects and their features. Radiometric and atmospheric correction of remotely sensed data normally involves the processing of digital images to improve the fidelity of the brightness value. The main purpose for applying radiometric and atmospheric corrections is to reduce the influence of errors or inconsistencies in image brightness values that may limit one's ability to interpret or quantitatively process and analyze digital remotely sensed images. Consequently, radiometric correction was carried out to normalize satellite images for factors such as sensor sensitivity, earth-sun distance variation, sun angle, topography, and time of data collection. To solve this problem it was necessary to convert a digital number (DN) into radiance and radiance into reflectance. Coefficients developed by Chamder and Markham (2003) were used for converting digital numbers to radiance, and to reflectance when metadata files that present calibration coefficients were not provided for Landsat TM images. Consequently, the following equation was employed:

$$L\lambda = (LMAX\lambda - LMIN\lambda / Q_{calMAX}) \cdot Q_{cal} + LMIN\lambda$$

where $L\lambda$ = spectral radiance at the sensor's aperture in $w/(m^2.sr.\mu m)$ units,[26] and Q_{cal} = quantized calibrated pixel value in units of digital numbers (DNs)

[26] Chamder and Markham (2003) used specific radiance units of watts per square meter per steradian per micrometer $w/(m^2.sr.\mu m)$.

(Chamder and Markham 2003). In the next step, I converted the radiance values to top of atmosphere reflectance using the following equation:

$$\rho P = \pi \bullet L\lambda \bullet d^2 / ESUN\lambda \bullet COS\phi_s$$

where ρP = unitless planetary reflectance, $L\lambda$ = spectral radiance at the sensor's aperture, d = earth-sun distance in astronomical units, $ESUN\lambda$ = mean solar exoatmospheric irradiances, and ϕ_s = solar zenith angle in degrees. The resulting satellite reflectance was then corrected for atmospheric effects producing surface reflectance. Using ERDAS image software, a model was created in modelmaker for the radiometric and atmospheric correction. Finally, geometric correction accuracy was calculated by matching common points on corrected images to points collected by GPS units from several locations within the Uruará area. Image rectification using 8- to 10-point coordinates were applied. Individual geometric correction was considered acceptable only if the root-mean square (RMS) was < 0.5 pixels. Figure 8 shows the procedures for performing these corrections. The last step was image classification. Landsat Thematic Mapper (1986 and 1991) and Enhanced Thematic Mapper (1999) images were individually classified. To carry out this task, I used a hybrid unsupervised/supervised classification method in each individual image (Figure 9).

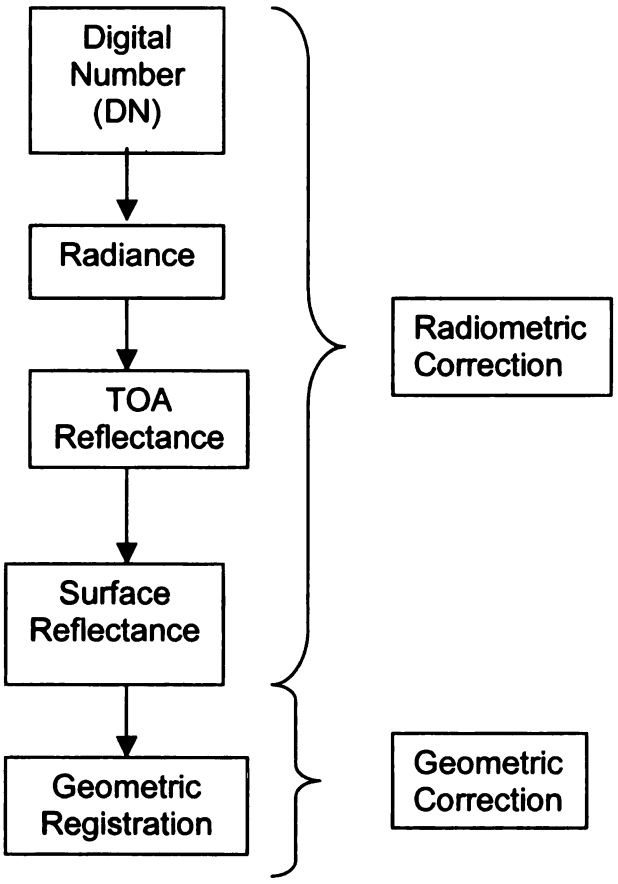


Figure 8. Radiometric and geometric corrections of Landsat imagery.

Through this method, four thematic classes were identified: forest, deforestation, clouds and shadows, and water. This approach starts with an unsupervised classification. *ERDAS IMAGINE* uses *ISODATA* classifier algorithm to perform this task. The *ISODATA* clustering method uses the minimum spectral distance formula to form clusters. The *ISODATA* algorithm repeats the clustering until a maximum number of interactions have been performed or a convergence threshold has been reached. In this process I identified 90 classes, and I recoded the classes to evaluate and test the accuracy

of the classification. I used the Raster Attribute Editor to compare original image data with the individual classes of the thematic raster layer that was created from the unsupervised classification. The final unsupervised image was than used in a supervised classification. A filter majority 5 X 5 window was than created in modelmaker and applied to the supervised images to remove any possible noise. The last step involved the mosaic of the supervised images. In doing classification analysis, notably, a significant portion of the land surface is obscured by clouds. Consequently, this complicates the observations of surface processes from space. The determination of cloudiness is essential to deforestation evaluation. To conclude my image preparation, a cloud mask was produced because my interest was to map the increment in deforestation from 1986 to 1999. The classified images were then overlaid on digital *assentamento* maps, thereby enabling the creation of a subset that was transformed into a grid. The calculation of deforestation associated with *assentamento* creation was possible because my deforestation maps showed forest cover before and after the *assentamentos* were formed given (a) the time period covered by our image archive, which predates the *assentamento* process, and (b) the availability of information on *assentamentos*, including dates of creation via public records called *portarias*. Also, spatial analysis was undertaken using the landscape pattern recognition software *FRAGSTATS* (McGarigal et al. 2002). To accomplish this task, I calculated the number of patch and the mean patch size to characterize the patterns of land cover changes occurring in the

assentamentos. I argue that **H3** is upheld if deforestation — and fragmentation — shows sharp increases after *assentamento* formation.

5.2 The Study Area

The dataset used in this dissertation was developed through two National Science Foundation research proposals titled "Brazil's Direct Action Land Reform Movement: Environmental Impacts and Socio-Spatial Dynamics" and "Settlement Formation and Land Cover and Land Use Change: A Case Study in the Brazilian Amazon." The second research proposal is my dissertation proposal that complements the first one, and both involve research in the State of Pará in the Legal Amazon region. The "Brazil's Direct Action Land Reform Movement: Environmental Impacts and Socio-spatial Dynamics" research has the main objective of understanding *direct action land reform* (DALR) and to assess its implications on land cover and land use change in the Brazilian Amazon. To achieve its objective, this proposal identified several key counties where social movement organizations (SMOs) are active. My dissertation complements this proposal by adding the case of spontaneous DALR, in which SMOs do not support settlement formation. Thus, to achieve the objectives, two locations where DALR is particularly prevalent in the State of Pará were identified and selected. The first location was in southern Pará (Figure 7), specifically, the *Polígono dos Castanhais* (Brazil Nut Polygon), an area that has experienced longstanding conflict over land and where settlements have been formed with (and without) SMO support (Simmons et al. 2007). The second location is the Transamazon region where much state-led colonization occurred in the 1970s.

However, in some areas along this highway, DALR is a relatively new phenomenon (Figure 7), and it is persisting around some of the federally initiated colonization projects (*Projectos Integrados de Colonização*-PICs), such as the municipality of Uruará where I identified relatively large numbers of recent settlements and new migrants.

5.2.1 A Brief Description of Southern Pará

Southern Pará is a place where boundaries are not clear and many authors have defined it in many different ways. Kotscho (1981), for instance, referred to this region as an area that lies along the border with Tocantins and Maranhão States, the so-called *Bico do Papagaio*, or Parrot's Beak. Schmink and Wood (1992) and Campos (2002) described it as the southeastern part of the State. Simmons et al. (2007) defined this region in a broader way, as those municipalities that lie within the geographic expanse below the Transamazon highway in the State of Pará and east of the Xingu River. This encompasses the southeastern corner of Pará and also areas west of the Araguaia River beyond State Highway PA-150, where land ownership has long been in contention.

This place has experienced significant political and socioeconomic changes since the early 1960s, served as a portal to the "opening" of the Amazon, and enjoyed a great deal of government interest (Simmons et al. 2007). Consequently, infrastructure development paved the way for migration and resource exploitation. As a result, land conflicts between private landowners (generally members of old oligarchies), *posseiros,* and landless people flourished in the region; and many SMOs joined the struggle for land reform in this area.

5.2.1.1 A brief history of the two spontaneous settlements in southern Pará

Two spontaneous settlements were identified in southern Pará, and these settlements have similar formation trajectories. Key informant interviews have similar opinions of how the settlements were created.

The PA Araras was created in 1987 by the federal government. It is considered a spontaneous settlement in this analysis because it started with 22 *posseiros* that demarked land inside indigenous areas without an occupation plan. In the beginning, *posseiros* were encamped for almost two years without a problem. The *posseiros* did not know that the lands were indigenous land. It was thought the land was *terra devoluta*. However, the history of free land started to spread and many new *posseiros* started to move to the area. The increase in the number of families started to create conflicts between *posseiros* and indigenous people, and the federal agency INCRA had to intervene. The federal agency decided to remove the *posseiros* from the indigenous area and negotiated new land in private property that had primary forest. However, to justify the settlement, the agency had to combine *posseiros* and landless people. Each settler received 10 *alqueires* (about 50 ha). After the officialization, 90 families were living in the settlement; although, today just 40 families of the original settlers are living in the area, and some land concentration started to occur.

The history of PA Alegria is similar to the history of PA Araras. The federal government officially created this settlement in 1999. This *assentamento* started with a small group of four *posseiros* families that were living in the area for more than 20 years. These *posseiros* decided to invite four more families to live and

help to secure the area. The area was primary forest with some secondary growth. The new group joined the original group of *posseiros* in 1997. However, the increase in the number of people generated conflict with the landowner who decided to use force to get the land back. The landowner had a document of *aforamento* of use for one part of the land, but he argued that the whole land belonged to him. The conflict between *posseiros* and landowner only stopped when INCRA decided to intervene and evaluate the property. After three months, INCRA expropriated the land and the settlement was to create.

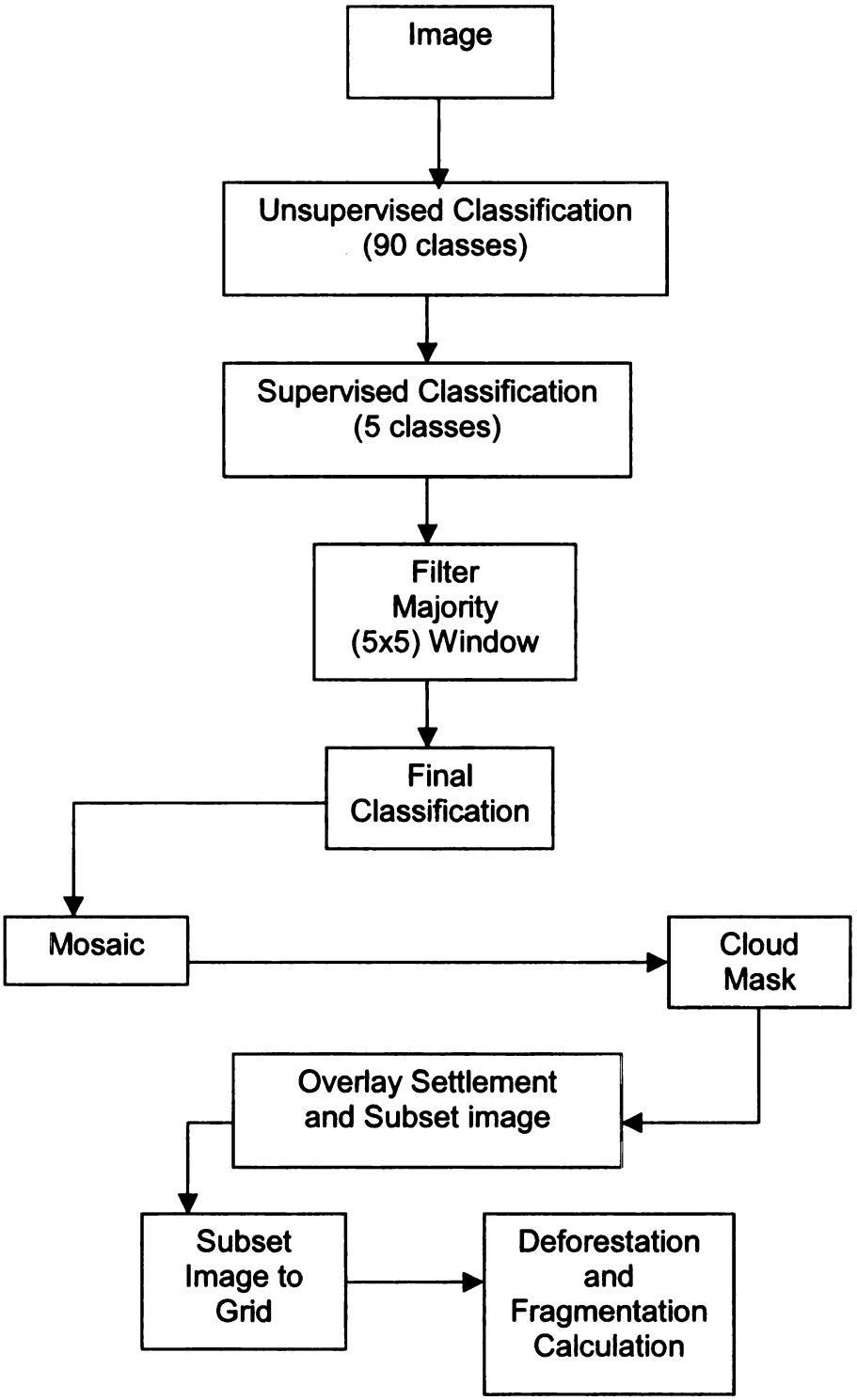


Figure 9. Hybrid classification: deforestation and fragmentation calculation.

5.2.2 The Transamazon Study Site

My other study site is the Transamazon highway around the municipality of Uruará. This city is an old colonization site located in the eastern part of the Amazon basin between the cities of Altamira in the east and Ruropólis in the west (Figure 6). This study area is part of the Transamazon colonization project (*Projeto Integrado de Colonização - PIC*), meant to resettle landless people from different parts of Brazil. The site was established in the 1970s by the Brazilian government as an *agrovila* along the Transamazon highway. The term *agrovila* was used by INCRA to define a state-directed roadside rural settlement in a colonization project (Perz et al. 2007). At this time, the Brazilian federal government was very active along the Transamazon highway. Consequently, the Uruará area was under the influence of federal policies that stimulated the inflow of population and agricultural and urban expansion. This influence was based on infrastructure creation (e.g., road construction), land allocation (e.g., *agrovilas* formation), and agricultural price support (e.g., minimum price). All these policies influenced the spatial dynamics of the landscape along the Transamazon highway. For instance, the INCRA was responsible for demarcating 100-ha lots (400 x 2,500 m and 500 x 2,000 m) for colonists and providing them with basic services (Moran 1981; Smith 1982). Also, large parcels, so-called *glebas*, ranging up to 3,000 ha were demarcated to develop agro-industry (Caldas et al. 2007). In addition to colonization responsibilities, INCRA was in charge of building the road system. Consequently, major roads (such as the Transamazon highway) were important to the colonization plans.

The Transamazon highway crosses east–west through Uruará linking the northeastern part of Brazil to the heart of the Amazon forest. To accomplish its task of colonization, INCRA also constructed secondary roads running north–south that intersect the Transamazon highway corridor perpendicularly at 5-km intervals and extend 5-10 km from the main road. Colonists know these roads as *travessões*, or settlement roads. The road system developed by INCRA is responsible for the appearance of the fishbone pattern in the Amazon landscape, where spacing between secondary roads did not consider any abiotic parameter, such as slope or river network. However, in the early 1980s federal government priorities shifted from colonization projects and road construction toward large-scale development projects; and many colonization sites, like Uruará, were abandoned by INCRA (Nascimento and Drummond 2003). On the one hand, abondonment by the federal government led to a decrease in federal infrastructure investment in colonization areas; on the other hand, these colonization sites developed into cities. However, the change from colonization site to city did not occur by chance. Institutional help was necessary. With the help of many institutions and private companies, such as logging firms, the Catholic Church, rural labor, and producer's unions, the abandonment by the state was remedied (Toni 2003). In addition, the prices of key perennial crops were important factors in attracting a second wave of migrants and stimulating market expansion for agricultural production in the mid-1980s (IDESP 1990). As a result, Uruará became one of the most important small towns along the Transamazon highway. However, its development was not planned and the city

of Uruará evolved spontaneously. The arrival of new migrants led the colonists to split lots that were initially used for agricultural purposes into parcels for commercial uses. Consequently, urban parcels emerged to accommodate migrants and services. Later, INCRA started to title urban parcels, and education and public health began to develop. Thus, economic activities flourished, ranging from farming to ranching to logging/lumber.

Farming in Uruará became the main activity with more than 6,500 rural households, where more than 70% of the agricultural properties have an area of < 150 ha (Veiga et al. 1996). The production in the area is divided between annual (rice, cassava, corn, beans) and perennial crops (pepper, coffee, cacao) and involves extensive cattle ranching (Ferreira 2001; Toni 2003; Caldas et al. 2007). Ranching in Uruará is the second most important economic activity with more than 250,000 head of cattle (IBGE 2007b), and timber production followed in third with an increase from 115,000 m^3 in the mid-1990s to 187,000 m^3 in 2003 (Bonaudo et al. 2003). The economic growth of Uruará during the mid-1980s led to political pressure by the community to become recognized as a municipality. Consequently, in May of 1988, state law number 5.435 created the municipal government, which assumed responsibility over the area. Besides some transfer of funds (based on population size) from the federal government for basic infrastructure development in the county, little change occurred in rural areas. However, since the 1990s, this county has grown rapidly with the immigration of small farmers and landless people coming from many regions, principally from the northeastern and southern regions of Brazil. The Brazilian demographic

census shows that Uruará had a population of 37,395 inhabitants in 1996; and it grew to 45,201 in 2004 (IBGE 2007c). In reality, Uruará has an urban population around 13,000 inhabitants and a rural population of 32,000 inhabitants, occupying 10,791 km^2 of land (IBGE 2007c), which gives a human density around 4 inhabitants/km^2 concentrated along the Transamazon highway and the secondary roads. This human density is low if compared with cities in more developed areas of Brazil; however, Uruará is an agricultural frontier area with < 20 years of existence.

In sum, Uruará has experienced important changes since its initial development, although fundamental characteristics persist, such as its rural frontier economy based on farming, ranching, logging, and migration. Consequently, all these characteristics have led to increased pressures on forest conversion.

5.2.1.1 A brief history of the origins of the surveyed settlements in Uruará

The settlement Rio do Peixe was created in 1995 by the federal agency INCRA through INCRA's document SR01/23 of October 25. The idea driving its creation was to promote land reform and regularize rural households that were occupying four *glebas*[27] of 3,000 ha. The areas where the settlement is located today were alienated by INCRA in 1972 and 1973 because of lack of payment (Brandão et al. 1998). The area of the settlement includes the *travessões* 180,185,190,195, and 200 and encompasses an area of around 26,234 ha

[27] *Glebas* are parcels of land put aside by the federal government in the 1970s to promote colonization through capitalized agro-industry.

(INCRA 2007a), although this number does not match the area calculated using shapefiles obtained from the same agency. The settlement has the capacity to settle 260 families on lots of 100 ha, but official numbers state that there are 241 families currently settled in the area (Table 3). The process of occupation of *assentamento* Rio do Peixe is characterized by different phases. The first occupations occurred within the boundaries of *Gleba* José de Souza, in the beginning of the 1980s, and later in the 1990s in *terras devolutas* of the Union (Brandão et al. 1998). In fact, the first *posseiros* started to occupy this area in 1981 when a group decided to build *picadas* (trails) to demarcate 40 lots of 100 ha (the size of a rural module in the region) to plant small subsistence plots to assure legal rights to the land (Brandão et al. 1998). In the beginning, these people did not move onto the lots. The lack of infrastructure and financial resources to build houses forced the new arrivals to work as hired laborers or sharecroppers in parcels located on the Transamazon highway. In addition, the lack of roads, transportation, and the uncertainty in obtaining land title obliged many *posseiros* to sell their rights to their lots.

The PA Tutuí Norte has a different formation history, although its origin is similar and related to the PA Rio do Peixe. This PA was created in 1999 by an expropriation of a supposed private land (*fazenda*). The area of this settlement is around 28,000 ha and began with a negotiation between INCRA and a private landowner (or *fazendeiro*) that supposedly had the rights to the land. INCRA was negotiating this land to give to *posseiros*, living the area for more than 10 years, when an occupation occurred to force the settlement formation and to increase

the number of families to be settled. This occupation was led by *posseiros* removed from PA Rio do Peixe because of lack of water in their lots. The negotiation between INCRA and *posseiros* led to an unofficial parcel demarcation of 70 to 80 ha, on average, to each family. The PA Tutuí has a capacity to settle 341 families, but official numbers state that there are currently 341 families settled in the area (Table 3). However, the lack of infrastructure led many settlers to abandon their parcels.

The PA Rio Trairão was formally created in 1997, and the argument that this land had a previous owner also appeared in the key informant interviews. The occupation of this *assentamento* started in 1981 with a spontaneous occupation of primary forest. *Posseiros* opened trails to demarcate lots and negotiated road building with logging companies. However, in contrast with PA Tutuí Norte, the supposed landowner donated the land for settlement formation. This settlement has a capacity to settle 170 families in an area of 17,000 ha, although there are currently 160 families settled (Table 3). Like PA Tutuí Norte, settlers in this area have abandoned their lots for lack of infrastructure and delays in demarcation by INCRA.

The occupation of PA Uirapuru is similar to the other occupations. It started spontaneously between 1981 and 1985 through the occupation of a private area that supposedly belonged to a private company called Cotrijuí. However, this company decided to abandon the area because it was having problems with indigenous groups, facilitating the occupation by *posseiros*. Key informant interviews identified three phases in this settlement formation. The first

phase started in 1997 with the regularization of 140 lots. The second phase occurred in 2001 when INCRA regularized lots for 90 families, and the last phase occurred in 2004 with the settlement of 35 families. The number of families settled in this period is slightly over the capacity of the settlement, designed for 262 households for an area of 18,900 ha.

The last *assentamento* used in this case study, PA Surubim, has its own history linked to the region. It is one of the oldest settlements, and its formation sometimes merges with the history of the Transamazon highway itself. The location of the settlement starts very close to the Transamazon highway, and it started as a spontaneous occupation of *terra devoluta* in 1988. The government idea of developing a sugarcane agro-industry in the Medicilândia municipality attracted thousands of rural workers to this area. However, the failure of the sugarcane industry generated a mass of rural workers that were not absorbed by the colonization plans. Far away from their places of origin, and without financial resources to return home, this mass of rural workers found the solution for their problems in the occupation of land. In other words, they encroached on the forest and started to demarcate parcels of land. Despite being one of the oldest settlements in the area, it is not in its full occupation capacity. The PA Surubim settlement has 1,627 families settled for an estimated capacity of 2,660 households (Table 3) in an area of 199,537 ha.

5.3 Data Collection

The data used in this dissertation is part of a major dataset collected in the State of Pará. The data collection was divided into three phases. Phase one

involved identifying and interviewing of key informants. In Brazil, settlement creation is the task of the federal government agency INCRA, who is responsible for implementing the national policy of land reform. Taking this into consideration, in the summer of 2004 I visited Uruará to make contact with key informants. On this visit, a short survey was elaborated and tested with *posseiros* to serve as background information for future fieldwork. In the summer of 2006, I traveled to Uruará and southern Pará to identify and interview INCRA officials responsible for settlement creation in the regions. Also, I identified and interviewed community and union leaders responsible for supporting *assentamento* formation in these two areas. These unstructured interviews allowed me to identify four spontaneous settlements around the municipality of Uruará (*assentamentos* Trairão, Uirapuru, Rio do Peixe, and Tutuí Norte) and one settlement in the municipality of Medicilândia (*assentamento* Surubim) along the Transamazon highway. Also, eight settlements were identified in southern Pará. Four settlements were located in the municipality of Eldorado do Carajás (*assentamentos* 17 de Abril, Canudos, Cabanos, and Santa Maria do Pontal), two *assentamentos* in the São João do Araguaia municipality (*assentamentos 1º de Março* and *Araras*), one *assentamento* in Paraubebas (*assentamento* Palmares II), and one in Marabá (Alegria). From these eight settlements, six were identified by key informants as receiving SMO support, and two were identified as spontaneous settlements (*assentamentos* Araras and Alegria), at least in the phase of occupation where no SMO helped in the selection of the site or in the occupation. Thus, having identified these settlements, in the next phase,

I undertook *in situ* interviews with key settlers,[28] such as presidents of settlement associations and the oldest settlers living in the settlements. This approach took into consideration the possibility that the interviewees did not know about the history of the settlement. Thus, it was necessary to compare responses from multiple interviewees in a given settlement in order to understand its entire history. In all these interviews, I discussed settlement history, paying special attention to how their locations were selected. I asked explicit questions in this regard, particularly about the legal issues involved in land occupation and about any reactions by municipal, state, or federal government (as well as by other interested parties, such as loggers). This method yielded histories of unofficial settlement formation by nonstate social actors, providing a local record of the sociospatial processes that generated, expanded, and altered the landscape. The last research phase involved satellite acquisition and land cover analysis. I acquired Landsat imagery (TM and ETM^+, paths 227, 226 and rows 62, 63), covering a 3-year period (1986, 1991, 1999) for the Transamazon region around the municipality of Uruará. In addition, I acquired from the federal agency INCRA digital *assentamento* maps showing the location of new settlements in the Transamazon.

[28] I decided to use the term settlers, or landholders, instead of landless people because some of them already have land, although they do not have the title of the land.

Table 3. Settlement Dates of Official Creation by the Brazilian Government.

Settlement	Municipality	Settlement capacity	Estimate # of families	Date of creation	Type of action	Date of expropriation
Transamazon region						
PA Uirapurú	Uruará	262	262	06/10/97	Expropriation	03/29/1971
PA Rio do Peixe	Uruará	260	241	10/25/95	Expropriation	03/29/1971
PA Surubim	Medicilândia	2.660	1.527	05/18/88	Expropriation	03/29/1971
PA Tutuí Sul	Uruará	200	166	06/10/97	Expropriation	03/29/1971
PA Trairão	Uruará	170	160	10/07/97	Expropriation	03/29/1971
PA Alto Pará	Placas	400	386	12/22/97	Expropriation	03/29/1971
PA Placas	Placas	344	270	11/27/98	Expropriation	03/29/1971
PA Rio de Pedras	Placas	259	226	11/27/98	Expropriation	03/29/1971
PA Tutuí Norte	Uruará	341	341	10/29/99	Expropriation	03/29/1971
South of Pará						
PA 17 de Abril	Eldorado dos Carajás	690	688	06/19/97	Expropriation	01/01/1997
PA 1 de Março	Sao João do Araguaia	350	350	06/15/98	Expropriation	04/29/1998
PA Alegria	Marabá	96	95	12/09/99	Expropriation	07/14/1999
PA Castanhal Araras	Sao João do Araguaia	92	128	08/04/87	Expropriation	01/15/1987
PA Canudos	Eldorado dos Carajás	62	58	08/16/04	Buy	07/22/2004
PA Cabanos	Eldorado dos Carajás	85	81	03/07/03	Expropriation	12/21/2001
PA Palmares II	Paraupebas	327	286	12/13/01	Expropriation	12/13/2001
PA Sta. Maria do Pontal	Eldorado dos Carajás	115	67	07/14/97	Expropriation	02/01/1997

Source: Ministério do Desenvolvimento Agrário,INCRA (2007a): Diretoria de Obtenção de Terras e Implantação de PA, Relatório 227 05/31/2007.

5.4 Sample Design

The data used in the empirical analysis comprise information reflecting settlement characteristics taken from a settler sample survey, and deforestation and fragmentation measures derived from the classification of satellite images. A team of fieldworkers composed of Michigan State graduate students and undergraduate students from the Federal University of Pará, Altamira campus, administered a 17-page survey (Appendix) during the months of July and August 2006. This survey collected information on lot history (including lot size, year of establishment, land title, length of residence, and area in forest at arrival), landownership history, household demography (family size, age composition, and migration pattern), socioeconomic conditions at arrival, previous experience with DALR, settlement history (including conflicts, violence, road building, and land demarcation), and farming system components.

Field data collection in new settlements around Uruará is not an easy task. To reach a new settlement, it is sometimes necessary to drive hours along the Transamazon highway and secondary roads. The remoteness of settlement locations made time a serious constraint on data acquisition. Also, settlement location is not always precise. In others words, settlers do not know with confidence where the new settlement starts and where it ends. Many settlements are in a process of legalization, and only a rough extent of settlement measurement exists. As a result, *posseiros* have demarcated their lots, but the lots are not officially demarcated by INCRA. Consequently, *posseiros* use small areas within their lots to produce subsistence crops. Thus, settlers' main

concern is whether INCRA officials will allow them to keep the area that they had chosen to live or force them to move. The difficulties of settlement and lot location complicate formal efforts at geospatial sample design (Griffith 2005). Consequently, random sampling was not possible by distance (such as every kilometer) and settler family count (every farmstead) was not viable. Counting houses was problematic because settlers do not invest in house construction without official confirmation of legal land status. Settler housing in some cases is just a camp, or a wattle-and-daub house, depending on their length of residence in the area. In addition, houses were sometimes hidden from view along the road. For reasons such as these, the data collection was, in some cases, opportunistic. In other words, our team conducted interviews with settlers we could find. In other cases, we first traveled to the settlement to make contact with community leaders. The main objective of the trip was to ask for help in locating or gathering settlers for interviews. Community leaders have local knowledge that facilitated meetings and created confidence between landholders and our group. I acquired a broadly dispersed sample across settlements, although time was a major constraint. The sample size represents between 13% and 15% of the settlement population. Obviously, the sample possesses both systematic and random spatial components. However, one strong characteristic associated with settlements is homogeneity of resident populations.

CHAPTER 6: RESULTS AND DISCUSSIONS

In the previous chapter I developed a conceptual model to explain spontaneous settlement formation in *terra devoluta*. In this chapter, I will present descriptive statistics of a number of settlements in the State of Pará to give a general overview of their characteristics. In addition, a Logit Model will be presented and discussed to explain the factors driving spontaneous settlement formation in the Amazon region. I will conclude this chapter with an evaluation of the land cover impact that spontaneous settlements are having on the landscape in the Transamazon region, using deforestation and fragmentation analyses.

6.1 Description of Spontaneous and SMO Settlement Characteristics

The survey results reveal how concentrated the origins of the settler population is from the northeastern part of Brazil. The vast majority of respondents were natives of one of the three following states: Maranhão, Bahia, and Ceará. However, in the spontaneous settlements, almost 70% of the respondents came from the States of Bahia (24.2%), Maranhão (25.6%), Ceará (8.1%), and Pará (10.9%). Considering the SMO settlement, nearly half of the settlers came from one state, the State of Maranhão. The city of Marabá in southern Pará is the main hub of the transportation system in the state, linking the state to the west-central and northeastern parts of Brazil. Also, the region borders Maranhão, which facilitates migration through railroads.

Settlers in spontaneous settlements had a previous residence in a rural area (around 70% of the settlers) before arriving on the settlement lot; while in SMO settlements, over half (51%) of the settlers came from an urban place. The average duration of residence for the sample varies between the two types of settlements. In SMO settlements, the average length of residence is 8 years, while in spontaneous settlements the length of residence is almost 11 years. Despite this trend, settlers had arrived from everywhere as far back as 30 years ago in spontaneous settlements, mainly in the Transamazon area. The mean age of household head was 47 years at the time of the survey for the spontaneous settlements and 48 years for SMO settlements. Lack of education is a serious problem in both types of settlements. The level of education of household heads shows that almost 90% of the settlers have between 0 and 5 years of education (an average 2.3 years of education).

In most cases, settlements lack infrastructure. At time of arrival, 40.0% of the settlers in spontaneous settlements reported the use of trails to access their parcels and 48.6% reported the use of existing roads. However, existing roads in spontaneous settlements are so precarious that in most cases they look like a trail. In SMO settlements, 48% of the landless people reported the existence of roads when they arrived and only 31.4% reported the existence of a trail (Table 4). For settlers, arrival at the lot is the most difficult phase because everything needs to be prepared, including building houses. Questioned about their present and past housing conditions, 40% of the settlers in spontaneous settlements

reported that they did not have a house at time of arrival, while 50% of the settlers in SMOs reported that they did not have a house (Table 5).

Table 4. Existence of previous roads before arrival by type of settlement.

Settlement	Road		Trail		Nothing		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Spontaneous	103	48.6	85	40.1	21	9.90	209	98.6*
SMO settlements	88	48.1	57	31.1	36	19.7	181	98.9*

* Three respondents did not answer this question for the spontaneous settlements and two respondents did not answer this question for the SMO settlement.

House types vary depending on the financial resources of the household, and in some cases vary with the household's length of residence in the area. In the beginning, very poor settlers build mud houses, and with time, this type of house is substituted with a wood or brick house. Also, very poor settlers do not arrive with any kind of personal goods. In fact, almost 68% of the settlers in spontaneous settlements did not possess any durable goods at time of arrival. In SMO settlements, this value was less, representing 59% of the settlers (Table 6). Settlement formation seems to improve the possession of durable goods and housing conditions. Brick houses become more common after recognition of settlements by the federal government. Settlement recognition facilitates credit acquisition through many programs, one of which is PRONAF (Programme for Strengthening of Family Agriculture). PRONAF facilitates access to credit to improve the living conditions of rural household families. House construction, tools, and agricultural input acquisition are among the basic needs facilitated by PRONAF, although demands and claims to be successful depend on the extent

to which settlers have been able to organize themselves and pressure INCRA for credit acquisition and infrastructure creation.

Table 5. Settler house type at arrival.

House type	Spontaneous		SMO settlement	
	At arrival	July 2006	At arrival	July 2006
Wood house	34.1%	60.5%	30.1%	58.0%
Brick house	1.90%	18.7%	5.5%	27.60%
Mud house	24.00%	20.20%	14.4%	7.8%
No house	40.00%	0.60%	50.0%	6.6%
Total	100%	100%	100%	100%

With regards to water supply, most settlements have problems with access to quality water. At arrival, just 15.4% of the settlers in spontaneous settlements had wells. This number improved to 56% at the time of the survey. In SMO settlements, 22% of the settlers had wells. Today, almost 65% of the settlers in these areas have wells. However, in general, water quality did not improve at either site.

Table 6. Settlers household possession of durable goods at time of arrival.

Settlements	Before		Now	
	Frequency	Percent	Frequency	Percent
Spontaneous	144	67.9	55	25.9
SMO settlement	108	59.0	25	13.7

Note: Durable goods are: stove, chainsaw, refrigerator, generator, television, car, or tractor.

6.1.1 Settlement Farming Systems and Land Tenure Characteristics

The farming systems in the two settlement types are highly diversified, integrating annual crops (rice, beans, manioc, and corn), perennials (coffee, cocoa, and pepper), and cattle. The general characteristics of the overall sample show that settlements in spontaneous settlements produce more annual crops than SMO settlements (Table 7). Many factors influence the use of a specific farming system in a settlement, including settlement distance from the main road and land title. The spontaneous settlements in the Uruará region are located an appreciable distance from the main highway, the Transamazon highway, or BR-230 (around 41 km); while SMO settlements in southern Pará are located 70 km (on average) from PA-150. However, this distance does not adequately represent the real transportation difficulties. Settlements located in *terra devoluta*, mostly in the Transamazon region, have difficult and arduous access to the closest major city in the area (the municipality of Uruará), requiring hours to travel a few kilometers. *Travessões* (or settlement) roads are unpaved roads that, even in the dry season, are almost nontrafficable from a lack of infrastructure and maintenance. Consequently, settlers usually face difficulties getting around, especially during the rainy season, further undermining their access to health and education and making it harder to sell their products at market. Roads in SMO settlements, mainly located in southern Pará, are better maintained, allowing traffic during most of the year. The distance factor presumably plays an important, though only partial, role in the choice of farming system because of its relationship with transportation costs associated with the movement of

commodities (Walker et al. 2002). Consequently, settlers in spontaneous settlements have to rely more heavily on subsistence crops than their SMO settlement counterparts.

But the annual crop system is not the only prominent system in spontaneous settlements. Spontaneous settlements also have more area in perennial crops and pasture than SMO settlements (Table 7), although the figures are not overly expressive of this fact. At first glance, these results contrast with expectations. However, an important distinction between these two types of settlements exists. Spontaneous settlements have an extensive amount of primary forest in *terra devoluta*, while SMO settlements in southern Pará are located in a very traditional *latifúndio* ranching area that long ago relied on its Brazil-nut trees. As a result, lot size is completely different between these two types of settlement. The lot size in spontaneous settlements is, on average, over twice the size of an SMO lot in southern Pará. In other words, spontaneous settlements (mainly in the Transamazon region) have a lot size of 81 ha on average, while in SMO settlements the average is 35 ha. These numbers seem to be related to population density. SMO settlements are concentrated in southern Pará, a much more populated region than the Transamazon. In addition, land concentration in southern Pará has left less land available for land reform. Another important factor to consider when analyzing the difference between these two types of settlement is the existence of a previous agricultural system. The characteristic of being a traditional ranching area led settlers in SMO settlements to dedicate less area to perennial cultivation. Many

expropriated farms that have subsequently been transformed into SMO settlements had immense areas of pastures that were divided into lots. Perennial crops (such as coffee, cocoa, and pepper) require investments that cannot be afforded by formerly landless people. This result suggests that settlers in SMO settlements located in southern Pará prefer to (and have to) rely on a traditional farming system based on extensive pasture rather than the planting of perennial crops. This approach differs from spontaneous settlements where the existence of more area in perennials can be seen as related to some market engagement. In other words, settlers may clear primary forest with the expectation that frontier development and maturation will bring markets and expanded opportunities for economic activity, including the sale of their holdings (Binswanger and McIntire 1987; Rudel and Horowitz 1993; DeShazo and DeShazo 1995; Margulis 2003; Arima et al. 2005).

Table 7. Land use by settlement type.

Settlement	Area (hectares)		
	Annual crop	Perennial crop[1]	Pasture
Spontaneous N = 212	3.83 (4.48)	1.89 (2.51)	30.5 (44.07)
SMO settlement N = 183	2.26 (2.80)	0.24 (1.09)	23.82 (25.98)

Note 1: The perennial crops include coffee and cocoa and the annual crops include rice, corn, beans, and manioc.
Note 2: The values between parentheses are standard deviations.
Note 3: The average lot size in the SMO settlement is 35.25 ha, while in the spontaneous settlement the average is 81.35 ha.

This adds another topic to the discussion: the issue of land title. The expectations that land market will appear and that the sale of holdings can occur suggests that landowners have land title. Thus, comparing the issue of land title between the two types of settlements, clearly some contrast exists. In spontaneous settlements, 34% of settlers have no documentation for their plots, while in SMO settlements almost 84% have no land title document (Table 8). When analyzing land reform in Brazil, two important factors need to be considered. First, land title is the dream of every landless settler, and settlement creation and emancipation of existing settlements is the dream of the federal agency INCRA. Second, land title and emancipation are not the immediate dream of SMOs struggling for land reform. Settlement emancipation can mean that every settler has their own land and the legal right over it. Thus, the government interprets land titling as indicating that the settlement is ready to sustain itself. In other words, emancipation means that the federal government will no longer invest in infrastructure creation or subsidize credit. However, SMOs disagree with this argument; land title is not enough for SMOs. Social movement organizations want settlements with better roads (preferably paved roads), schools, energy, water, and credit. To achieve their dream, SMOs advise settlers to not accept land title (key informant interview 2006), while the settlement does not have all necessary infrastructures to bring social justice and dignity to the people.

Table 8. Land title by settlement type.

Land title	Spontaneous		SMO settlement	
	Frequency	%	Frequency	%
No document	72	34.12	153	83.6
Some type of document	139	65.88	30	16.4
Total	211	100	183	100

Note 1: type of document could include any of the following: contract of sale, protocol, or INCRA declaration.
Note 2: One respondent did not answer this question for spontaneous settlements.

This attitude toward title contrasts with spontaneous settlements where the preoccupation with land title seems to be more evident. In spontaneous settlements, almost 65% of the settlers reported to have some type of document, such as a protocol number from INCRA or a contract of sale from a previous owner (Table 8). Provision of collateral is a common prerequisite for commercial bank loans, especially for medium- and long-term loans (Dorner and Saliba 1981; Caldas et al. 2007). However, land is useful as collateral only if ownership by the borrower can be proven. Hence, documents that indicate legal ownership enhance the owner's access to institutional lenders, who typically lack personal knowledge about the potential borrower and his background (Feder and Onchan 1987). Muller et al. (1994), Alston et al. (2000), and others have described the impact of insecure land tenure on resource use in the frontier and what this means for agricultural decisions. The results presented in Table 8 seem to suggest that in spontaneous settlements settlers could be planting more perennial crops given the existence of some type of land titling documentation. However, spontaneous settlements also have more areas in annual crops; and settlers may be assuming risk aversion behavior because, in general, land

ownership cannot be proven until settlement officialization. Nevertheless, this hypothesis is borne out by empirical studies in Brazil (Homma et al. 1996; Faminow et al. 1999) and new research is linking farming systems to household characteristics and economic circumstances (Caldas et al. 2007). Whatever the factors that influence land use decisions, the type of document that *posseiros* retain in *terra devoluta* cannot be used as collateral for credit acquisition. Although, apparently this requisite is not being applied in settlement areas. More than 58% of the settlers in spontaneous settlements and 75% in SMO settlements had some type of credit, varying from money to buy cattle to funds to build houses and buy equipment. Thus, settlement creation facilitates credit even without legal documents, probably because settlement recognition takes years to occur.

Land security is a very important factor for *posseiros* living in the Amazon region. *Posseiros* on public lands who lack security of land ownership are subject to possible eviction, and this type of document seems to give a kind of security for someone that never had their own land. Even so, eviction is not overly common in *terra devoluta*. Two factors can contribute to ownership acquisition: length of residence and productive use of the land. In spontaneous settlements, settlers have been living in settlement lots for an average of almost 11 years (even though some settlers have been living on the same land for almost 30 years) compared to an average of 8 years of residence in SMO settlements (Table 9).

An important factor that merits mention is the time period during which land was expropriated for settlement formation. In general, spontaneous settlements in the Transamazon region have been created in lands that were expropriated in 1971 as part of the federal decree 1,164 (April 1971) that allocated a 100-km strip on both sides of federal roads in the Legal Amazon for colonization proposes. However, in the case of SMO settlements located in southern Pará, land expropriation is more recent, starting at the end of the 1990s and continuing today. Currently, encampments are waiting to become settlements throughout southern Pará, although the process of settlement formation is not an easy one and land expropriation can take months or years to occur after initial occupation.

Table 9. Average length of residence in the settlements.

Settlements	Sample size	Length of residence
PA Rio do Peixe	35	12.4 (6.99)
PA Trairão	28	10.25 (6.89)
PA Tutuí Norte	24	3.54 (2.04)
PA Uirapuru	65	12.02 (7.95)
PA Surubim	22	13.59 (7.41)
PA 17 de Abril	57	8.59 (2.72)
PA 1 de Março	27	6.09 (3.20)
PA Alegria	22	6.95 (2.84)
PA Araras	14	16.86 (4.29)
PA Canudos	23	7.02 (0.80)
PA Cabanos	22	7.06 (1.29)
PA Palmares II	30	10.97 (2.90)
PA Sta. Maria do Pontal	23	9.30 (3.51)

Note 1: Values between parentheses are standard deviations.
Note 2: One respondent in the PA Cabanos did not answer this question.
Note 3: The average length of residence in the spontaneous settlements is 11 years (maximum of 30) and in the SMO settlement it is 8 years.

Land occupations are distinct in both settlement types. In the spontaneous settlements, 12% of the settlers said that they just occupy the land, while 49% said that they negotiated for access to the land. Those numbers are different in SMO settlements where 57% of the settlers said that they occupied the land while 31% said that INCRA negotiated the land with the previous owner (Tables 10 and 11). Here, an important distinction appears between *terra devoluta* and private land. Negotiation and occupation in settlements located in *terra devoluta* represent 61% of all settlers. However, negotiation occurred with the previous owner who demarcated the land for many reasons, such as speculation, selective logging, or productive use. In this case, settlers buy the land through a contract that transfers the right to the land to the new *posseiro.*[29] In contrast, in SMO settlements more than 89% of settlers affirmed that they occupied the holdings of a previous owner, and INCRA negotiated the land and provided it to them. Also, in spontaneous settlements almost 60% of settlers affirmed that their lands were *terra devoluta*, while in SMO settlements 84% affirmed that their lands were part of a *fazenda* (or farm) before they arrived (Table 12). These results suggest that private holdings have their defenders and INCRA acts to solve a contentious problem between landless people and private owners.

[29] Many factors can influence a *posseiro* decision to sell their land, such as insecurity, deception, lack of infrastructure, illness, and so on.

Table 10. How settlers acquired land in the spontaneous settlement.

Type of action	Frequency	%
Settler occupied	21	12.07
Settler negotiated	86	49.42
Other	9	5.18
Did not answer	58	33.33
Total	174	100

Note: Other includes people who inherited or exchanged land and people that think that INCRA negotiated for the land.

Table 11. How settlers acquired land in SMO settlements.

Type of Action	Frequency	%
Settler occupied	126	57.53
INCRA negotiated	70	31.96
Other	7	3.20
Did not answer	16	7.31
Total	219	100.0

Note: Other includes settlers who exchanged the land.

Table 12. Land type before settlement formation.

Settlements	Farm		*Terra devoluta*	
	Frequency	%	Frequency	%
Spontaneous settlement	12	6.89	104	59.77
SMO settlement	184	84.02	8	3.65

Note: Fifty-eight settlers did not answer this question for the spontaneous settlements and 27 respondents did not answer this question for the SMO settlements.

6.1.2 Settlement and Contention for Land Reform

Contention for land reform is another important distinction between both study areas. In spontaneous settlements, only 6% of the settlers were involved in direct action land reform (DALR) activities (such as strikes, encampments, manifestations, *frente de massa,*[30] or private land occupation) compared with 62% in SMO settlements (Table 13). Since 1985, SMOs have used land invasions as their main tactic in their struggle for land reform. The main goal of SMOs is to force the federal government to execute the constitutional clause that authorizes land expropriation for agrarian reform (Wolford 1996). Through landless militants, SMOs spend months recruiting families in both urban and rural places with the objective of targeting different groups of poor people with the final goal of invading a private property that is believed to be unproductive and therefore eligible for agrarian reform. In general, these SMOs often move in on targeted lands with military-like quickness and discipline, looking for areas with easy access, close to main roads and within the agricultural frontier, usually private land of high value, as in southern Pará. Here, the contentious process for settlement formation seems to be in contrast with the Transamazon region where contention appears to be almost nonexistent. In this area, contention occurs after individuals acting in isolation, or disarticulated from each other, have occupied their lands. To achieve their goals of land ownership, settlers find the need to organize and mobilize to struggle for their rights. The collective organization and commitments help to pressure INCRA for settlement formation (key informant

[30] *Frente de massa* is a group of landless militants that work as movement recruiters and guide occupations.

interviews 2007). Consequently, settlement creation affords an institutional mechanism for obtaining land title and liberation of resources for infrastructure creation, such as road construction and schools, among other services. Thus, settlement formation has made landownership and social justice almost possible for people that have historically been excluded by society.

Table 13. Settler involvement in DALR activity by type of settlement.

Settlements	Yes		No		Total	
	Frequency	%	Frequency	%	Frequency	%
Spontaneous	11	6.32	163	93.68	174	100
SMO	137	62.56	81	36.99	218	99.44

Note: One respondent did not answer this question for the SMO settlement.

6.2 Spontaneous Settlements in the Transamazon Region

Settlement formation is not new. Settlements started to appear at the end of the 1960s and the beginning of the 1970s as a consequence of land reform policies. Through the National Integration Plan (PIN-*Plano de Integração Nacional*), the federal government executed a series of acts, such as road construction (particularly of the Transamazon highway and the Cuiabá-Santarém highway), land expropriation (100 km on both sides of federal roads), and the creation of INCRA with the objective of carrying on its Amazon colonization plan. Two phases can be described in the process of colonization. The first phase corresponds to the period of 1971 to 1974 when the State, through INCRA, created the infrastructure conditions to settle the first colonists in the area, the so-called *colonização oficial* (Moran 1981). The second phase, from 1974 to

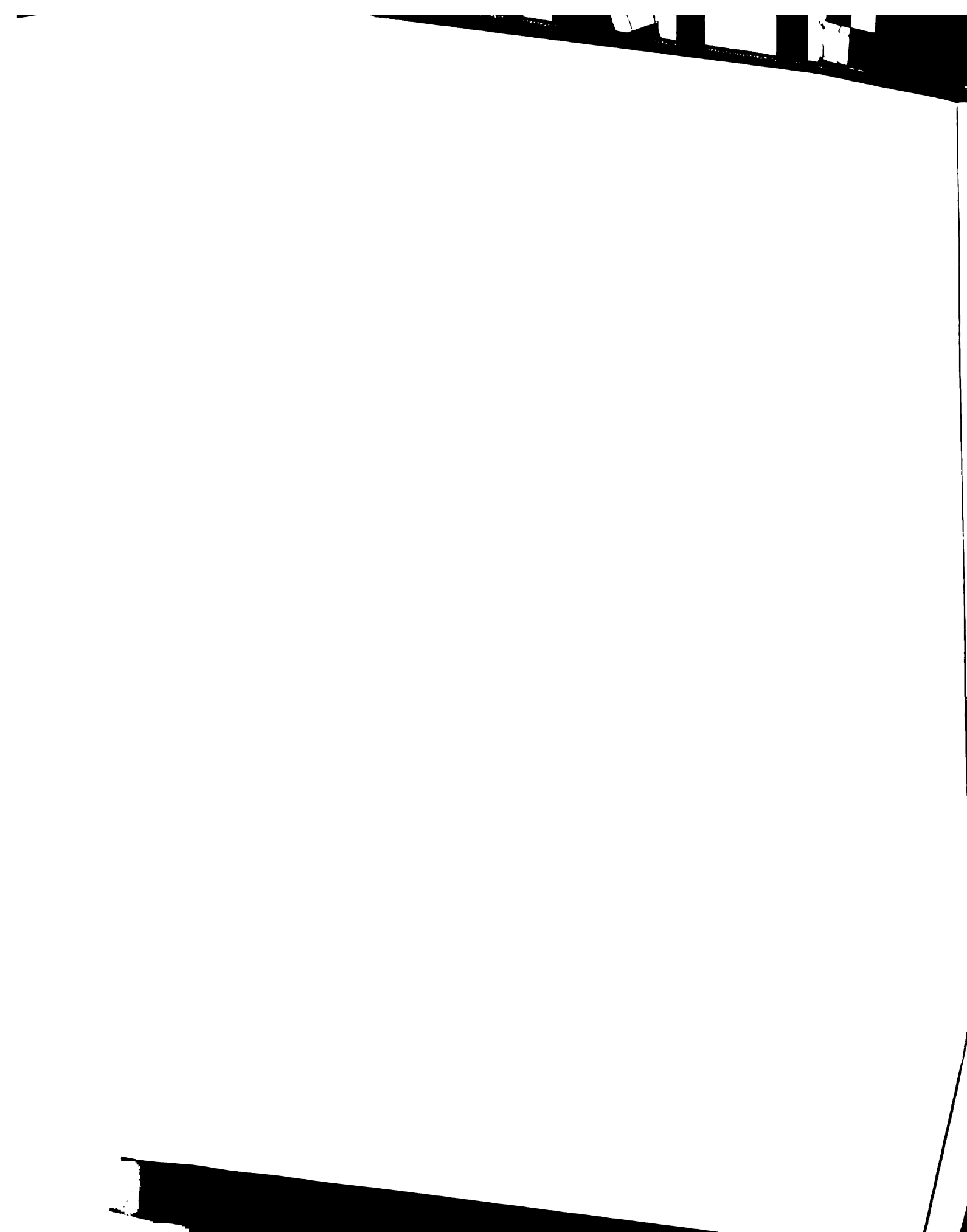
1980, was characterized by a decreased pace by which land was demarcated. Until the beginning of the 1980s, the federal government was very active in attracting colonists to the region. However, the loss of interest in colonization by the federal government did not stop migration, and many families continued to migrate spontaneously to the area. The lack of interest in attracting people was a consequence of new objectives. In other words, the State changed its interest from public colonization (*colonização oficial*) to private colonization (*colonização particular*), thus limiting its actions to the consolidation of existing settlements, among them the *Projeto Integrado de Colonização de Altamira* (PIC-Altamira) (Moran 1981). This phase was the starting point of land occupation in *terra devoluta* (Brandão et al. 1998). Becker et al. (1990) argued that in this phase, the *travessões* started to be elongated to augment colonization sites.

6.2.1 Characteristics of Spontaneous Settlements

The farming systems of the settlements in the Transamazon region are highly diversified across annual crops (rice, beans, manioc, and corn), perennials (coffee and cocoa), and cattle. Pasture is the dominant land use system and averages about 31 ha per property. Pasture itself raises land values because of improvements from cleared forest and preparation for agricultural use (Perz 2001). The nature of the settlements ensures that the size of the land holdings is very similar to the original plan of the older colonization parcels. In other words, settlers demarcated parcels as the same sizes found in already legitimated colonization sites (i.e., 100 ha). In addition, the farming systems of settlements

are not much different from other colonization areas and are diversified across the same component crops (i.e., annuals, perennials, and cattle). However, some differences exist among the settlements. For instance, the *assentamentos* Rio do Peixe, Uirapurú, and Surubim have more area in pasture than the *assentamentos* Tutuí Norte and Trairão. Also, these settlements have on average more perennial crops and fewer annuals. This is probably related to the length of residence in the parcel and distance from the main road (the Transamazon highway). The average length of residence for the *assentamentos* Rio do Peixe, Uirapurú, and Surubim is 12.4, 12.02, and 13.5 years, while the distance is around 39, 29, and 24 km, respectively (Table 14).

These observations contrast with the other two settlements. The average length of residence in the PA Tutuí Norte and PA Trairão is around 3.5 and 10 years, respectively. In tropical frontiers, welfare is likely to depend on a highly restricted set of items, given low incomes and lack of access to markets for consumer goods (Walker et al. 2002). Economic resources, such as available capital and the lack of access to markets for consumer goods clearly influence farm decisions. The data suggest that settlers in PA Tutuí Norte and PA Trairão are more dependent on subsistence crops. These results are not different from other studies in the Brazilian Amazon. Walker and Homma (1996) documented region-scale switches in farm systems focused on rice production to ones with large components of perennials, pasture, and cattle along the Transamazon highway between the early 1970s and 1993. Although their analysis did not track individual farms but instead was based on two different surveys, they explained



the phenomenon in terms of processes observed by CAT (1992) in southern Pará. In particular, household age and maturation of the family workforce enable farm evolution from annual production to ranching. Also, Walker (2003) and Caldas et al. (2007) described a two-stage process of farm evolution among colonists in the Transamazon region.

Table 14. Spontaneous settlement characteristics in the Transamazon.

Crop types (hectares)	PA Rio do Peixe		PA Tutuí-Norte		PA Trairão		PA Uirapurú		PA Surubim	
	Sample size	Mean	Sample size	Mean	Sample size	Mean	Sample size	Mean	Sample size	Mean
Corn	35	0.89 (1.21)	24	1.37 (1.83)	28	1.25 (1.45)	65	1.86 (2.67)	22	0.54 (0.68)
Rice	35	1.07 (1.53)	24	2.65 (2.95)	28	2.65 (2.10)	65	1.71 (2.65)	22	0.60 (0.97)
Beans	35	0.45 (0.59)	24	0.22 (0.37)	28	1.87 (0.49)	65	0.38 (0.95)	22	0.18 (0.33)
Manioc	35	0.27 (0.54)	24	1.74 (2.51)	28	1.09 (2.26)	65	0.39 (0.85)	22	0.52 (1.08)
Coffee	35	0.67 (0.97)	24	0.05 (0.14)	28	0.11 (0.30)	65	0.30 (0.70)	22	0.92 (1.54)
Cocoa	35	1.30 (1.89)	24	1.78 (1.93)	28	0.72 (1.51)	65	2.43 (2.79)	22	2.51 (2.42)
Pasture	35	33.23 (37.58)	24	1.67 (5.61)	28	19.78 (33.84)	65	44.81 (61.58)	22	34.36 (39.5)
Household Characteristics in Spontaneous Settlements										
Parcel size	35	92.78 (59.17)	24	85.33 (12.94)	25	108.2 (84.74)	64	87.62 (59.93)	22	76.41 (26.67)
Age of the head	35	48.23 (14.48)	24	48.04 (10.19)	28	38.78 (11.99)	63	44.90 (13.33)	22	45.27 (12.04)
Length of residence	35	12.4 (6.99)	24	3.54 (2.04)	28	10.25 (6.89)	65	12.02 (7.95)	22	13.59 (7.41)
Distance	34	39.20 (50.01)	23	66.87 (27.71)	28	59.75 (17.77)	63	29.68 (16.06	22	24.95 (8.27)
Education of the head	30	2.37 (2.14)	23	2.30 (2.58)	26	3.08 (2.91)	65	2.32 (2.66)	21	1.76 (1.37)
Number of families	35	1.26 (0.50)	24	1.04 (0.46)	28	0.93 (0.26)	65	1.15 (0.59)	21	1.19 (0.51)
Number of people	35	5.8 (3.10)	23	4.21 (2.86)	27	4.15 (2.64)	65	5.83 (3.83)	21	5.95 (3.01)
Number of children	33	1.73 (1.74)	20	1.4 (1.04)	24	1.58 (1.44)	62	1.87 (2.05)	21	2.00 (1.67)

Standard deviation shown in parentheses.

In phase one, they argued that colonists are in the early years of farm formation and face a pure subsistence process with market detachment. In phase two, colonists face commercial production with a household economy open to markets for products, labor, and land. The results above seem to suggest that these settlements are experiencing the same process of farm evolution. In addition, the demographic characteristics, such as age of the household head, length of residence, number of children, and years of education of household head have similar results; and they are not much different from other colonization areas (see Caldas et al. 2007). However, two points need to be highlighted here. First, the *assentamentos* PA Trairão and PA Tutuí Norte were created more than 10 years ago, but this does not mean much if the parcels within the *assentamento* are not demarcated, as is the case in both of these settlements. Settlers in these two places are not investing in perennial crops because they are not sure where their lots will be located once demarcation occurs. They know where they would like to live and are planting in the area, but insecurity plays a role in land use decisions (Settler personal communications 2006). In other words, risk aversion creates strong incentives to achieve food security through annual crops. Second, the distance of the two settlements to the main road is more than 60 km, almost twice the distance of the other three settlements. Consequently, transportation and market accessibility costs increase. This lowers output prices as it increases input prices, thereby reducing the market value of land (Nelson and Hellerstein 1997).

6.2.2 Land Tenure Characteristics

Table 15 explores the land title characteristics of each settlement. Today, 65.71% of the settlers in the *assentamento* Rio do Peixe have some type of document that confirms their rights to the land while one-third of the settlers still do not have any kind of land security document. The length of residence in this settlement varies from a minimum of 1 year to 23 years with the average tenure being 12.4 years. This suggests that land occupation is still occurring in the PA Rio do Peixe, which is likely the case given the availability of land for up to 19 families according to INCRA's own estimates (INCRA 2007a). On the one hand, PA Rio do Peixe seems to have more people with some kind of land tenure; on the other hand, PA Trairão has more settlers without any kind of land security document. Only 25% of the settlers in this settlement project have some type of land document. One factor that has contributed to this problem is the fact that the area where the settlement is located today had been previously claimed by a logging company that argued to have a *carta de sesmarias*[31] (Key informant interview 2004). The possible existence of conflict between the company and the *posseiros* led the federal agency INCRA to act to solve the problem. Meetings between *posseiros* and the logging company allowed INCRA to achieve an agreement to demarcate the settlement, but the location of the parcels have yet to be defined. A similar problem faced the *assentamento* Tutuí Norte and a similar solution was used. Even though the same process to create the settlement was used, the Tutuí Norte has more settlers with some form of

[31] *Carta de sesmaria* is a land grant document from colonial times.

documentation. However, the document may only be a contract of buying the right to the land from a previous *posseiro.* The PA Surubim and PA Uirapurú have fewer settlers without land documentation. *Assentamento* Surubim is the oldest land reform settlement in the area, created in 1988. It is also one of the largest settlements along the Transamazon. INCRA's report shows that its capacity is around 2,660 families, although only 1,527 were settled there by 2007 (INCRA 2007a). Much like other settlements in the region, land claims are still occurring in the area. In contrast, PA Uirapurú is at full capacity with 252 families settled on 252 parcels. However, some settlers are still waiting for land title.

Table 15. Land title by settlement.

Spontaneous settlements	No document		Some type of document		Total	
	Freq.	%	Freq.	%	Frequency	%
PA Rio do Peixe	11	31.42	23	65.71	34	97.13
PA Trairão	21	75.00	7	25.00	28	100
PA Tutuí Norte	2	8.33	22	91.67	24	100
PA Uirapuru	14	21.54	51	78.46	65	100
PA Surubim	4	18.18	18	81.82	22	100

Note 1: Some type of document indicates if the settler has a contract of sale, or if the settler has an INCRA protocol number or INCRA declaration. A contract of sale is a simple document passing the land right to another settler. An INCRA protocol number is a document that confirms that the settler has made a petition to the federal government claiming his right to the land. An INCRA declaration is a provisory land title.
Note 2: One respondent in Rio do Peixe settlement did not answer this question.

6.2.3 The Contentious Characteristics of Settlement Formation

Contention in the struggle for land in the Amazon region rises from a convergence of many factors, such as political interests, social needs, and institutional opportunities. All three factors are important for settlement formation.

However, in the case of the settlements in areas of *terra devoluta*, political opportunity facilitates land occupation. This opening emerges as a consequence of land rights law created by the Brazilian Constitution. Under this set of laws, individuals wanting land have clearly stated rights. The Constitution establishes that land must serve a social function, where social function is interpreted as "being in use." In other words, the principle of *"cultura efetiva e morada habital"* (effective cultivation and continuous habitation), the basic principles of *usucaption*, favor the occupation and use of *terra devoluta*. As a result, *terra devoluta* in the Brazilian Amazon is presently the land most vulnerable to occupation. The feeling that *terra devoluta* is free for all seems to avoid contention in land occupation. Contentious acts in all spontaneous settlements along the Transamazon highway are almost nonexistent (Table 16). Approximately 97% of the settlers never were involved in DALR activity, such as strikes, encampments, etc.

Table 16. Settler involvement in DALR activity by settlement.

Spontaneous Settlements	Involved in DALR		Not involved in DALR		Total	
	Freq.	%	Freq.	%	Freq.	(%)
PA Rio do Peixe	1	2.86	34	97.14	35	100
PA Trairão	4	14.29	24	85.71	28	100
PA Tutuí Norte	2	8.33	22	91.67	24	100
PA Uirapuru	3	4.62	62	95.38	65	100
PA Surubim	1	4.55	21	95.45	22	100

Conflict in land occupation does occur when the land has an established owner. In the settlement Rio do Peixe, Uirapurú, and Surubim, 77%, 80%, and 64% of the respondents, respectively, stated that the area where the settlement

is located did not have a previous owner (Table 17). In contrast, 57% and 50% of the respondents in the *assentamentos* Trairão and Tutuí Norte stated that the land had an owner before. However, the landowner may have been a previous *posseiro* who sold the right to use the land or the respondents were referring to the logging company. In the first case, a simple contract of sale had solved the problem of occupation; while in the second case, the possible conflict between the logging company and the *posseiros* was solved by INCRA's action as stated earlier. Also, recognition that the land was *terra devoluta* avoids conflicts in land occupation. Almost 59% of the occupants in the Surubim settlement stated that their lands were *terra devoluta* before occupation. This number is more impressive for the *assentamento* Tutuí Norte where 91% of the respondents affirmed that the land was *terra devoluta* before they arrived. The only settlement where 17% answered that the land was a *Fazenda* before occupation was the *assentamento* Rio do Peixe (Appendix C). However, in this case, the owner of the *Fazenda* did not have the legal rights over the land (Settlers' personal communications 2006). In other words, the *Fazenda* area was alienated by INCRA by lack of payment (Brandão et al. 1998).

Table 17. Existence of previous landowner.

Spontaneous settlements	Land owner before		No land owner before		Total	
	Freq.	%	Freq.	%	Freq.	%
PA Rio do Peixe	7	20.0	27	77.14	34	97.14
PA Trairão	16	57.14	12	42.86	28	100
PA Tutuí Norte	12	50.00	11	45.83	23	95.83
PA Uirapuru	12	18.46	52	80.00	64	98.46
PA Surubim	7	31.81	14	63.63	21	95.44

Table 18. Land type before occupation.

Spontaneous settlements	*Fazenda*		*Terra Devoluta*		No Information		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
PA Rio do Peixe	6	17.14	17	48.57	12	34.29	35	100
PA Trairão	1	3.58	19	67.85	8	28.57	28	100
PA Tutuí Norte	0	0	22	91.66	2	8.34	24	100
PA Uirapuru	4	6.17	33	50.76	28	43.07	65	100
PA Surubim	1	4.54	13	59.10	8	36.36	22	100

Note: Four respondents did not answer this question in the spontaneous settlements

In contrast to SMO settlements found in southern Pará, where contention occurred before land occupation (or invasion from the perspective of the owner), contention in the Transamazon region only occurred after settlers had occupied their lands. Key informant interviews indicated that 60% of *posseiros* in the Transamazon region were on their lots before settlement creation (Key informant 2004). However, to legalize their claims *posseiros* had to organize themselves through associations, communities, affiliation with local syndicates, or some other form of grouping, formal or informal. Using the constitutional clause of *morada habitual,* the *posseiros* attempt to show that they are using and living on the land. Organization is crucial to obtain settlement recognition. *Posseiros* acting together can create structures (such as associations or cooperatives) in order to reach decision-makers so they can influence INCRA to regularize their land holdings. Settlement recognition can facilitate infrastructure creation, such as schools, electricity, and credit access. However, only recognition is not sufficient to gain these infrastructural enhancements. Settlement recognition helps to assure land

security, but to gain infrastructure creation it is necessary to develop a plan, the so-called Settlement Development Plan (PDA - *Plano de Desenvolvimento do Assentamento*). The PDA typically must show the reality of the settlement, such as its history, soil and vegetation type, water quality, and so on. The PDA should be an action plan with directions to be executed by INCRA, City Hall, and other institutions, public or private. This plan is generally created by the settlement community with the guidance of a specialized organization (such as an NGO or a private institution contracted by INCRA). With the help of technical support, *posseiros* define the size of their lots, the location of roads, the infrastructure needed in the settlement, the demarcation of legally required biological and forest reserves, and the choice of better soils for annual and perennial crops, among other important factors. The PDA is supposed to be initiated as soon as the families arrive in the settlement. However, in the case of *terra devoluta*, the *posseiros* are living in the area and have already demarcated their land and built the roads they need. Thus, the PDA plan sometimes conflicts with on-the-ground conditions and delays *posseiros* who wish to have the land title to a specific parcel. *Posseiros* with no previous technical orientation select their lots using simple preferences, and these preferences can conflict with the technical recommendations in the PDA. As a result, convincing the *posseiros* to change the location of their lots is necessary if they are not suitable for planting. If *posseiros* cannot be convinced to move, they can still have their lots demarcated — but they assume the risk of failure.

In sum, settlement formation in *terra devoluta* in the Transamazon region is seemingly "easy" to create, but these settlements face more difficulties than SMO settlements in southern Pará. In addition, their land use systems and road building in primary forest are creating environmental problems, such as deforestation and fragmentation, a topic that I will discuss in the next sections.

6.3 The Regression Analysis

In this dissertation, survey data have helped to develop a great deal of contextual information and have shed light on the hypothesis that spontaneous DALR seeks out unclaimed lands beyond the frontier, so-called *terra devoluta*. I argued that, given the low land value of primary forest areas, *posseiros* minimize the risk of occupying land without organizational support or assistance from the state. But to test the hypothesis that spontaneous DALR is a consequence of early land reform policies that stimulated in-migration to the region and created the PICs, I use a Logit regression model (Table 19). More precisely, four Logit models were used. In these four models, a dichotomous dependent variable was set to 1 if an individual chose to create a spontaneous settlement or 0 (zero) if he/she decided to create an SMO settlement. These four models were based on the conceptual model of settlement formation outlined earlier and should have many variables in common. However, the main difference among them is related to the individual or family experience in contentious activities or in urban-to-rural migration. I chose these two variables to differentiate the models because these variables characterize most of the settlements that have support from SMOs from those that do not. In other words, settlements with social movement support

have more people participating in contentious activities than settlements in *terra devoluta*. In addition, social movement settlements have more people who migrated from urban-to-rural areas than spontaneous settlements.

Thus, all independent variables were taken from the settlement survey and included those addressed in the theoretical development of settlement formation. The conceptual model argues that settlement efforts with SMO support seek areas to occupy with easy access. In other words, SMO settlements seek areas close to urban places, preferably through access to a paved road and within the frontier. Also, in general, these areas are private property with some type of officialized land ownership. On the one hand, SMO settlements seek areas close to urban centers; on the other hand, the conceptual model also argues that spontaneous settlements are formed in low land value areas with difficult access and distant from urban places. In addition, I argue that an endogenous process characterizes these settlements. In general, this process occurs through a second generation of original settlers (or colonists) that now seeks its own land beyond the frontier on *terra devoluta*. Consequently, I argue that if these settlers have kin living in the colonization zone, then it increases the probability of a spontaneous settlement formation.

Knowledge about available land in frontier areas is difficult to acquire. Information about free land can minimize risk of land occupation and can have a positive impact on settlement formation. Previous knowledge can be a consequence of an informal network that transmits information outside the region, attracting people and stimulating migration. Thus, the previous knowledge

variable captures information acquired about free land from friends and relatives. Also, length of residence in the area can facilitate social capital and information networking, thus having a positive impact on spontaneous settlement formation. The last two independent variables in the models address contentious experience and urban-to-rural migration. The contentious experience can be characterized by a settler's own experience (Personal SMO Activity) or from the experience of a settler's kin (Kin SMO Activity). In other words, the settler may have participated in contentious activities himself or someone from his family had participated in DALR activities. Here, I expect to observe individuals with less experience in contention having a higher probability in creating spontaneous settlements rather than SMO settlements. My expectation of this variable can be explained by the lack of infrastructure that creates difficulties in accessing and mobilizing people in areas beyond the frontier. Also, SMOs (such as the Movement of Rural Landless Workers) recruit more people from urban places. Thus, I argue that people with more urban-to-rural migration will have a lower probability to create a spontaneous settlement.

6.3.1 Results and Discussion

One of my hypotheses in this dissertation argues that information about land availability is an important factor in explaining spontaneous settlement formation. However, the variable that tries to capture this effect (Prior knowledge) has no effect on spontaneous land occupation. However, knowledge about free land can be related to length of residence in the area. In other words, individuals with a long length of residence are expected to have more knowledge about free

areas. The result of the length of residence variable is robust across all models, and suggests that long periods of residence in the frontier increase the probability for spontaneous settlement creation. Period variables such as this (cf., age of household head) are often taken to represent human capital. In the present setting, my interpretation is that length of residence proxies community, or social capital, which functions as a substitute for the institutional resources carried by SMOs.

Contrary to my expectation, the distance variable has a negative effect on spontaneous settlement formation. In other words, settlements located farther away from cities are less likely to be spontaneous. In general, distance variables are related to transportation costs, because distance increases the prices of inputs and outputs. However, in the case of settlements in the Amazon region, attention needs to be paid to the role of distance. Spontaneous settlements in the Transamazon region are located on average between 18 km and 52 km from the nearest cities (Appendix E). These distances are less than those (between 17 km to 98 km) found for SMO settlements, most of which are found in the South of Pará. No doubt, those SMOs settlements are farther from cities. However, distance measured in kilometers does not necessarily reflect the real cost associated with transportation given road conditions. In general, it takes less than an hour to travel 60 km in the South of Pará, in contrast to the more than 5 hours to cover the same distance in the Transamazon region. Consequently, a pure distance measure, as used in the regressions, may not reflect actual travel times, which is the decisive factor. Future research needs to take the condition

of roads into account, and accessibility of urban centers and markets, more generally.

In the survey, the type of land that existed before settlement formation was also investigated. The *terra devoluta* variable demonstrates that land in *terra devoluta* is linked to the appearance of a spontaneous settlement. This result is consistent with the hypothesized effect, and is one of the main institutional factors differentiating spontaneous assentamentos from those created by SMOs.

Regarding a settler's personal experience in SMO activities, the results are in agreement with the conceptual model. Contentious experience in DALR decreases the probability that an individual will create a spontaneous settlement, although the kin experience has a sign contrary to expectations. Also, urban-to-rural migration seems to have no effect on spontaneous settlement formation. Finally, having relative living in colonization zones does not appear to influence the formation of spontaneous settlements, as was hypothesized via life-cycle effects. Although none of the models show significance, one of them is borderline (model 3), and the signs of the coefficients are all positive across the various specifications. Thus, I interpret the results in this regard as inconclusive, and deserving of additional research.

In sum, the regression analyses confirm my hypothesis that spontaneous settlements have some characteristics that differentiate them from SMO settlements. Also, the results suggest and reinforce the idea that these settlements have, in some way, been affected by early land reform that attracted colonists to the region. The role of colonists as drivers of land cover change in

the Brazilian Amazon are very well known (Caldas et al. 2007; Walker et al. 2002; McCraken et al. 1999). Given that the same land use practices used by early colonists are in use by new settlers, it is not difficult to imagine that the new settlements could be leading to the same process of deforestation and fragmentation, a topic that will be evaluated in the next section.

Table 19. Logit regression of settlement formation.

Independent variables	Model 1		Model 2		Model 3		Model 4	
	Coefficient	P > z	Coefficient	P > z	Coefficient	P > z	Coefficient	P > z
Prior Knowledge	1.145 (-1.22)	0.222	0.821 (0.86)	0.390	0.862 (0.95)	0.341	0.914 (0.95)	0.344
Distance to City	-0.093 (-4.65)	0.000	-0.922 (-4.50)	0.000	-0.088 (-4.99)	0.000	-0.092 (-4.69)	0.000
Length of Residence	0.248 (3.54)	0.000	0.250 (3.60)	0.000	0.198 (3.33)	0.001	0.249 (3.59)	0.000
Terra Devoluta	5.124 (0.958)	0.000	5.100 (5.34)	0.000	5.376 (5.86)	0.000	5.049 (5.35)	0.000
Personal SMO Activity	-1.615 (-2.59)	0.009	-1.453 (-2.32)	0.021			-1.484 (-2.38)	0.017
Kin SMO Activity					1.117 (1.67)	0.095		
Land Ownership	-0.451 (-0.59)	0.554	-0.547 (-0.72)	0.474	-0.906 (-1.21)	0.227	-0.562 (-0.73)	0.463
Urban-Rural							0.406 (0.880)	0.381
Kin in Colonization Zone			0.975 (1.03)	0.304	1.601 (1.62)	0.105	1.142 (1.18)	0.236
Constant	1.322 (1.39)	0.165	1.168 (1.22)	0.222	0.743 (0.79)	0.431	0.954 (0.96)	0.335
Number of Observations	304		300		294		300	
Log Likelihood	-45.885		-44.828		-46.916		-44.428	
LR Chi^2	329.02		325.38		312.87		326.18	
Prob > Chi^2	0.0000		0.0000		0.0000		0.0000	
Pseudo R^2	0.7819		0.7840		0.7693		0.7859	

Note: values between parentheses are *z* values

6.4 Settlement Formation and its Effects on Deforestation and Fragmentation

Many factors have been pointed out as drivers of deforestation in the Brazilian Amazon, ranging from the role of markets in southern Brazil to the size of individual farming households. Human activities (e.g., farming systems, logging, and road building) can disturb the structural integrity of the landscape and can compromise its functional integrity by interfering with critical ecological processes necessary for the maintenance of biodiversity (Gardner et al. 1993; With 1999). The environmental impacts of farming systems, roads, and logging have been well documented in the literature with specific relevance to the Amazon (Arima 2005; Andersen et al. 2002; Walker et al. 2002; Cochrane et al. 2002; Laurance 1998; Reid and Bowles 1997; Schelhas and Greenber 1996). However, much remains to be learned about the effects of spontaneous settlement formation in primary forest on *terra devoluta* where forest fragmentation can be a critical concern. To address the ecological concern of forest fragmentation, I made use of quantitative measurements of landscape patterns through the application of landscape metrics. Landscape metrics come from a specific geographical and ecological subdiscipline that attempts to quantitatively describe landscape form and structure through both global and local indices. Landscape ecology theory has stated that landscapes have spatial organizations that interact between spatial elements and experience modifications over time (Forman and Gordon 1986). Various landscape metrics have been used to quantify aspects of spatial pattern and correlate them to

ecological processes (Riitters et al. 1995; O'Neill et al. 1988) and land use and land cover change (Walker 2004). For my specific case, I selected two simple metrics that are weakly correlated, the number of landscape patches and mean patch size, on the hypothesis that settlement formation in primary forest increases fragmentation. To test my hypothesis, I conducted this analysis in nine *assentamentos* found in the Transamazon highway region.

The derivation of the metrics was achieved through algorithms contained within the FRAGSTATS software package (McGarigal and Marks 1995). First, spontaneous settlement boundaries were acquired from INCRA in digital format. In sequence, a GIS overlay function joined the digital map with classified images. Using an ArcInfo GRID command, I clipped the spontaneous settlements from the 1986, 1991, and 1999 classified satellite images (Figure 10). The resulting grids were then used as input to FRAGSTATS to compute selected landscape metrics. The results show that overall forest cover decreases, while deforestation and forest fragmentation increases (Appendix C). In general, all settlements found along the Transamazon highway have experienced increases in the number of patches cleared and the number of patches in forest, but the mean forest patch size has decreased (Appendix C and D). However, this study showed notable differences in magnitudes among the five settlements sampled. For instance, the *assentamento* Tutuí Norte is the only settlement where the number of patches in forest does not change much in the study period (Figure 11). Also, the mean patch size of forest increases between 1986 and 1999 (i.e., from 3,554 to 3,992 ha) (Figure 12). The survey data shows that in this

assentamento settlers have to rely more on subsistence crops. Annuals involve limited capital inputs, but require labor for clearing, planting, weeding, and harvesting. Given these characteristics, annuals receive low prices in the local market, but they also involve low risks because they produce quickly and price fluctuations are limited (Perz 2003). Also, annual crops cannot be cultivated continuously in most of the Amazon without capital inputs (Moran 1994; Sanchez 1994), so new land must be cleared, implying an increase in deforested land over time (Walker et al. 2002; Perz 2003).

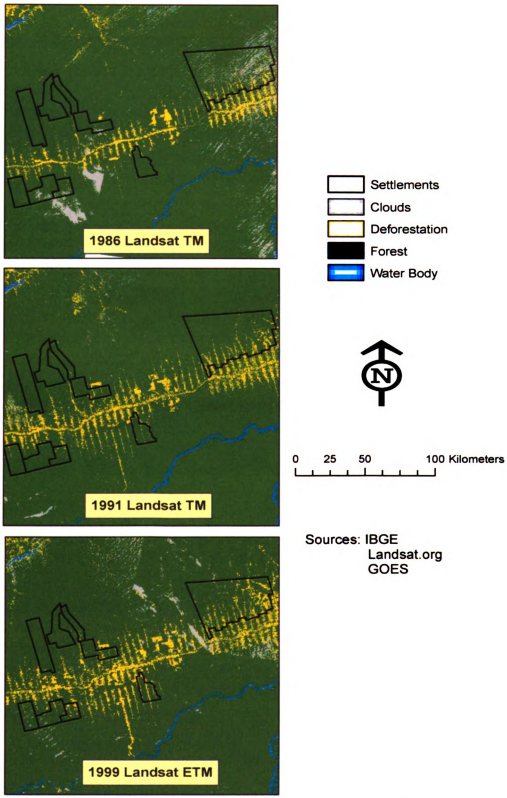


Figure 10. Land cover along the Transamazon region, State of Pará, Brazil

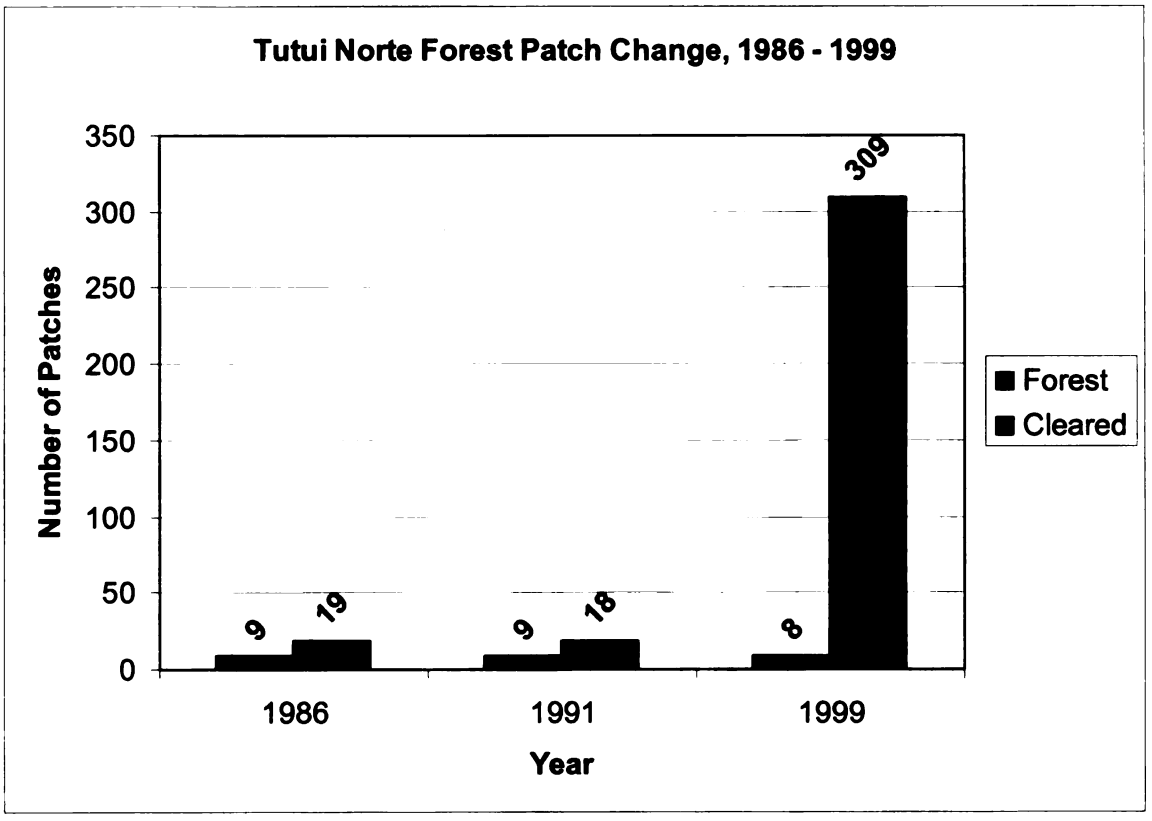


Figure 11. PA Tutuí Norte - Number of Patches, 1986 - 1999. Date of creation: 10/29/1999

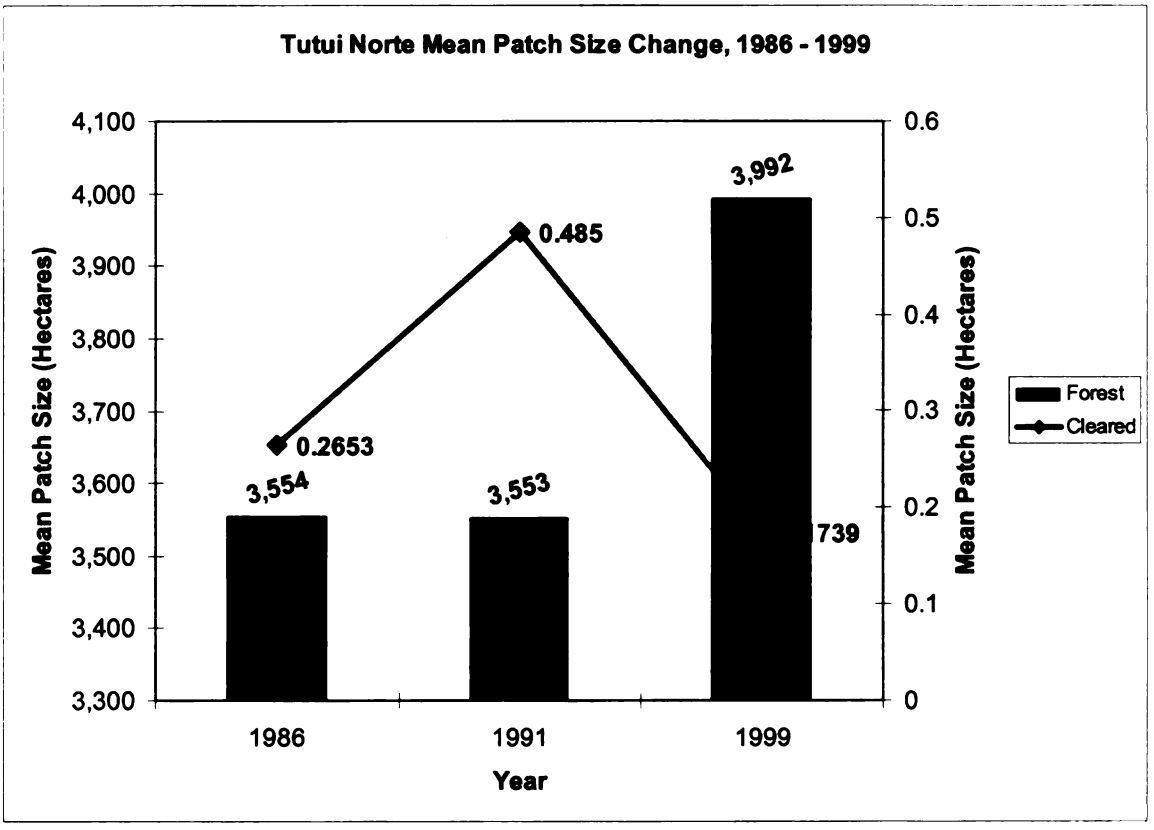


Figure 12. PA Tutuí Norte - Mean Patch Size, 1986 – 1999.

Cultivation in the Amazon involves fallow periods that increase regrowth and renew soil fertility. Although food security is also important, areas in fallow are also apparently playing an important role. In other words, the increases in the mean patch size of forest area could be an artifact of secondary regrowth. The results for PA Trairão show a different history. The number of patches in forest increases more than tenfold between 1986 and 1999, from 4 to 48 patches (Figure 13). Also, the number of patches of cleared land increases from 13 to 210 patches (Figure 13). In addition, the mean patch size of forest decreases dramatically from 3,916 ha in 1986 to 315 ha in 1999 (Figure 14).

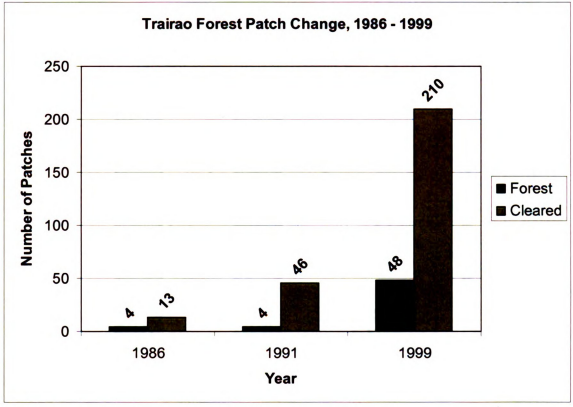


Figure 13. PA Trairão - Number of Patches, 1986 - 1999. Date of creation: 10/07/1997.

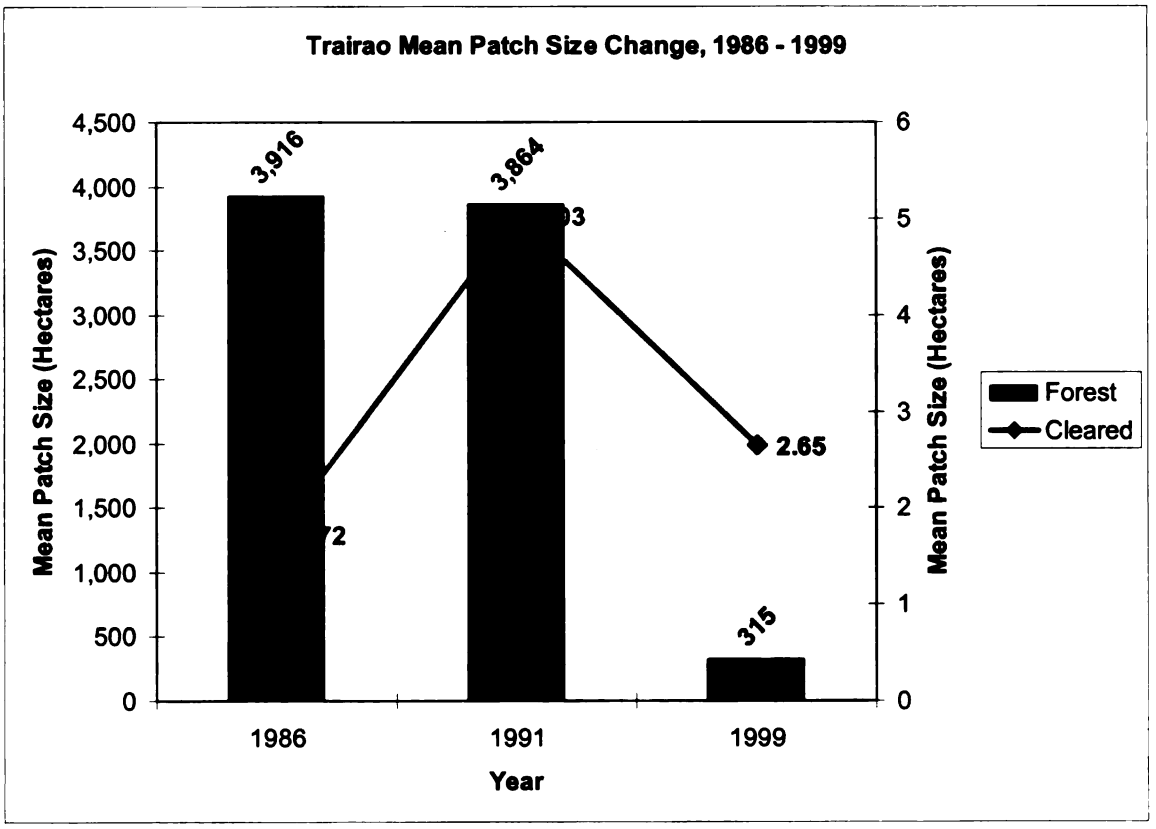


Figure 14. PA Trairão - Mean Patch Size, 1986 - 1999.

Much as *assentamento* Tutuí Norte, PA Trairão does not have parcel boundaries delimited. However, two differences exist between these settlements. The length of residence in settlement PA Trairão is around 10 years, while in the PA Tutuí Norte the length of residence is about 3 years. Moreover, the PA Trairão has more area in pasture. This result suggests that settlers in this settlement are more confident that INCRA will not remove them from their parcels. The *assentamentos* Surubim, Uirapurú, and Rio do Peixe show analogous outcomes with increases in the number of patches in forest, but with different outcomes for cleared areas (Figures 15, 16, & 17).

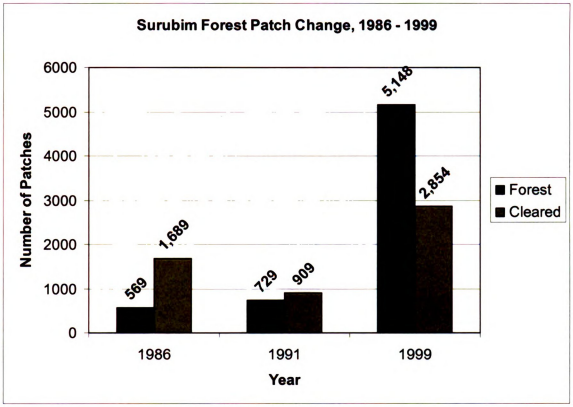


Figure 15. PA Surubim – Number of Patches, 1986 – 1999. Date of creation: 5/18/1998.

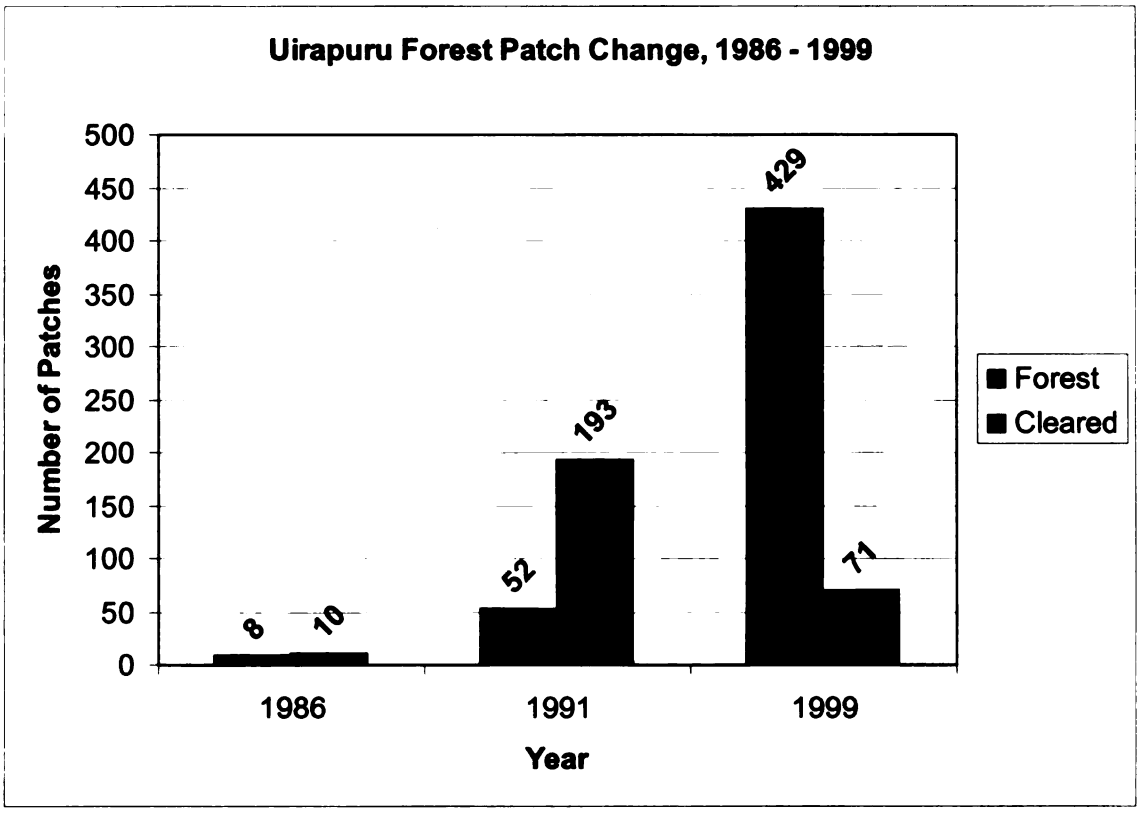


Figure 16. PA Uirapuru - Number of Patches, 1986 - 1999. Date of creation: 6/10/1997.

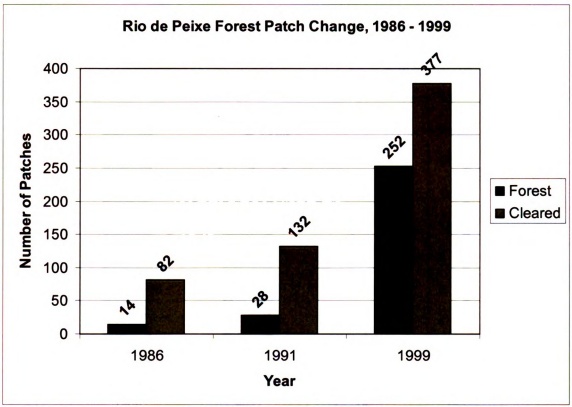


Figure 17. PA Rio do Peixe – Number of Patches, 1986 - 1999. Date of creation: 10/25/1995.

Also, the mean patch size of forest has decreased, and the mean patch size for cleared area has showed different outcomes depending on the period. For instance, the *assentamento* Surubim has showed an increase in the mean patch size of cleared area between 1986 and 1991 (from 6.09 ha to 15.83 ha), and a decrease between 1991 and 1999 (from 15.83 ha to 8.43 ha) (Figure 18). Similar results for mean patch size of forest and cleared area are found for *assentamento* Rio do Peixe, although with different magnitudes (Figure 19). On the one hand, these two settlements showed similar patterns; on the other hand, the *assentamento* Uirapurú showed a decrease in mean patch size of forest and cleared area (Figure 20).

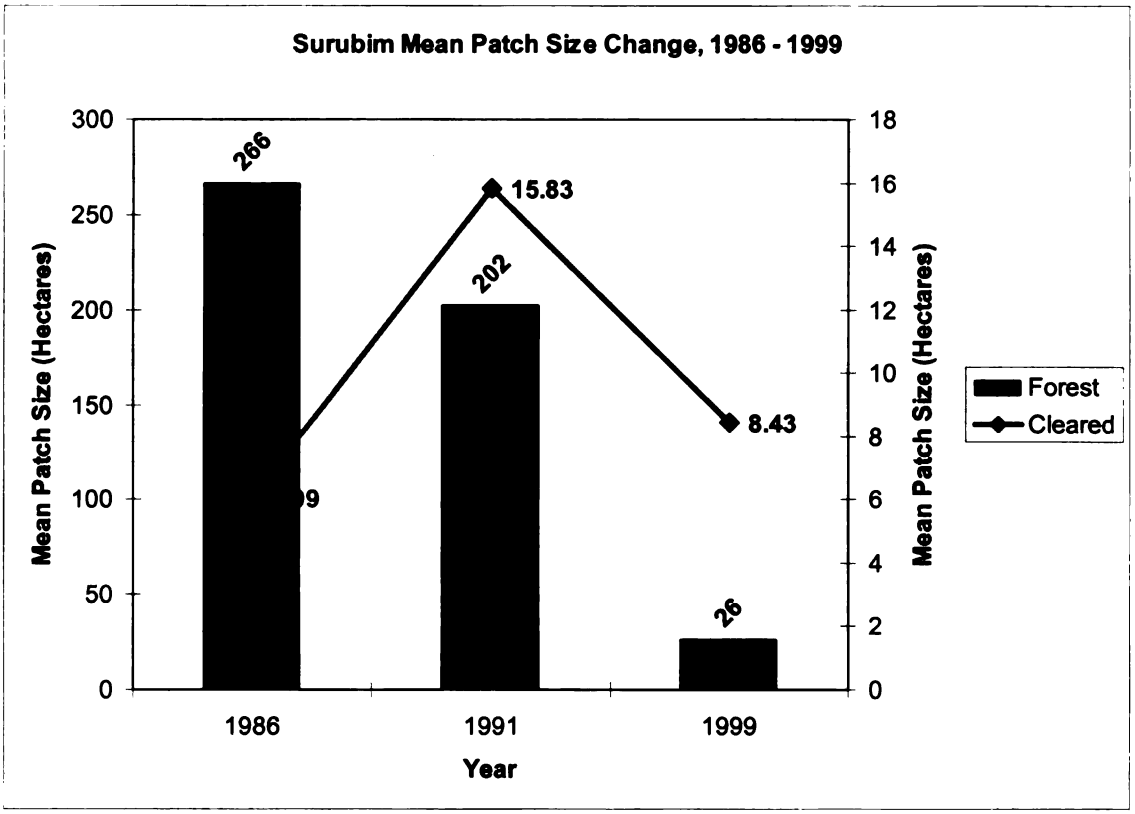


Figure 18. PA Surubim - Mean Patch Size, 1986 - 1999.

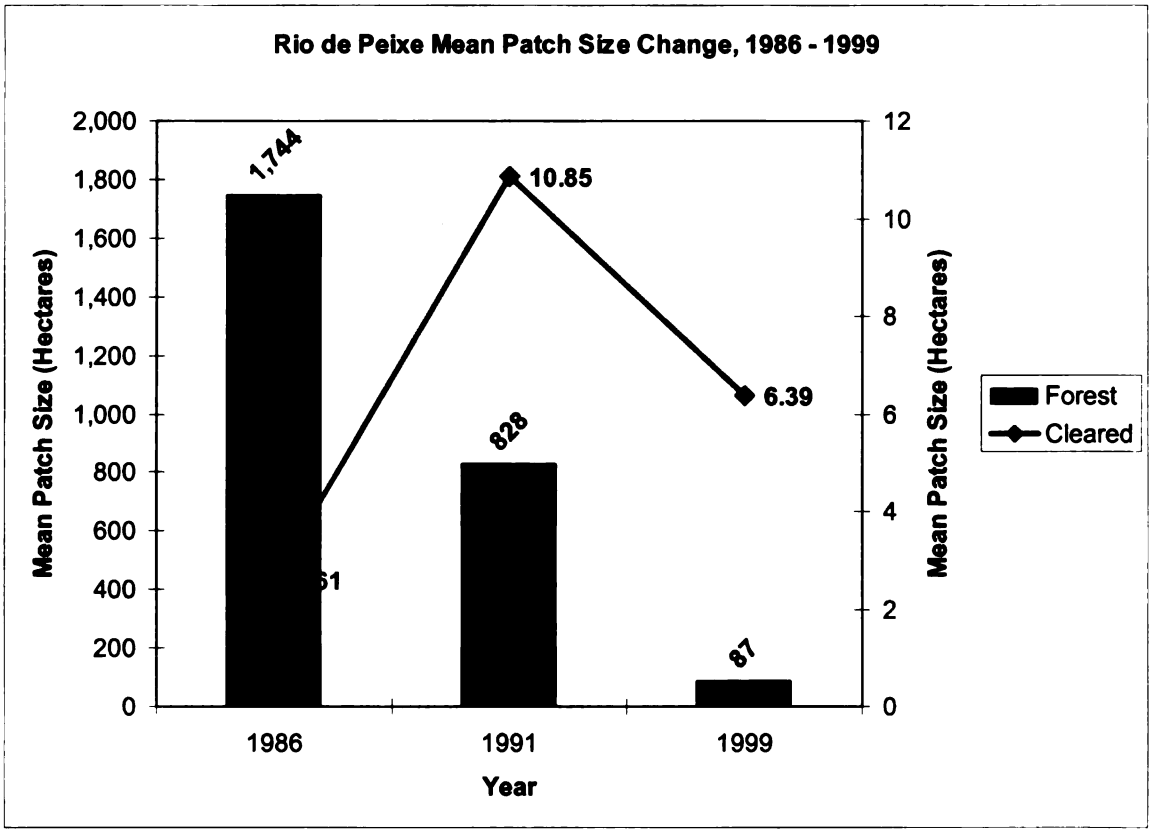


Figure 19. PA Rio do Peixe – Mean Patch Size, 1986 - 1999.

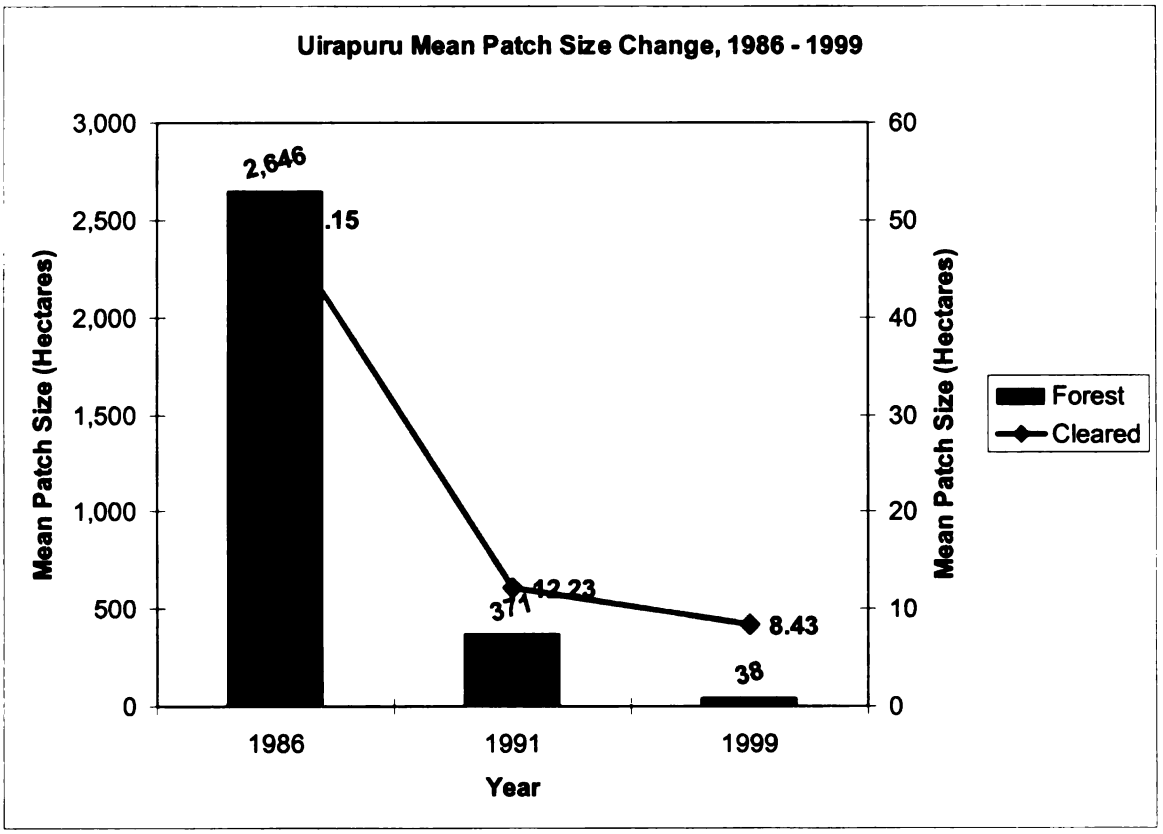


Figure 20. PA Uirapuru - Mean Patch Size, 1986 - 1999.

These three settlements are among the oldest settlements in the sample, and consequently, pasture has increased over time and constitutes additional land value. As a result, much deforested land in these settlements has shifted from crops to pasture, increasing deforestation.

Clearly, from the results above, settlement formation on *terra devoluta* is affecting the landscape with different patterns of fragmentation. Before government authorization, few tracts of deforested land inside the settlements existed. After settlement creation, infrastructure improved through credit for road building and agriculture improvements, increasing deforestation and fragmentation. Consequently, over time this process can bring serious consequences to the environment. As forest patch size decreases and as

patches of habitat become more isolated from one another, species population sizes dependant upon contiguous blocks of forest may decline below the threshold needed to maintain their survival and general landscape biodiversity.

CHAPTER 7: CONCLUSIONS

Many factors have been identified as drivers of deforestation, and this work does not deny this affirmation. However, I argue in this study that much needs to be learned about drivers of forest loss. This dissertation seeks to address this problem in a different perspective; I try to comprehend land cover and land use change in the Brazilian Amazônia through a direct reference to the underlying social and institutional circumstances that have contributed to a source of deforestation in the basin in recent years (and shows no signs of abating): the case of direct action land reform (Simmons 2006). This dissertation addresses a very particular type of DALR presently affecting the most vulnerable parts of the Amazon forest, which is found on *terra devoluta*, and I refer to as spontaneous DALR.

The main objective of this research was to investigate the social processes leading to spontaneously formed settlements (or *assentamentos*) and to assess associated impacts on deforestation. To accomplish this, I defined DALR as a form of contentious politics, and I sought to situate it in a conceptual framework that has been elaborated by the land cover and land use change research community. Three hypotheses were tested about spontaneous DALR and developed with the support of anecdotal field evidence. Two were related to factors driving the appearance of these settlements, and one related to the environmental impacts on the landscape. More specifically, the first one stated that spontaneous DALR occurs on unclaimed public lands beyond the frontier, given the low land value of primary forest areas. The second hypothesized that

spontaneous DALR is a consequence of early land reform policies that stimulated in-migration to the region as well as from demographic household life cycle. The last hypothesis stated that spontaneous DALR increases deforestation and fragmentation. Also, I argued that the underlying/proximate causation (UPC) framework of land use and land cover change to date tended to provide considerable generalization across highly aggregate factors, which complicates applications to specific processes of possible interest. Despite this complication, I adapted the UPC conceptualization to the purposes of this study by drawing attention to *assentamento* formation processes and land cover change in the Amazon basin. Thus, to achieve my goals, I conducted key informant interviews with community leaders and government officials about settlement location selection process and undertook a case study of 13 (or near fully) formed settlements in the State of Pará. In these settlements, I applied a 17-page survey instrument focusing on household demography and, in particular, on familial linkages between *assentamento* residents and earlier colonists in the region. Questions addressed household demography (age cohorts, location of immediate family members, kinship ties in the *assentamento*), migration history (place of birth, prior residence(s), year of all municipal moves), and social capital (organization memberships, church, syndicates, etc.). I also probed respondents about the land occupation process. Specifically, I wanted to know if the state or other agents (e.g., loggers, ranchers) offered resistance and whether land titles had been secured and, if not, how long they expected to wait. Finally, I asked whether *assentamento* creation liberated any federal resources, especially for

road building. In addition, I conducted a remote sensing analysis of deforestation and fragmentation occurring in nine *assentamentos* found in the Transamazon highway region with the objective of evaluating their impacts on the landscape.

The first and second hypotheses in this dissertation addressed the question of spontaneous settlement formation and the role of early land reform policies. These two hypotheses were evaluated through descriptive statistics and regression analysis. Descriptive analysis of the data suggests that spontaneous *assentamento* formation is really occurring in the Amazon region. In contrast to SMOs settlements where social movement organizations are playing a significant role in land occupation, the results confirmed my hypothesis that the lands where the spontaneous settlements have been formed today were *terra devoluta* before occupation. Also, key informant interviews give support to these findings through the finding that 60% of the people in the settlements were already there before government authorization of settlement creation (Key informant interview 2004).

I recognize that occupation of *terra devoluta* is not a new process; it has been occurring since the colonial period. However, the relatively novel statement of land rights found in the Constitution of 1988 has facilitated land occupation. According to this set of laws, private land can be expropriated if it is not meeting its social use function. Despite the changes meant to decrease land concentration and modernize agriculture, Brazil still presents one of the worst patterns of income distribution in the world, with rural poverty levels still high. As a result, masses of rural workers are led to social marginalization. Here, the institutional opportunity afforded by *terra devoluta* favors the occupation of these

lands by marginalized individuals. Having the perception that *terra devoluta* is a "free good," individuals migrate to the region and start to demarcate the land. This migration process does not seem to occur by chance. The results suggest that posseiros with kin in colonization zone may be involved in spontaneous settlement formation, although none of the models show significance, one of them is borderline, and the signs of the coefficients are positive across all models. Even though previous knowledge of the area has no explicative power in spontaneous settlement formation, length of residence in the settlement is an important factor in explaining spontaneous settlement appearance. It is important to remember that the first colonization policies of the military government in the 1970s opened the Amazon frontier and attracted thousands of migrants to the region. This first wave of migrants arrived with their families; and after three decades, these areas are acting as a pull factor, attracting people from different regions. In addition, old colonist families are maturing and their growing children are starting to search for land in order to begin their own families, thus generating new land demands outside old sites and consequently stimulating land occupation. This contrasts with SMOs settlements formed in southern Pará. In this region, marginalized individuals do not act in isolation. They are recruited and convinced by SMOs to occupy private land believed to be unproductive and, consequently, eligible for agrarian reform for a failure to fulfill its social use function. Furthermore, the occupation of private lands creates contention. Landowners do not simply give up their land in favor of land reform; consequently, months of contention can occur between landless people and

landowners. The results clearly demonstrate this difference. Contention in spontaneous settlements is nearly nonexistent, and when it occurs, it is ex-post. In other words, land reform occurs after individuals acting in isolation or disarticulated from each other have occupied their lands. Here, the contentious process occurs for land regularization (or *regularização latifúndiaria*), while in SMOs settlements located in the southern Pará contention occurs for land expropriation. The logit regression analysis confirmed my expectation. Contention has a lower probability in influencing spontaneous settlement formation. However, this result does not mean that the region containing these settlements will always be "contention free." Every day, a dozen migrant families arrive in Uruará, a county in the sample of spontaneous settlements (Key informant interview 2004). Many of them will probably have previous experience with DALR occupation, and this experience can affect the way that land occupation occurs in the region. The variable in the regression model, which measures the urban-to-rural movement, evaluated the origin of last migration before settlement occupation. In SMOs, landless people are recruited in urban places, generally around the area to be invaded. Migration to the Transamazon region is still small when compared to southern Pará where hundreds of landless families arrive every day (Key informant interview 2006). As discussed in chapter 4, this part of the State has a paved transportation system that serves as a hub linking the region to the northeast and west-central areas of Brazil. Thus, it is not difficult to imagine that as soon as the road infrastructure along the Transamazon improves, migration will increase. The variable distance from city projects the

idea that the larger the distance from cities the less the probability that an individual will be living in a spontaneous settlement in *terra devoluta*. However, improvements in road infrastructure will decrease distances, and thus, will facilitate SMOs to recruit and mobilize people for DALR occupations.

The third hypothesis in this dissertation questioned the effects of settlement formation on primary forest through the argument that settlement creation in *terra devoluta* increases deforestation and fragmentation. Apparently, from the fragmentation analysis presented here, settlement formation on *terra devoluta* is modifying the landscape. Before government authorization for settlement formation, the areas where the settlements are located showed few large tracts of forest inside their boundaries. After settlement creation, forested areas decrease and landscape fragmentation increases. However, the magnitude of deforestation and fragmentation will vary with settlement socioeconomic history. Government approval generates incentives for demands, such as credit for pasture formation, cattle acquisition, and infrastructure improvements. Despite this, government approval for settlement formation is not a sufficient condition to stimulate deforestation and fragmentation. *Posseiros* need to organize and pressure INCRA to demarcate their lots for documentation of their land rights, which facilitates loans from credit agencies. Here, the policy aspect will play an important role in Amazon land reform. Many studies have shown that credit lines in colonization areas have favored cattle acquisition and pasture formation, and there is no evidence that will change in the future. *Terras devolutas* along the Transamazon highway have immense areas in primary

forest, and if this same approach continues, it suggests that ranch formation will increase deforestation and fragmentation in this region. From a policy perspective, it would be wiser to increase credit lines for perennials crops, such as cocoa, rubber trees, and fruit trees (e.g., cupuaçu, *Theobroma grandiflorum*). This suggestion seems to be an "old-fashioned" idea. However, the failure of this policy in the past is linked to bad infrastructure and lack of technical assistance. The excuse that a market does not exist for these products sounds false. What make these products noncompetitive with others are their higher transportation cost, low productivity, and lack of technical assistance.

In conclusion, if the goal of the land reform program in Brazil is to bring social justice and dignity to the poor, then it is time to recognize past mistakes and adapt land policy to the new reality in the Amazon that takes into consideration the environmental problems that current laws are causing. If we do not act now, the future of the poor in the region will not change; and the same cyclic processes of land occupation and degradation will occur until no forest will remain to support life in the region.

APPENDICES

APPENDIX A

Explanatory variables used in models of land use and land cover change in the Amazon Basin

Aggregate Studies	Dependent Variable	Market Factors			Environment Factors		Socio-Demographic Factors		Control Variables		
		Distance	Paved road	Unpaved road	Veget.	River Density	Urban Pop.	Rural Pop.	Cleared Land	Cattle Head	Logging
Southgate, Sierra and Brown (1991)a	Extent of Land Clearing						+***	+***			
Reis and Guzman (1994)	Agricultural Clearing	-**	-**	+**	-**	-**		+**		+**	
	Deforestation Density	-**	+**	+**	+**	+**	-**	+**		+**	-**
	Share of Deforested Area in Forest	-**	+**	-**	-**	-**	+**	-**	-**	+**	+**
Andersen (1996)	Change in (the log of) deforestation	-***						+***		-***	+***
Wood and Skole (1998)	Area Deforested (# Km)				-**						
Pfaff (1999)	Proportion of Land Cleared for Agriculture	-***	+***	-ns	-***	-***					

a.tenure security is an index; b. vegetation is a proportion of the area in savanna; *p<.10; **p<.05;***p<.01

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Aggregate Studies	Dependent Variable	Market Factors			Environment Factors		Socio-Demographic Factors		Control Variables		
		Distance	Paved road	Unpaved road	Veget.	River Density	Urban Pop.	Rural Pop.	Cleared Land	Cattle Head	Logging
Andersen et al. (2002)	Growth of Cleared Land (1980-85)			-**				+**	-**		
	Growth of Cleared Land (1985-95)		+**	+**			+**	-**	+**	+**	
Chomitz and Thomas (2003)b	Proportion of Land Cleared for Agriculture				+***						

a.tenure security is an index; b. vegetation is a proportion of the area in savanna; *p<.10; **p<.05;***p<.01

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Market Factors	Environment Factors		Socio-Demographic Factors						
		Distance	Soil	Flat Land	Origin	Age	Age Square	Years School	Property Size	Wealth	Length of residence
Ozório de Almeida (1992)	Total value of farm investment				-ns		-ns			+ns	-ns
	Total value of durable goods				-ns		-ns			+**	+**
	Total value agricultural receipts received				+**		+ns			+ns	+ns
Rudel and Horowitz (1993)	Percentage land deforested										
Sydenstricker and Vosti (1993)	Area deforested										
Alston, Libecap, and Schneider (1993)	Investment	-**					+ns	+*		+ns	+**
	Percentage land area under annuals	-ns			+**		+ns	-**		-*	-ns
	Percentage land area under perennials	-*			+ns		-ns	+ns		-**	+ns
	Percentage land area under pasture	+ns			-**		-ns	+**		+**	+ns

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Market Factors	Environment Factors		Socio-Demographic Factors						
		Distance	Soil	Flat Land	Origin	Age	Age Square	Years School	Property Size	Wealth	Length of residence
Ozório de Almeida and Campari (1995)	Total hectares deforested since arrival	+*					-ns		+ns	+ns	+ns
	Hectares deforested in 1991	+ns					+ns		+ns	+ns	+ns
Thapa, Bilsborrow, and Murphy (1996)	Whether respondent is involved in planting or harvesting					-**		-**			
Murphy, Bilsborrow, and Pichón (1997)	Total income	-**	+**					+*	+**		+**
	Total assets (durable goods, housing, livestock)	-**	+ns					+ns	+**		+**

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Market Factors	Environment Factors		Socio-Demographic Factors						
		Distance	Soil	Flat Land	Origin	Age	Age Square	Years School	Property Size	Wealth	Length of residence
Pichón (1997)	Percentage land area under perennials	-**	+**					+ns	-**	+ns	+ns
	Percentage land area under pasture	-ns	+ns					+**	+*	+**	+**
	Percentage land area in forest	+**	-**					-**	+**	-**	-**
Godoy et al. (1998)	Hectares of primary forest cut	-ns					-**	-*	-ns		+**
Godoy, Franks, and Claudio (1998)	Probability of using chemical fertilizers or insecticides	-**						-ns			
Godoy, Groff, and O'Neill (1998)	Hectares of old-growth forest cut						+ns	-ns			+**
Godoy, Jacobson, and Wilkie (1998)	Hectares of primary forest cut						-ns	-**		+ns	

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Market Factors	Environment Factors		Socio-Demographic Factors						
		Distance	Soil	Flat Land	Origin	Age	Age Square	Years School	Property Size	Wealth	Length of residence
Walker et al. (2002)	Cattle	-***			+***	+ns	+ns	+ns		+ns	+ns
	Perennials	-ns			+*	-ns	-ns	+ns		-ns	+**
	Perennials with Cattle	-***			+ns	+ns	-ns	+**		-*	+ns
	Annuals with Perennials	-**			+ns	+ns	-ns	+ns		-ns	+**
	Annuals with Cattle	-ns			+**	+ns	-ns	-ns		-ns	+ns
	Perennials with Annuals	-***			-ns	-ns	+ns	+ns		+ns	+***
Pan and Bilsborrow (2004)	Forest (primary and secondary fallow > 7 years old)	+***		-ns				-**			
	Others (young and old Fallow < 7 years old, swamp)	-***		+ns				+ns			
Caldas et al. 2007	Area deforested	-***	+*			-ns				+***	+ns

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Socio-Demographic Factors					Institutional Factors		
		Family Size	# Men	# Women	# Children	Hired Labor	Title	Credit	Tech. Assist.
Rudel and Horowitz (1993)	Percentage land deforested	+*						+ns	
Sydenstricker and Vosti (1993)	Area deforested		+**	+*	+ns				
Alston, Libecap, and Schneider (1993)	Investment	+*					+**		
	Percentage land area under annuals	-ns					-ns		
	Percentage land area under perennials	-ns					+ns		
	Percentage land area under pasture	+ns					+ns		
Ozório de Almeida and Campari (1995)	Total hectares deforested since arrival						-ns	+*	
	Hectares deforested in 1991						+ns	+**	
Thapa, Bilsborrow, and Murphy (1996)	Respondent: involved in planting, harvesting				+***				

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Socio-Demographic Factors					Institutional Factors		
		Family Size	# Men	# Women	# Children	Hired Labor	Title	Credit	Tech. Assist.
Murphy, Bilsborrow, and Pichón (1997)	Total income		+ns	+ns				-ns	+**
Pichón (1997)	Percentage land area under perennials	+**			+**	+**	-**		+ns
	Percentage annual area	+**			-ns	+**	-**		+ns
	Percentage pasture area	+ns			+*	+ns	-ns		-ns
	Percentage land area in forest	-**			-**	-**	+ns		+ns
Godoy et al. (1998)	Hectares of primary forest cut		-**	+ns	+ns				
Godoy, Franks, and Claudio (1998)	Probability of using chemical fertilizers or insecticides		+*						
Walker et al. (2002)	Cattle		-*			+**			
	Perennials		+ns			+**			
	Perennials with Cattle		+*			+**			

Explanatory variables used in models of land use and land cover change in the Amazon Basin (cont.)

Agent Focused Studies	Dependent Variable	Socio-Demographic Factors					Institutional Factors		
		Family Size	# Men	# Women	# Children	Hired Labor	Title	Credit	Tech. Assist.
Walker et al. (2002)	Annuals with Perennials		+**			+ns			
Pan and Bilsborrow (2004	Forest (primary and secondary fallow > 7 years old)		-***		-ns	-***	-**		
	Pasture		+ns		-ns	+***	+***		
	Perennials		+**		-**	+ns	-**		
	Annuals		+ns		+***	-ns	-ns		
	Others (young and old Fallow < 7 years old, swamp)		-ns		+**	-ns	+ns		
Caldas et al. 2007	Area deforested		+**	-ns	-ns	-ns		+**	

APPENDIX B

DALR – Household Surveys

001. Questionnaire number: _____ **002.** Date: _____

003. Interviewer: _____ **004.** Reviewer: _____

005. GPS type: _____

Position:
5.1_____
5.2_____

006. Settlement name: _____

007. Settlement was officially created?

_____No _____Yes

7.1 When: _____

008. Municipality: _____

009. Gleba: _____

010. Lot number: _____

011. Secondary road number (Travessão): _____

012. Distance (Transamazon/City): _____

013. Name of the interviewee: _____

014. Position of interviewee:

1. Owner
2. Spouse
3. Son/Daughter
4. Other (specify e.g., sharecropper): _____

015. Name of the owner? _____

016. Where does the owner live?

1. Lives in the lot: _____Yes_____No
2. Lives in the city: _____ State: _____
3. Lives in another lot: _____ Municipality: _____State: _____
4. How many lots does the owner have: _____

017. House where the family is living

	Before arrival		After arrival	
	No	Yes	No	Yes
Wood walls	( )	( )	( )	( )
Brick walls	( )	( )	( )	( )
Mud walls	( )	( )	( )	( )
Well	( )	( )	( )	( )

Questions about history of the lot

018. Year acquired? _____

019. How long have you lived in this settlement? _____

020. What is the size of this lot? _____Hectares _____Alqueires

021. Does the owner have any type of land document?

_____Yes _____No

022. If Yes, what is the type of the document?

( ) Definitive title (Year received: _____)
( ) Provisional title (Year received: _____)
( ) Contract of sale
( ) Other (Specify: _____)
( ) No document

023. If No, when do you expect to receive documentation?

( ) 6 months to 1 year
( ) 1 year to 2 years
( ) 2 years to 5 years
( ) More than 5 years

024. How was the physical condition of the lot at arrival?

1._____ (%) Primary forest
2._____ (%) Some open areas but nothing cultivated
3._____ (%) Some areas in production
3.1_____ annual crops (ha)
3.2_____ perennial crops (ha)
3.3_____ pasture (ha)
3.4_____ secondary forest (ha)
4. _____ (%) Other characterization (specify: _____)
99. ___ NA

025. Do you have water in the lot?

_____Yes _____No _____NA

026. If Yes, how do you use the water?

0. _____irrigation of crops
1. _____cattle and other animals
2. _____to drink

3. _____do not use why? _____
99. _____NA

027. Were you owner since the beginning?
0._____No 1._____Yes

028. If Not, 1. How many owners did the lot have before you? _____
2. What year was this lot bought for the first time? _____

Landownership history (urban-rural link)

029. Does the owner of this lot have rural or urban properties in the State of Pará? 0._____No 1._____Yes 99._____NA

030. If Yes, what is the type of the property?
1._____residential property
2._____business
3._____Other (specify :_____)

031. Does the owner of this lot have other lots or rural properties in the State?
0._____No 1._____Yes 99._____NA

032. If Yes, how many rural properties do you have?
_____ (# of properties)

033. What is the area of all rural properties that you have (please, include this lot)?
1._____Hectares 2._____Alqueires 99._____NA

034. How many properties did the owner have that were sold? _____
_____Year Size of the property (Hectares):_____

Socio Economic Background:

035. How many families and persons are living in this lot today?
1._____families 2._____persons 3._____children

036. Beginning with yourself and then your spouse, please provide the age, sex, and number of years of education of each member of your household, along with their relationship to you:

	Age	Sex	Relationship	Years of school
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____

037a. How many days of labor did you pay for in the past year?_____

037b. How many days labors did you exchange last year? _____

038. How many days of labor did members of your household work for others in the past season?_____

039. Where were you born?

a. State _____

b. Municipality _____ 3. City_____

040. When were you born?

a. Year _____

b. Month _____

041. When you arrived here, did you bring any equipment?

	Had upon arrival		Today	
	No	Yes	No	Yes
a. Chainsaw	( )	( )	( )	( )
b. Generator	( )	( )	( )	( )
c. Cocoa dryer	( )	( )	( )	( )
d. Tractor	( )	( )	( )	( )
e. Truck	( )	( )	( )	( )

042. When you arrived here, which kind of durable good did you have?

	Had upon arrival		Today	
	No	Yes	No	Yes
a. Stove	( )	( )	( )	( )
b. Sewing machine	( )	( )	( )	( )
c. Refrigerator	( )	( )	( )	( )
d. Television	( )	( )	( )	( )
e. Parabolic antenna	( )	( )	( )	( )

f. Bicycle	( )	( )	( )	( )
g. Car	( )	( )	( )	( )
h. Radio	( )	( )	( )	( )
i. House in the city	( )	( )	( )	( )

Migration Questions

043. Please give the year and month (or your age) when you moved to another place of residence, along with the state, municipality, and type of residence (rural/urban):

	Year-month	State	Municipality	Rural/urban
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
8.	_____	_____	_____	_____
9.	_____	_____	_____	_____

Social/political capital Questions

044. Do you (or the owner) participate in a rural syndicate in the municipality?
0._____No 1._____Yes 99._____NA
045. Do you (or the owner) participate in any association in the municipality?
0._____No 1._____Yes 99._____NA
046. Do you (or the owner) participate in any cooperative in the municipality?
0._____No 1._____Yes 99._____NA
047. Are you (or the owner) a member of a church in the municipality?
0._____No 1._____Yes 99._____NA

048. Please list all of the organizations that you are involved in (i.e. rural workers union – STR).

	Name	Type	Date	Office held
1.				
2.				
3.				
4.				
5.				

DALR Experience:

049. Have you been involved in DALR activities?
0.____No 1._____Yes 2. ____Which type 99. _____
(If No, go to question 050)

DALR event	When Month/year	Where State/city	Duration	Results	A	B	C

* Type of event: 1=protest; 2=Encampment; 3 Settlement

A. Who organized the occupation?
(1) Nobody
(2) City hall
(3) Rural union
(4) INCRA
(5) MST
(6) CPT
(7) Other: specify_____

B. How did you learn about this occupation?
(1) Through parents/relatives
(2) Friends
(3) SMO (MST, CPT, STR, etc.) Which one: _____
(4) Government agency (INCRA, City hall) Which one: _____
(5) Commentary in the city (sounds car and advertisements)
(6) Other: specify _____

C. How did you choose this area to occupy? Which factors were important in the choice?
(1) Lot is close to parents/relatives house
(2) Roads
(3) Lot w/ valuable trees

(4) Close to the city
(5) Other: specify _____

050. Has, or is, anyone in your family been involved in DALR activities?
0. _____No 1. _____Yes 99. _____NA

(If No, go to question 051)

DALR event	When Month/year	Where State/city	Duration	Results	A

* Type of event: 1=protest; 2=Encampment; 3 Settlement

A. Who organized the occupation?
(1) Nobody
(2) City hall
(3) Rural union
(4) INCRA
(5) MST
(6) CPT
(7) Other: specify_____

History of the settlement

051. How did you learn about this occupation?
(1) Through parents/relatives
(2) Friend
(3) SMO (MST, CPT, STR, etc.) Which one: _____
(4) Government (INCRA, City hall) Which one: _____
(5) Comments in the city
(6) Other: specify _____

052. How did you choose this area to occupy? Which factors were important in the choice?
(1)Lot is close to parents/relatives house
(2)Roads
(3)Lot w/ valuable trees
(4)Close to the city
(5)Other: specify _____

053. What was this area before occupation?

1. Fazenda ( ) 2. Terra devoluta ( ) 3. Other ( ) specify:_____

054. Do you have roads in the lot?

0._____No 1._____Yes

055. If Yes, who built the road?

(1) The owner
(2) City hall
(3) Logger
(4) INCRA
(5) Other: specify_____

056. When you arrived here, the settlement had:

1._____Trail 2._____Road 3._____Nothing

057. Who built the trail/road?

(1) The owner
(2) City hall
(3) Logger
(4) INCRA
(5) Other: specify_____

058. Did this lot have a landowner before your arrival?

0. _____No 1._____Yes 2. Who_____

059. If Yes, how did you get this lot?

(1) You just occupied the lot
(2) You made a deal with the landowner
(3) Other: specify _____

060. Who helped you to create the settlement?

(a) Nobody
(b) City hall
(c) STR
(d) INCRA
(e) MST
(f) CPT
(g) Other: specify _____

Explain the process: _____

061. What did you do to create the settlement?

(a) Occupied the area
(b) Strike
(c) Encampment in front of INCRA
(d) Encampment in the road
(e) Other: specify _____

062. Were you a member of *Frente de Massa*?

0._____ No 1. _____Yes

Explain: _____

063. Did you join any association before or after lot demarcation?

( ) Before ( ) After ( ) NA

Why did you join the association? Explain:_____

Who created the association? Explain _____

064. Do you think that was difficult to demarcate this lot?
0. _____No 1. _____Yes
Explain: _____
065. How were the lots divided? Who divided them? Explain: _____
066. Did you have any conflict with others in demarcating the lot?
0. _____No 1. _____Yes
Who? _____
067. Do you follow any environmental or land use rule?
0. _____No 1. _____Yes
Explain: _____
068. If yes, which rules do you follow? Do you agree with these rules?
0. _____No 1. _____Yes
Explain: _____
069. The settlement creation helped you to obtain credit for:
(1) House
(2) Roads
(3) Energy
(4) School
(5) Other
(6) It did not help
070. Do you want your children to have land here?
0. _____No 1. _____Yes
If not, why not? _____
071. Do you have any relative or parent living the old colonization area?
0. _____No 1. _____Yes
How many? _____
072. If yes, who?
( ) Father/Mother Where? _____
( ) Brother/Sister Where? _____
( ) Uncle/Aunt Where? _____
( ) Other: specify
073. Do you have relative or parent living here in the secondary road?
0. _____No 1. _____Yes
How many? _____
074. If yes, who?
( ) Father/Mother Where? _____
( ) Brother/Sister Where? _____
( ) Uncle/Aunt Where? _____
( ) Other: specify
075. What do you think about land reform in Brazil? Explain?

Agriculture experience

076. What was your parent's occupation?
0. _____Farmer 1. _____Business man 2._____Other

Urban____ Rural_____ Specify:_____

077. Years respondent practiced agriculture: _____

078. Agricultural (or ranching) education/training?

0. _____No 1. _____ Yes 99. _____NA

What type? _____

How many months/years? _____

079. Where do you get your information about planting/harvesting?

( ) Parents/relatives
( ) Friends
( ) SMO (CPT, MST, OTC, STR)
( ) INCRA, City Hall
( ) School
( ) Other: specify _____
( ) Nobody

080. Did anybody living here receive credit to buy equipment, commercialize, or soil conservation practices?

0. _____No 1. _____Yes 99. _____NA

081. If yes, please, describe the objective of the credit?

1. _____
2. _____

082. Do you receive technical assistance?

0. _____No 1. _____ Yes

083. If yes, from who?

1. _____ 2. _____
3. _____ 4. _____

084. If yes, did you receive incentives to use?

	No	Yes	
Curvas de Nivel	( )	( )	
Soil cover	( )	( )	
Terracing	( )	( )	
Crop rotation	( )	( )	
Mulch	( )	( )	
Other	( )	( )	Which one? _____

085. Using these practices did you observe any improvement in production?

0. _____No 1. _____Yes 99. _____NA

086. If yes, where did the improvement occur?

( ) corn ( ) beans ( ) rice ( ) pasture

( ) other: specify _____

087. Do you have any interest in reforestation?

0. _____No 1. _____ Yes 99. _____NA

088. If yes, which kind of tree would you use?

1. _____ 2. _____ 3. _____

089. Do you raise cattle?

0. _____No 1. _____Yes 99. _____NA

090. If yes, how many different pasture areas do you have in your lot? What is the size of each area and condition?

	Pasture 1	Pasture 2	Pasture 3	Pasture 4	Pasture 5	Pasture 6
# of cattle heads						
Area (ha)						
Condition (a)						
Mineral salt/vaccine (Y/N)						
Rent to other - 2005 (Y/N)						

(a)Code: AL: active clean pasture; As: Dirty pasture; B: abandoned pasture; C: Pasture in reform

091. In case you rented any pasture area did you receive income from it?

0. _____No 1. _____Yes How much (R$____/head/month)

99. _____NA

092. Agriculture – land use during 2005

Annual crops	**Lot 1**	**Lot 2**	**Lot 3**	**Lot 4**
Corn Hectares Production Fertilize (f) Pesticide (p)				
Rice Hectares Production Fertilize (f) Pesticide (p)				
Bean Hectares Production Fertilize (f) Pesticide (p)				

Manioc Hectares Production Fertilize (f) Pesticide (p)				
Vegetables Hectares Production Fertilize (f) Pesticide (p)				
Water melon Hectares Production Fertilize (f) Pesticide (p)				
Sugar-cane Hectares Production Fertilize (f) Pesticide (p)				
Other Hectares Production Fertilize (f) Pesticide (p)				

093. Agriculture – perennials land use during 2005

Perennial crops	**Lot 1**	**Lot 2**	**Lot 3**	**Lot 4**
Coffee Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Cocoa Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Banana Planted Hectares Year planted Total harvest (unit)				

Sale+exchanged (unit) Price (unit)				
Citrus Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Rubber tree Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Cotton Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Cashew Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Guaraná Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Black pepper Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				
Other Planted Hectares Year planted Total harvest (unit) Sale+exchanged (unit) Price (unit)				

094. How many years do you leave the land in fallow? _____

095. Do you sell your produce (or production) in the market?

0. _____No 1. _____ Yes

096. If yes, how do you transport the product to the market?

( ) Own car
( ) Bus
( ) Kombi van
( ) *Carro de linha*
( ) Other
( ) NA

097. If not, why? Would you like to sell your product in the market in the future?

098. Do you have problem with loss of soil fertility or erosion?

0. _____No 1. _____Yes 99. _____

099. Why or why not? _____

100. Do you use fire to clear or prepare your land?

0. _____No 1. _____Yes 99. _____

With what frequency do use fire?(how many times a year?) _____

When? (Month?) _____

101. Have you had problems with fire in your property in the last 10 years?

0. _____No 1. ____Yes 99. _____NA

Year	# of fires	Burned area (ha)	Crops/infrastructure (a)	Fire/causes (b)
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2005				

Code:
(a) CA: annual crops; CP: perennial crops; PA: pasture; CP: secondary forest
CE: fence; PR: buildings; VE: vehicle; OU: other (specify: _____)
(b) VZ: fire from neighbor; FP: own fire; OU: other (specify: _____)

Forest

102. When you arrived in the lot:

a. how much deforestation did the lot have?

b. Who opened the area?

	Open area (after arrival)	Year	Who opened
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____

Plan for the future (next 2 years)

103. If you had to decide your plans for the next two years, which changes would you like to make in your lot?

104. What would you do with your annual crops?
0. _____keep the same area
1. _____increase the area
2. _____decrease the area
9. _____NA

105. What would you do with your perennial crops?
0. _____keep the same area
1. _____increase the area
2. _____decrease the area
99. _____NA

106. What would you do with your pasture area?
0. _____keep the same area
1. _____increase the area
2. _____decrease the area
99. _____NA

107. In case you want to increase the area in annual or perennial crops, where would you increase the area?
0. _____secondary forest
1. _____forest area
99. _____NA

108. What is your plan for your cattle?
0. _____keep the herd size
1. _____increase the herd size
2. _____decrease the herd size
99. _____NA

109. In the next two years, what would you like to do?
1. ____stay in the same lot
2. ____move to another lot in the Pará State
3. ____move to the city
4. ____other:_____

110. In the next two years, what would you like to do?

1. ____sell the lot
2. ____expand agriculture production
3. ____keep the production the same
4. ____leave the lot as inheritance

APPENDIX C

Deforestation Measures by Settlement

Spontaneous settlements	1986		1991		1999	
	Forest (ha)	Cleared (ha)	Forest (ha)	Cleared (ha)	Forest (ha)	Cleared (ha)
PA Rio do Peixe	24,421.14	213.75	23,205.33	1,431.63	22,159.08	2,407.77
PA Trairão	15,666.57	22.32	15,457.41	231.48	15,132.60	556.29
PA Tutuí Norte	31,984.70	4.95	31,981.00	8.73	31,935.90	53.64
PA Uirapurú	21,171	501.48	19,311.21	2,360.97	16,307.64	5,337.81
PA Surubim	151,870.59	10,288.80	147,811.95	14,390.37	138,114.9	24,075.72
PA Tutuí Sul	13,388.13	279.27	12,880.53	786.87	11,534.49	2,132.91
PA Alto Pará	44,446.23	80.19	44,195.49	330.93	44,126.10	400.14
PA Placas	25,688.79	105.12	25,377.39	416.52	24,508.80	1,268.82
PA Rio de Pedras	23,919.48	86.94	23,454.27	552.15	23,229.99	763.47

Landscape Metric: number of patches in forest by settlements

Spontaneous settlements	Date of creation	Number of Patches					
		1986	1991	ΔForest	1991	1999	ΔForest
		Forest	Forest	86-91	Forest	Forest	91-99
PA Surubim	1988	569	729	160	729	5,148	4,419
PA Rio do Peixe	1995	14	28	24	28	252	224
PA Trairão	1997	4	4	0	4	48	40
PA Uirapurú	1997	8	52	44	52	429	377
PA Tutuí Sul	1997	19	23	4	23	90	67
PA Alto Pará	1997	3	5	2	5	20	15
PA Rio de Pedras	1998	32	36	4	36	71	35
PA Placas	1998	24	31	7	31	79	48
PA Tutuí Norte	1999	9	9	9	9	8	-1

Landscape Metric: number of cleared patches by settlements

Spontaneous settlements	Date of creation	Number of Patches					
		1986	1991	ΔCleared	1991	1999	ΔCleared
		Cleared	Cleared	86-91	Cleared	Cleared	91-99
PA Surubim	1988	1,689	909	-780	909	2,854	1,945
PA Rio do Peixe	1995	82	132	50	132	377	245
PA Trairão	1997	13	46	33	46	210	164
PA Uirapurú	1997	10	193	183	193	71	-122
PA Tutuí Sul	1997	47	74	27	74	128	54
PA Alto Pará	1997	46	91	45	91	108	17
PA Rio de Pedras	1998	17	124	107	124	175	51
PA Placas	1998	66	125	59	125	199	74
PA Tutuí Norte	1999	19	18	-1	18	309	291

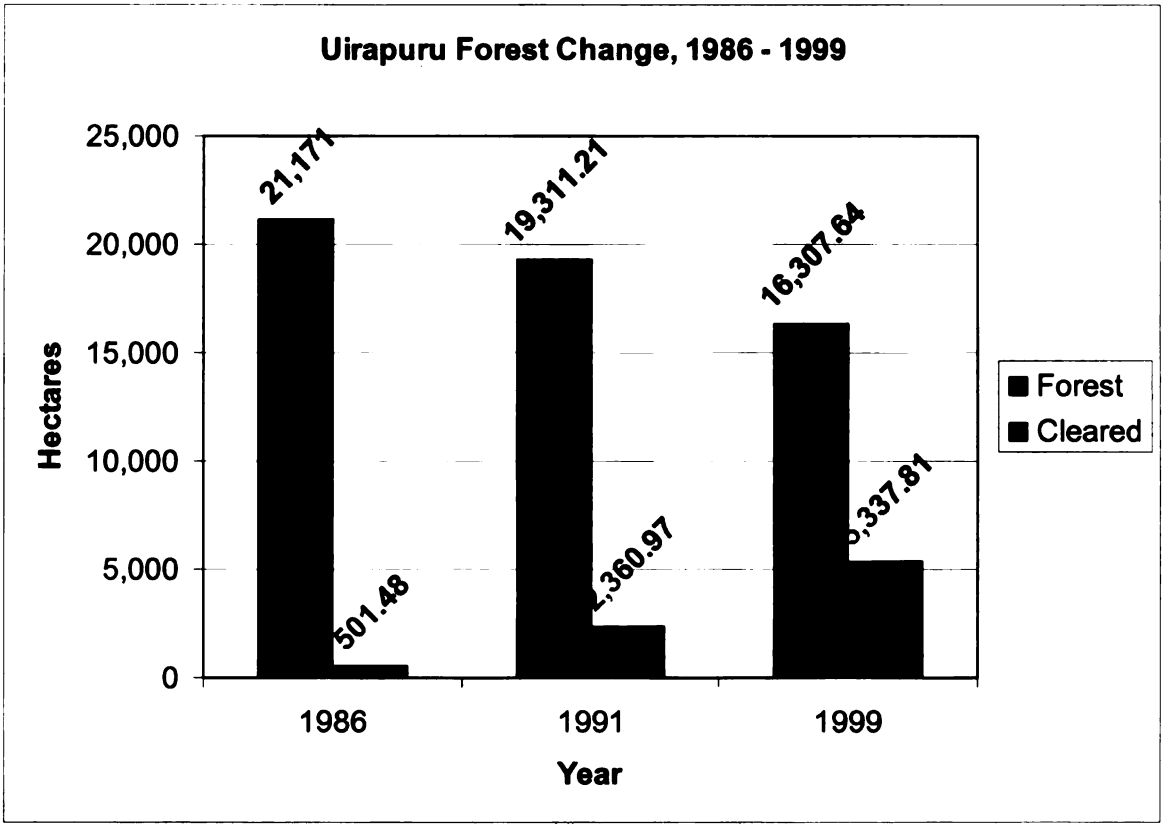
Landscape Metrics: forest mean patch size by settlements

Spontaneous settlements	Date of creation	Mean Pach Size (ha)					
		1986 Forest	1991 Forest	ΔForest 86-91	1991 Forest	1999 Forest	ΔForest 91-99
PA Surubim	1988	266	202	-64	202	26	-176
PA Rio do Peixe	1995	1,744	828	- 916	828	87	-741
PA Trairão	1997	3,916	3,864	-52	3,864	315	-3,549
PA Uirapurú	1997	2,646	371	-2,275	371	38	-333
PA Tutuí Sul	1997	704	560	-144	560	128	-432
PA Alto Pará	1997	14,815	8,839	-5,976	8,839	2,206	-6,633
PA Rio de Pedras	1998	747	651	-96	828	327	-501
PA Placas	1998	1,070	818	-252	818	310	-508
PA Tutuí Norte	1999	3,554	3,553	-1	3,553	3,992	429

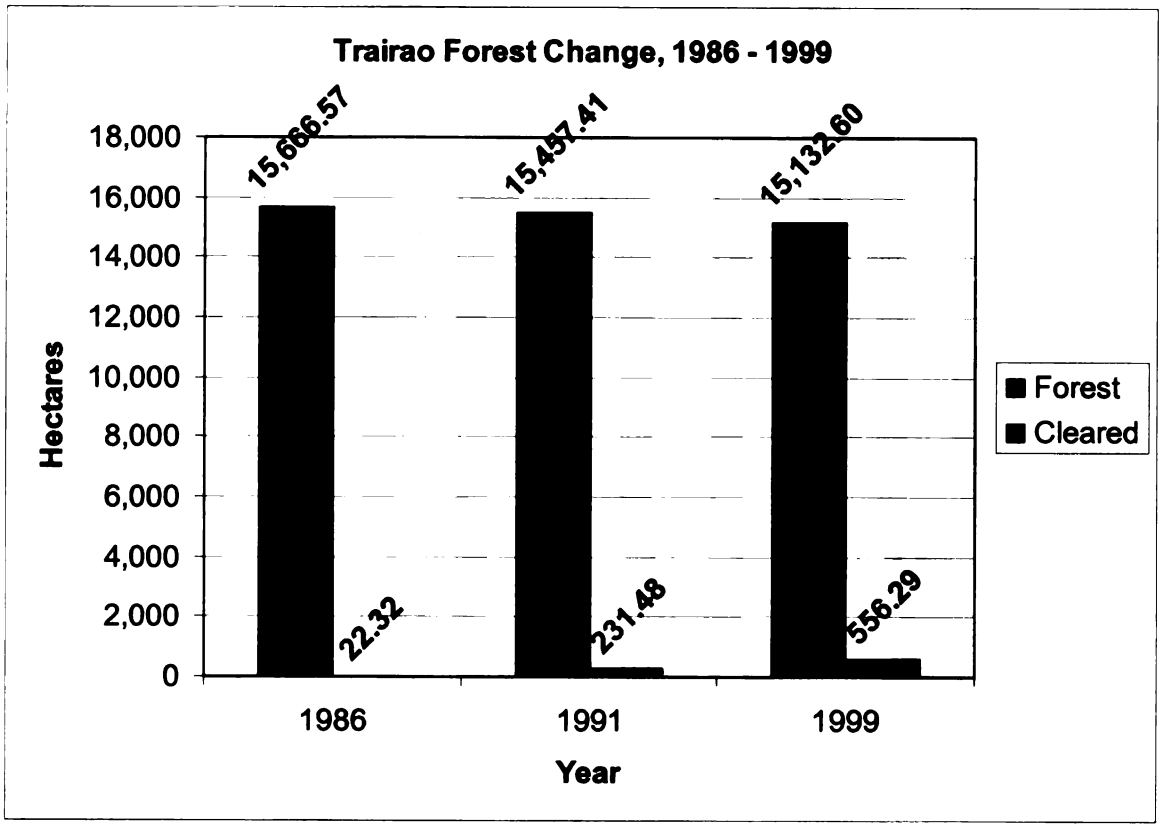
Landscape Metrics: cleared mean patch size by settlements

Spontaneous settlements	Date of creation	Mean Pach Size (ha)					
		1986 Cleared	1991 Cleared	ΔCleared 86-91	1991 Cleared	1999 Cleared	ΔCleared 91-99
PA Surubim	1988	6.09	15.83	9.74	15.83	8.43	-7.4
PA Rio do Peixe	1995	2.61	10.85	9.24	10.85	6.39	-4.46
PA Trairão	1997	1.72	5.03	3.31	5.03	2.65	-2.38
PA Uirapurú	1997	50.15	12.23	-37.92	12.23	8.43	-3.8
PA Tutuí Sul	1997	5.94	10.63	5.69	10.63	16.66	6.03
PA Alto Pará	1997	1.74	3.64	1.9	3.64	3.70	0.06
PA Rio de Pedras	1998	5.11	4.45	-0.66	4.45	4.36	-0.09
PA Placas	1998	1.59	3.33	1.74	3.33	6.38	3.05
PA Tutuí Norte	1999	0.26	0.48	0.22	0.48	0.17	-0. 31

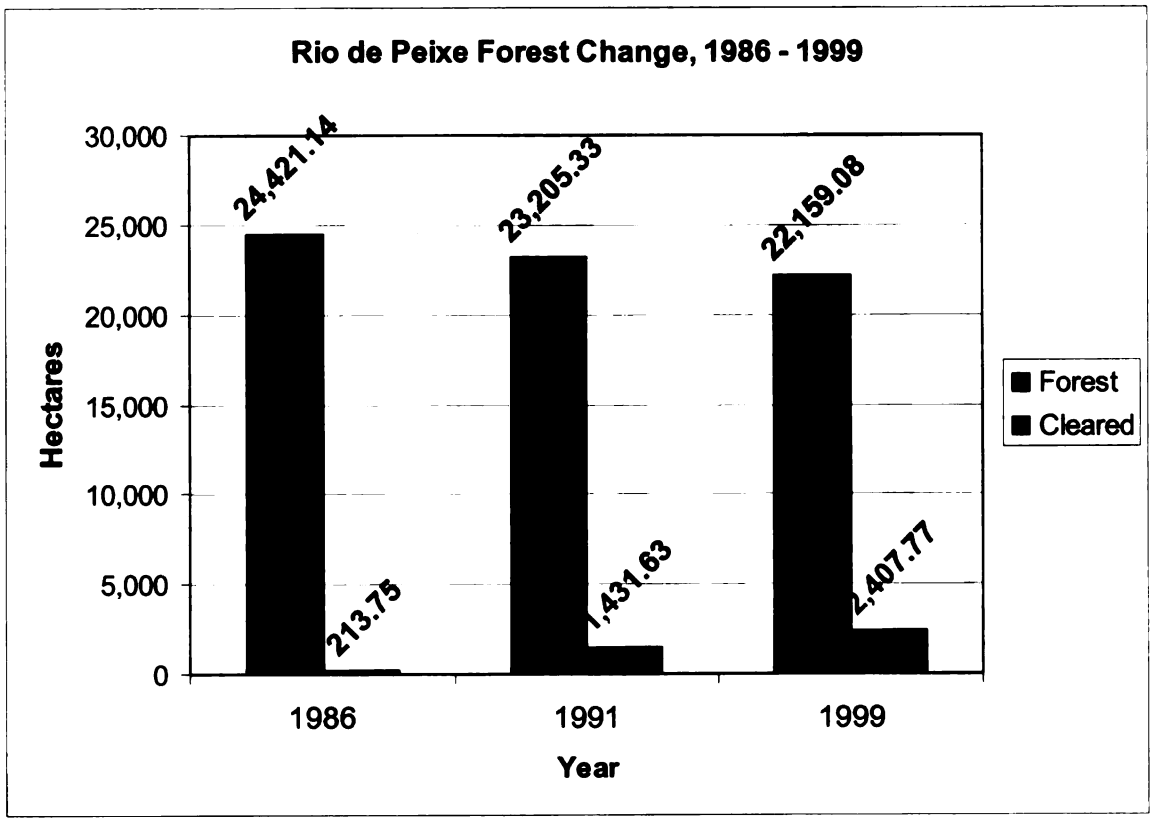
APPENDIX D



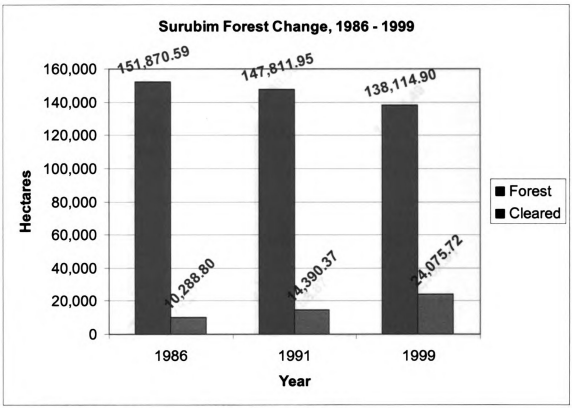
PA Uirapuru - Land Cover Change, 1986 – 1999



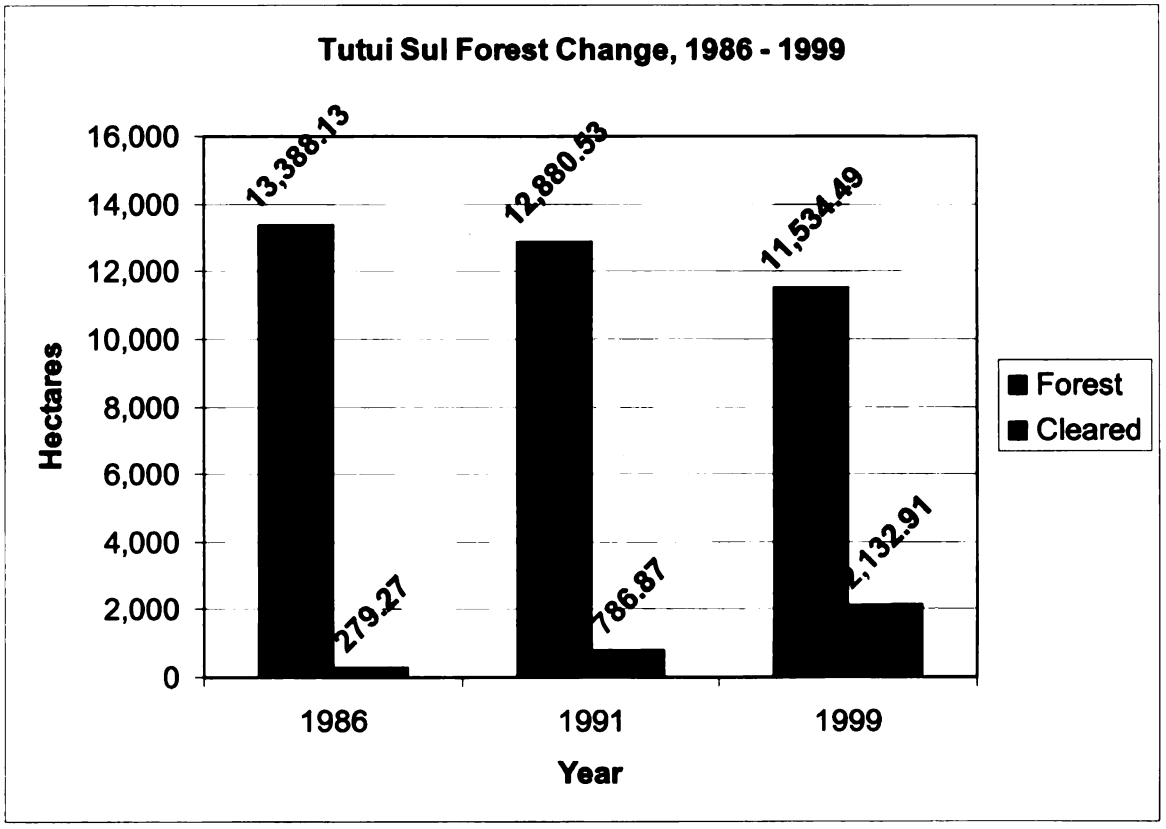
PA Trairão - Land Cover Change, 1986 - 1999



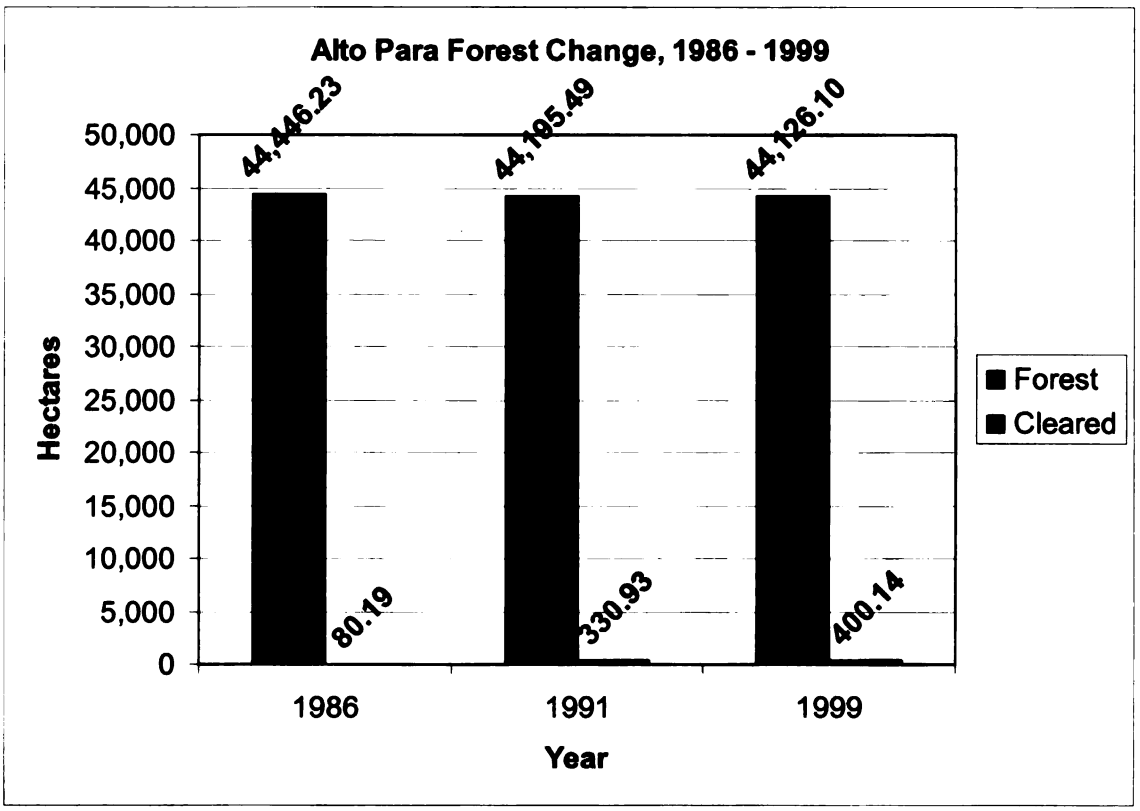
PA Rio do Peixe - Land Cover Change, 1986 - 1999



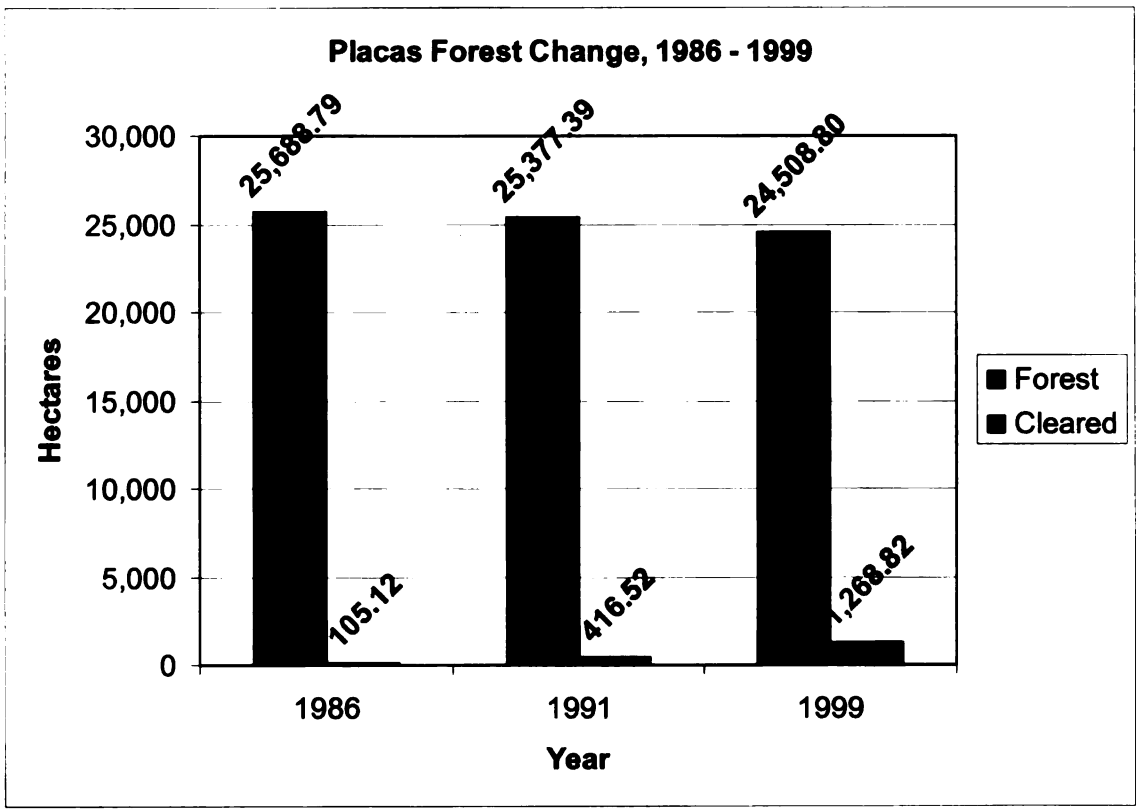
PA Surubim - Land Cover Change, 1986 - 1999



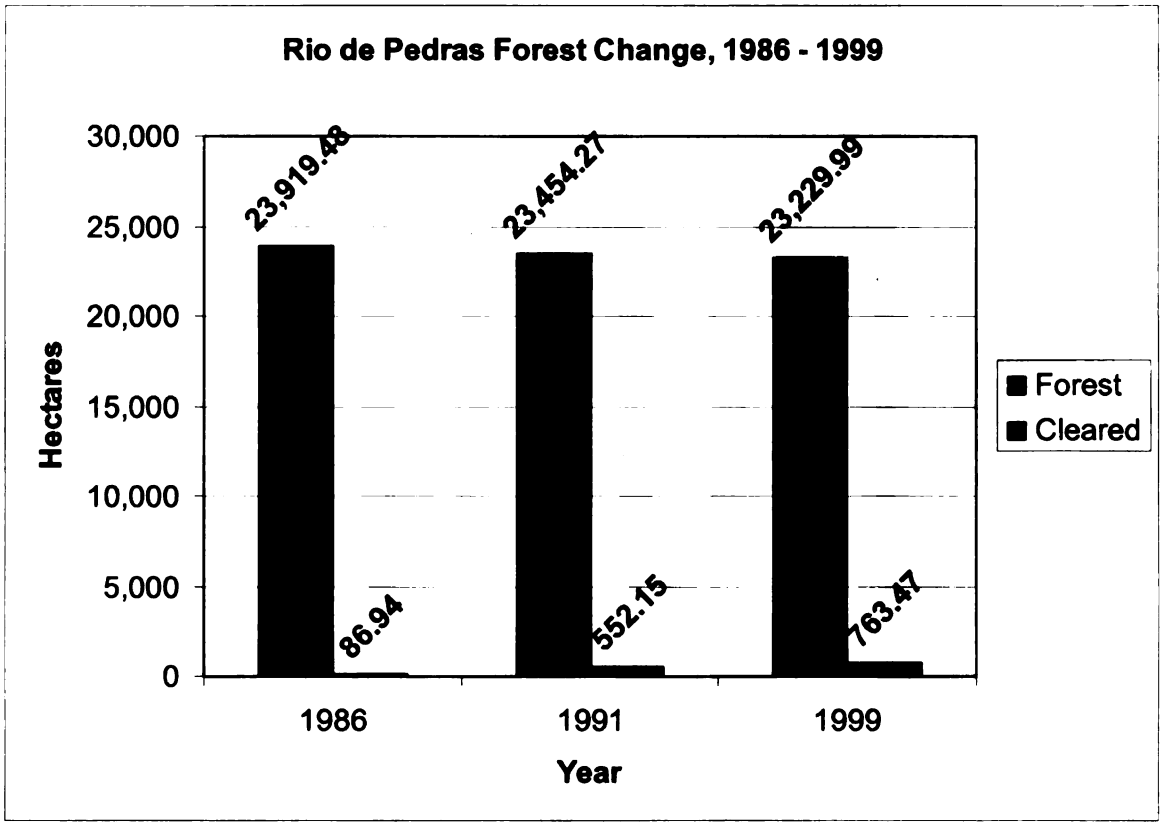
PA Tutuí Sul - Land Cover Change, 1986 – 1999



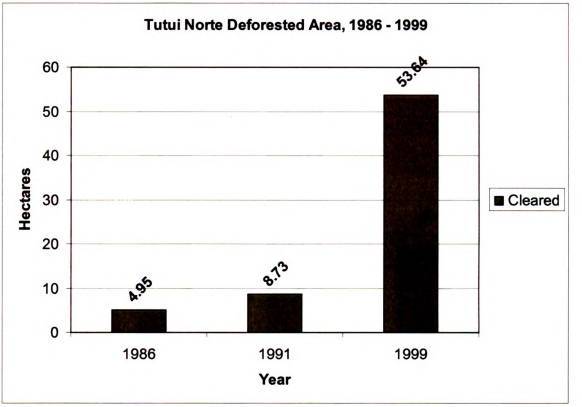
PA Alto Pará - Land Cover Change, 1986 - 1999



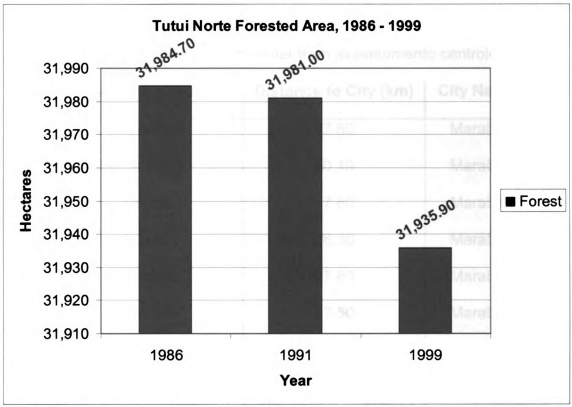
PA Placas - Land Cover Change, 1986 – 1999



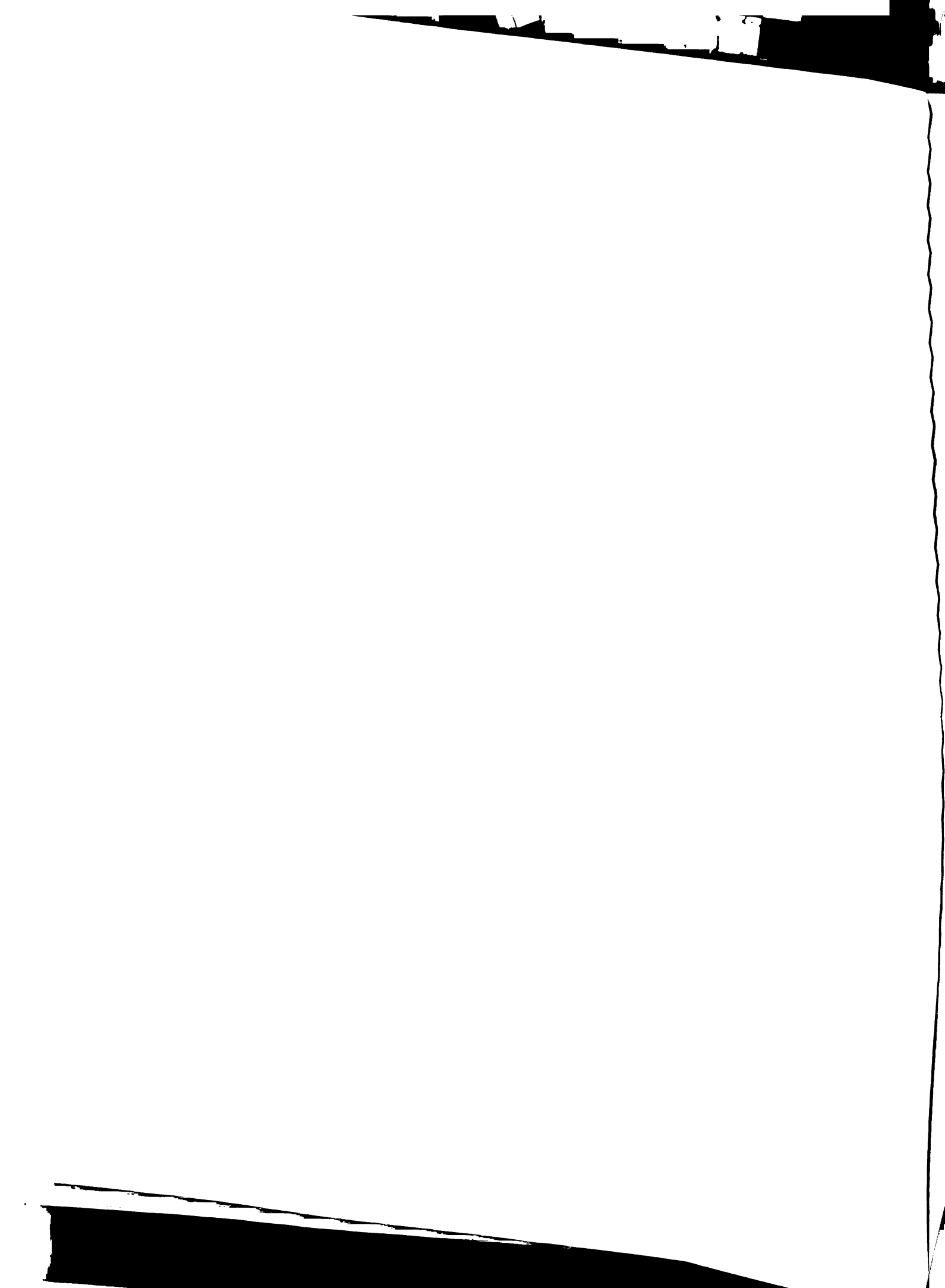
PA Rio de Pedras - Land Cover Change, 1986 - 1999



PA Tutuí Norte – Land Cover Change: Cleared Area, 1986 - 1999



PA Tutuí Norte – Land Cover Change: Forest Area, 1986 – 1999



APPENDIX E

Distance to major urban center from assentamento centroid.

Assentamento	Distance to City (km)	City Name
17 de Abril	97.80	Maraba
1st de Março	20.10	Maraba
Alegria	17.80	Maraba
Araras	26.30	Maraba
Cabanos	97.80	Maraba
Canudos	97.80	Maraba
Palmares II	98.00	Maraba
Santa Maria do Pontal	64.10	Maraba
Surubim	29.10	Medicilandia
Rio do Peixe	18.60	Uruara
Trairão	52.40	Uruara
Tutuí Norte	49.70	Uruara
Uirapurú	28.30	Uruara

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