

DESMAT  
E.J.Reis  
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**DESMAT**  
**DATABASE ON THE DEMOGRAPHY, ECONOMY AND GEOGRAPHY OF**  
**BRAZILIAN AMAZONIA**

DESMAT is the database of the research project "The Economics of Brazilian Amazon Deforestation" undertaken by Eustaquio J. Reis at IPEA (Institute of Applied Economic Research) in Rio de Janeiro since 1989. It is a multi-level geographic database on the economy, demography, and geo-ecological aspects (soil, vegetation, climate, etc.) of Brazilian Legal Amazônia (AML). The project is part of [Nemesis](#) (Network of Spatial Models and Studies sponsored by Cnpq/Pronex since 1997) and the database is partially accessible through the regional page of [www.ipeadata.gov.br](http://www.ipeadata.gov.br).

The database consists of data panels including thousands of variables, mostly IBGE (Brazilian Institute of Geography and Statistics) data from the Demographic, Economic, and Agricultural Census in particular, comprising the entire territory of Brazilian Legal Amazonia at different geographic or administrative levels and time spans. [Leb-Sig-Aml](#) (Sistema de Informacoes Georeferenciadas sobre a Amazonia Legal do Laboratorio de Ecologia e Bio-Geografia da Universidade Federal Fluminense) provides tabulation of georeferenced information on geo-ecological aspects.

The basic units of observation are the município (Brazilian county) and the Census tract which is the smallest geographical unit for which Census data is made public. The changes in number and area of municípios of AML require that municípios are lumped in Minimum Comparable Geographic Area (MCA) to allow consistent comparisons in time.

With regards to time coverage, at state and municipal level, Census data are available for the years 1920, 1940, 1950, 1960, 1970, 1975, 1980, 1985, and 1995; minimum comparable areas (MCA), however, are available only for the 1970-2000 period; at Census tract level data is available for the Agricultural Census of 1985 and 1995 and the Demographic Census of 1991 and 2000.

For some of the municípios and minimum comparable areas (MCA) the geographic area is too large for reliable geo-ecological characterization or spatial analysis. Census tract is the best compromise between the spatially detailed geo-ecological information available in geographic information systems (GIS) and the socio-economic data available in the Census. Thematic map of Census tract division, however, is available only for the Agricultural Census of 1995, and the Demographic Census of 1991 and 2001. Thus, it is impossible to make comparisons or dynamic analyses of land use or any other agricultural change between 1985 and 1995 at Census tract level. To get the 1985 Census tract map is a priority task.

To give a brief idea of the usefulness of the database for statistical analyses, the number of municipalities in AML were 335 in the 1970 Census and 762 in the 2000 Demographic Census. Minimum comparable areas (MCA) depend of the period of analysis: for instance, for the the 1970-2000 period they are 257 and for the period 1980-1995 period they are 296, thus generating panel data of Agricultural Census information with 257 x 5 and 296 x 2 observations, respectively. Census tracts surveyed in the Agricultural Census were 9309 in 1995 and 9414 in 1985 out of which 8343 and ??? where located in the rural areas, respectively. Table 1 summarizes the administrative divisions of municípios of AML in the Census since 1970. Table 2 summarizes the Census tract information in the Census 1985 and 1995. Diagram 1 presents the map of municípios of Legal Amazonia in 2000, and the minimum comparable geographic areas in the 1970-2000 period. Diagram 2 show the Census tract map of 1995.

For the years before 1970, minimum comparable area (MCA) are not available. Therefore the information on administrative divisions refers to the former North Region which was restricted to the states of Rondonia, Amazonas, Pará, Amapá, Acre, Rio Branco. The number of municipalities in the Old North Region was 89 in 1920, 97 in 1940, 183 in 1960.

## **1. Data and Sources**

### **1.1. Economic data:**

- **Agriculture**

At **municipal level**, IBGE Agricultural Census of 1920, 1940, 1950, 1960, 1970, 1975, 1980, 1985, and 1995/96 provide information on land use in agriculture (annual crops, permanent crops, pastures, fallow lands, plantations and natural forests), rural employment, value of land, and other main assets, quantity and value of major agricultural outputs, destination of shipments, herd size, among other. For the 1985 and 1995/96 Census, it is possible to obtain the information disaggregated according to 14 classes of size of agricultural establishments and the legal arrangements concerning property of land or work relations (proprietor, sharecropper, squatter and other conditions). For these same years the information is provided at **Census tract level** as well. [Agro85list](#) presents (in portuguese) a complete list of the variables available both by size of agricultural establishments and by Census tract for the 1985 Agricultural Census. The list of variables for the 1995/96 Census is practically the same.

En passant, it should be noted that due to changes in the methodology and survey dates, comparison of the 1985 and 1995/96 Census results require caution ([Helfand 2000](#))

Also from IBGE, annual municipal surveys from 1973 to 2002 gathered data on the quantity, value, and crop area of agricultural products, as well as on the quantity and value of output of cattle raising activities (meat, dairy products, eggs, etc.), cattle prices, and herd size.

- **Logging and lumber**

IBGE PEV (Pesquisa provide information on the annual quantity and values of logging output as well as of other forest extractive products from 1975 to 2002. Monthly data on volume, price, and value of exports of wood products according to main commercial species, degree of processing and port of shipment, from 1980 to the present are provided by SECEX (Department of Trade in Brazil). Information on energy and raw material (quantity of logs, fuel wood, etc.) consumed by the lumber industries are available from a 1994 Survey of IBAMA (Brazilian Environmental Protection Agency). For the municípios of the state of Pará, additional information on employment, equity capital, and starting date of lumber establishments is available for the years from 1984 and 1994 (FIEPA, Cadastro Industrial do Pará, various years)

- **Other activities**

At municipal level, IBGE Economic Census of 1970, 1975, 1980, 1985, provide information on employment, quantity and value of output in Forestry activities, Manufacturing Industries, Mining, Trade and Services. For 1995 on IBGE CEMPRE (Cadastro de Empresas) provide annual information on employment and number of establishments and PIA provide more detailed information for tu establishments with more than 30 employees.

- **GDP and capital stock**

Estimates of GDP and the value of capital stock (disaggregated by machinery, building and other) at municipal level according to main economic sectors (Agriculture, Industry, Trade, and Other Services) were built for the Census years of 1920, 1970, 1975, 1980, and 1985. Due to the lack of an Industrial Census, for 1996, “proxies” for industrial activities are used in GDP estimates and capital stock estimates are restricted to rural activities.

## **1.2. Demographic data**

Demographic Census provide decennial data on municipal population from 1920 to 2000. For the Census years 1970, 1980, 1991 and 1996 (Contagem da Populacao) and 2000, it is possible to get detailed data for urban and rural population; size distribution of income; interregional and inter-municipal migration flows according to time of migration, origin and destination of migrants.

## **1.3. Social and political data**

PNUD/IPEA/FJP (Fundacao Joao Pinheiro) estimated IDH (human development index) at municipal level for the Census years 1970, 1980, 1991, and 2000. For the same years, based upon IBGE Demographic Census data, Gini and Theil indices as well as poverty ratios for both rural and urban households in the municipios of AML are available .

Data on health infrastructure is found in IBGE/AMS (Assistencia Médico-Sanitária), an annual survey of establishments of health services from 1972 to 1992 (last year available) which gather information on physical and medical capacity and health service production according to major types of establishments.

TSE (Superior Court of Elections) is the source of municipal data on votes given to main parties and candidates in all the elections (Presidency, Senate, Federal Assembly, Governor, State Assembly, Mayor, Municipal Assembly) which took place after 1992, as well as the Presidential election and the state elections which took place in 1989 and 1982, respectively.

## **1.4. Government policies**

Data of financial and economic reports of the projects approved by the regional development agency SUDAM (the Superintendence for the Development of Amazon) from 1967 to 1985 aggregated at municipal levels. The reports include all sorts of information on the projects: ownership, equity, financing, assets and liabilities, value of fiscal incentives, value and quantity of outputs, size of herds, uses of lands, employment and labor relations, among others. Updating the SUDAM daabase is a priority task.

STN (Secretaria do Tesouro Nacional) provides data from the Fiscal Budget of State and Municipios from 1981 to 2002 distinguishing major items of current and capital accounts of receipts (tax, transfers, and credit operations) and expenditures (wages, other current expenditures, and investments).

BACEN (Banco Central do Brasil) provides data at municipal level on main types of agricultural credit (investment, working capital, commercialization for both cattle raising and agricultural activities) from 1991 to 2002.

## **1.5. Access and transportation conditions:**

The distances of municipalities (and of 1995 Census tracts) to state and federal capital obtained from IBGE, complemented by the distance between any pair of municipality seats estimated through their geodesic coordinates also obtained from IBGE, are available as "proxies" of the municipalities access conditions to local and national markets.

At municipio level, transportation conditions are described by the extension of state and federal roads (paved and non-paved, in use and planned) estimated from the Road Maps of DNER-MT (Department of Roads of the former Ministry of Transportation) in 1968, 1976, 1980, 1986, 1991, and 1995.

At Census tract level, LEB-SIG-AML tabulated information on roads available at IBGE-SIG-AML for each tract of the Agricultural Census of 1996 including the name, code, extension position in the road network (main or subsidiary axis) disaggregated according to their technical conditions (natural way, implanting, implanted, unpaved, paving, paved, double-lane).

Complementary information on transport conditions is provided by the geographic location of ports and the municipal network of rivers (with more than 2.10 meters of depth in at least 90% of the time) estimated from the maps available in IBGE-SIG-AML and the 1985 Statistical Yearbook of Portobras.

Based upon information on roads and river, Castro (2002) estimated economic distances (routes of minimum transport costs given the network of river, roads and their technical characteristics) to Sao Paulo (as a proxy to national markets) and to nearest state capital (as proxy to local markets) for the years 1968, 1970, and 1995. For 1995 the same procedure was applied at Census tract level to estimate the economic distances to Sao Paulo, nearest state capital, and nearest municipio.

## **1.6. Special areas and conservation unities:**

At municipio level, [SCT/PR-Pnud-Funatura](#) provides data on national and state conservation unities distinguished by categories -- park, ecological reserve, biological reserves, protection areas, national forests, extractive reserves – existing in 1991, including the following information: date and decree of creation, perimeter, area, land to be acquired, cost of land, demarcation, management, infrastructure, equipment, and maintenance costs. Georeferenced information on conservation unities in 1991 at the scale of 1:2.500.000 is provided by IBGE – Diagnóstico da Amazônia Legal.

At Census tract level, [Leb-Sig-Aml](#) provides data on the name, category, area and perimeter of special areas (conservations unities and indian reservations) in each of the Census tract of the Agricultural Census of 1996.

## **1.7. Deforestation**

### **• At municipio level**

UNH (University of New Hampshire) estimates the extent of deforestation at municipal level based upon Landsat images for whole Legal Amazon Area (AML) for the years 1975, 1978, and 1988. Estimates of forest and savana areas, as well as of carbon and nitrogen content in the soil are also tabulated. For more recent year these data are complemented by tabulation at Census tract level describe below.

INPE/PRODES (Brazilian National Institute of Space Research/Programa de Monitoramento da Amazônia Brasileira por Satélite) – based upon the interpretation of LANDSAT images -- provides estimates of deforestation, that is, changes in the extent of

deforested areas from 1992 to 2002 for critical “scenes” which supposedly includes the municipios responsible for approximately 90% of the deforested area observed in the AML.

IBAMA (Brazilian Institut of Environment and Renewable Natural Resources) based upon the interpretation of LANDSAT images -- provides estimates of deforestation, that is, changes in the extent of deforested areas from 1997 to 1999 for all the municipios of AML.

INPE/IBDF/IBGE are sources of old tabulated estimates of the extent of deforested area for a sample of 224 municipalities *circa* 1985 summarized in Table 2. For a sub-sample of these municipalities, data on the extent of deforestation is available according to the major types of pristine vegetation cover: dense forests and open forests, campinaranas, savannas, wetlands, and areas of ecological tension.

IBGE/DAML (Diagnóstico da Amazônia Legal) used Landsat images as well as other IBGE cartographic sources to provide tabular estimates at the scale 1:2.500.00 of the extent of deforested area in each município for 1971, 1976, 1986, and 1991. Cross tabulations of deforestation with vegetation, soil, are yet to be done.

For Eastern Amazon, FUNCATE (Fundação de Ciência, Aplicações e Tecnologia Espaciais) provides estimates of total geographic area and deforested area in belts of 25, 50, 100 km on each side of the Carajás Railroad (EF Carajás) and major axial roads (BR230, BR010, BR222, BR226, BR158, PA150 e PA270) in the years 1975, 1978, 1985, 1990, 1995 e 1999.

- **At Census tract level**

LEB/UFF (Laboratório de Ecologia e Biologia da Universidade Federal Fluminense) based upon the MSU-TRFIC interpretation of satellite images tabulated the extent of deforestation in 1986, 1992 and 1996 in the Census tract of the Agricultural Census 1995/96 distinguishing seven classes of images (forest, deforestation, forest in regeneration, savannas, water, clouds, and shadows of clouds).

LEB/UFF based upon LANDSAT images from INPE/PRODES in 2000 tabulated the extent of deforestation in 2000 for Census tract of the Demographic Census of 2000

### **1.8. Climate, soil quality, vegetation cover and biomass**

Data for the areas covered by main types of vegetation or ecological regions - dense forests and open forests, campinaranas, savannas, wetlands, and areas of ecological tension - from the Diagnostico da Amazonia Legal (IBGE 1997) are tabulated at municipal level (for the 1997 division of municipios) and at Census tract level (according to the 1995 Agricultural Census tracts) by the [Leb-Sig-Aml](#).

Also available are data on species, height, diameter at breast height (DHB), and volume of trees were obtained from 2,113 samples of forest inventory made by RADAMBRASIL Project and IBGE. Based upon this information it is possible to obtain estimates of biomass content in each município and Census tract according to main types of vegetations.

IBGE (Diagnóstico da Amazônia Legal, 1997) provided data on soil type and relief at the scale of 1:2.500.000 which were tabulated at Census tract level (Agricultural Census of 1995 division) reclassified according to main classes of agricultural aptitude by the [Leb-Sig-Aml](#)

The database also contains estimation at municipal level of 30 year average precipitation and temperature in March, June, September and December from climate stations obtained from Alves (19??) .

### **1.9. Other geographic information:**

In addition to standard geographic information like area, distances to state and federal capital, geodesic coordinates and height of the seats of municípios, the database provides information on the genealogy of municipalities and municipal areas since 1970 which made possible to construct panels of comparable geographic areas in the periods 1970-97, as well as matrices of the structure of contiguity of municipalities, the extent of contiguity, and distances between them for different years in this period. These matrices are crucial information for spatial statistical analysis.

The Geographic Information System of AML (Diagnóstico da Amazônia Legal) provide thematic information on the locations of município seats, ports, airports, roads (federal and state, paved, non-paved, in construction, planned, and others); rivers (according to navigation conditions); land-use (~40 classes based on interpretation of LANDSAT TM-5 images from 1984-92); disturbances in various periods (IBGE-RADAMBRASIL, 1:1,000,000, 1973-76; IBDF and INPE-LANDSAT 1:250,000, 1977-87; IBDF and INPE 1:250,000, 1987-91); soil types (~500 classes of soil texture and declivity; RADAMBRASIL and EMBRAPA); vegetation (~100 classes of height, geographic incidence, and more RADAMBRASIL); conservation units, including Indian reservations (from IBAMA).

## **2. State level data**

To analyze Amazon deforestation within a broader context, the municipal database is complemented with information available at state level on major aspects of the Brazilian economy. The objective is to build a panel data at state level to make the analysis of the long run determinants of the expansion of the Brazilian agricultural frontier.

Census data starts in 1920 and are available for 8 periods and 20 observations, thus resulting in a sample of 140 observations. For most of the variables it is possible to obtain annual data for 23 states starting in the mid sixties.

State GDP figures for 9 major sectors are available in annual periodicity from IBRE-FGV for the years 1939, 1947 to 1967, and from IBGE for Census years 1970, 1975, 1980 and annually from 1985 to 2000.

Demographic data (on urban, rural and state capital residents, and estimates of interstate migration flows), as well as data on agricultural output, employment (according to major contractual categories) and crop area for major annual and perennial crops, major categories of land use, major size and ownership categories, herd stocks, milk production, and tractors available in the IBGE Census starting in 1920. Output of charcoal, firewood, and log output were obtained for selected years since 1949. Data on the use of fertilizer and availability of agriculture technicians at state level are available for Census years since 1960.

Public finance data at state level on expenditures classified according to major economic categories (consumption and investment), functions (defense, health, educating, infrastructure, etc.) and government spheres (federal, state, and municipal), as well as on receipts (including taxes, transfers among spheres, and other receipts) in annual periodicity, from 1965 to 1988, were obtained from the Ministry of Finance.

BACEN ( Banco Central do Brasil) provides data on agricultural credit according to purpose (commercial, investment and current expenditure finance) and destination (cattle raising, agriculture, and fishing) for the period 1969-2002.

Annual data on acreage, output and values for the major 21 agriculture crops for the period 1965-70, 1973-1992 were obtained from the IBGE Statistical Yearbook. Bi-annual (June and December) data at state level on agricultural prices (land prices, rent, and wages) were obtained from CEA-FGV from 1966 to 2003.

Concerning transportation infrastructure, data on roads (paved and non paved) for the years 1952, 1955, 1960, 1965, 1970, 1975, 1980 were obtained from IBGE Statistical Yearbooks and railroad data for 1907, 1939, 1949, 1959, 1970 1975, 1980, 1985, and 1990, as well as extension of Class A river network extension and major ports were obtained from various issues of the Statistical Yearbook of the Ministry of Transportation.

Finally, information on major classes of soil, vegetation cover, as well as on anthropic alteration were obtained from IBGE for a single point in time.

### **3. Econometric Models and Simulations**

The original motivation of the database was to develop econometric models to secular projections and policy analysis of Brazilian Amazon deforestation and its environmental consequences - in particular the contribution to CO<sub>2</sub> emissions.

Based upon scenarios for the growth of Brazilian economy and population, the models project, for each Amazon municipality, the growth of population, output, uses of land, deforested areas, by major types of vegetation, and CO<sub>2</sub> emitted to the atmosphere.

Policy simulations include, among other, the effects of regional patterns of growth, the evaluation of the impact of roads, regional development programs, and other government policies on deforestation, as well as the estimation of the trade-offs between regional GDP, patterns of deforestation and CO<sub>2</sub> emissions. Furthermore, through historical simulations they make significant contributions to the controversy on the causes of Amazon deforestation.

The models, parameters, and scenarios used in simulations, as well as geographically disaggregated results of simulations are part of the database.

**Contact:**

Eustáquio J. Reis

IPEA/DIMAC

Av. Antonio Carlos, 51 s/1703

Rio de Janeiro, R.J. Brazil 20.020

Tel.: +55 (21) 3804 8180

Fax: +55 (21) 3804 8115

[ejreis@ipea.gov.br](mailto:ejreis@ipea.gov.br)

<http://nemesis.org.br>

Number of Municipalities of Legal Amazonia Surveyed by the Demographic and Agricultural Census  
and Panel of Comparable Geographic Areas between the Census of 1970 and 2000

States	Censo Dem70	Censo	Panel			Panel	Panel		Panel	Panel	Panel		Panel	Panel	Panel
Panel	Agr70	Dem80	1970	Censo	Censo	1970	1980	Censo	1970	1980	1991	Censo	1970	1980	1991
1995	Agr75	Agr80	1980	Agr85	Dem91	1991	1991	Agr95	1995	1995	1995	Dem00	2000	2000	2000
2000															
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RONDONIA 33	2	7	1	15	23	1	6	40	1	5	18	52	1	3	15
ACRE 22	7	12	6	12	12	6	12	22	4	8	8	22	4	8	8
AMAZONAS 62	44	44	44	59	62	27	27	62	27	27	62	62	27	27	62
RORAIMA 4	2	2	2	8	8	1	1	8	1	1	8	15	1	1	4
PARA 126	83	83	83	87	105	81	81	128	74	74	96	143	72	72	94
AMAPA 15	5	5	5	5	9	4	4	15	4	4	8	16	4	4	8
TOCANTINS <sup>1</sup> 118	-	-	-	-	79	42	42	123	34	34	66	139	34	34	63
MARANHAO 93	103	103	103	105	109	102	102	109	102	102	109	182	88	88	93
MATO GROSSO 113	34	55	32	58	95	27	45	117	23	38	80	126	23	38	77
GOIAS <sup>2</sup> 5	55	55	55	63	4	3	3	4	3	3	5	5	3	3	5
AMAZÔNIA LEGAL <sup>3</sup> 591	335	366	331	412	506	294	323	628	273	296	460	762	257	278	429
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Source: IBGE

Obs.:

<sup>1</sup> Before 1989, when it was created, the State of Tocantins was part of Goias.



Numero de municipios, distritos, sub-distritos e setores por estado  
Estrutura municipal de 1996

Estados	Setores									
	Situacao do setor									
	Municipios		Distritos		Sub-distritos		Rural		Urbano	
	Obs. (1)	Todos (2)	Obs. (1)	Todos (2)	Obs. (1)	Todos (2)	Obs. (1)	Todos (2)	Obs. (1)	Todos (2)
RONDONIA	40	40	52	52	52	56	760	934	104	761
ACRE	22	22	22	22	22	22	212	221	34	241
AMAZONAS	62	62	81	81	81	90	921	1055	69	1174
RORAIMA	8	8	8	8	8	8	129	194	15	133
PARA	128	128	217	219	217	219	1911	2685	156	1942
AMAPA	15	15	27	28	27	28	64	92	6	225
TOCANTINS	123	123	140	140	140	140	633	694	139	514
MARANHAO	109	109	136	136	136	136	2739	3100	192	1536
MATO GROSSO	117	117	217	218	218	224	929	1174	233	1301
GOIAS	4	4	6	6	6	6	45	50	18	54
Amazonia Legal	628	628	906	910	907	929	8343	10199	966	7881

(1) Provenientes dos dados do Censo Agropecuario 1995

(2) Provenientes da lista dos setores em 1996 fornecida por Ricardo Cardoso (IBGE)

Table 3  
Sample of municipalities with information on deforestation

Total Munic States	Municipalities w/deforestation informat.								
	1988	Number			Geograph.area		Deforest.area		%
Rondonia	23	23	100%	238379	100%	22913	100%	9.6	1987
Acre	12	12	100%	153697	100%	8133	100%	5.3	1987
Amazonas	71	60	84%	1248082	79%	12434	75%	1.0	1987
Roraima	8	8	100%	225017	100%	1170	100%	1.0	1983
Para	105	89	85%	1178981	95%	114770	90%	..52	1987
Amapa	9	4	45%	142358	85%	338	na	.24	1983
Old North	229	196	86%	3186514	90%	159758	na	5.0	-
Mato Grosso	96	28	29%	151078	20%	19718	na	13.1	1985
Tocantins	62	0							-
Goias	4	0							-
Maranhao	109	0							-
Total	500	224	45%	3337592	81%	79476	na	5.4	-

Source: IBGE (1989) for the number and geographic areas of municipalities;  
INPE and IBDF/IBAMA, various publication for deforested areas.

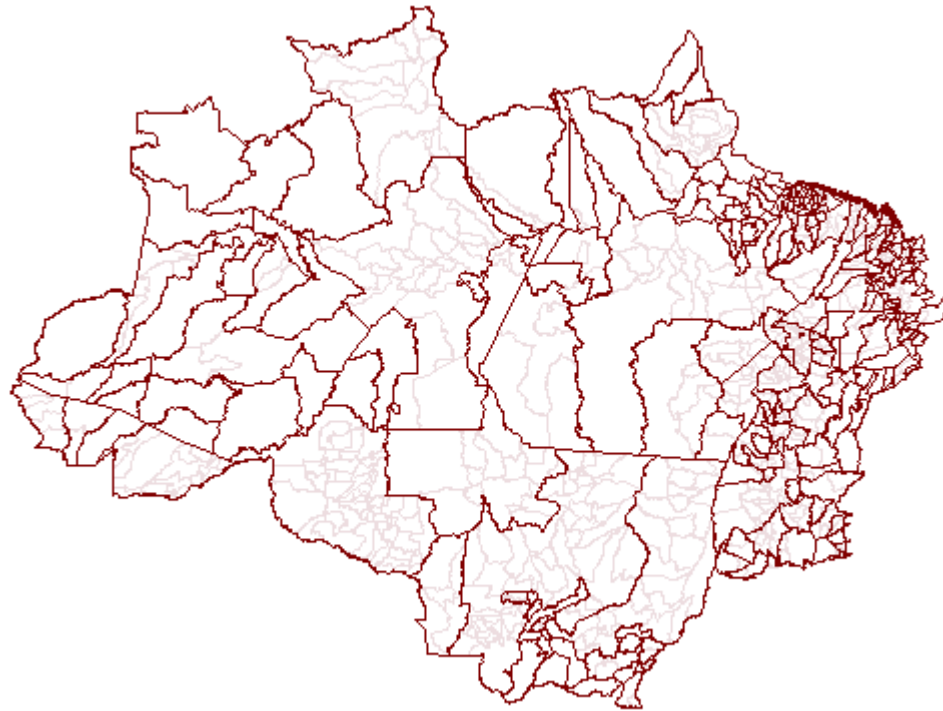
Obs.:

Areas

in

km<sup>2</sup>

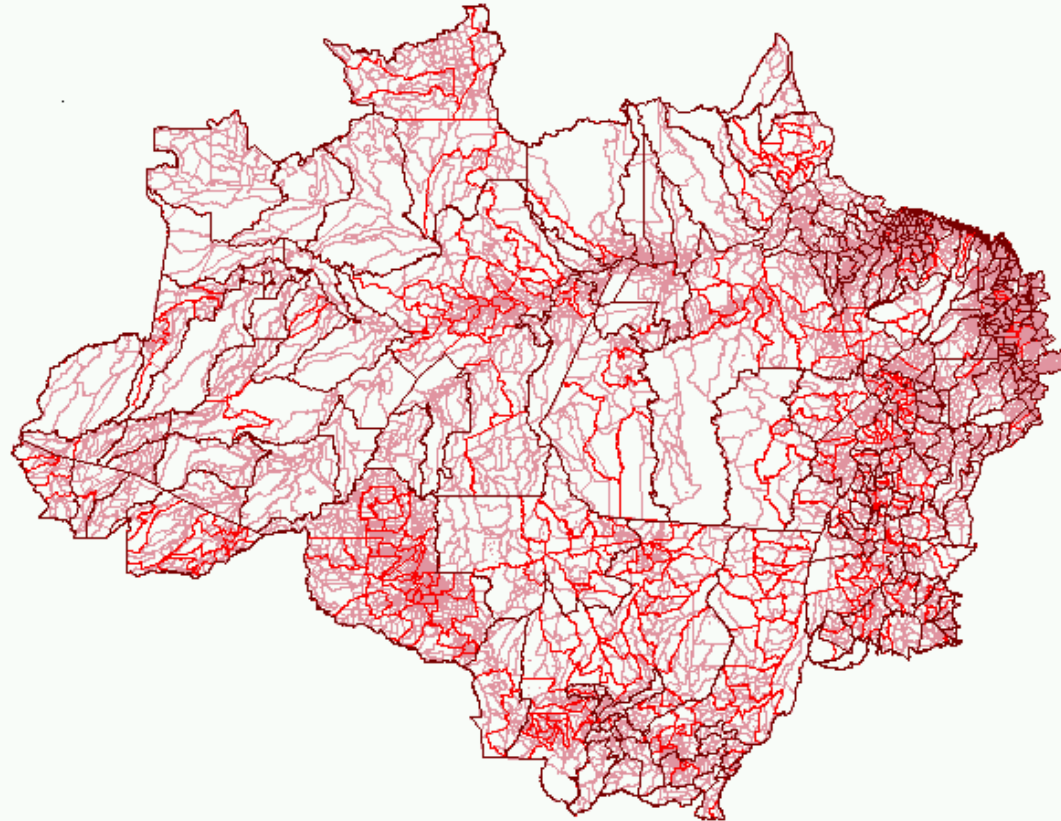
AML: Minimum Comparable Areas (MCA) for 1970-2000 period and Municipal Division in 2000 (fainted lines)



Source: IPEA/DESMAT based upon IBGE/DCG/DCAR maps of municipio in 2000

## AMAZONIA LEGAL

Áreas Mínimas Comparáveis entre 1997 e 1970  
Divisão Municipal e Setores Censitários 1996



Elaboração: IPEA/DIMAC utilizando Malha Municipal Digital do Brasil 1996 (IBGE/DGC/DECAR)

Legend: MCA in black, municípios in red, and Censuses tracts fainted