

DEFORESTATION AND FRONTIER EXPANSION IN BRAZILIAN AMAZÔNIA

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Summary

Deforestation data derived from satellite imagery, and conditions of life indicators and socio-economic statistics were compared to investigate how deforestation and conditions of life have evolved in Brazilian Amazon. Deforestation has been concentrated near major networks, particularly near roads in Maranhão, Mato Grosso, Eastern Pará, and Rondônia. Conditions of life have presented major improvements in some areas of high deforestation rates but important regional variations were found. New research is needed to understand how different social, urban, agrarian and production systems coexist and evolve, what are they characteristics, and how these differences may influence changes in deforestation magnitude and impacts.

Deforestation expansion in Brazilian Amazon

Brazilian Legal Amazônia consists of 9 states (Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and the part of Maranhão West of W44°), that have been the object of Brazilian Government policies to stimulate development, colonization and occupation. Starting in the 1950s and considerably reinforced after 1970, these policies were marked by the establishment of an extensive road network, government-assisted migration and farming, and the appropriation of a 100-km land zone to each side of major roads for colonization projects (Becker 1997).

Most road construction, colonization and farm establishment were done in forested areas, resulting in continually increasing deforestation, from 10 million hectares in the 1970s to an estimated 60 million hectares by 2000 (total deforested area reported, respectively, by Tardin *et al.* 1980 and INPE 2001).

Large-scale deforestation affects climate, land-atmosphere interactions, and ecosystems (<http://lba.inpe.br>). Furthermore, the expansion of the agricultural frontier has led to land degradation, increased social tension and precarious settlement of unassisted migrant populations (Becker 1997, Machado 1998, Schmink and Wood 1992).

The geographic disposition of roads has imprinted a general direction over the recent occupation in Amazônia. In fact, 90% of the 1970s and 1991-1997 deforestation have occurred within 100 kilometers from major roads (Alves in press^a). Deforestation has also spread at a relatively slow pace, with 87% of the 1991-1996 deforestation being observed within 25 km from areas already deforested in the 1970s (Alves in press^b). As a result, forest clearing has concentrated in some areas, particularly near major roads linking the State capitals Cuiabá and Belém to central Brazil, northern Mato Grosso, Porto Velho and Rio Branco, leading to the repeated aggregation of vast expanses of deforested areas generally dominated by pastures, where forest areas have been reported below limits required by Federal legislation (Alves in press^a, Alves *et al.* 1999, Venturieri, A. *pers. comm.* 1998). Most deforestation has occurred where roads offer relatively efficient access to more developed regions of Brazil in Maranhão, Mato Grosso, Eastern Pará, and Rondônia, implying a scenario of land use intensification instead of expansion into more distant areas (Alves in press^a).

Evolution of conditions of life from BRA/97/007 indicators

The evolution of conditions of life considered here was based on socio-economic indicators generated by a joint project by the United Nations Development Program (UNDP), Instituto de Pesquisa Econômica Aplicada (IPEA), and Fundação João Pinheiro, with the collaboration of IBGE, for years 1970, 1980 and 1991 (BRA/97/007 Project).

The project's condition of life index (ICV) (BRA/97/007 Project) was compared for municípios inside and outside Legal Amazonia to detect specific characteristics for Amazônia. The ICV index combines indicators on income, longevity, infancy, education, and housing conditions and increases as its basic indicators show improvements in life conditions.

Although a more detailed study would be required to discuss ICV evolution, the ICV index appears to have consistently increased for all Brazilian States as shown in Table 1. ICV also presented some improvement for individual municípios as illustrated in Figure 2 municípios from the Legal Amazonia, NorthEast and South regions.

Despite an overall improvement in conditions of life, important variations occurred among municípios as shown in Figure 3. In the case of Legal Amazonia, Figure 3 shows a noticeable ICV increase in contiguous areas of Mato Grosso and Rondônia, where ICV has evolved from the second lowest to the second highest category since 1970. In addition, most of the Eastern Amazônia has presented important ICV increases, as well as some municípios in more remote areas like Manaus and Boa Vista.

The important variations among municípios show a disparity in life conditions that is critical to understand regional differences. Such differences may require analysis of more detailed, primary data to be understood. Here statistical data on percent illiteracy, households served by treated water, school backwardness, child labor, life expectancy, infant mortality, urban population, family per capita income, and insufficient income from the BRA/97/007 project were tentatively analysed to try to explain some of the observed regional differences.

Data were found to be generally uncorrelated, except for life expectancy and infant mortality data, and for family per capita income and insufficient income data. No general relationship was found between any of these variables and deforested area in the 1991-1995 period (figure 1) (this exercise was done for 255 municípios that could be found in both the BRA/97/007 and deforestation datasets). At this stage, the difficulties in finding such relationship might be attributed to differences in the nature of the data that could not be dealt with for the Open Meeting (the analyzed socio-economic statistics were relative data, while deforested area consisted of absolute values for municipal units very different in size; socio-economic statistics ended at 1991 and deforestation data were available for the subsequent half decade). However, the lack of correlation among statistical data also show that municípios and regions significantly differ for these statistics, suggesting that regional differences could probably be explained by the absence or presence of different phenomena. This would mean that the investigation of such differences might represent an important contribution to understand how socio-economic systems work in the Amazon, even if general relationships or trends were seldom to be found for the entire Amazonian region.

Understanding the linkages between deforestation and frontier expansion

Comparison of socio-economic statistics and deforestation data shows that important regional differences are present in the Amazon, and suggests that understanding such differences may be critical to understand how deforestation and general socio-economic conditions have evolved. Emphasis on understanding such differences is complementary to the general, more frequent emphasis on scaling-up from

regional research, but can contribute to understand the entire diversity of Amazon social groups, that might also provide important subsidies for many stages of policy making.

In general, we noticed an overall increase in conditions of life and some of the regions of more significant improvement coincide with regions presenting high deforestation rates. Conditions of life depend on general income and on improvements in life conditions that depend on the development of economic systems, generally based on cattle and agriculture, and on the existence of efficient links to other regions. Also, the recent Amazon colonization was urban-based (Becker 1997) and the urban network serves well to establish public policies, that may contribute to improve life conditions, reducing and mitigating negative impacts of deforestation.

To conclude, it might be noted that analysis of data performed for this Meeting motivated the formulation of some questions that are summarized below.

1. How the agrarian structures are related to conditions of life and deforestation regional differences ?
How these differences evolve as agrarian structure and land tenure evolve ?
2. How the urban structures are related to conditions of life and deforestation regional differences ?
How these differences evolve as urban structures relationships change ?
3. How the production systems are related to conditions of life and deforestation regional differences ?
How these differences evolve as production systems evolve ?
4. How the urban-rural structures and dynamics are linked to conditions of life and deforestation regional differences ? How these differences evolve as urban-rural relationships change ?
5. Are such structures and its institutions appropriate to reduce deforestation rates and mitigate deforestation impacts ?

Such questions would require far more detailed and complete data on social groups, conditions of life and production systems, but it could be argued that they could help research to provide new subsidies for the formulation new public policies, that might contribute to both improving life conditions and reducing deforestation rates and impacts.

**Table 1 - Life conditions index (ICV) for
Brazilian States in 1970, 1980 and 1991**

Source: BRA/97/007 project

State	ICV (1)		
	1970	1980	1991
Legal Amazônia			
Acre	0.382	0.486	0.580
Amapá	0.494	0.598	0.665
Amazonas	0.444	0.571	0.632
Maranhão	0.359	0.426	0.502
Mato Grosso	0.456	0.581	0.691
Pará	0.473	0.580	0.606
Rondonia	0.461	0.552	0.655
Roraima	0.491	0.623	0.674
Tocantins	0.387	0.470	0.561
Center region (2)			
Distrito Federal	0.649	0.770	0.818
Goiás	0.500	0.631	0.720
Mato Grosso do Sul	0.493	0.630	0.720
North-East region (3)			
Alagoas	0.379	0.459	0.537
Bahia	0.419	0.536	0.586
Ceará	0.362	0.474	0.561
Paraíba	0.368	0.468	0.566
Pernambuco	0.420	0.525	0.616
Piauí	0.353	0.451	0.547
Rio Grande do Norte	0.370	0.500	0.611
Sergipe	0.412	0.523	0.612
South-East region			
Espírito Santo	0.541	0.684	0.741
Minas Gerais	0.526	0.673	0.734
Rio de Janeiro	0.696	0.750	0.789
São Paulo	0.669	0.739	0.806
South region			
Paraná	0.520	0.675	0.753
Rio Grande do Sul	0.624	0.737	0.795
Santa Catarina	0.579	0.729	0.796
Brasil			
	0.532	0.655	0.723

(1) ICV as a normalised indicator based on indicators of longevity, infancy, income, education and housing (BRA/97/007 project)

(2) - Mato Grosso included in Legal Amazônia

(3) - Maranhão included in Legal Amazônia

Desflorestamento na Amazônia Legal segundo sua intensidade em 1991-1995

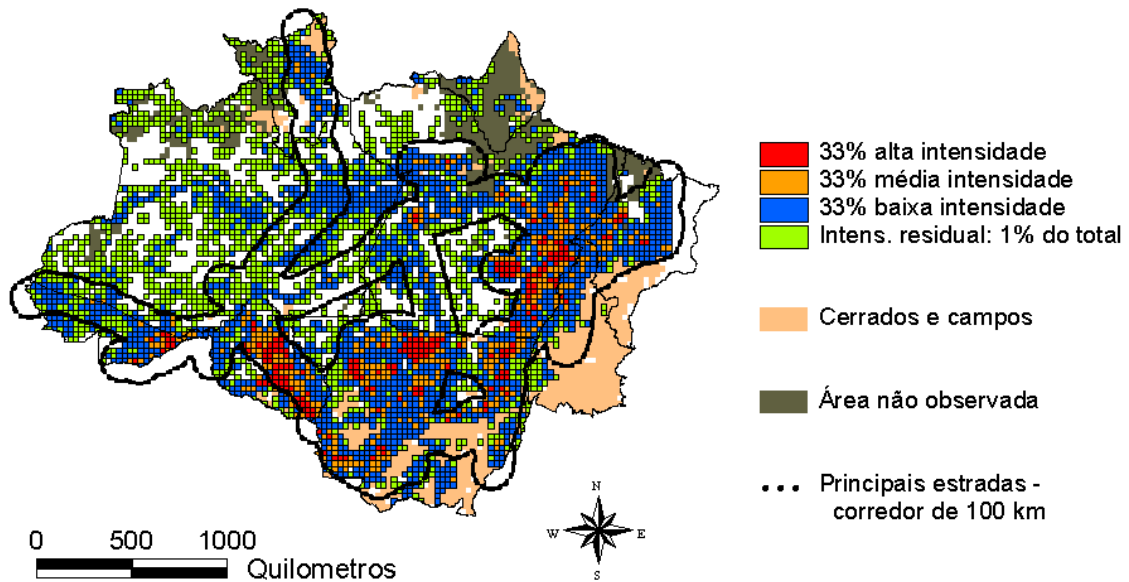


Figura 1

Figure 1 – Deforestation rates in 1991-1995 by $1/4^\circ$ grid-cells divided into four intensity categories (red=high (33% of the total); orange=medium (33% of the total); blue=low (33% of the total); light green cells presented very low deforestation and accounted for 1% of the total). Gray cells covered by clouds in 1995 and pink cells dominated by non-forest vegetation (cerrados and campos). Dotted line show limits of the 100-km area around major roads. Source <http://www.dpi.inpe.br/dalves/abstracts>.

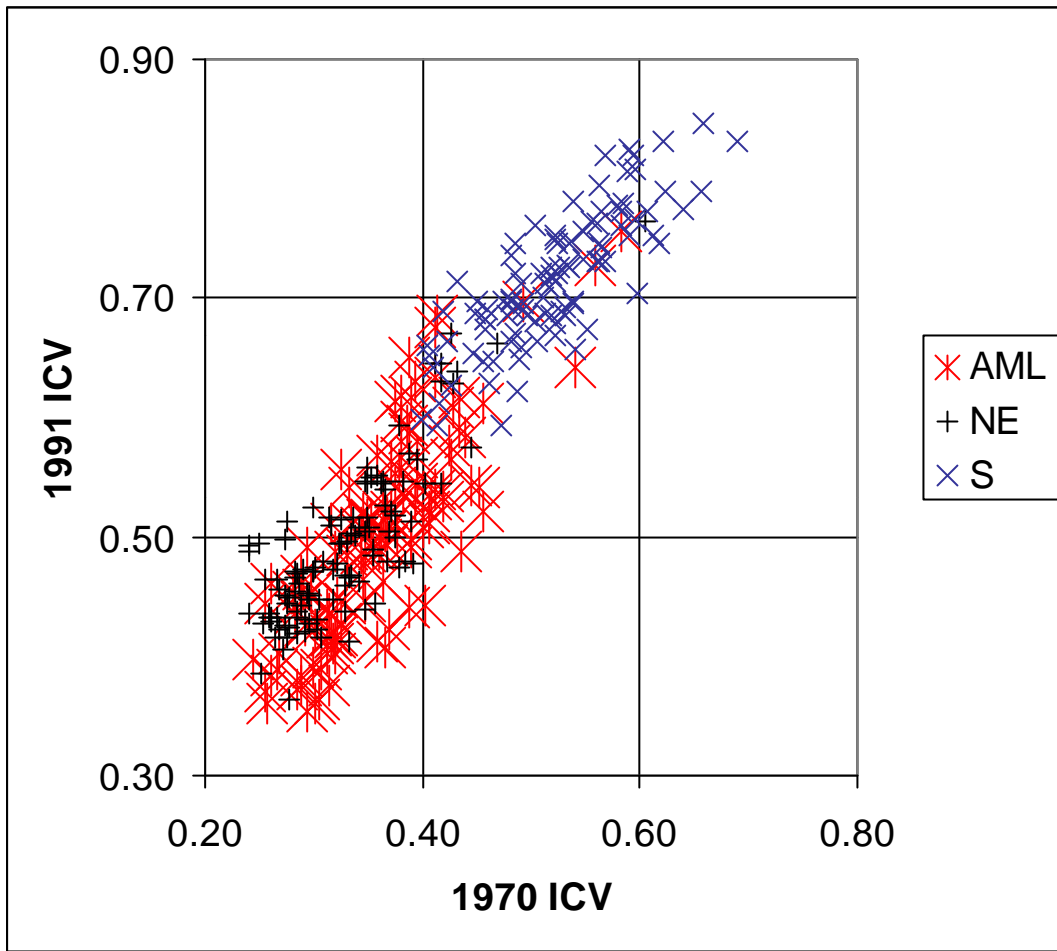


Figure 2 – Comparison among 1970 and 1991 conditions of life index (ICV) for 100 randomly-selected municípios from the Legal Amazonia (AML), northeast (NE) and south (S) regions of Brazil. ICV combines data on income, longevity, infancy, education, and housing. Data from BRA/97/007 Project.

Brasil (Municípios)
Índice de Condições de Vida (ICV), 1970-1991

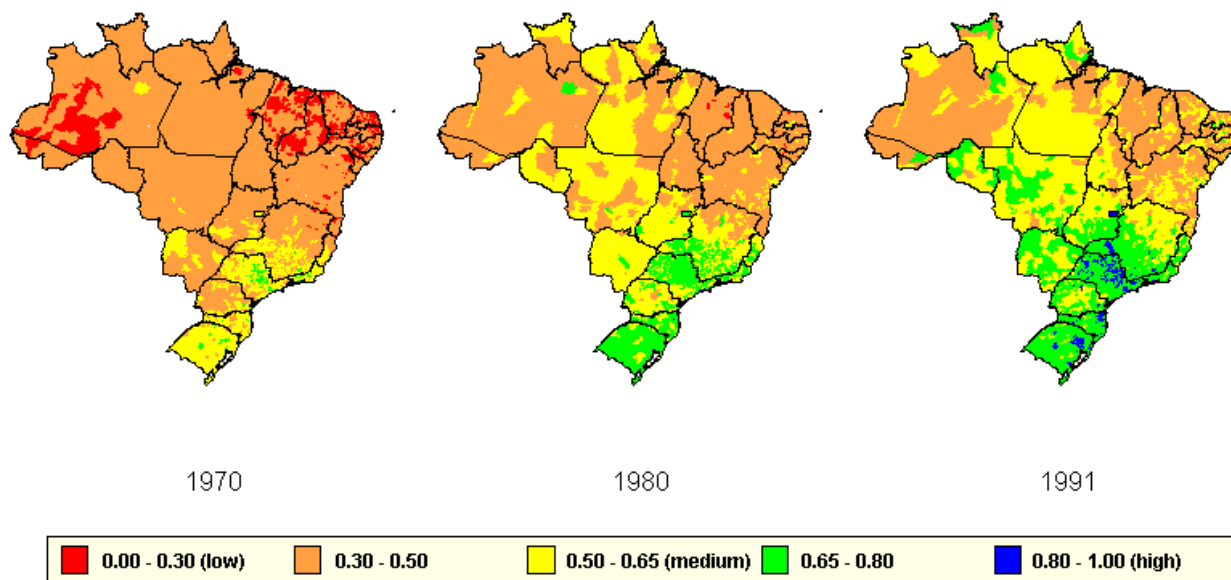


Figure 3 – Evolution of ICV for Brazilian municípios from 1970 to 1991. ICV combines data on income, longevity, infancy, education, and housing derived from socio-economic statistics. Map generated by the computer software BRA/97/007 Project.

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