Estimating population in protected areas of the state of Amazonas, Brazil

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Abstract

This paper presents an estimation of the population volume in the federal protected areas of the state of Amazonas, Brazil. The objective of this study is to contribute methodologically to the quantification of the people living in protected areas. The methodology uses data from the 2007 Population Count in regular grids to estimate the number of people living in these areas and their spatial distribution.

Keywords: population, protected areas, grid, Amazonas, Brazil.

1. Protected Areas in Brazil

In Brazil, the term "protected areas" may be used to refer to indigenous lands or environmental protected areas, called "Unidades de Conservação" (conservation areas). These areas are destined for environmental preservation, with no residents, or for the use of natural resources by traditional populations as shown by Pereira and Scardua (2008, p. 90-91).

The legal definition of Protected Area, in Brazil, is a territorial space and its environmental resources, including inland waters, with relevant natural characteristics, legally instituted by the Government, with conservation objectives and boundaries set under a special administration regime, which applies appropriate safeguards for its protection (BRASIL, 2000).

Brazilian law defines two groups of Protected Areas (PA) according to their uses: integral protection (IP), which allows indirect use only, and sustainable use (SU).

The Integral Protection PA is intended to preserve the environment and only the indirect use of its natural resources is permitted. The meaning of indirect use is the use that does not involve consumption, collection, damage or destruction of natural resources (BRAZIL, 2000, article 2, section IX). The objective of the Sustainable Use PA is to reconcile environment conservation and sustainable use of part of its natural resources. The meaning of sustainable use is the exploitation of the environment in order to guarantee the

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sustainability of renewable natural resources and ecological processes, maintaining biodiversity and other ecological attributes, in a socially just and economically viable manner (BRAZIL, 2000, article 2, section XI).

The integral protection PA is classified in Ecological Station (ES), Biological Reserve (BR), National Park (NP), Natural Monument (NM), and Wildlife Refuge (WR) [*]. The sustainable use PA is classified in Environmental Protection Area (EPA), Area of Ecological Interest (AEI), Extractive Reserve (ER) Faunal Reserve (FR), National Forest (NF), Sustainable Development Reserve (SDR), and Private Reserve (PR) [**].

The presence of people inside protected areas is a reality in many regions of Brazil and the state of Amazonas is not different. In face of this reality and because of the absence of data, this population is not completely welcome in those areas. Therefore, it is necessary to monitor the dynamics of this population in order to maintain the objective of creating these protected areas and define a suitable management. To reach this goal data and analysis are necessary. However, the political administrative units for which socioeconomic data are available do not adjust to these areas, so population estimates using these units could lead to significant errors. A method to solve this problem is performing surveys, but they are very specific in time and space, expensive, and cause some problems in data comparability (D'ANTONA et al., 2011). Thus, we can conclude that there is a lack of methods to obtain data that can guarantee a minimum accuracy in studies and analysis of the population dynamics in these areas.

2. Methodology

The methodology used in this paper is an evolution of the one presented in BUENO & DAGNINO (2011).

To perform the population estimate we used two types of data from 2007 Population Count. The first refers to rural dwellings. It includes the geographical coordinates of each dwelling, and population can be estimated from the average number of residents per household. This average was obtained from data by census tract and related to each dwelling (considered as a point). These points were aggregated into cells of a statistical grid for the entire region.

The second type of data refers to the rural or urban settlements, whose data are aggregated by census tracts and represented by polygons. Those data were related to the statistical grid cells using the proportional area method. This method considers that population is homogeneously distributed in a census tract. The percentage of population equivalent to the area of the census tract that lies inside a cell is attributed to this cell.

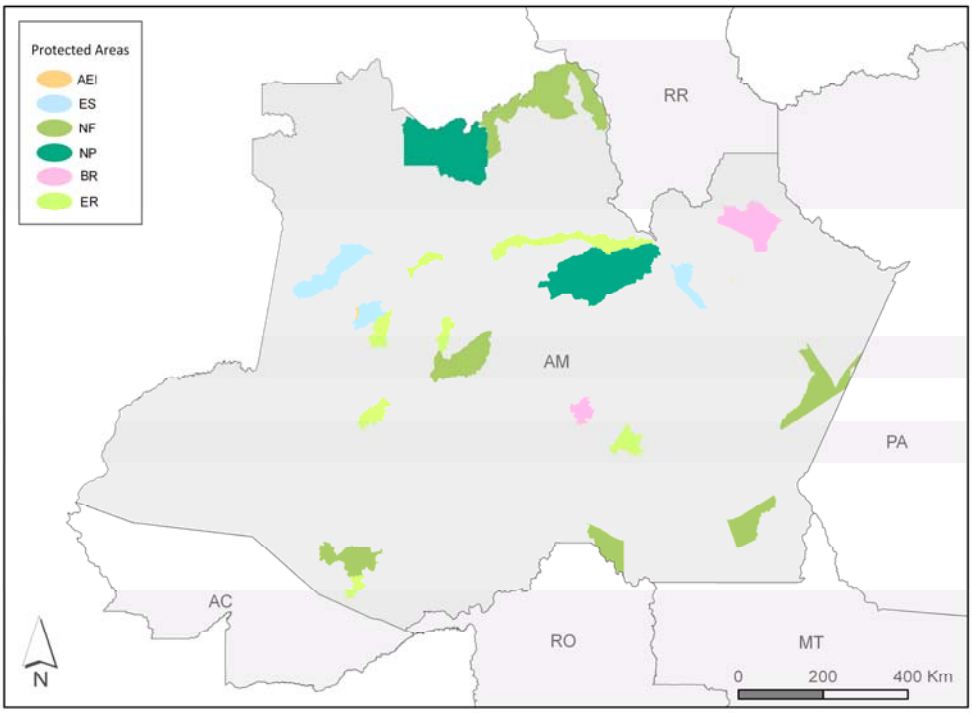
We used a statistical grid with the dimensions of 1 min and 15 sec, equivalent to 2,320 m in Ecuador. For the state of Amazonas the total number of cells is 295,338, and 32,329 cells or around 11% are inside protected areas.

We used PA boundaries provided by the Ministry of Environment. We considered all the federal areas created until 2006 that are entirely in the state of Amazonas. The total number of protected areas considered was 23, with 16 sustainable use areas and 7 integral protection areas. In the sustainable use

[*] The integral protection PA corresponds to the IUCN categories Ia, Ib, II, III, and IV.
[**] The sustainable use PA corresponds to the IUCN categories V and VI.

group we have 2 Area of Ecological Interest, 7 National Forest and 7 Extractive Reserve; in the integral protection group we have 2 Ecological Station, 3 National Park and 2 Biological Reserve.

Figure 1 – Protected Areas in the state of Amazonas



Reference: Ministry of Environment, 2010. Prepared by the authors.

The PA boundaries vectors were overlapped with the statistical grid, so that we could obtain population estimates for each protected area.

We use the program ArcGIS / ArcMap, version 9.3, for data processing and spatial analysis.

Figure 2 – Top-down Approach

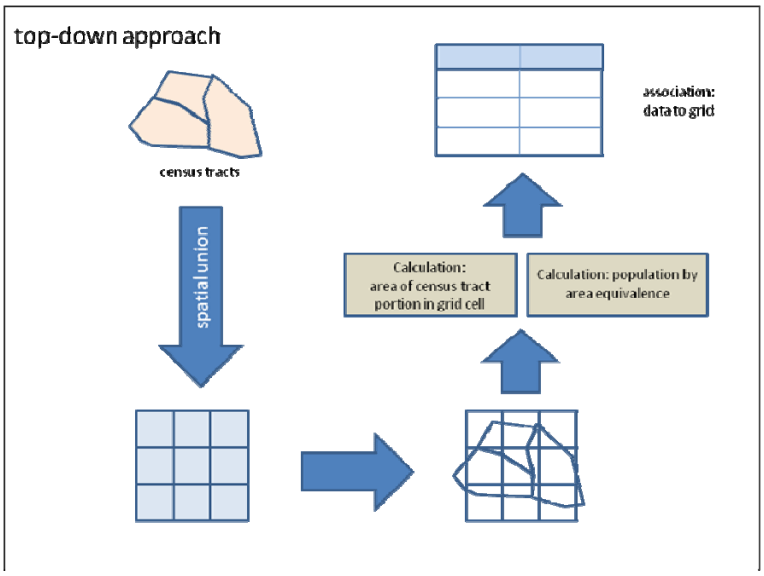


Figure 3 – Bottom-up Approach

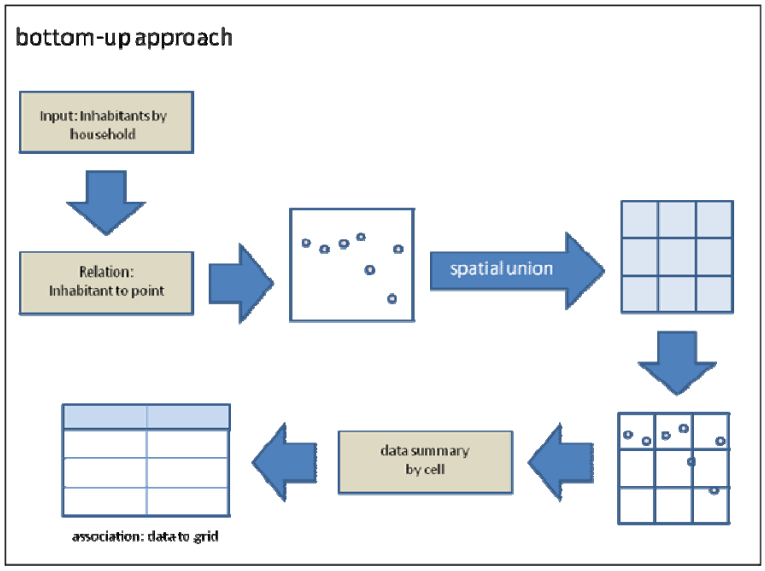
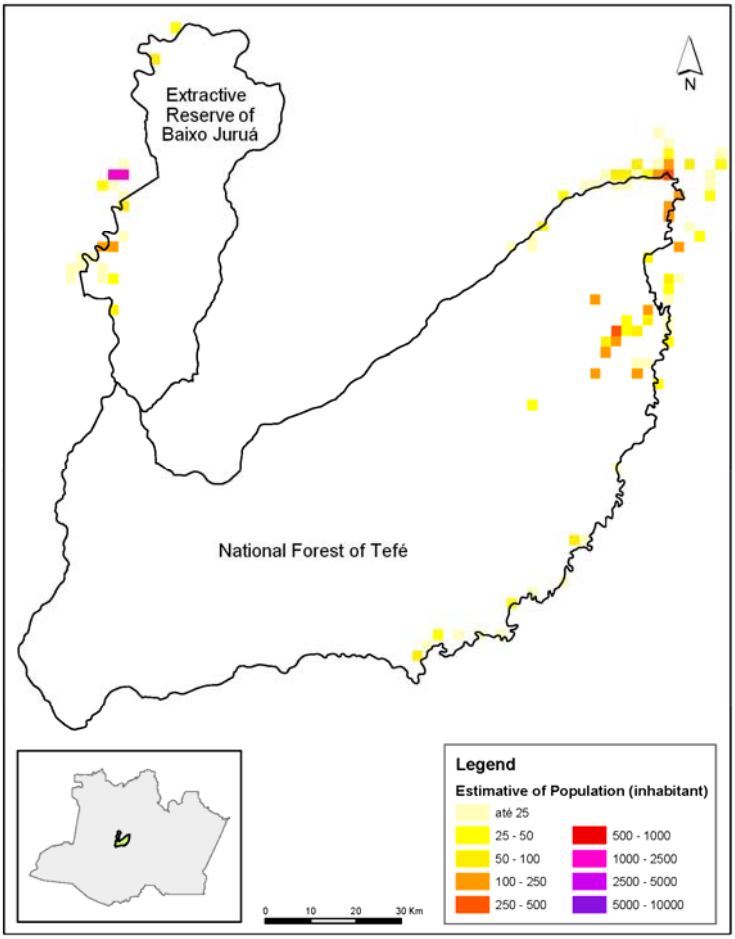


Figure 4 shows the results obtained for a protected area, with population data classified according to the estimated volume for each statistical grid cell.

Figure 4 – Results to NF Tefé and ER Baixo Juruá.



Prepared by the authors.

3. Results

The results obtained represent a first approach to a complex issue, namely the population distribution in protected areas. This work deserves further analysis, taking into account the amount of variables involved and the differences between each protected area. According to the methodology employed, the population living in the protected areas of the state of Amazonas is about 27,000 inhabitants. This population lives predominantly in rural areas.

Analyzing the volume of population in protected areas with respect to the total population in the state of Amazonas (Table 1), we can observe that the total people living in protected areas is 27,217 inhabitants, equivalent to almost 1% of the rural population of the state of Amazonas. The rural population inside protected areas accounts for around 4% of the population (N = 26,772). Only one protected area, the National Forest of Purus, has urban population (N = 445).

Table 1 – Population in Protected Areas and total and rural population of the state of Amazonas, 2007.

	N	Total Population	Rural Population
State of Amazonas[1]		N = 3,221,939	N = 726,060
Inside PA[2]	27,217	0.84%	3.69%[3]

[1] Data from SIDRA (IBGE), http://www.sidra.ibge.gov.br.

[2] Value for rural and urban population inside protected areas.

[3] To estimate the population percentage inside PA for rural population of the state of Amazonas we diminished from N=27 217 the value of 445 people located in the urban areas of the National Forest of Purus.

In Table 2 we can see the population by group and class of protected areas. We can observe that from a total of 27,000 people, about 18,000 (or 67%) are in areas of sustainable use and almost 9,000 (33%) are in areas of integral protection. This distribution by group is as expected, because the areas from the first group are more flexible in relation to human occupation.

Table 2 –Population in Protected Areas of the state of Amazonas, by group and class.

Group	**Class**	**Number**	**Population**	
			N	**%**
Sustainable Use	AEI	2	134	*0.5*
	NF	7	9,682	*35.6*
	ER	7	8,499	*31.2*
	Subtotal	**16**	**18,315**	***67.3***
Integral Protection	ES	2	483	*1.8*
	NP	3	6,953	*25,5*
	BR	2	1,466	*5.4*
	Subtotal	**7**	**8,902**	***32.7***
	Total	**23**	**27,217**	***100.0***

Analyzing the data by class, we can observe that three classes of protected areas are occupied by 92% of the entire population that lives in Protected Areas in the state of Amazonas. Those classes are, in order of overall

population, the National Forest - NF (35.6%), Extractive Reserve - ER (31%) and National Park - NP (25.5%). It is important to note that the latter are from the Integral Protection group, while the former are from the Sustainable Use group.

In Table 3 we can see the data for each protected area. It can be noted that two areas concentrate almost 25% of all people living in the protected areas of the state of Amazonas. They are the National Park of Pico da Neblina (created in 1979), which currently has almost 4,000 people, and the National Forest of Tefé (created in 1989), which is home to approximately 3,000 people.

Table 3 – Protected Areas of the state of Amazonas by creation date and population.

Creation Decade	Number of Protected Areas			Population (2007)		
	Integral Protection	Sustainable Use	Total	Integral Protection	Sustainable Use	Total
1970	1	-	1	3,881	-	3,881
1980	4	6	10	5,021	7,862	12,883
1990	1	1	2	0	1,899	1,899
2000	1	9	10	0	8,554	8,554
Total	**7**	**16**	**23**	**8,902**	**18,315**	**27,217**

With respect to the date of creation of the protected areas, shown in Table 3, we can see that the creation of sustainable use areas in the state of Amazonas was major in 1980 and 2000 and that integral protection areas stand out in the late 1980s. In general, for both groups, the decades 1970 and 1990 were very poor in terms of creation of protected areas. In the oldest Integral Protection PA, the population in 2007 was higher than the population in the most recently created areas. On the other hand, in the newest Sustainable Use PA, the population is greater than in the older ones. It should be noted that the largest population in the entire PA in the state of Amazonas was found in the National Park of Pico da Neblina, created in 1979, which is the oldest protected area of the state.

One point worth mentioning is that in two Integral Protection areas most recently created (Biological Reserve of Uatumã, established in 1990, and Ecological Station of Juami Japurá, created in 2001) there was no resident population in 2007. This may be due to a preference in setting up more restrictive areas related to population (integral protection areas) in areas previously unpopulated.

Table 4 presents the summarized population data for all protected areas considered in this paper.

The use of grids leads us to think about building metrics that allow for the comparison of these protected areas. Thus, the Occupancy Rate was created, which is the ratio between the number of cells with population and the total number of cells in the protected area. This rate, being relative, allows us to make comparisons between areas with different sizes. Observing the values found (Table 5), we conclude that the Occupancy Rate presents some unexpected values: high values for areas of restricted use (Biologic Reserve of Abufari, rate = 0.07; National Park of Anavilhanas, rate = 0.06) and low values for areas of sustainable use (National Forest of Jatuarana and National Forest of Amazonas, rate = 0.01).

Table 4 – Protected Areas in the state of Amazonas by creation date, area and population.

Name	Creation date	Area (km²)		Population	
		N	%	N	%
AEI Projeto Dinâmica Biológica de Fragmentos Florestais	1985	32	0.02	27	0.10
AEI Javari-Buriti	1985	150	0.10	107	0.39
ES Jutaí-Solimões	1983	2 843	1.94	483	1.77
ES Juami-Japurá	2001	5,727	3.90	0	0.00
NF Pau-Rosa	2001	8,279	5.64	1,699	6.24
NF Tefé	1989	10,200	6.95	2,864	10.52
NF Amazonas	1989	15,731	10.72	2,322	8.53
NF Balata-Tufari	2005	8,020	5.46	223	0.82
NF Jatuarana	2002	8,371	5.70	32	0.12
NF Purus	1988	2,560	1.74	1,527	5.61
NF Mapiá-Inauiní	1989	3,110	2.12	1,015	3.73
NP Anavilhanas	1981	3,408	2.32	901	3.31
NP Jaú	1980	22,720	15.48	2,171	7.98
NP Pico da Neblina	1979	22,000	14.99	3,881	14.26
BR Abufari	1982	2,880	1.96	1,466	5.39
BR Uatumã	1990	9,387	6.40	0	0.00
ER Arapixi	2006	1,336	0.91	291	1.07
ER Auati-Paraná	2001	1,470	1.00	1,782	6.55
ER Baixo Juruá	2001	1,880	1.28	682	2.51
ER Lago do Capanã Grande	2004	3,041	2.07	1,089	4.00
ER Médio Juruá	1997	2,532	1.73	1,899	6.98
ER Rio Jutaí	2002	2,755	1.88	1,537	5.65
ER Rio Unini	2006	8,334	5.68	1,219	4.48
Total		**146,766**	**100.00**	**27,217**	**100.00**

4. Conclusion

The results presented provide an approximation of the population living in the federal protected areas. In addition, the results show that it is possible to know the volume and distribution of this population using existing data, without the need for local surveys.

A broader and deeper analysis of the results can be interesting, taking into account the various factors that can affect human occupation, such as accessibility and proximity to urban areas. And still using the same data, we can use landscape metrics to evaluate the concentration or dispersion of this population. In this paper we only analyze the population volume, without considering the possibility of a concentration in specific locations. Another aspect that should also be evaluated is the connectivity of this population, considering the transport routes (roads and rivers).

We believe that this work represents an advance in studies of Population, Space and Environment (PSE), as it seeks to enable the inclusion of the human dimension in these studies. Specifically on Population and Space in Protected Areas, this work represents an unprecedented advance and points to the use of politically-oriented methodologies, in order to save resources for future studies on these areas.

Table 5 – Occupancy Rate in Protected Areas of the state of Amazonas.

	Name	Number of Cells			Occupancy Rate
		without pop.	with pop.	total	
sustainable use	NF Amazonas	4,349	29	4,378	0.01
	NF Jatuarana	1,182	15	1,197	0.01
	NF Balata-Tufari	1,687	23	1,710	0.01
	NF Pau-Rosa	2,064	29	2,093	0.01
	AEI Javari-Buriti	48	1	49	0.02
	NF Tefé	1,744	49	1,793	0.03
	ER Rio Unini	1,834	54	1,888	0.03
	ER Baixo Juruá	410	14	424	0.03
	ER Lago do Capanã Grande	649	25	674	0.04
	ER Arapixi	309	16	325	0.05
	NF Mapiá-Inauiní	781	42	823	0.05
	ER Médio Juruá	553	33	586	0.06
	ER Rio Jutaí	575	35	610	0.06
	ER Auati-Paraná	349	32	381	0.08
	NF Purus	525	53	578	0.09
	AEI Projeto Dinâmica Biológica de Fragmentos Florestais	27	3	30	0.10
integral protection	ES Juami-Japurá	1,763	0	1,763	0.00
	BR Uatumã	1,908	0	1,908	0.00
	NP Jaú	4,569	78	4,647	0.02
	NP Pico da Neblina	4,485	91	4,576	0.02
	ES Jutaí-Solimões	623	18	641	0.03
	NP Anavilhanas	713	43	756	0.06
	BR Abufari	462	37	499	0.07
	Total	**17,086**	**453**	**17,539**	**0.03**

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