

Population and Environment in Brazilian Ecosystems

Population and Environment in the Brazilian
Center-West: the challenge of sustainable
development

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Population and Environment in Amazônia:
from just the numbers to what really counts

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Environment and Population in the Semi-arid
Northeast

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Introduction

It is well known that tropical rainforests have phenomenal importance for maintaining global environmental quality. Among the direct and indirect benefits and environmental services they provide, scholars have highlighted biological diversity, local and global climate interactions, carbon sequestration, and stabilization of hydrological systems (Aber and Melillo, 1991; Dickinson, 1987; Melillo et al., 1996; Phillips et al., 1998; Salati and Vose, 1984; Salati et al., 1983; Wilson 1988). Therefore, the increasing changes in land cover and land use in the tropics have raised worldwide concern and heated debates.

Brazilian Amazônia stands in the center of these concerns and debates because it contains approximately 40% of the remaining tropical rainforests and has seen the highest absolute rates of forest conversion. Significant deforestation has disturbed ecosystem functioning and impoverished rural livelihoods (Bunker, 1985; Dincao e Silveira, 1994; Fearnside 1990 and 2000; Hall, 1997; Hecht and Cockburn, 1989; Moran, 1981; NRC-NAS, 1993; Schmink and Wood, 1992). Therefore, there has been a call to better understand the determinants of deforestation and an effort to integrate the human and biophysical dimensions of it with remote sensing technologies (Frohn et al., 1996; Liverman et al., 1998; Lucc, 2002; McCracken et al., 1999; Moran and Brondizio, 1998; Moran et al., 1994; Rignot et al., 1997; Rindfuss and Stern, 1998; Wood and Skole, 1998; Vosti et al., 2000).

Although significant progress in our understanding of the demographic dimensions in changes in land cover and land use has been made, demographers have not been able to fully overcome the prevalent view that population pressure is always to be blamed for forest destruction. As recent studies have shown, the population-environment equation is more complex and demographers ought to fully embrace its complexity. This paper aims to contribute to this effort. Initially, I present a brief overview of the causes of deforestation in the tropics followed by a general characterization of recent trends in deforestation, agricultural expansion, and population increase in Legal Amazônia. Then, I assess the importance of the "population factor" as a cause of deforestation and conclude by highlighting the appropriateness of the "mediating perspectives" concept (Marquette and Bilborrow, 1994) in order to understand population-environment relations.

1. Causes of deforestation in the tropics

Our current understanding of the major causes of tropical deforestation has largely been established by Kaymowitz and Angelsen's (1999) comprehensive review of economic models of tropical deforestation and Geist and Lambin's (2001) meta-analysis of over 150 local-scale case studies on tropical deforestation. When examining the agents of deforestation (small-scale farmers, ranchers, loggers, etc.), these authors identified two levels of causes: the immediate or proximate causes and the underlying driving forces.

Geist and Lambin (2001) detail the factors in each of these levels and break them down into major clusters. The immediate causes are due to direct human actions at the local level and can be organized into three major clusters. The most significant of these clusters is classified as agricultural expansion including permanent cultivation, shifting cultivation, cattle ranching, and colonization agriculture. The other two clusters include wood extraction (commercial, fuelwood/polewood, and charcoal production), and infrastructure extension. This last group encompasses transport infrastructure (roads, railroads, etc.), public and private markets, rural and urban settlements, and public and private services such as waterlines, hydropower, mining, and oil exploration.

The underlying causes include major social processes that operate at the macro level constraining the latitude of local agents. The major clusters within this level are: a) demographic factors (population growth, migration, life cycle, etc.); b) economic factors (market growth, economic structures, urbanization and industrialization, income, price increases, etc.); c) policy and institutional factors (formal policies such as economic development, policy climate such as corruption, and property rights); and d) cultural factors including public attitudes, values and beliefs and individual and household behavior.

Other factors cited in several economic models and case studies, which interfere in the dynamics between proximate and intermediate causes, are predisposing environmental factors (land characteristics), biophysical drivers (e.g. fires, drought, etc.), and social trigger events (e.g. war, revolution, etc.).

The basic message of these reviews is that there is no single cause or simple chain-effect that can explain deforestation in the tropics in general or in a diverse region such as Legal Amazônia. Multiple factors operate simultaneously, interact and affect one another. These complex, synergetic dynamics, operating at different levels, are not universal but rather historically and geographically site-specific.

2. Legal Amazônia – general characterization

Legal Brazilian Amazônia comprises an area of 5.1 million km² including the North Region of Brazil (generally called Amazônia) with its seven states – Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins – and the states of Maranhão and Mato Grosso (Figure 1).² Approximately 4 million km² of Legal Amazônia used to be covered by forest formations. This does not include open fields, scrubby vegetation called *cerrado*, and seasonally flooded land bordering rivers known as *várzeas*.

Figure 1
Legal Amazônia



2.1. DEFORESTATION

Until the early 1970s, Brazilian Amazônia had experienced little deforestation. However, in the last three decades, deforestation has plagued the region, becoming a worldwide concern. It is estimated that previous to 1978, 152.2 km² had been deforested, which represents 3.0% of the total area and 3.8% of the forest formations in Legal Amazônia. By 1990, the total deforested area had increased to 415.2 thousand km² and in 2000 it reached almost 590 thousand km². This represents 11.5% of Legal Amazônia's area and 14.7% of its forest formations (INPE, 2002). For the 1978-00 period, the growth in deforested area for the entire Legal Amazônia was 286.2%.

Table 1 presents data on total deforested area in Legal Amazônia by state between 1978 and 2000. This data does not include small clearings (less than 6.25 ha) and areas affected by selective logging or surface fire (INPE, 2002). Although Maranhão was the state with the largest deforested area in 1978 (63 thousand km²), over the decades Pará became the most prominent one, reaching over 200 thousand km², followed by the state of Mato Grosso with almost 144 thousand km². While in Pará, deforestation, resulting from road-building,

ranching, logging, mining, and small-scale farming, goes back to the 1960s and 1970s, in Mato Grosso these processes started in the 1980s and became more prominent in the 1990s with the expansion of large-scale grain farming (mainly soybeans). Rondônia and Roraima became increasingly deforested primarily due to an occupation of new areas for small-scale farmers and subsequent land consolidation. During the period of 1978-2000, deforestation increased over thirteen-fold in Rondônia and sixty three-fold in Roraima while in the 1990s it increased approximately 70% in each of the states.

Table 1
Total Deforested Area in Legal Amazônia, 1978-2000

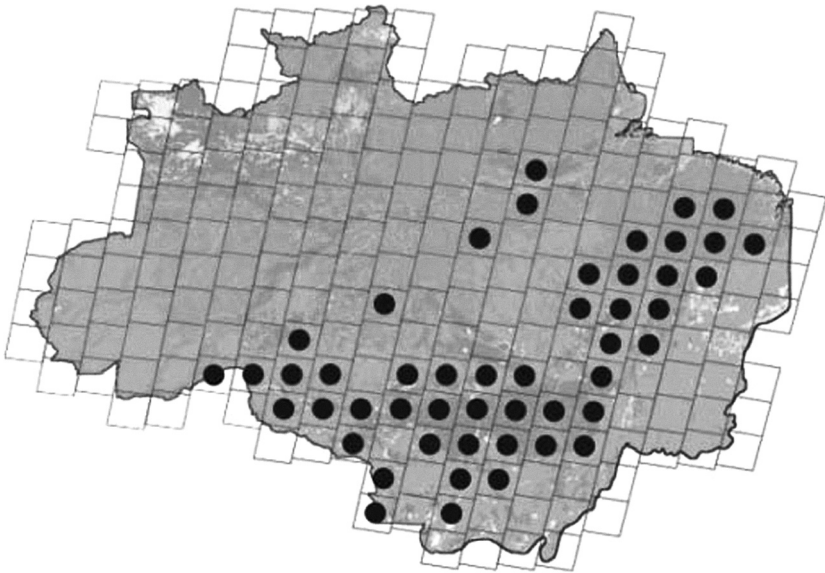
States and Regions	1978 (km ² , Jan)	1990 (km ² , Aug)	2000 (km ² , Aug)	% Growth in Deforested Area		
				1978/90	1990/00	1978/00
Acre	2,500	10,300	15,767	312.0	53.1	530.7
Amapá	200	1,300	1,963	550.0	51.0	881.5
Amazonas	1,700	22,200	30,322	1,205.9	36.6	1,683.6
Pará	56,400	144,200	200,118	155.7	38.8	254.8
Rondônia	4,200	33,500	58,143	697.6	73.6	1,284.4
Roraima	100	3,800	6,386	3,700.0	68.1	6,286.0
Tocantins	3,200	22,900	26,842	615.6	17.2	738.8
Amazônia	68,300	238,200	339,541	248.8	42.5	397.1
Maranhão	63,900	93,400	104,256	46.2	11.6	63.2
Mato Grosso	20,000	83,600	143,930	318.0	72.2	619.7
Legal Amazônia	152,200	415,200	587,727	172.8	41.6	286.2

Source: INPE, 2002.

In summary, the annual rate of deforestation in Legal Amazônia has remained very high and is concentrated in a relatively small area. During the 1990's, the deforestation rate averaged 16, 900 km² per year.³ Over 75% of this deforestation was concentrated in the eastern portion of Pará and the states of Mato Grosso and Rondônia. Accordingly, this critical area, known as the "Arc of fire" (*Arco do fogo*) and shown in Figure 2 with black dots, has been more closely monitored.

Deforestation has been sensitive to the Brazilian economic performance. Periods of economic recession have led to decline in deforestation, while periods of lower inflation and more stable currency have seen the contrary. For instance, in the year of 1994/95, the area deforested increased exponentially, reaching 29.1 thousand km² (annual rate of 0.81%). For 2000-01, even with a projected decrease of 13% of the deforested area recorded in 1999-00, the addition of new clearings will approach almost 16 thousand km² (Folha de São Paulo, 2002).

Figure 2
Critical Areas



2.2. AGRICULTURAL EXPANSION

Despite problems with undercount and comparability, the Agricultural Censuses of 1985 and 1995/6 are the best sources for recent economic data on rural areas in Legal Amazônia.⁴ Table 2 presents the number and total occupied area of agricultural establishments by state for 1985 and 1995/6.

The total number of agricultural establishments in Legal Amazônia is around 1 million encompassing a total area of approximately 118 million hectares. The general decrease in the number of agricultural establishments cannot be entirely explained by under enumeration. It is very likely that it is mostly showing concentration of land ownership in fewer hands in previously settled frontier areas that are now more established or consolidated. Land concentration has been the rule rather than the exception throughout Brazilian agrarian history. It tends to emerge even in frontier areas in which land has been distributed to small-scale migrants, including previously landless settlers from other regions of Brazil.

Although the number of establishments for Legal Amazônia has increased by 4.2%, for most states data shows a decrease in area. This decrease is very likely to indicate the reported undercount of the census in 1995/96 but could also mean that interviewees misreported the actual size of their properties.⁵ The three states with significant increases in area of agricultural establishments – Rondônia, Roraima, and Mato Grosso – are the ones in which frontier expansion,

mainly based on farming and ranching activities, has steeply increased in the past decade.

Table 2
Agricultural Establishments in Legal Amazonia, 1985 and 1995/6

States and Regions	Number of Establishments			Total Area of Establishment (1,000 ha)		
	1985	1995/96	% Change	1985	1995/96	% Change
Rondônia	80,615	76,956	-4.5	6,024	8,890	47.6
Acre	35,049	23,788	-32.1	5,235	3,183	-39.2
Amazonas	116,302	83,289	-28.4	5,860	3,323	-43.3
Roraima	6,389	7,476	17.0	2,150	2,977	38.5
Pará	253,222	206,404	-18.5	24,728	22,520	-8.9
Amapá	4,816	3,349	-30.5	1,208	700	-42.1
Tocantins	47,320	44,913	-5.1	17,354	16,766	-3.4
Amazônia	543,713	446,175	-17.9	62,558	58,359	-6.7
Mato Grosso	77,921	78,762	1.1	37,836	49,840	31.7
Maranhão	531,413	368,191	-30.7	15,548	12,561	-19.2
Legal Amazônia	1,153,047	893,128	-22.5	115,942	120,759	4.2

Source: IBGE (Brazilian Statistical Bureau), Agricultural Census 1985 and 1995/6.

Table 3
Agricultural Establishments in Legal Amazônia, 1995/6

States and Regions	Establishments in 1995/96				Total Area % of States
	Number	Total Area (1,000 ha)	Number %	Total Area %	
Rondônia	76,956	8,890	8.6	7.4	37.2
Acre	23,788	3,183	2.7	2.6	20.8
Amazonas	83,289	3,323	9.3	2.8	2.1
Roraima	7,476	2,977	0.8	2.5	13.2
Pará	206,404	22,520	23.1	18.6	18.0
Amapá	3,349	700	0.4	0.6	4.9
Tocantins	44,913	16,766	5.0	13.9	60.2
Amazônia	446,175	58,359	50.0	48.3	15.1
Mato Grosso	78,762	49,840	8.8	41.3	55.0
Maranhão	368,191	12,561	41.2	10.4	37.6
Legal Amazônia	893,128	120,759	100.0	100.0	23.6

Source: IBGE (Brazilian Statistical Bureau), Agricultural Census 1995/6.

The importance of agricultural activities across states and land concentration for 1995/6 is better depicted in Tables 3 and 4. Maranhão and Pará have the largest number of agricultural establishments but in terms of area, they are far surpassed by Mato Grosso, which comprises 41% of the agricultural area in the region and twice as much as in Pará. In relation to the proportion of the total area in each state comprised by agricultural establishments (last column), the state of Tocantins peaks with more than 60%, followed by Mato Grosso (55%), Maranhão (38%) and Rondônia (37%). The most dramatic picture shown in this table is the sharp contrast in terms of land concentration between Mato Grosso and Maranhão. Mato Grosso has 9% of the total number of agricultural establishments in Legal Amazônia occupying 41% of the total area. In contrast, Maranhão has 41% of the establishments and 10% of the total area.

Another dimension of land concentration is offered in Table 4. Here, the data on number of establishments and total area are organized by size of establishment for the entire region. It is worth noting the sharp contrast between the establishments with less than 10 ha (47% in terms of number and less than 1% in terms of occupied area) and the ones with an area equal to 1,000 ha or more (less than 2% in terms of number and 63% in terms of occupied area). Even in the intermediary categories that include the 30-100 ha parcels distributed to small-scale farmers, land concentration is also a hallmark – 50% of the total number and 36% of the total area.

Table 4
Agricultural Establishments by their Total Area in Legal Amazônia, 1995/6

Area of Establishments	Establishments in 1995/96			
	Number	Total Area (1,000 ha)	Number %	Total Area %
Less than 10 ha	416,704	921	46.7	0.8
10 to less than 100 ha	313,533	12,693	35.1	10.5
100 to less than 1,000 ha	128,304	31,298	14.4	25.9
1,000 to less than 10,000 ha	16,465	42,395	1.8	35.1
10,000 ha and more	1,249	33,452	0.1	27.7
Legal Amazônia	893,128	120,759	100.0	100.0

Source: IBGE (Brazilian Statistical Bureau), Agricultural Census 1995/6.

Finally, Table 5 presents selected data on land use for the establishments in 1995/6 organized by the size of the establishments. It is particularly interesting to note that there is only a difference of 2.5% between the total deforested area in Legal Amazônia as reported by the agricultural census (48.52 million ha) and INPE's estimate based on remote sensing devices (49.71 million ha, August 1995).⁶ Another important point is that none of the categories of establishments comply with the new and controversial regulation requiring that at least 80% of the area of the establishments should remain in forest.

Table 5

Land Use by Total Area of Agricultural Establishments in Legal Amazônia, 1995/6

Total Area of Establishments	Deforested Areas (%)			Natural Areas (%)		Establishments Total Area (1,000 ha)
	Deforested Total	Crops	Planted Pasture	Natural Pasture	Primary Forest	
Less than 10 ha	79.3	63.2	5.8	3.0	13.7	921
10 to less than 100 ha	51.4	9.6	24.8	7.7	37.5	12,693
100 to less than 1,000 ha	45.2	4.2	30.9	16.3	35.3	31,298
1,000 to less than 10000 ha	43.1	4.5	31.9	18.3	35.1	42,395
10,000 ha and more	26.5	2.1	19.5	13.0	56.9	33,452
Legal Amazônia	40.2	4.8	27.3	15.1	41.3	
Total Area (1,000 ha)	48,516	5,738	32,932	18,217	49,824	120,759

Source: IBGE (Brazilian Statistical Bureau), Agricultural Census 1995/6.

Note 1. Total deforested area includes: crops, planted pasture, planted forest, fallow, and productive areas not used.

Note 2. Total area (100%) includes: total deforested area (Note 1), natural areas, and infrastructure (roads, dams, other constructions).

Regarding crops and pasture, the trends are the opposite. The proportion of land in crops decreases with the increase in the size of the establishments. The smallest establishments show an average of 63% of their area in crops, while the largest ones only have 2%. For pasture, with the exception of the establishments with 10,000 ha and above, larger establishments show a higher proportion of land in pasture both planted and natural. Pasture is very important even for those establishments more directly focused on subsistence. In small establishments (10 to less than 100 ha), the average total proportion in pasture approaches one third of their total area.

2.3. POPULATION INCREASE

Although the annual population growth rate in Amazônia has remained higher than in other regions in Brazil, it has fallen dramatically in the past three decades. From an annual increase of 5% in the 1970s, it has dropped to less than 3% in the last decade. This is explained by a decrease in migration to the region from elsewhere in Brazil and a sharp decline in fertility in urban areas and rural as well. This fertility decline has been recorded for the whole country and is even more remarkable since it has happened in the absence of an official family control policy.

In 1991, the total population in Legal Amazônia was 17 million, which by 2000 had risen to 21 million or 12.4% of Brazil's population. Within Legal Amazônia, population is unevenly distributed, being concentrated primarily in the states of Pará (over 6 million), Mato Grosso (5.6 million), Amazonas (2.8 million), and Maranhão (2.5 million). While the highest absolute population increases in the 1990s were in Pará and Maranhão, the rate of change was the highest in the states of Amapá and Roraima at 65% and 49%, respectively. Table 6 summarizes the population changes in the last decade broken down by states.

Table 6
Total Population in Legal Amazônia and Brazil, 1991 and 2000

States and Regions	1991	2000	Increase 1991-2000		Annual Growth %
			Number	%	
Rondônia	1,132,692	1,379,787	247,095	21.8	2.2
Acre	417,718	557,526	139,808	33.5	3.3
Amazonas	2,103,243	2,812,557	709,314	33.7	3.3
Roraima	217,583	324,397	106,814	49.1	4.5
Pará	4,950,060	6,192,307	1,242,247	25.1	2.5
Amapá	289,397	477,032	187,635	64.8	5.7
Tocantins	919,863	1,157,098	237,235	25.8	2.6
Amazônia	10,030,556	12,900,704	2,870,148	28.6	2.8
Mato Grosso	2,027,221	2,504,353	477,132	23.5	2.4
Maranhão	4,930,253	5,651,475	721,222	14.6	1.5
Legal Amazônia	16,988,030	21,056,532	4,068,502	23.9	2.4
Brazil	146,825,475	169,799,170	22,973,695	15.6	1.6

Source: IBGE (Brazilian Statistical Bureau), Demographic Census 1991 and 2000.

Table 7
Urban and Rural Population in Legal Amazônia and Brazil, 2000

States and Regions	Total Number	Urban		Rural	
		Number	%	Number	%
Rondônia	1,379,787	884,523	64.1	495,264	35.9
Acre	557,526	370,267	66.4	187,259	33.6
Amazonas	2,812,557	2,107,222	74.9	705,335	25.1
Roraima	324,397	247,016	76.1	77,381	23.9
Pará	6,192,307	4,120,693	66.5	2,071,614	33.5
Amapá	477,032	424,683	89.0	52,349	11.0
Tocantins	1,157,098	859,961	74.3	297,137	25.7
Amazônia	12,900,704	9,014,365	69.9	3,886,339	30.1
Mato Grosso	2,504,353	1,987,726	79.4	516,627	20.6
Maranhão	5,651,475	3,364,070	59.5	2,287,405	40.5
Legal Amazônia	21,056,532	14,366,161	68.2	6,690,371	31.8
Brazil	169,799,170	137,953,959	81.2	31,845,211	18.8

Source: IBGE (Brazilian Statistical Bureau), Demographic Census 2000.

The urban-rural contrast for 2000 categorized by state is presented in Table 7. The high proportion of urban population in all states is notable. For the entire Legal Amazônia, 68% of its population resides in urban areas and for the individual states this proportion varies from 60% in Maranhão to 89% in Amapá. As pointed by Veiga (2002), this proportion of urban residents might be overestimated as a result of a convention of IBGE, the Brazilian Statistical Bureau, leading to what he has coined as "imaginary cities." IBGE classifies as urban the areas comprised by the seat of a municipality (city) and the seat of districts within the municipalities (towns and villages) regardless of other characteristics. Veiga (2002:31-33) proposes a comprehensive criterion including population size, population density, and spatial location as a means to identify urban and rural spaces.

Using just population size as the criterion and counting as urban only the urban population residing in municipalities with at least 20,000 people, the proportion of urban population in Legal Amazônia would be 57%. Although lower than IBGE's figure (68%), it is quite remarkable that the largest area of forest in the world has more than half of its population living in urban centers. Even more notable is that the state capitals in Legal Amazônia concentrate over 5 million inhabitants or 35% of the total population of the region, including Manaus with 1.4 million inhabitants, Belém with 1.3 million, and São Luis in Maranhão with 0.8 million.

3. Is population a problem?

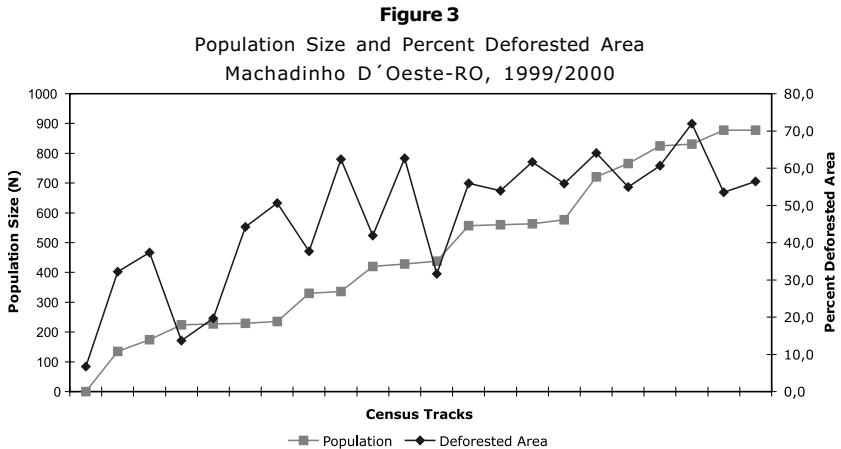
3.1. FIELD REALITIES AND LITERATURE FINDINGS

As the saying goes, "where there is smoke, there is fire; where there is fire, there is clearing; where there is clearing, there are people." For Legal Amazônia, a comparison between protected areas such as parks and reserves (Indian, extractive, and biological) and areas that have been more intensively occupied show that this saying holds true. Areas that have remained relatively inaccessible to people over time have a higher proportion of standing forest. The municipality of Machadinho D'Oeste in Rondônia illustrates the case.

Machadinho started as a government-sponsored colonization area for small-scale farmers in the mid-eighties in a region of primary forest with almost no environmental disturbance at that time. The settlement project layout design combined a grid of irregularly shaped parcels, averaging 40 hectares in size, with blocks of forest reserves in areas considered critical for watershed protection. Since the mid-1990s, these forest reserves have been under state-community management.

Visual inspection of maps of land cover for Machadinho D'Oeste (not shown) reveals that these forest reserves remain almost entirely covered by primary forest. Figure 3 presents data on deforested area in 1999 and population size for 2000 at the census track level. Deforestation was estimated from Landsat satellite imagery and demographic data was taken from the 2000 census. The data was then sorted according to population size. The graph highlights the strong relation

between the two variables, supported by a Pearson correlation of 0.74 and significant at the 0.01 level.



This example is just one among many others in Legal Amazônia but the conclusions we can derive from it can also be misleading. It can easily be interpreted as unconditional support for the generally accepted assumption that population growth is the driving force in deforestation in the tropics. Although several studies have correlated population with degradation of natural resources (Allen and Barnes, 1985; Cropper and Griffiths, 1994; Cropper et al. 1999; Lugo et al., 1981; Myers, 1984), scholars are increasingly questioning these findings. At the root of these questionings have been heated debates on the methodologies used in the studies including issues such as geographic and temporal scales, limited number of variables incorporated into the models, and chain effects not taken into account. Also, it has been stressed that population is an endogenous factor and population migration occurs as a response to economic incentives.

For Legal Amazônia, Pfaff (1999) in a county-level analysis for the period 1978-1988 found that population density was not a significant variable to explain deforestation. Spatial and temporal distribution of population, however, emerged as important dimensions to be taken into account. In-migration into "empty-counties" had significantly more impact on the environment when compared to the same absolute population increase in previously occupied areas.

These spatial and temporal dimensions of the demographic factors become even more meaningful if analyzed at the farm-level, the *locus* of decisions that ultimately determine the fate of standing forests. In an earlier study, Sydenstricker-Neto and Vosti (1993) found that during the initial stages of parcel development in new areas, deforestation rates were directly linked to the number of adult males residing in the parcel and that hired labor did not play an important role. A model on the life cycle of households proposed by McCracken et al. (1999) has shed new light on the relations between household dynamics and

decision-making processes affecting land use at the parcel level and the understanding of the colonist footprint over time (Brondizio et al., in press).

3.2. MEDIATING PERSPECTIVES: CULTURAL FACTORS

While household demographics is an important piece of the story about land use change over time, mediating factors are also key to better understand how human population shape the surrounding environment (Marquette and Bilsborrow, 1994). This perspective holds that social, institutional, and cultural factors mediate and shape population-environment relationships (Arizpe and Velásquez, 1994; Bilsborrow, 1992; Hogan, 1992; McNicoll, 1990). In order to illustrate how some of these factors might operate, I examine more closely two neighboring parcels in Machadinho D'Oeste, Rondônia.

The settlers on these two parcels have several things in common. First, they were migrants who came to the frontier in search of a piece of land in which they could cultivate crops and make a better living. Second, they were both part of the first group of settlers to receive a parcel in Machadinho in 1984-85. Currently they are small-scale farmers occupying a single parcel of about 50 hectares. Both household heads are in their sixties and are the only available adult male labor force in the household. Forth, after more than 15 years living in the area both settlers consider themselves adapted to the region and expect to live in and from the parcel until the end of their lives.

There are also some notable differences between the two settlers. One settler is an individual living by himself while the other is married. There is also a significant difference in terms of their present income sources. While the married couple makes a living from the production of their parcel (mainly milk and coffee), the single settler earns a modest retirement pension that covers a great portion of his basic needs and is supplemented by his farm income.

The most remarkable differences between the two neighbors are in relation to how they have developed their parcels and changed the landscape. The single settler has more than half of his parcel covered with primary forest, less than 2% in pasture, no herds, and around 6% in various crops including annual subsistence crops, fruit trees, and perennial crops such as coffee and cacao. One third of the parcel is a mix of secondary forest in various stages of regrowth, including a small area in fallow and areas previously cropped and currently semi-abandoned. A significant portion of the area in secondary forest has been enriched with various native species such as hardwood and fruit trees. There is also a small home garden with herbs and medicinal plants.

The married settler knocked down more than 80% of the primary forest, 39% percent of the parcel is in pasture, 10% is planted with coffee, and 28% is a mix of secondary forest and old coffee and cocoa trees no longer in production. According to the settler, they plan to change this area that is currently out of production (28%) into pasture and almost double their milking herd.

What would explain these very different outcomes regarding land use? Based on extensive field research, I conclude that in these cases cultural factors play a crucial role in mediating settlers' relation to the environment. Although a migrant,

the single settler has lived in Legal Amazônia for more than forty years and is very used to the challenges of hostile environments. He has worked most of his life cropping the land but also interacted extensively with rubber tappers. According to him, he learned about the "mysteries of the forest" from them and considers himself quite knowledgeable about uses of many native plants. He relates to the forest in a very natural way, suggesting a "symbiotic" interaction with the local environment. His house resembles more a cabin built by locals rather than a typical house of a settler. When questioned about why he does not expand his agricultural area, he did not hesitate to say, "... without the interest of my son and daughters in this parcel, the only alternative is to live from my subsistence crops, allow the forest to recover, and extract some products from it."

The other settler and his spouse are *gaúchos*, natives from the South of Brazil and came to the Amazon just a few years before getting their parcel in Machadinho. They were raised in an area known for its open natural fields, extensive beef herds, and are very proud of its cultural traditions. Some of these traditions such as the *chimarrão* – hot herb tea shared among friends and drank from the same gourd and silver tube – are still part of the daily family routine. *Gaúchos* are also known to be entrepreneurial and good managers, a reputation that this settler has among the small-scale farmers along the feeder road where he lives and in the community at large. When asked about the expansion of pasture he paused for a second and then provided a detailed explanation about his rationale and how it had evolved over time. In the end, he concluded by saying that "now, having only the two of us in the parcel there is no way but moving into pasture in order to have it clean, organized, and well taken care of."

In summary, the illustration shows that similar stories led to quite different outcomes. Also, it highlights that several factors – some quantifiable and others only qualitatively assessed – mediate and shape the ways in which human populations interact with the environment. The cases reported above focused essentially on the individual characteristics and responses. However, they are part of a broader context, which includes collective action and community behavior as well. The link between entrepreneurship and the "rancher" suggests a view of local development project more identified with traditional agricultural expansion rather than environmental management. Certainly this has very much to do with the policies and incentives operating in the region and the story could be different if mechanisms such as a credit for carbon sequestration or more robust incentives promoting agroforestry systems were in place.

3.3. MEDIATING PERSPECTIVES: LOCAL GOVERNANCE

Another important factor within the mediating perspective on population-environment relations is the role of institutions. Scholars have underscored that in particular, "institutions at the local level – together with the incentives and behaviors they generate – lay at the heart of explanations of forest use and condition" (Gibson et al., 2000:3). The attention is not only given to the role of institutions (e.g. rules and norms) but to their implementation by formal

organizations (e.g. government agencies at all levels, NGOs, etc.) and less structured groups such as interest groups at the community level.

The ongoing debate in *Science* on development in Amazônia (Laurance et al. 2001; Laurance and Fearnside, 2002; Nepstad et al. 2002a and 2002b)⁷ particularly addresses these issues. Although the authors share a common ground in some issues, their assessment of the magnitude of impacts of development projects in the region and the alternatives to cope with them are orthogonal. For instance, the authors spell out a similar concern about the environmental consequences of expansion of infrastructure in the region such as highways, railroads, river channeling projects, and hydroelectric dams put forward by the federal government with its *Avança Brasil* program (IPAM and ISA, 2000).⁸ However, regarding the magnitude of the impacts of this program and other smaller ones, their views are in opposite camps. Laurance and colleagues (from now on referred to just as Laurance) are far more pessimistic about the "damages" than Nepstad and his group (from now on referred to just as Nepstad).

Another point shared by the two groups is the need to develop institutions (e.g. rules and norms) that take more seriously into account the environment, strengthen the mechanisms to more broadly and efficiently enforce these institutions, and finally support – financially and politically – the organizations expected to make this process operable. The agreement ends there. Nepstad is confident about changes and identifies an increasing will among the Brazilian society at large to redirect Amazonian development from what he coins as "business-as-usual frontier expansion." Although Laurance recognizes important improvements in environmental protection, legislation, and attitudes towards Amazônia, he does not foresee changes in the destructive developmental path Amazônia has already undergone. According to Laurance and Fearnside (2002:1643), "there is no compelling evidence that the planning process has fundamentally changed, and the threats to Amazonian ecosystems remain very real."

The hidden dimension of this debate is the contrasting perspective these authors have on the "population factor." From my perspective, a neo-Malthusian approach has informed Fearnside and Laurance's extensive interdisciplinary writing on the Legal Amazonia. Adopting this framework, there is no alternative but to assume the intrinsic human ability to degrade the environment, in particular in situations in which there is population pressure. On the opposite side, the Boserupian perspective (Boserup, 1965; 1981) argues that human ingenuity will allow for adaptation to new realities and discovery of novel solutions to environmental degradation. Nepstad contends that the "passive protection of the forest" represented by constraining access to it will not preserve the natural resources in the long run. Rather than just "blocking the roads," he argues that society should promote and strengthen a wide range of ongoing planning initiatives to arrest deforestation. These initiatives, particularly the ones at the local level, are a window of opportunity for real change. As new institutions emerge, incentives and behaviors are generated and are likely to reinforce environmental concerns and appreciation, promote larger participation in the decision-making processes, and empower local stakeholders.

Conclusions

The levels of deforestation in Legal Amazônia remain very high and raise broad national and international concern. No matter what the different perspectives on the causes of deforestation in the region are, the scientific findings are more than sufficient to warn against persisting in the path of massive annual deforestation of new areas.

Three decades of forest destruction have created smoke and burned trunks to an extent that it has frequently shortened our minds and limited our ability to see beyond the "environmental mess." However, in recent years big and small initiatives have emerged and could become cornerstones in arresting natural resource degradation and promoting environmental conservation. Several promising cases point in the right direction, suggesting that if they are not sufficient neither are they a mere fiction (Estado de São Paulo, 2002; Hall, 1997; Monte-Mór, 2002).

If periods of greater economic uncertainty can be a source of hope for diminishing deforestation rates, limits imposed by natural conditions are also playing in the same direction. Recent analyses on the determinants of forest conversion and pasture productivity have found that, controlling for other factors, high levels of precipitation in extensive portions of Legal Amazônia represent a severe constraint to ranching activities (Chomitz and Thomas, 2000). A similar rationale has been raised by experts regarding the expansion of soy production. In this case, along with weather constraints, exorbitant costs to plow the land and mechanize it would make the enterprise not cost-effective (EMBRAPA, 1999).

The majority of analyses on population-environment relations in Legal Amazônia have been framed within a conceptual framework confined to a simplistic view of these relationships: a question of the pressure of numbers on resources. There is hope, however, since new initiatives and research projects in the region are exploring, testing, and obtaining findings that support the mediating perspective (Marquette and Bilsborrow, 1994). Some of the most promising ones are undertaking their efforts in the context of renewed debate on the population/resources equation (Birdsall et al. 2001; NRC-NAS, 1986). If population pressure cannot be taken for granted the opposite is also true. We ought to examine in each case how historically grounded local social relations and specific conditions of natural resource systems jointly shaped the ways in which society perceives and interacts with the environment.

In summary, population-environment relations in Legal Amazônia are complex rather than simple. In order to better understand them, and hopefully contribute to better balance conservation and use of natural resources, there is no way but to grapple with this complexity. Simplistic analyses have taken us out of track and created myths. From a methodological standpoint, we have so far agreed much more on studies that count what is countable, rather than the ones – perhaps not always statistically significant – that are telling stories about what really counts. In the particular case of studies on population and environment, there is also a real need for analytical approaches, which in a cohesive and coherent way, integrate the biophysical and social realities (including their reciprocal relations) and do not simply juxtapose them.

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Notes

¹ This paper is part of a larger research project titled "Institutions, Demographic Factors, and Land Use in the Brazilian Amazon: A Temporal-Spatial Analysis, 1986-95/00." This project examines changes in land cover as a function of land use over time in the forest margins as well as the relationship between these changes and institutional arrangements and demographic patterns among small-scale farmers (Sydenstricker-Neto, 2000).

² Officially, only the area of Maranhão west of the meridian 44°W is included in Legal Amazônia. For simplification, in this paper the entire state of Maranhão is included as part of Legal Amazônia.

³ Deforestation rate averaged 16, 900 ± 4,900 km² per year.

⁴ For problems of comparability between the agricultural censuses of 1985 and 1995/6 and the Municipal Agricultural Survey (PAM), see Helfand (1999), cited in Ferraz (2001).

⁵ This is more likely to be the case with larger properties and is based on the same rationale about interviewees misreporting their income.

⁶ Although the period of reference of both sources is different, the comparison is adequate. INPE's data on total deforested area was measured in August 95, and the census on December 31, 1995. August is a dry month in most of Legal Amazônia and by this time in the agricultural cycle most forest clearing has occurred. Also, August has been consistently reported as the month with the highest number of burnings. Therefore, the total cleared area as of 1995 is

fully captured by both sources. If we were to compare the 1995/6 census data with INPE's total deforested area in August 96, the difference would be 6.7%.

⁷ The following site <http://www.sciencemag.org/cgi/eletters/291/5503/438> has the entire electronic debate responses to Laurance's et al. (2001) article.

⁸ Although the direct translation of *Avança Brasil* would be Advance Brazil, the alternative "Move Forward Brazil" provides a better sense of the development project mentality behind the whole conception of the program. Critics of the initiative have compared it to the disastrous regional development projects such as the Trans-amazon sponsored by the militaries in the early 1970s.

