THE INFLUENCE OF FAMILY ORIGIN AND SOCIOECONOMIC VARIABLES ON LAND USE AND DEFORESTATION OF FAMILY LOTS IN THE BRAZILIAN AMAZON BASIN

Luciano Mattos[1]

1 – Researcher of Brazilian Agricultural Research Corporation (Embrapa); Professor of Getúlio Vargas Foundation (FGV); Invited Researcher of the Research Group on Ecological Economics and Natural Resources (Unicamp); Collaborative Researcher of Indiana University; address: Embrapa Cerrados – BR 020 – KM 18 – Caixa Postal 08223 – CEP: 73.310-970 – Planaltina, DF – Brazil; luciano.mattos@embrapa.br

THE INFLUENCE OF FAMILY ORIGIN AND SOCIOECONOMIC VARIABLES ON LAND USE AND DEFORESTATION OF FAMILY LOTS IN THE BRAZILIAN AMAZON BASIN

Abstract

This article examines the influence of eleven independent variables (family origin, time of lot occupation, couple's schooling, generational index, gender index, size of lot, land title, annual family income, access to rural credit, access to transportation to market the production, and access to electricity to benefit the production) on land use and deforestation of 2,555 family lots selected by the Brazilian federal policy denominated "Social and Environmental Development of Rural Family Production Program" (Proambiente). The paper discusses six independent variables that demonstrated significant statistical influence on the deforestation of legal reserves of family lots: family origin, time of lot occupation, size of lot, annual family income, access to rural credit, access to transportation and access to electricity. This paper aims to provide data to the literature about land use and to collaborate with the improvement of governmental programs those combines agroecological transition and supply of environmental services to the global society.

Keywords: family farming, land use, deforestation, legal reserve, Amazon Basin, Proambiente.

THE INFLUENCE OF FAMILY ORIGIN AND SOCIOECONOMIC VARIABLES ON LAND USE AND DEFORESTATION OF FAMILY LOTS IN THE BRAZILIAN AMAZON BASIN[1]

1 – Introduction

This article discusses six independent variables (among eleven) which demonstrated significant statistical influence on deforestation of legal reserve[2] of 2,555 family lots seated on sub-seven regions from the Brazilian Amazon Basin. These seven sub-regions and 2,555 family lots were selected by the pilot federal policy denominated "Social and Environmental Development of Rural Family Production Program" (Proambiente). The process of selection was based in two criteria of social capital: (a) level of experience in implementing governmental and non-governmental projects about agroecological transition and (b) participation in community associations with high level of social organization. And the article focuses in the interpretation about decisions on deforestation before the benefits generated by Proambiente.

Proambiente was proposed by main social movements from the Brazilian Amazon Basin in 2003 (first year of Lula's government) as a strategy to harmonize the agroecological transition, environmental conservation and supply of environmental services in rural landscape scale to the global society. So, this proposal searches for a new concept of environmental services linked to the productive process under agroecological transition and environmental conservation. Although the Brazilian federal government has not given the expected priority in defining a legal framework what would operate the payment of environmental services, Proambiente presents itself as an important initiative that provides economic and ecological planning of the family lots (during 15 years, from 2005 to 2020) and formalizing of community agreements for environmental services in rural landscape scale. The program lists the environmental services of avoided deforestation, carbon sequestration, soil and water conservation, protecting biodiversity and reducing the flammability of the rural landscape.

Mattos (2010) demonstrates that among eleven independent variables ["family origin", "time of lot occupation", "couple's schooling", "generational index" (ratio of potential labor and consumption demand in the family lots) "gender index" (ratio of potential male and female labor in the family lots), "size of lot", "land title", "annual family income", "access to rural credit," "access to transportation to market the production " and "access to electricity to benefit the production"], only six ["family origin", "time of lot occupation", "size of lot", "annual family income", "access to rural credit" and "access to electricity to benefit the production"] are statistically significant in deforestation of legal reserve (One-Tail Test Probability less than 0.100 – see Tables 1 and 2).

Thus, this study aims not only provide data to the literature on deforestation, but also to collaborate with the improvement of governmental programs as Proambiente, which seeks to innovate by joining co-management and co-implementation between federal government and organized civil society in the Amazon Basin. However, it is worth emphasizing that it is not intended to assign responsibility about deforestation to family farming, especially those selected by Proambiente, but to demonstrate the most relevant independent variables to be worked by policies to mitigate the processes of deforestation in family lots from Brazilian Amazon Basin.

By comparing the Brazilian state rate of deforestation in 2003, Brondízio et al (2009a) showed that the small deforestation (up to 20 hectares) are the most frequent, and it represents approximately 88.1% of the total number of open forests in Acre State, 74.0% in Pará State and 73.2% in Rondônia State. However, when we consider the deforested area, it represents only 7.6%, 3.2% and 2.1%, respectively, of total deforestation in those states. In turn, the large-scale deforestation (higher than 2,000 hectares) cover approximately 0.10%, 0.47% and 0.40% of total events in Acre, Pará and Rondônia States, respectively, but account for correspondent 86.0 %, 91.2% and 94.5% of total deforested area. Thus, the highest percentage of deforestation events and lowest absolute corresponding deforested amount to family farming show both the primary responsibility of deforestation in the Brazilian Amazon to patronal farming as the importance of family farming in the fragmentation of the regional landscape.

The counterpoints of Batistella (2001) and Batistella et al (2003) are relevant that the high number of deforestation events of family farming, while relatively small in total area, may also have major implications for environmental change, and for the sustainability of their production systems, depending on the context of each local landscape. In areas of family farming, the design of colonization projects and institutional arrangements contribute to the spatial pattern of deforestation that causes depletion of natural resources, soil erosion, and an important range of accidental fires.

Another point worth noting is that in most circumstances absent a positive association between property size and yield by area, which increases the importance of the agrarian reform (Ramos, 2001). Data of Brazilian rural establishment

[1] This article is part of my PhD thesis. See more details in Mattos (2010).

[2] Brazilian environmental legislation defines "legal reserve" as the relative amount of forest cover that should be retained by rural properties in each biome. In the case of the Amazon biome, 80% of the area should have legal reserve.

demonstrates, including an inverse relationship between size and income, which are prominently family lots the more profitable in the relationship between Gross Value of Agricultural Production and area unit. However, it is essential to keep in mind that within the family lots narrowly cutting, this relationship becomes straightforward, with the size of lot being important in generating income. Small portions of land demand high intensification of productive systems (because the livestock, which leverages the family capitalization, needs broader areas) to become economically viable, scenario that often diverges from the reality of Amazon family lots productive context and puts at risk the very process of social reproduction of rural family and ability to retain deforestation events.

Mattos (2010) raised as hypotheses that the reach to the principles of economic and ecological land use of Proambiente (agroecological transition associated with the retention of legal reserves) come from families with (a) origin in the Legal Amazon (because the empirical knowledge of the biome), (b) more time of lot occupation, (c) higher size of lot, (d) superior annual family income, (e) access to rural credit and (f) access to electricity to benefit the production (because the last five issues provide more capacity to invest in agroecological systems associated with retention of legal reserve cover). Then, it is presented a literature review that includes data on the influence of the six independent variables mentioned above in the deforestation of family lots in the Brazilian Amazon Basin, as well as the test of these hypotheses based on the results obtained by Mattos (2010).

2 – Importance of the variables study of Amazon deforestation in intra and inter-regional scales

Since the last decade, in several scientific journals, articles have focused attention to the causes and consequences of deforestation in the Amazon Basin, with the common characteristic of making an analysis of the biome. This perspective offers important conclusions, such as the connection between road building and deforestation, however, this regional approach hides inter and intra-regional differences, which disappear when the data are statistically aggregated (MORAN et al, 2009). This work represents an intermediate step, because it includes seven sub-regions of aggregated form (with more details related to the biome as a whole, but without a specific range of each sub-region), in future studies to turn to the particularities of each sub-region.

Few places on Earth have been so directly affected by political and economic changes of land use and land cover as the Amazon Basin. Therefore, the challenges of incorporating inter and intra-regional diversity (when it is considered the Amazon Basin) represents great political, economic and ecological relevance. With the global environment in focus, the main paradox of research on population and environment is that the generalizations are necessary to obtain an overall that neglect important local details. Although the macro-processes remain extremely important, the spread of change cannot be generalized because of the diversity of inter-and intra-regional, socio-cultural variations of socio-cultural history of each place, ways of overcoming the low marginal productivity of labor, economic arrangements and environmental characteristics of rural landscapes underlying to land use. Highlight the factors that mediate the macro and micro levels contribute to the understanding of rural development in the Amazon Basin, including the processes of deforestation, economic cycles, the working arrangements and capital controls (BRONDIZIO, 2009).

The present study extends the local detailed analysis of 2,064 Use Plans of Production Units (PUs) selected by Proambiente, which represents a sample of 83.0% of the program (total: 2,555) and significant 0.43% of the family lots of the Amazon Basin. As six independent variables demonstrated statistical significant, the discussion below separates them, because becomes more relevant to interpret them individually than compare them with each other.

2.1 Family origin

The cultural bases of productive practice and ecological sensitivity of a family farming join itself, in part, to their region of origin, and allied to objective conditions of natural resources availability, may constitute an advantage or disadvantage to justify in the context given, the changes dynamic of land use in pursuit of greater productive and ecological efficiency (CARVALHO, 2000; MATTOS, 2010).

The productive rationalities and the different identities of settler (or “colono”), which can be defined as an ethos of settler, intend relational spheres at the same time while accommodating internal and external situations according to their experiences. When we talk about ethos, we are talking about cultural representations entered, produced and issued on the living and the social and ecological reality in which the individual belongs, socialized, and that also influences their behavior on land use and natural resources use (TEDESCO, 2001).

When we speak of an ethos of settler, we are not willing to present a coherent and stagnant of logic of local reproduction, supported by a subsistence production away from commercial links. The notion of ethos of settler is surrounded, in part, in a moral economy that does not exclude an internal economic rationality to its environment lived and conceived with the objective characteristics, pragmatic and rational of broader economic universe (WOORTMANN, 1990). Therefore, it is necessary to emphasize the ecological and socio-cultural aspects interwoven with economic dynamics and space of rural families.

Many studies have characterized the cultural differences by how people perceive and relate with the environment, i.e., as rescind forms of identification and interaction between humans and nature (BRONDÍZIO et al, 2009b). Therefore, the study of the 'family origin' variable becomes pertinent to build a reading of how the different origins are relevant on land use decisions. It is not the case to compare deterministically most viable types of land use and natural resources use, agricultural capability or ability to work according the native region of rural families, but to interpret relationship among origin and land use decisions. This type of response is important to subsidize the construction of public policies that address the different experiences with productive systems, knowledge of ecosystems, economic expectations and preferences in shaping the local landscape (MATTOS, 2010).

According to Ploeg (2006), the social and material resources available represent an organic unit and are owned and controlled by those directly involved in the work process. The rules that govern the interrelationships between the actors involved (and that define their relations with mobilized resources) are typically derived from (and linked to) local cultural repertoires. Pan & Bilsborrow (2005) identify three perspectives in understanding of interaction between population and environment: (A) cultural and historical interpretation, (b) reading of individual behavior with regard to decision making and (c) understanding of the rules that circulate around the institutions and establishing the opportunities and restrictions on decision-making.

At the beginning of the Amazon Basin expansion, the local people tended to explore the forest environment in parallel to the annual agriculture in an economy based on a wide variety of fruit and non-timber forest products. Moreover, family farming of Southern origin, with a strong tradition of agriculture and livestock, beyond a little forestry knowledge, they supported in subsidized rural credit to formation of their lots (LUDEWIGS, 2006). However, this does not mean that a family lot originally from either region have more or less agronomic skills, but only illustrates the various special modes of land use and natural resources (MORAN, 1981).

Brondizio (2009) points out, that ethno botanical interpretations distinguish the Amazonian people of the migrants through the reading of the economic potential of forests before their conversion via deforestation. Moreover, the creativity of migrants to develop agroforestry systems creates opportunities for reconciling forest management and economic land use in rural development programs. Mattos (2010) also diagnosed greatest amount of legal reserve and minor of perennial crops in lots from Amazonian families. However, the greatest difficulty of forest products in relation to agricultural in the access to markets helps to explain the lower incomes of the Amazonian people, besides expressing the lack of policies of forest demand induction.

According to data from Moran (1981), after three years of occupation, the Southerners were those who enjoyed the largest deforested portion and a strong targeting livestock, followed by farmers originally from the Midwest. Already the northern Amazonian people were among those with less traditional livestock, due to their particular ways of land use and natural resources use. These results are corroborated by Mattos (2010), which indicates the bias to livestock producers in the South, Southeast, and Midwest, and maintenance of legal reserves from producers in the North.

According to Walker et al (2002), the form of diversified sustenance of Amazonian people can contribute to increase of production systems resilience. Thus, multiple systems have not only the economic potential, but also ecological, being possible integrates them into the registration of legal reserve. Also for Moran et al (2009), socioeconomic differences affect the regional dynamics of deforestation, because if migrants are from Amazon Basin (within internal processes of migration), the probability of maintaining more mild standards of deforestation will be greater than migrants from non-Amazonian regions, with other production systems and other traditions of natural resource management.

Ludewigs (2006) found that in a rural settlement located in Humaitá (Acre), the lots of Amazonian people maintain highest percentage of land under forest cover, secondary forest and annual crops, while perennial crops and livestock activity are more significant in lots of migrants that originate outside the Amazon region. The migrants also have demonstrated higher proportions of land recently abandoned when compared to Amazonian people, who may indicate their greater difficulty in maintaining clean grass, while lots of Amazon had average proportion of forest cover in 2003, around 14% above the observed average in lots of migrants.

For the independent variable 'family origin', Mattos (2010) raised the hypothesis that attending to the principles of economic and ecological land use from Proambiente come from families with origins in the Amazon Basin due to its empirical ecological knowledge of the biome. The study of the author shows that lots led by families from Amazon Basin clearly stand out by the greatest amount of legal reserve in relation to led by families of migrants. In the class of percentage of 60-100% of legal reserve, 69.97% of lots of families from the North concentrate forest cover, compared to 26.64% of Northeast, 13.39% of Southeast, 11.25% of Midwest and 8.46% of South. By further restricting the analysis to establishing environmental laws in the Amazon biome (minimum 80% legal reserve) it is possible see that 44.84% of the lots of Amazonian people are on the legality, versus only 8.23% of Northeast, 3.35% of Southeast, 2.50% of Midwest and 2.49% of South. Therefore, a clear relationship between family origin and legal reserve preservation may be explained by the agroextrativist tradition of the Amazonian people and agricultural tradition of producers from other regions. For the relationship between family origin and legal reserve, the hypothesis is confirmed.

2.2 Time of lot occupation

For Brondízio et al (2009a), Van Wey et al (2009), McCracken et al (1999) and Walker (2003), the domestic units develop, generally, from nuclear units with small children to units with teenagers and young adults (a) that leaves the parental home in search of their own units or (b) that forming extended families with multiple generations. To the extent that changes occur, the consumption needs (determined by the number of unit members, particularly the number of dependents) and the available labor force (determined by the number of members of working age) also change. In this conceptual model, the unit primarily focuses on cutting down the forest, slash and burn systems and the cultivation of annual crops for the next stages to engage in land uses that offer lower short-term dividend and higher of long term. This theoretical perspective suggests that the land use and natural resources use (particularly the deforested extent) varies between units mainly due to the time of occupation and family composition of productive units over time.

Mattos (2010), as well as the authors above, recognize that deforestation rates are not only related to the different periods of occupation of the lots and the changes in family composition, but also with the availability of capital and technology and the strategies of land use and natural resources use that are matured in the evolution of the process of colonization in the agricultural frontier.

Pan et al (2007) and Brondízio et al (2002) noted that the positive relationship between time of lot occupation and deforestation is not strictly random in space and time of different groups of migrants from the Amazon Basin. In general, families with more time of lot occupation have larger portions of deforestation. However, the type of forest used varies over time. Families with more time of lot occupation tend to use most significantly the secondary forests compared with families recently discharged from their place of origin, which guide its efforts in opening up forests.

In similar studies, Brondízio et al (2009a), Perz & Walker (2002) and Perz (2001) found that significant portions of deforested areas usually occur in rural properties composed of families with substantial work capacity, including own family work (which is strengthens over time of lot occupation), contract worker or under exchanges of daily work.

For McCracken et al (2002), family farming settled along the Trans-Amazonian Highway (Pará State) in the early 70's held approximately 55% rate of deforestation in their lots in 1985, being the area under bare soil (with capability to plant annual crops), pastures or secondary forests in various successional stages. In 1988, an average additional of 4% of the area had been deforested, while the area of bare soil and pasture had slightly receded and the area of secondary forests advanced in 40% of the lot. The authors assume that the land use (and the consequent rate of deforestation) is also influenced by public policy, market needs and economic trends. This means that the rural landscape depends on a mosaic of rural properties in different stages of human occupation that react in the same time as its structural conditions. Besides access to rural credit and the market needs, the authors found that the family origin and the time of lot occupation appear as relevant variables.

Brondízio et al (2002) and McCracken et al (1999) used remote sensing to measure the relationship between time of lot occupation (from time zero or when opening the family lots) and forest cover, relating these phenomena to the family life cycle. The authors found evidence of changes in rates of deforestation along the family life cycle, with mild rates in the beginning of the occupation, followed by a first peak of deforestation between 3-5 years and the second peak between 10-15 years.

For Moran et al (2009) and Brondízio et al (2002), after about five years (on average), while the family farming consolidate and use areas already deforested, there is a second increase of deforestation, given by a new expansion phase of activities in the family lots, which can give rise to new areas of annual and perennial crops and pasture, depending on the capital-labor ratio and the availability of land and water.

According to McCracken et al (1999), the time between the lot occupation and the consolidation of production systems presents a growing initial curve followed by a stable curve of deforestation. Therefore, the time of lot occupation is a relevant variable in the process of deforestation and regeneration of capoeira areas.

Brondízio et al (2002) exposes that the process of deforestation tends to be more intense in the first five years of settlement, due to the need to establish the annual productive systems, but after a few years, the rate tends to decline, but starts to increase with the introduction of animal raising and stabilizing or decrease slightly with the consolidation of perennial systems in areas of secondary forest, which can be used for registration of legal reserve.

Another factor to be considered in the relationship between time of lot occupation and deforestation refers to the turnover of families in the same lot. As show Van Wey et al (2007) and Schmink & Wood (2002), in the mid 70's, many families who claimed title to the land abandoned their lots, in part already been deforested, due to lack of economic conditions of production and public safety. Ludewigs et al (2009), Moran et al (2002) and Smith (1982) illustrate that pioneer owners had already abandoned 19% of the lots from Marabá and 30% of the lots from Altamira (both in Pará

State) in the late '70s (less than a decade after the first process of human occupation). Ludewigs (2006) argues that while the turnover of the land can interrupt the relationship between family life cycle and land use, it does not necessarily interrupts the cycle of the family lot itself, on the contrary, tends to keep it. Therefore this phenomenon is a complex measurement, vide the study of Pan & Bilsborrow (2005), where there was no significant relationship between time of lot occupation and land use. Despite the official incentives, Romeiro (1998) also noted a high turnover of family lot owners along the time of occupancy, a phenomenon characteristic of the agricultural frontier regions that varies according to different seasons and areas, without their causes are clearly identified and prioritized. So Mattos (2010) highlights that high turnover can be demonstrated as an indicator of failure of the geopolitical strategy of the military government to create a productive environment for family farming in the Amazon Basin.

For the independent variable 'time of lot occupation', Mattos (2010) assumed as hypothesis that attending to the principles of ecological and economic land use from Proambiente come from families with more time of lot occupation due to the greater investment in agroecosystems associated with retention or recovery of legal reserve. The author found a negative relationship between time of lot occupation and amount of legal reserve. In class of percentage 60-100% of legal reserve, there is a decrease over time of 37.34% (0-5 years) to 34.85% (5-10 years), 32.87% (10-20 years) and 28.79% (more than 20 years) of the family lots. Within the environmental legislation in the Amazon biome (minimum of 80% of legal reserve), the decline is more accentuated: 23.65% to 13.35 % up to 20 years, and 10.61% to over 20 years. For legal reserve, the hypothesis is not confirmed, although the growth of perennial crops found in the family lots can be used for registration of legal reserve. The non-confirmation of the hypothesis is also associated with the high turnover of families in the lots, which trigger new processes of deforestation.

2.3 Size of lot

Data of Guanziroli et al (2001), based in the 1995/1996 Brazilian Agricultural Census of Brazil, shows that family lots from Amazon Basin have the second largest national average size of around 57 hectares, just below the Midwest region with 84 hectares, and over the Southeast with 30 hectares, South with 21 hectares and Northeast with 17 hectares. In Brazil as a whole, the average size of the family plot revolves around 26 hectares, less than half the Amazon Basin average. But as warning Arima (2000), the lots size are varied within the Amazon Basin, and smaller in oldest areas of agricultural borders and largest in agricultural recent border. Three characteristics of land use should be highlighted: (1) the proportionate amount of capoeira (growth of secondary vegetation that signals deforestation) is greater in family lots of ancient occupation, (2) the proportionate amount of primary forest and exploited forest is greater in family lots of recent occupation, (3) the expansion of livestock (and consequent deforestation) in family lots of recent occupation is remarkable, because the availability of area and poor infrastructure make it an economic activity more interesting.

Mattos (2010) shows the relationship between lot size and age of the agricultural frontier. As the author illustrates, the oldest agricultural frontier (with land prices recovered due to established infrastructure) have smaller lot sizes, while new agricultural frontiers can gather lots between 100 and 400 hectares, a fact that affects strongly the sub-regional profile of each family property. By comparing data from seven sub-regions by Proambiente, Mattos (2010) shows that the lots selected for the program hold larger portions of land in the new agricultural frontier, i.e. in Alto Acre (Acre State) with an average of 281 hectares and Trans-Amazonian (Pará State) with 94 hectares. For the first case, it emphasizes the particularity of contemplate both agricultural individual use areas, and collective extractive reserves, which increases its average. Already in sub-regions located in the oldest agricultural frontier, the family lots are smaller, averaging 19 hectares in Baixada Maranhense (Maranhão State), 33 hectares in Northwest (Mato Grosso State), 35 hectares in Ouro Preto d'Oeste (Rondônia State) and 38 hectares in Bico do Papagaio (Tocantins State). The exception is for the Rio Capim (Pará State), which holds family lots with averages of 43 hectares, although it is located in the oldest agricultural frontier in the Amazon Basin. The fact is explained by two reasons: (A) by its history of occupation stemmed from migrants from the Northeast in the late 19th and early 20th century, which consolidated the earlier sub-region (half a century before the beginning of Amazon frontier expansion) as a food producer, ahead of exploitation of the Amazonian rubber, one of the two most important export products of the country at that moment, (b) confirmation of its family productive profile also sustained due to the location near the metropolitan area of Belém (the capital of Pará State), a market with two million consumers.

Data of Carvalho (2000), Guanziroli et al (2001), Ludewigs et al (2009) and Mattos (2010) in different studies also indicate that the amount of work related to the size of the area cultivated in family lots of Amazon Basin determines the intensity of productive system and the deforestation processes. Regarding the productive system, in general, with more land and less labor, more extensive will be the productive system, whereas with less land and more work, more intensive will be the productive system. In some cases, the availability of area per worker is so broad that it does not justify the introduction of intensive systems, being prioritized the introduction of systems that guarantee good labor productivity, albeit with low yield by area unit. In reverse, as lower the availability of area, the greater the relative importance of crops in highly demanding work force and highly intensive land use. Already under consideration to the processes of deforestation, smaller lots present higher proportional rates of deforestation, because it is cultivated at more time, thus, passed through successive processes of fragmentation, as well as there is a uniform demand of area for annual cultivation for subsistence (rice, beans, corn and cassava) that takes a proportionally larger area with smaller lot.

In the range of properties, Moran et al (2009) demonstrates that the initial conditions of the family lot that encourage or discourage the productivity of land, productivity of labor and use of technologies explain the spatial pattern of deforestation, while the temporal intensity is defined by unit size, composition of domestic labor and access to sources of capital, as well as the goals for the short and long term of its residents.

Analysis of Pan et al (2004) indicate a high division of spontaneous colonization lands between 1990 and 1999 in the Ecuadorian Amazon. Initially divided into family lots with average of 50 hectares, the study area went through the process of subdividing of lots due to the arrival of new settlers attracted by the leveraged oil economy in the region. Thus, the former landowners have negotiated some of their land to new settlers newly egress from other parts of the country, a phenomenon that raised the local population density and caused an increase in deforestation and pasture areas, and concomitant increase in the area of annual and perennial crops. However, the same family lots studied by Pan & Bilsborrow (2005), which did not undergo subdivision still held 56.1% of forest cover in 1999, while family lots that have gone through one or two subdivisions were 47.0% and 32.0%, respectively, of primary forest.

Brondízio et al (2009a) showed that the majority of family lots from Santarém sub-region (Pará State) with up to 10 hectares maintains at least 25% of the forest cover, those it holds lots of 10-20 hectares maintains approximately 40%, while those between 20-50 hectares maintains more than 50%. Similarly, when studying the relationship between lot size and deforestation in family lots, McCracken et al (1999) found that each additional hectare of forest cover is positively correlated with 0.05 hectares of annual deforestation, i.e., a lot with more 20 hectares of forest should clear approximately one hectare more than the production unit correspondingly smaller. However, the invariability of the annual crop area, which is around 3-5 hectares per lot (due to ability of work), directs it to the deforestation proportionally smaller in family lots with larger size, unless if the lot is strictly characterized by livestock activity.

It was exactly this exception that Mattos (2010) found in a study of Proambiente for the specific case of the sub-region of Trans-Amazonian (Pará State), where larger family lots have a higher quota of deforestation due to livestock profile of many families. With the need to expand the extensive margin of livestock activity (typical in great portions of land), the proportional area of legal reserve was significantly reduced. On the other hand, Brondízio et al (2009a) explains that the family farming of the Amazon estuary (with proportionally smaller lots) stopped the process of deforestation with forest management and agroforestry systems based on the “açaí” (tropical fruit) due to growing market needs. Here again figure an exception where smaller lots have larger numbers of legal reserves due to the intensification of land use.

For the independent variable ‘size of lot’, Mattos (2010) assumed as hypothesis that attending to the principles of economic and ecological land use from Proambiente come from families with lots proportionally higher due to increased investment capacity in agroecosystems associated with retention or recovery of legal reserve. The author found that symbolic data that confirm the positive relationship between lot size and legal reserve. Within the Amazon environmental legislation (more than 80% of legal reserve) are 48.95% of the lots with more than 100 hectares, 23.39% between 50-100 hectares, 10.72% between 10-50 hectares, 1.48 % between 5-10 hectares, and no less than 5 hectares, which demonstrates the relevance of the discussion of rural social movements on reduction of environmental legal limits for family lots less than 100 hectares. Thus, over the years, there is withdrawal of the legal reserve, and more significantly in smaller lots, however there are exceptions, as the sub region Trans-Amazonian (Pará State), where larger lots have a lower percentage of legal reserves due livestock to the tradition, with direct replacement of legal reserve by pasture. For the lot size, the hypothesis is confirmed and it demonstrates the demand by integrated policies of agricultural production and environmental conservation.

2.4 Annual family income

Data available in Brazilian literature concerning the annual monetary average income per family lot are somewhat controversial, because they do not consider family consumption and intermediate consumption of animal feed. According to Hoffmann (2006), the annual monetary average income in Amazonian rural area is R$ 4,707.11, while Guanziroli et al (2001) records a much lower value of R$ 2,904.00 (this study considers an exchange rate around R$2.00:US$1.00). Be supported by Hoffmann (2006) or Guanziroli et al (2001), Mattos (2010) notes that most family lots selected by Proambiente is in an equivalent landing (33%) or higher (49.7%) of annual monetary family income in relation to the average of biome.

Mattos (2010) and Graziano da Silva (1999) warn that the relative reduction of growth of strictly agricultural rural job in opposed to the increase in non-agricultural rural job cannot be interpreted in the case of Amazon Basin as indicators of a structural trend of transformation of rural areas similar to what occurred in developed countries.

The non-agricultural rural jobs in the region configure much more on strengthening to the strategies of land use of family farming compared to the historical lack of infrastructure and rural credit costs and investment enough to finance the next crop than actually an exodus of agricultural activity (MATTOS, 2010). Therefore, opportunities of work outside the family lots are associated with what Dirven (2000) calls the "refuge occupation". Under the perspective of a

more equitable distribution of income opportunities, the challenge is to overcome what Reardon et al (1998) call of "paradox of non-agricultural rural jobs", i.e., the more poor establishments are those most need additional sources to those that are generated by agriculture, however, are precisely those that face the greatest limitations of human and productive capital, difficulties to offer rural credit guarantees and administrative capacity.

Guanziroli et al (2001), Romeiro (1999) and Romeiro (1998) differentiate family farming in three basic categories of income: (1) capitalized family farming, with agricultural income exceeding to the opportunity cost of labor, product primarily aimed at the consumer market (although devote part for own consumption), accumulation of capital in machinery, improvements and land, provision of resources sufficient for agricultural production, comfortable agricultural incomes and relatively remote risk of disinvestment or elimination of the productive process, (2) family farming in process of capitalization, with agricultural income from the subsistence level and the opportunity cost of labor, production mainly dedicated to subsistence (though on the rise for the consumer market), mild accumulation of capital and income insufficient to keep them away from the risk of disinvestment or disposal of the productive process, (3) undercapitalized family farming, with lower agricultural income subsistence level, production for own consumption, without accumulation of capital and income at risk of elimination of the productive process.

For Mattos (2010) and Guanziroli et al (2001), raising of opportunity cost does not necessarily lead to the elimination of family farming, which has technological alternatives that permit raising labor productivity and income level of agricultural establishments *pari passu* to the increase in opportunity cost. Moreover, Schultz (1965) defends that the challenge is to determine how low can be the cost of work opportunities and how much growth can be obtained for each type of investment. Therefore, that family farming presents gradual demands of growth, because the innovative equity turnover rate can be high compared to the old patterns of production.

Boserup (1987) warns that in the interpretation as for resistance to innovation, economists should not abandon the explanation offered by anthropologists and sociologists before investigating whether they have before them a case where technical change represents diminishing yields of work, so that the resistance need not be explained as lack of responses to economic incentives, but as an inappropriate way to fulfill the demand of gradual processes of technological innovation of family farming.

For Mattos et al (2010), agricultural land has the components of "natural qualities" and "capital structure", being the first one determinant of agricultural aptitude and the second one consequent of past investments. Mattos & Hercowitz (2010) warn, however, that such harmonization between capital structure and natural qualities of the land is still presented as a distant reality in the planning of federal public policies, despite recent advances. In this sense, innovative public policies are formed as the most effective way to access the capital structure harmonized to demands of environmental sustainability, such as mitigation of deforestation.

The environmental specificity of the Amazon Basin, the greater reserve of biodiversity on the planet, requires a strategy of agricultural development compatible with preserving the largest possible area of the biome. The reason to claim the almost complete preservation of forest cover in the region lies in the rising value of the rainforest over the limited value of agricultural production, both due to the dramatic reduction of forest reserves of the world as the progress of scientific knowledge that can open up new possibilities of its sustainable use of forests as a source of biodiversity and as a base for fundamental natural processes. Under current conditions, the cost-benefit analysis indicates that the present value of agricultural development projects worth replacing the forest, however, even without considering the possible benefits associated with biodiversity, deforestation implies considerable future economic losses in the value of species, whose production could be managed sustainably. The basic problem is that the benefits of conservation and management are potential and not enter in calculus of economic agents, a fact that exposes the demand for compensation policies for environmental services in rural landscape scale (ROMEIRO, 1998; MATTOS, 2010).

Therefore, legal reserve areas in the family lots should be destined to natural regeneration and the introduction of agroforestry systems, but due to lack of specific policies, part of them is utilized for the formation of extensive pastures. The pure and simple reforestation has little chance of success if the family farming cannot withdraw income, while agroforestry systems resulting of enrichment of secondary forests present potential of income aggregation and ability to restore of legal reserve (MATTOS, 2010; & PERZ WALKER, 2002; GUANZIROLI ET AL, 2001). Pichón (1996) states too that without the directing of technological politics and infrastructure for the forest economy, forest conversion in agricultural areas and livestock involves an opportunity cost that opposes annual family income and legal reserve.

Van Wey et al (2009) demonstrate that domestic income of human populations is the most important factor that affects the environmental conditions, being the institutions an important contextual factor that interferes with the effects of size and growth rate of a population on the forest cover. It's what Mattos (2010) found in the study of Proambiente, where the presence of more consolidated social capital (as defined with experience in projects and participation in community associations) in some sub-regions allowed better planning of sustainable land use. However, even where there is strong institutionalization, the highest income variable is crucial in promoting deforestation.

For the independent variable 'annual family income', Mattos (2010) assumed as hypothesis that attending to the principles of economic and ecological land use from Proambiente come from families with more time of lot occupation, due to the greater investment in agroecosystems associated with retention or recovery of legal reserve. The author found a negative relation between elevation of annual family income and retention of legal reserve, i.e., the higher the annual family income, the lower the proportional occupation of the lot with the legal reserve. In family lots with annual family incomes of up to R$ 20,000.00 (divided into eight categories of income), from 29.77% to 35.95% of the family lots concentrate more than 60% of legal reserve, a percentage that drops to only 16.79 % of family lots with annual family incomes over R$ 20,000.00. The case becomes more critical when examining the environmental legality in Amazon biome (more than 80% of legal reserve), where only from 12.29% to 18.11% of the lots with incomes up to R$ 20,000.00 meets the requirement, a level that drops to 9.49% of the family lots with annual family income exceeding R$ 20,000.00. Another point highlighted in the study is that, as annual family income rises, the contingent of perennial crops and livestock in an equivalent way rises also, and the sum of the two areas are equal in the removal of legal reserve. In fact, more capitalized family farming invest more in perennial systems, which ensure greater environmental sustainability, but at the same time, establish with greater strength to livestock, an activity that competes for space with the legal reserve. For annual family income, the hypothesis is not confirmed, which indicates that policies of stimulus to family farming production need to be integrated with environmental legislation, appearing as options the agroforestry systems (PS: this study considers an exchange rate around R$2.00:US$1.00).

2.5 Access to rural credit

For Walker & Homma (1996) and Mattos and Uhl (1994), any distortion of access to rural credit may impose serious financial burden to family farming, take them to bankruptcy and direct them to the inevitable migration to a new agricultural frontier. However, the family farming can stay in their lots under appropriate conditions, being the livestock activity one of the most important for reduction of financial risks. Although pastures are commonly associated with large agribusiness corporations, scientific evidence shows that reduced operations of conversion of land for pasture are viable because of their low opportunity costs of labor and capital, although imply quota equivalent of deforestation.

The recognition of the strategic importance of the family farming would not be sufficient to justify the politics of financial support if they did not show its capacity to produce with efficiency under the economic viewpoint, to absorb technical progress and to meet demands for food and fiber of urban-industrial sector (VEIGA, 1991). A significant part of Brazilian family farming (including the most undercapitalized, who received some type of financial support, especially access to rural credit under special grace, repayment schedules and interest rates) diversify their production systems course trajectories and give the successful capitalization (GUANZIROLI et al, 2001). Therefore, it is misguided vision of family farming as self-sufficient and very risk-averse financial transactions because in practice the vast majority need external funds to operate its plants more efficient and sustainable manner.

However, Mattos (2010) and Norder (2006) speculated that the demand for rural credit of family farming tends to be highly heterogeneous in an integrated process of productive diversification and mitigation of deforestation. Access to rural credit lines can provide greater autonomy in production and a reduction in dependence on relationships with certain market, as well as inflexibility in the rural credit system may represent an additional obstacle to the revival and diversification of local economies.

In this sense, a fact of great social and political repercussions in the Amazon Basin occurs with the 1988 Brazilian Constitution, creating the Constitutional Funds, which established the obligation of the Federal Budget destines 3% of the national collection of Income Tax (IR) and Industrialized Products Tax (IPI) to be invested in programs to finance the productive sectors of the North (0.6%), Midwest (0.6%) and Northeast (1.8%). For the Northern Region was created Constitutional Financing Fund of the North (FNO), with funding programs to rural productive private and industry sectors (TURA & COSTA, 2000; BASA, 2000).

Mattos (2010) and Mattei (2007, 2001) also report that from 1994, another major institutional change was initiated to meet the interests of family farming. First, the government of President Itamar Franco established the Enhancement Program for Small Rural Production (Provap), which was designed to allocate rural credit with interest rates more accessible to family farming, defining them as a single category from the gross income. Although the results of Provap are insignificant, it fulfilled the relevant transitional role for future differentiation of policies by family farming categories. In 1995, with the government of President Fernando Henrique Cardoso, Provap was completely redesigned, resulting in 1996, the National Program for the Strengthening of Family Farming (Pronaf). Since 1999, with start of the second presidential term of Fernando Henrique Cardoso, Pronaf went through institutional changes, including the stratification of program beneficiaries in five categories of gross income, allowing better matching of funding rules to the different realities that make up the family farming. In 2003, year of possession of President Luiz Inácio Lula da Silva, were taken new institutional changes as the beginning of significant budgetary increase Pronaf (around 600% between 2003-2010), creating a further category of gross income, falling interest rates, increased grace period and amortization periods, important measures to allow the introduction of processes of gradual transition of productive family farming. More recently, in 2008, in the second presidential term of government Luiz Inácio Lula da Silva, were

unified some income categories, with readjustment of interest rates as the range of annual income of each borrower. This process initiated from three different governments that move in different political ideologies (especially the last two), shows that the initiative to create Pronaf has established itself as the main government program for the family farming. Thus, Pronaf ceases to be a circumstantial policy of government to become an important state policy, with budget in the 2008/2009 agricultural year around R$ 12 billion. What can also be seen in the last four years is that Pronaf has high capillarity in signing the majority of its contracts with groups of less capitalized family farming while dedicating most of their principal amount on the consolidation of more capitalized family farming.

As well as the Pronaf and FNO, that with its diverse lines of rural financing offer opportunities for the productive transition of the family farming, Proambiente appears as important mean for qualify that productive transition (and the own operations of the Pronaf and FNO) from the ecological and economic planning integrated enabled by the its Use Plans of Production Units (PUs) and Communal Agreements of Environmental Services (ACs), that take care by productive agroecological practice and retention of legal reserve.

Despite the fundamental importance of emergence of FNO and Pronaf from the year 1990, Costa (2000) demonstrates that the underlying investments of family farming in the Northeastern State of Pará (Brazilian Amazon Basin), during the 80 and 90, were the own resources family lots, except in cases of restriction of labor and abundance of land, where there is a more significant percentage of rural finance applied in livestock (other types of credit in rural than FNO and Pronaf). Investments for all other groups (restriction of labor and land, abundance of labor and land, abundance of labor and restriction of land) made up less than 10% of rural financing (also in other types than FNO and Pronaf).

Recently, agriculture has become a priority in the rural credit policy of FNO due to reduced ecological impacts that causes when compared with livestock. The financial agent of FNO has assumed a policy of restricting livestock to prevent the conversion of forests into pastures, and one of the strategies based on the requirement for purchase of animals with certification of origin, which have a market price higher and thus discourage the taking of funding (LUDEWIGS, 2006). However, relations between land use changes and rural credit are complex to treat, not only by imply a wide range of conditions, but also because the rural credit lines vary according to the funding policy of the financial agent (MATTOS, 2010).

Rural credit policies may have positive and negative effects depending on characteristics of them in deforestation. The capital inflow can support the diffusion of technologies with potential to reduce pressure on tropical forests, as observed in Ecuador, Ivory Coast and Indonesia, or from bringing more deforestation, as mapped experiences in Brazil, Bolivia and Ecuador (ANGELSEN & KAIMOVITZ, 2001).

The system of rural financing through tax exemptions and subsidies of the military government of Brazil (60-80 years) for extensive livestock farming in the Amazon Basin set up a relation of elevation of the access to rural credit and reduction of legal reserves (VAN WEY et al, 2009). Already the institutionalization of Pronaf comes to corroborate and FNO invert this relationship between rural credit and legal reserves (MATTOS, 2010).

For Brondízio (2009) and Brondízio et al (2002), the significant increase of deforestation in the family lots form Brazilian Amazon Basin (observed up to 1996) may be associated with the country's economic stabilization and the return of incentives for rural credit. The trajectories of deforestation present a clear standard for occupied family lots in different periods, where pulses of deforestation associated with annual crops and pastures mark the formation cycles of the family lots. The magnitude of these pulses of deforestation related to the interaction between the decisions of family farming and periodic macroeconomic effects, institutional conditions (e.g. rural financing policies) and infrastructure (e.g. roads paving and opening to consumer markets).

However, the relationship between time of lot occupation, rural credit and deforestation is nonlinear. McCracken et al (1999) notes that a number of hypotheses have been developed for understanding of how family farming, distinctly, is responding to rural credit policies in their agricultural strategies. For Ludewigs et al (2009), one of the fundamental changes that ensure a more equitable distribution of rural credit, a priority for regional integration and environmental responsibility occurs with the structuring of FNO.

For the independent variable ‘access to rural credit’, Mattos (2010) assumed as hypothesis that attending to the principles of economic and ecological land use from Proambiente come from family lots with access to rural credit due to greater investment capacity in agroecosystems associated with retention or recovery of legal reserve. It is worth stand out that the study of the author did not aim to trace the relations of cause and effect between the independent variable ‘access to rural credit’ and the dependent variable ‘legal reserve’, because the collected data only tell us the type of rural credit taken by borrowers selected by Proambiente without specifying whether the term of the loan is in grace period, amortization or discharge, that is, the influence of access to the financial agent may already have or do not manifest in the legal reserve. However, it was only proposed to search of relationships between rural credit and profiles of family lots as to deforestation. The study found that the legal reserve has negative relationship with the access to rural credit of Pronaf and positive relationship with access to rural credit of FNO. Among the lots accessing rural credit of Pronaf,

only 8.24% are in line with environmental legislation of Amazon (minimum 80% legal reserve) against 20.57% of those with access to rural credit of FNO. At the other extreme, in the class of percentage of 0-20% of legal reserves are located 41.36% of the lots with Pronaf and only 17.02% with FNO. Family lots with access to rural credit of FNO predominate in intermediate levels. In the present study, FNO has been shown as a rural credit policy more congruent to the environmental legality that Pronaf, certainly for its decision to finance agroforestry systems registered as legal reserve. In this case, Pronaf induced cattle raising of legal reserves areas more aggressively than the FNO, which although also expand the livestock shows at the same time greater capacity to promote diversification of production systems and facilitate its registration as legal reserve. For access to rural credit, the hypothesis is confirmed for the FNO and not confirmed for the Pronaf. In this study, family lots with access to rural credit of Pronaf tend to use the land with cattle rising, which occupies half share in the legal reserve areas, besides showing a decrease of perennial crops relative to non-borrowing. Already lots with access to rural credit of FNO advance in cattle raising of family lots, but on third part in relation to Pronaf being visible that also lead to the cultivation of perennial and particularly the containment of legal reserves compared to non-borrowers in rural credit.

2.6 Access to electricity to benefit the production

Inhetvin (2000) states that technological barriers (inadequate Green Revolution package for family farming), commercial barriers (lack of internal markets with purchasing power), institutional barriers (lack of rural credit) and infrastructure barriers (unavailability of transport networks, access to electricity and communication), as well as a great economic dependence on relatively few products with fluctuating prices, imply in an unstable base both for the economic outcome of family farming, as to their social reproduction.

Pan et al (2004) demonstrate that the increase of rural credit operations and the supply of electricity expanded by 21% to 73% in lots of the Ecuadorian Amazon Basin close to highways, which highlights the importance of integrated logistics processes. And as access to infrastructure increases the price of land, three additional variables are important for achieving long-term investments in household production and curb the possession of the land: rural credit (MATTEI, 2007), agrarian regularization (BENATTI, 2003) time of lot occupation (ROMEIRO, 1999).

In field study, Pan & Bilsborrow (2005) identified the importance of infrastructure variables in land use, as well as the relevance of using multivariate models to predict such relationships. Several studies with such models trace these relationships. Pan et al (2004) found that access to electricity affects positively and significantly the agricultural diversification, while Ludewigs (2006) found that access to electricity is extremely relevant for the expansion of perennial systems. Mattos (2010) also identified the importance of access to electricity for the productive diversification based on perennial systems and for annual family income generation, as well as the removal of legal reserve. The last author stresses that access to electricity opens up the possibility of improvement of production in installed packinghouses on individual family lots or collective areas (cooperatives, neighborhood association, and agricultural industries) and ensures a temporal margin of wider trading to the family farming because it reduces the perishability of perennial crops, but enhances the deforestation.

Also for Pichón (1996), the access to electricity adds value to land and make agricultural production more viable, however, attract human settlement and land speculation on the agricultural frontier, consequently, triggers new deforestation events. Likewise, for Alves (2002), deforestation tends to be more intense in areas with availability of electricity, so this relation of cause and effect must be taken of particular interest to the redefinition of public policies for regional development. Mattos (2010) suggests additional mechanisms to mitigate deforestation processes arising from the works of regional infrastructure, such as improvement of environmental legislation, creation of protected areas and extractive reserves, approval of indigenous territories, economical ecological zoning and management capacity improvement and public oversight.

For the independent variable ‘access to electricity to benefit the production’, Mattos (2010) assumed as hypothesis that attending to the principles of economic and ecological land use from Proambiente come from family lots with access to electricity to benefit the production due to the greater investment capacity in agroecosystems associated with retention or recovery of legal reserve. The study of the author found that the preservation of the legal reserve has negative relationship with access to electricity to benefit the production. Family lots without access to electricity have greater capacity to comply with environmental legislation of Amazon Basin (minimum 80% legal reserve), i.e. 25.33% of them are presented in accordance with environmental legislation, against only 2.38% of those with access to electricity. It still remain 26.07% of the family lots without access to electricity that holds between 60-80% of legal reserves and approach of environmental legality, a level that falls to 7.54% of the family lots with access to electricity. For access to electricity, the hypothesis is not confirmed, because there is a clear relationship between the presence of this infrastructure and the deforestation of legal reserve. Access to electricity is both an indicator of economic growth (because it helps with the formation of capital, and compared to transport, in more 30%) as deforestation of legal reserve, which demonstrates the need for adequacy of economic instruments (e.g. rural credit and policies of regional food purchases) to the infrastructure and environmental legislation of Brazilian Amazon Basin.

3 – Conclusions

The independent variable ‘family origin’, which connects the cultural aspects (among others factors), had confirmed its hypothesis, because lots led by families with origins in the Amazon Basin preserve a larger contingent of legal reserve. Among the variables that are linked to economic aspects, the ‘lot size’ and ‘access to rural credit of FNO’ have also confirmed its hypothesis. There is a clear positive relationship between lot size and legal reserve, except for lots with a profile strictly family livestock, which require large tracts of land and trigger deforestation processes proportionally broader. This result corresponds to the demands of rural social movements of review of environmental legislation to family lots of the region. For the ‘access to rural credit of FNO’, it is apparent that economic development policies for Amazon Basin require planning with a focus on regional characteristics of the biome. In the opposite case, ‘access to rural credit of Pronaf’ does not confirm the hypothesis. If by a side, Pronaf fulfills an important role in catalyzing the process of capitalizing on family lots, on the other hand, is still too narrowly focused on the productive logic of the agriculture and livestock from Midwest and South regions, ignoring the extractive and agricultural demands of Amazon Basin. For the independent variables ‘time of lot occupation’, ‘annual family income’ and ‘access to electricity’, the hypotheses are also not confirmed. In the case of the ‘time of lot occupation’, this article confirms the relation between high turnover on family lots and deforestation. The entry of new families in the lots establishes new deforestation events, i.e., within the family circle, there is stabilization of deforestation over time, but in the cycle of the lot with family rotation, this specificity does not occur. The direct relationship of increase in ‘annual family income’ and ‘access to electricity’ with the deforestation of legal reserve also shows that processes of capitalization and structural heterogeneity demands a more integrated logistics to the ecological questions of Amazon Basin. In general, family origin, lot size and access to electricity are very important independent variables for preservation or not of legal reserves, stating that cultural factors, besides the economic, should be considered in rural development processes in the Brazilian Amazon Basin.

Finally, it is worth emphasizing two points. The first is that future researches will disaggregate the data and interpret the influence of each variable in land use and deforestation in each of the seven sub-regions studied, in addition to analyzing the influence of multiple variables. The second is that current and future studies intend to collaborate not only with the improvement of Proambiente, but with possible strategies and integrated policies for rural development, family farming production and environmental services in rural landscape scale. Proambiente went through a profound process of emptying of the first one (2003-2006) for the second (2007-2010) government's mandate Luiz Inácio Lula da Silva and tends to become extinct in the next government, whatever their political tendency, but information gaps that this program demand does not refer only to itself, but to a process of rural development with broader social, cultural, economic, ecological and political balance.

Acknowledgements

This study is part of the PhD dissertation conducted at the Institute of Economics (IE), Campinas State University (Unicamp) by the first author, who gratefully acknowledges financial support from the Brazilian Agricultural Research Corporation (Embrapa) to graduate school, field work and international academic exchange of one year developed in the Anthropological Center for Training and Research on Global Environmental Change (ACT) at Indiana University (IU), Bloomington, IN, United States of America.

References

ALVES, D. (2002). An Analysis of the Geographical Patterns of Deforestation in the Brazilian Amazon in the Period 1991-1996. In C. H. Wood & R. Porro (Eds.), Deforestation and land use in the Amazon (pp. 133–161). Gainsville, FL: University Press of Florida

ANGELSEN, A.; KAIMOWITZ, D. (eds) (2001). Agricultural Technologies and Tropical Deforestation. CABI Publishing, Oxfordshire, United Kington.

ARIMA, E. (2000). A distribuição espacial do crédito do FNO no estado do Pará. In: Tura, L.R. & Costa, F. de A. (Org.) Campesinato e estado na Amazônia: impactos do FNO no Pará. Cap. 3, pág 63-106. Brasília: Brasília Jurídica-FASE.

BASA (Banco da Amazônia) (2000). Programa de aplicação de recursos 2000 à 2003. Belém: BASA.

BATISTELLA, M.; ROBESON, S; MORAN, E.F. (2003). Settlement Design, Forest Fragmentation, and Landscape Change in Rondônia, Amazônia. Photogrammetric Engineering & Remote Sensing. Vol. 69, No 7, July, PP 805-812.

BATISTELLA, M.; (2001). Landscape Change and Land-Use / Land-Cover Dynamic in Rondônia, Brazilian Amazon. CIPEC Dissertation Series, N.o 7, Center for the Study of Institutions, Populations and Environmental Change, Indiana University, Bloomington (IN).

BENATTI, J.H. (2003). Direito de Propriedade e Proteção Ambiental no Brasil: apropriação e uso dos recursos naturais no imóvel rural. Tese de Doutorado. NAEA/UFPA. Belém/PA.

BOSERUP, E. (1987). Evolução Agrária e Pressão Demográfica. São Paulo: Hucitec.

BRONDIZIO, E. S. (2009). Análise intra-regional de mudanças do uso da terra na Amazônia. In: Moran, E.; Ostrom, E. (org) – tradução Alves, D.S.; Batistella, M. (2009). Ecossistemas florestais: interação homem-ambiente. São Paulo: Editora Senac: Edusp.

BRONDIZIO, E. S.; CAK, A. CALDAS, M.; MENA, C.; BILSBORROW, R.; FUTEMMA, C.; LUDEWIGS, T., MORAN, E.; BATISTELLA, M. (2009a). Small Farmers and Deforestation In Amazonia. In: Keller, M.; Gash, J; Dias, P.S. (Eds). Amazonia and Global Change: A Synthesis of LBA Research.

BRONDIZIO, E.S.; GATZWEILER, F.; ZOGRAFOS, C. (2009b). Social-cultural context of ecosystem and biodiversity valuation. Post-Ispra Meeting.

BRONDIZIO, E. S.; Mc CRACKEN, S. D.; MORAN, E. F.; SIQUEIRA, A. D.; NELSON, D. R.; RODRIGUEZ-PEDRAZA, C. (2002). The colonist footprint: Toward a conceptual framework of land use and deforestation trajectories among small farmers in the Amazonian frontier. In C. H. Wood & R. Porro (Eds.), Deforestation and land use in the Amazon (pp. 133–161). Gainsville, FL: University Press of Florida

CARVALHO, V.R.V. (2000). Inovação, Diversificação Cultural e Sociabilidade. In: COSTA, F. de A. (org). Agricultura Familiar em Transformação no Nordeste Paraense: o caso de Capitão Poço. Belém: NAEA/UFPA

COSTA, F. de A. (2000). Economia Camponesa e Dinâmica Inovativa: o caso eloqüente de Capitão Poço. In: COSTA, F. de A. (org). Agricultura Familiar em Transformação no Nordeste Paraense: o caso de Capitão Poço. Belém: NAEA/UFPA

DIRVEN, M. (2000). Empleo rural, grupos etários e gênero. In: Ornas, Ocupações rurais não agrícolas. Oficina de atualização temática. Londrina: Iapar.

GRAZIANO DA SILVA, J. (1999). Tecnologia e agricultura familiar. Porto Alegre: Editora UFRGS.

GUANZIROLI, C; ROMEIRO, A; BUAINAIN, A.M; DI SABATTO, A; BITTENCOURT, G. (2001). Agricultura familiar e reforma agrária no século XXI. Rio de Janeiro: Garamond.

HOFFMANN, R. 2006. Elasticidade-renda das despesas e do consumo de alimentos no Brasil em 2002-2003. Cap. 6 do vol. II de Silveira, F. G. et al. (org.) Gasto e consumo das famílias brasileiras contemporâneas. Brasília, IPEA

INHETVIN, T. (2000). Produção Camponesa e Redes Mercantis em Capitão Poço. In: COSTA, F. de A. (org). Agricultura Familiar em Transformação no Nordeste Paraense: o caso de Capitão Poço. Belém: NAEA/UFPA

LUDEWIGS, T; D'ANTONA, A.O.; BRONDIZIO, E.S.; HETRICK, S. (2009). Agrarian Structure and Land-Cover Change along the Lifespan of Three Colonization Areas in the Brazilian Amazon. World Development. (in press).

LUDEWIGS, T. (2006). Land-Use Decision Making, Uncertainty and Effectiveness of Land Reform in Acre, Brazilian Amazon. Dissertation of PhD in Environmental Science submitted to the School of Public and Environmental Affairs – Indiana University; Bloomington – Indiana - USA.

MATTEI, L. (2007). Políticas de apoio ao desenvolvimento da agricultura familiar no Brasil: o caso recente do Pronaf. Revista Econômica do Nordeste, Fortaleza, v.38, no 1, jan-mar.

MATTEI, L. (2001). Programa Nacional de Fortalecimento da Agricultura Familiar (Pronaf): concepção, abrangência e limites observados. IV Encontro da Sociedade Brasileiro de Sistemas de Produção. Belém.

MATTOS, L. (2010). Decisões sobre uso da terra e dos recursos naturais na agricultura familiar amazônica: o caso do Proambiente. Tese de Doutorado. Campinas: Instituto de Economia, Universidade Estadual de Campinas (Unicamp), 380 pg.

MATTOS, L.; ROMEIRO, A.R.; HERCOWITZ, M. (2010). Economia do meio ambiente. In: Mattos, L. & Hercowitz, M. (2010) (org). Economia do meio ambiente e serviços ambientais: estudo aplicado à agricultura familiar, populações tradicionais e povos indígenas. Brasília: Embrapa Informação Tecnológica (in press).

MATTOS, L.; HERCOWITZ, M. (2010). Pontos fundamentais para o desenho de políticas públicas de serviços ambientais voltadas às populações tradicionais e povos indígenas. In: Mattos, L. & Hercowitz, M. (2010) (org). Economia do meio ambiente e serviços ambientais: estudo aplicado à agricultura familiar, populações tradicionais e povos indígenas. Brasília: Embrapa Informação Tecnológica (in press).

MATTOS, M.; UHL, C. (1994). Economic and ecologic perspectives on ranching in the Eastern Amazonia. World Development. 22(2): 145-158

McCRACKEN, S.D.; SIQUEIRA, A., MORAN, E. F., & BRONDÍZIO, E. S. (2002). Land use patterns on an agricultural frontier in Brazil; Insights and examples from a demographic perspective. In C. H.Wood & R. Porro (Eds.), Deforestation and land use in the Amazon (pp. 162–192). Gainsville, FL: University Press of Florida.

McCRACKEN, S.D.; BRONDIZIO, E. S.; NELSON, D.; MORAN, E. F.; SIQUEIRA, A. D.; RODRIGUEZ-PEDRAZA, C. (1999). Remote sensing and GIS at farm property level: Demography and deforestation in the Brazilian Amazon. Photogrammetric Engineering & Remote Sensing, 65(11), 1311–1320.

MORAN, E.F.; BRONDIZIO, E.S.; BATISTELLA, M. (2009). Trajetórias de Desmatamento e Uso da Terra na Amazônia Brasileira: uma análise multiescalar. In: Batistella, M.; Moran, E.F.; Alves, D.S. (org). Amazônia: natureza e sociedade em transformação. São Paulo: EDUSP.

MORAN, E.F., BRONDIZIO, E.S., & McCRACKEN, S. (2002). Trajectories of land use: Soils, succession, and crop choice. In C.H. Wood & R. Porro (Eds.), Land use and deforestation in the Amazon (pp. 193–217). Gainsville, FL: University of Florida Press.

MORAN, E.F. (1981). Developing the Amazon. Indiana University Press, Bloomington, 292p.

NORDER, L.A.C. (2006). Mercantilização da agricultura e desenvolvimento territorial. In:

PAN, W.K.; CARR, D.; BARBIERI, A; BILSBORROW, R; SUCHINDRAN, C. (2007). Forest cleaning in the Ecuadorian Amazon: a study of patterns over space and time. Population Research and Policy Review, 26(5-6), 635-659.

PAN, W. K. Y.; BILSBORROW, R. E. (2005). The use of a multilevel statistical model to analyze factors influencing land use: A study of the Ecuadorian Amazon. Global and Planetary Change, 47, 232–252.

PAN, W. K. Y.; WALSH, S. J.; BILSBORROW, R. E.; FRIZZELLE, B. G., ERLIEN, C. M.; BAQUERO, F. (2004). Farm-level models of spatial patterns of land use and land cover dynamics in the Ecuadorian Amazon. Agriculture Ecosystems & Environment, 101(2–3), 117–134.

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

PERZ, S. G., & WALKER, R. (2002). Household life cycles and secondary forest cover among small farm colonists in the Amazon. World Development, 30(6), 1009–1027.

PICHON, F. J. (1996). Settler agriculture and the dynamics of resource allocation in Frontier Environments. Human Ecology, 24(3), 341–371.

PLOEG, J.D. van der (2006). O modo de produção camponês revisitado. In: SCHNEIDER, S. (org). A Diversidade da Agricultura Familiar. Porto Alegre: Editora UFRGS.

RAMOS, P. (2001). Propriedade, estrutura fundiária e desenvolvimento rural. Estudos Avançados, 15 (43).

REARDON, T; CRUZ, M.H., BERDEGUÉ, J. (1998). Los pobres en el desarrollo del empreo rural no agricola en America Latina: paradoja y desafios. In: Tercer Simposio Latinoamericano sobre investigación y extensión en sistemas agropecuarios. Lima.

ROMEIRO, A.R. (1999). Meio ambiente e produção agropecuária na Amazônia. Revista de Economia e Sociologia Rural, Rio de Janeiro, v. 37(1), p. 9-33.

ROMEIRO, A.R. (1998). Agricultura Familiar em Áreas de Reforma Agrária. Síntese Regional. Região Norte. Brasília: FAO/INCRA.

SCHMINK, M.; WOOD, C. (1992). Contested Frontiers of Amazonia. Columbia University Press, New York.

SCHULTZ, T. W. (1965). A transformação da agricultura tradicional. Rio de Janeiro: Zahar, 207 p.

SMITH, N. (1982). Rainforest Corridors. University of California Press, Berkeley, 248p.

TEDESCO, J.C. (2001). Contratualização e racionalidade familiar. In: Tedesco, J.C. (org) (2001) 3. ed.. Agricultura familiar: realidades e perspectivas. Passo Fundo: EDIUPF. 406 p.

TURA, L.; MATTOS, L.(2002). Financiamento da transição para a agroecologia: a proposta do PROAMBIENTE. In: Encontro Nacional de Agroecologia (ENA). Rio de Janeiro.

VAN WEY, L.K.; OSTROM, E.; MERETSKY, V. (2009). Teorias subjacentes ao estudo de interações homem-ambiente. In: Moran, E.F.; Ostrom, E. (org) – tradução Alves, D.S.; Batistella, M. (2009). Ecossistemas florestais: interação homem-ambiente. Sao Paulo: Editora Senac: Edusp.

VAN WEY, L.K.; D´ANTONA, A; BRONDIZIO, E.S. (2007). Household Demographic Change and Land Use / Land Cover Change in the Brazilian Amazon. In: Population and Environment. No 28: 163-185.

VEIGA, J.E. (1991). O desenvolvimento agrícola: uma visão histórica. São Paulo: EDUSP-HUCITEC.

WALKER, R. (2003). Mapping process to pattern in the landscape change of the Amazonian frontier. Annals of the Association of American Geographers, 93(2), 376–398.

WALKER, R.; PERZ, S.; CALDAS, M.; SILVA, L. G. T. (2002). Land use and land cover change in forest frontiers: The role of household life cycles. International Regional Science Review, 25(2), 169–199

WALKER, R. T.; HOMMA, A. K. O. (1996). Land use and land cover dynamics in the Brazilian Amazon: an overview. Ecological Economics, 18, 67–80.

WOORTMANN, K. (1990). Com parente não se neguceia. In: Anuário Antropológico, no 84, Brasília: UnB, p 11-73.

Table 1 - Relationship between independent variables and percentage of legal reserve

	Non-standardized Coefficients		**Standardized Coefficients**	**t**	**OTTP***
	B	**Standard Error**	**B**		
(Constant)	+52.797	4.102		+12.872	0.000
1-Variable of reference: Origin (North)					
Origin (Northeast)	-17.994	1.703	-0.216	-10.565	**0.000**
Origin (Midwest)	-26.677	3.403	-0.133	-7.840	**0.000**
Origin (Southeast)	-27.372	2.217	-0.226	-12.346	**0.000**
Origin (South)	-29.507	2.399	-0.229	-12.298	**0.000**
2-Continuous variable: Time of lot occupation (years)					
Time of lot occupation	-0.136	0.074	-0.032	-1.842	**0.066**
3-Variable of reference: Man scholarity (illiterate)					
Man scholarity (1st - 4th grade)	+0.665	1.861	+0.008	+0.357	0.721
Man scholarity (5th - 8th grade)	+4.211	2.829	+0.030	+1.489	0.137
Man scholarity (high school)	+0.174	3.538	+0.001	+0.049	0.961
Man scholarity (higher education)	-3.786	9.170	-0.007	-0.413	0.680
3-Variable of reference: Woman scholarity (illiterate)					
Woman scholarity (1st - 4th grade)	+1.058	2.045	+0.012	+0.517	0.605
Woman scholarity (5th - 8th grade)	+0.338	2.886	+0.002	+0.117	0.907
Woman scholarity (high school)	+2.850	3.267	+0.018	+0.872	0.383
Woman scholarity (higher education)	-10.788	6.857	-0.027	-1.573	0.116
4-Continuous variable: Generational index (0.0-1.0)					
Generational index	-1.617	3.181	-0.008	-0.508	0.611
5-Continuous variable: Gender index (0.0-1.0)					
Gender index	+2.205	2.915	+0.012	+0.756	0.449
6-Continuous variable: Size of lot (hectare)					
Size of lot	+0.101	0.005	+0.380	+21.469	**0.000**
7-Variable of reference: Title (unregulated lot)					
Title (regulated lot)	-0.609	1.435	-0.007	-0.425	0.671
8-Continuous variable: Annual family income (R$)					
Annual family income	-0.340	0.000	-0.074	-4.245	**0.000**
9-Variable of reference: No access to farm credit					
Access to farm credit (PRONAF)	-6.395	1.526	-0.077	-4.192	**0.000**
Access to farm credit (FNO)	+7.117	1.871	+0.067	+3.803	**0.000**
10-Variable of reference: No access to transportation					
With access to transportation	-1.231	1.941	-0.011	-0.634	0.526
11-Variable of reference: No access to electric power					
With access to electric power	-13.264	2.241	-0.100	-5.918	**0.000**

* OTTP – One-Tail Test Probability (variables and values in bold with statistical significance – OTTP <0.100)
Source: Mattos (2010)

Table 2 - Relationship between independent variables and percentage of legal reserve

% legal reserve	Breadwinner origin											
	North		Northeast		Midwest		Southeast		South		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
60-80 %	190	25.13	123	18.41	7	8.75	24	10.04	12	5.97	356	18.31
80-100 %	339	44.84	55	8.23	2	2.50	8	3.35	5	2.49	409	21.04

% legal reserve	Time of lot occupation									
	0 - 5 years		5 - 10 years		10 - 20 years		+ 20 years		Total	
	n	%	n	%	n	%	n	%	n	%
60-80 %	33	13.69	70	17.68	98	19.52	72	18.18	273	17.79
80-100 %	57	23.65	68	17.17	67	13.35	42	10.61	234	15.24

% legal reserve	Size of lot											
	0-5 ha		5-10 ha		10-50 ha		50-100 ha		+ 100 ha		Total	
	n	%	n	%	n	%	n	%	n	%	N	%
60-80 %	1	1.09	4	2.96	116	11.62	111	28.53	137	28.78	369	17.66
80-100 %	0	0.00	2	1.48	107	10.72	91	23.39	233	48.95	433	20.72

% legal reserve	Access to farm credit									
	No access		Pronaf		FNO		Other types		Total	
	n	%	n	%	n	%	n	%	n	%
	Classes percentage of annual crops (2005)									
60-80 %	130	16.75	78	12.60	81	28.72	38	13.97	327	16.78
80-100 %	206	26.55	51	8.24	58	20.57	61	22.43	376	19.29

% legal reserve	Access to electric power to benefit production					
	No access		With access		Total	
	n	%	n	%	n	%
60-80 %	140	26.07	19	7.54	159	20.15
80-100 %	136	25.33	6	2.38	142	18.00

% legal reserve	Annual family income											
	No information		Until R$ 100.00		From R$ 100.00 to R$ 200.00		From R$ 200.00 to R$ 500.00		From R$ 500 to R$ 1,000		From R$ 1,000 to R$ 2,000	
	n	%	n	%	n	%	n	%	n	%	n	%
60-80 %	2	9.09	1	14.29	2	40.00	4	16.00	9	14.29	2	9.09
80-100 %	5	22.73	3	42.86	1	20.00	3	12.00	10	15.87	5	22.73

% legal reserve	Annual family income									
	From R$ 2,000 to R$ 6,000		From 6,000 to R$ 10,000		From R$ 10,000 to R$ 20,000		Plus than R$ 20,000		Total	
	n	%	n	%	n	%	n	%	n	%
60-80 %	96	16.75	62	16.27	42	12.14	10	7.30	268	15.42
80-100 %	110	19.20	69	18.11	61	17.63	13	9.49	297	17.09

Source: Mattos (2010)