Department of Geography, University of Reading

Mapping and Assessment of Permanent Preservation Areas in Amazonia

Geographical Paper No. 192

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Introduction

Despite its importance for the provision of ecosystem services worldwide (MEA 2005), more than 40% of the Brazilian Amazon is currently under some type of human pressure including deforestation, urbanisation and mineral development (WRI 2006). These pressures are predicted to intensify and urgent action is required, including the establishment of additional protected areas and the monitoring of existing ones, to mitigate negative impacts on the environment. For this reason, special attention should be given to areas yet to be occupied or that have been little exploited by humans. The Legal Amazonia is one such area, formed by several Brazilian states located in the north and central west region of Brazil with a total area of 5000 km^2. Several studies are underway to understand and identify factors that influence the exploitation of natural resources and develop and support the implementation of environmental policies which will reduce the negative impact of human activity.

Much effort has been made by the Brazilian government to make deforestation monitoring more effective and to develop tools to detect and support enforcement actions against illegal deforestation in Amazonia. The PRODES project, Program for the Estimation of Deforestation in Brazilian Amazon, is an example of such a tool (INPE 2008). Developed by INPE in the last two decades, PRODES aims at quantifying annual deforestation rates in Amazonia. Another example, also developed by INPE, is the DETER (Real Time Deforestation Detection System) project the objective of which is to identify irregular deforestation areas in 'near real time'. This is an essential tool in environmental monitoring and auditing (http://www.obt.inpe.br/deter/). These efforts have so far improved enforcement of laws and regulations to protect forested land and therefore, contributed to a reduction in deforestation. Although the results are important for the environmental preservation of Amazonian ecosystems, they only apply to environmental legislation in a broad sense i.e. illegal deforestation, legal reservation areas, etc.

Complementary approaches are also employed in an attempt to understand how environmental, technological and socio-economic parameters have influenced deforestation (Barbosa 2003; Bierwagen and Ventorin 2006) and to develop models to predict deforestation rates and the locations where deforestation will take place. For example, Aguiar (2006) applied a dynamical LUCC (Land Use and Cover Change) model to examine different exploration scenarios of land use change in the Amazon Region until 2020. In this study 40 variables were analyzed relating to environment, population, agrarian systems, technological factors and market proximity as well as land-use patterns. The main conclusions were that connection to national markets is the most important factor determining the spatial pattern of the new Amazonian frontiers.

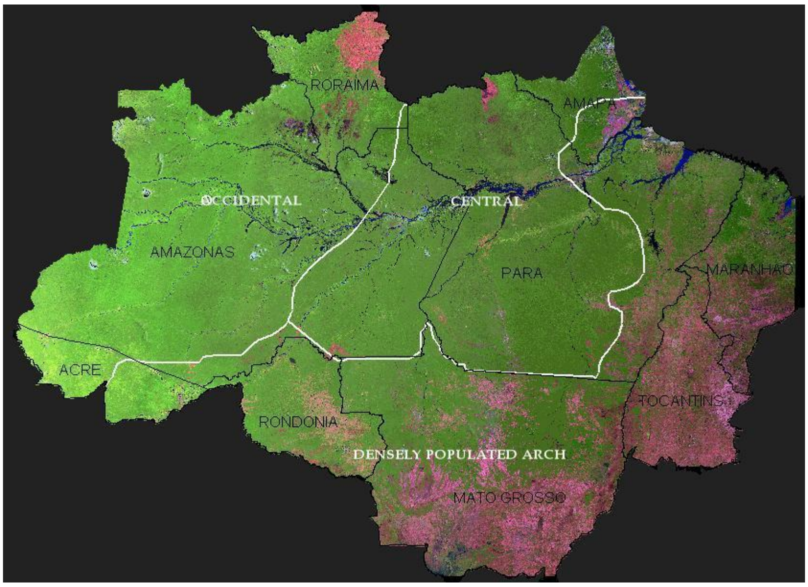

Figure 1. Legal Amazonia area and three macro-regions (adapted from Becker, 2005)

The results of Aguiar (2006) and other studies (e.g. Damião 2007; Becker 2005) show that Amazonia cannot be analysed as a homogeneous area in terms of settlement processes and transformation dynamics. In reality the Amazonia Region can be divided into several fairly homogeneous sub-regions according to Becker (2005) on the basis of the history of human occupation: Densely Populated Arch, Central Amazonia, and Occidental Amazonia (Figure 1). Each of these sub-regions necessitates different analysis and policy approaches.

As shown in Figure 1, the Occidental Amazonia is the most pristine region located outside the influence of the main road network (Becker, 2005). This region should be managed according to forest conservation and government effort should focus on reducing people's access. The second region is Central Amazonia where economic activities cause medium to high rates of deforestation. In this region deforestation monitoring and control activities should be intensified, particularly at the border with the Densely Populated Arch. Therefore, government policy for this sub-region should focus on effective legislation enforcement and control. The last sub-region, the Densely Populated Arch has suffered the highest deforestation. This area deserves special attention and a new approach with respect to environmental policy with emphasis placed on restoration of the illegally deforested areas. Therefore, increased knowledge over the area, with a detailed cadastre and implementation of new tools for monitoring, will be essential to maintain and restore the remaining forest.

The current environmental legislation for the Legal Amazonia establishes that for privately owned land in the area a percentage of the farm land must be conserved with native vegetation, known as Legal Reserve (RL). The Legal Reserve designation is valid for the whole of the country and is enforced by law. The percentage (the index of legal preservation) ranges between 20% and 80% of a property's total area, depending on the type of original vegetation that the area belongs to (Figure 2). For the Legal Amazonia the range is 35-80%. Although the RL is an important tool for environmental protection, the *Permanent Preservation Area* (PPA), a complementary system of protection covering a more extensive area, has not been studied in sufficient detail to come to any real conclusions about its effectiveness as a tool for protection

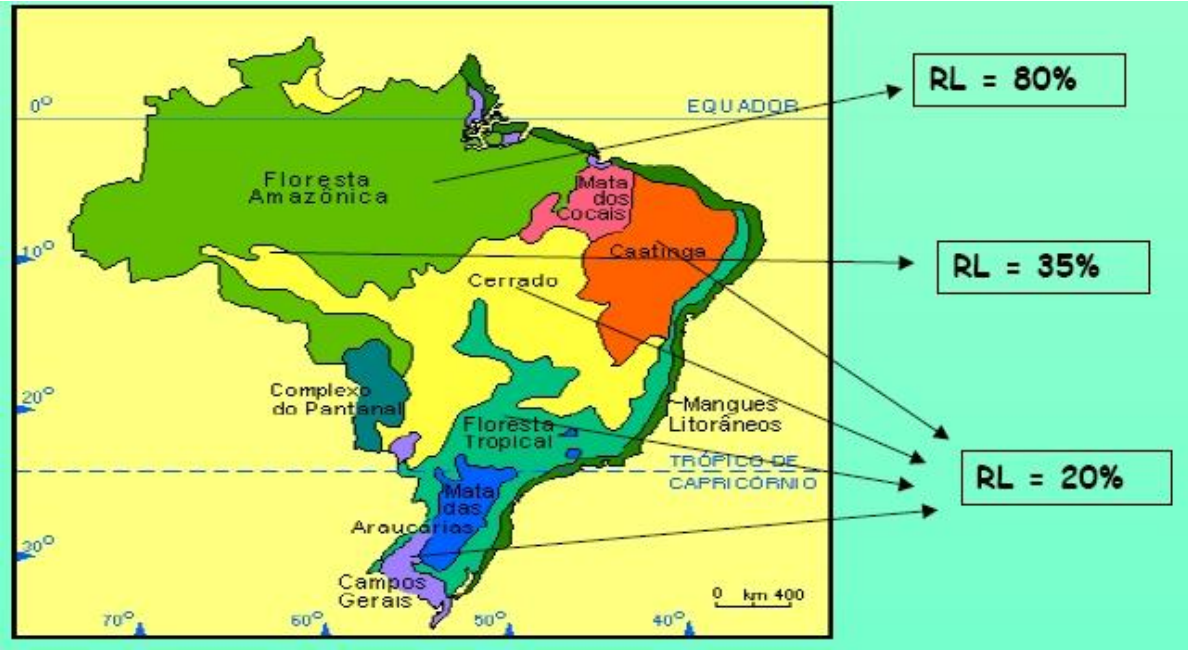

Figure 2 Percentage of Legal Reserve (RL)

Permanent Preservation Areas include forests and other forms of natural vegetation along rivers, lakes, lagoons and reservoirs, water springs, hilltops, slopes (see section 2.3). Their main purpose is to preserve vegetation cover in order to maintain functioning ecosystems. These are highly sensitive areas of extreme importance for the preservation of flora and fauna and for hydrological processes including the maintenance of drinking water quality. Such areas act as filters, ecological corridors and provide protection for fragile environmental areas.

Despite the effort to detect, measure and control the extent of annual deforestation in Amazonia there is still a lack of understanding of the effectiveness of environmental legislation and forest regulations to protect native vegetation. Therefore the *aim* of this work is to evaluate to what extent environmental legislation related to PPAs has been respected, and how effectively PPAs fulfil their environmental role. The specific objectives were to map the mandatory PPAs according to existing environmental legislation, using satellite imagery with a GIS environment.

MATERIALS & METHODS

2.1 Study Area

The study area is the Palmeiropolis Municipality, located in the south of Tocantins State, which is part of the region designated as Legal Amazonia. The Palmeiropolis Municipality was established in 1980 and, according to IBGE, has an area of 1,703.80 Km^2 (Figure 3). Two key factors were taken into consideration for the selection of the study area: the representativeness of different agricultural systems and different PPA parameters, as well as the availability of ALOS (Advanced Land Observing Satellite) and Quick Bird images. The Municipality is located in the Tocantins river basin at the boundary of Legal Amazonia, within the limit of the Densely Populated Arch sub-region where a large part of the native vegetation has already been removed. It is drained by the Mucambinho, Mutum, Cocalinho and Limoeiro rivers and is bounded by the Tocantins and Mucambão rivers. The predominant climate in the region is wet semi- tropical, with two well defined periods: a wet period from October to March and a dry period from April to September. The Cerrado vegetation is predominant, but in some areas deciduous seasonal high forest also occurs. The relief of this municipality is varied ranging from relatively flat in the southeast to hilly/mountainous in the west, where the Dourada Sierra crosses the municipality in a North – South direction. The altitude ranges from 250 to 1100 meters.

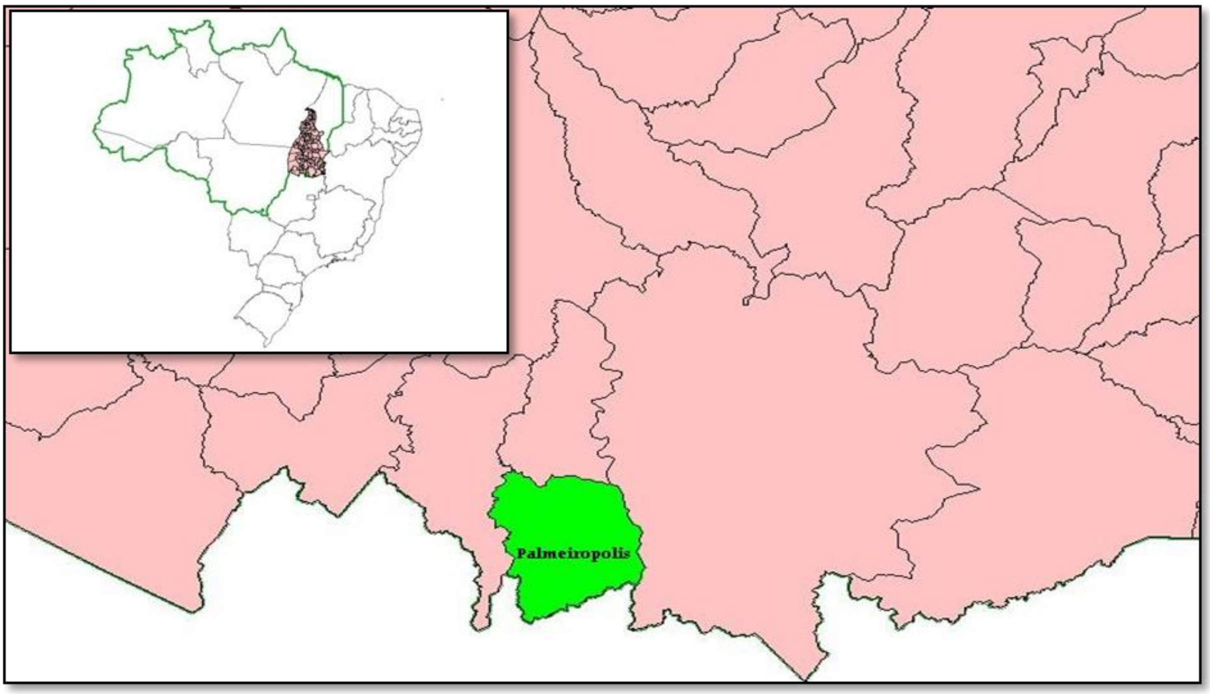

Figure 3 Study Area – Palmeiropolis Municipality

2.2 Socioeconomic data analysis and organization

The main economic activities in the area are crop and cattle farming. A summary of economic activities surveyed by IBGE in the 2007 census is given in Annex II. The socio-economic data collected and used in this study came mainly from National Agricultural Census 2006 (conducted in 2007 and Population Census in 2007: IBGE 2007), which are found in Annex II. IBGE conducted, in 2007, a census operation encompassing the Census of Agriculture, Population Count 2007 and the National Register of Addresses for Statistical Purposes, with the objective of updating population estimates and information about the economic activities conducted in the country by members of society and agricultural companies (http://www.ibge.gov.br/english/estatistica/economia/agropecuaria/censoagro/2006).

In 2007 IBGE published the preliminary results for the Census of Agriculture 2006. The preliminary results are available on the IBGE website and refer to data on, the number and total area of agricultural establishments, use of land, degree of mechanisation, employed persons, total numbers of livestock and animal production,. On the aforementioned IBGE website, technical information about the survey and concepts needed to understand the results released can be found. Other important agricultural and socio economic indicators collected by IBGE in the Census 1996 were used, due to the Census 2006 results being unavailable for this study. This information refers to the number of farms that received technical assistance and the percentage of small, medium and large farms.

2.3 Permanent Preservation Areas Legislation

The PPAs environmental legislation was established by Law n° 4.771 published in September 15, 1965, and regulated by the resolution n° 303 of March 20, 2002. The resolution n° 303 of 20 March 2002, the Brazilian National Council on the Environment (CONAMA) established the parameters, definitions and limits regarding the PPA areas. A summary of the main PPA parameters used in this study are given below, while further information can be found in Annex I (Resolution 303 of March 20, 2002). According to CONAMA's resolution of March 2002, PPAs consist of areas:

a) along rivers or any waterway from its highest level on marginal buffers whose minimum width is:
    - 30 meters for waterways less than 10 meters wide;
    - 50 meters for waterways 10 to 50 meters wide;
    - 100 meters for waterways 50 to 200 meters wide;
    - 200 meters for waterways 200 to 500 meters wide;
    - 500 meters for waterways wider than 600 meters;

b) Around natural or artificial lakes, lagoons or water reservoirs;
c) In the springs, intermittent or not, whatever its topographic situation within a minimum range of 50 meters;
d) On hilltops, hills, mountains, and mountain ranges;
e) On slopes or part of them with declivity greater than 45, equivalent to 100% at their highest points;
f) On coastal pioneer vegetation such as dune or mangrove stabilizers;
g) On mesa or plateau edges from the rupture line, in horizontal projections never inferior to 100 meter bands;
h) At altitudes over 1800 meters irrespectively of the vegetation type present.

2.4 Spatial Data Acquisition and Analysis

The methodology used in this study is summarized in the flowchart (Figure 4). A critical issue at the inception of the project was the availability of remotely sensed data for the extraction of accurate information about PPA parameters and the acquisition costs, given the large size of the area of study. Therefore, Advanced Land

Observing Satellite (ALOS) images were selected, while Quick Bird images available in Google Earth were used to train and adjust the interpretation process and to validate the land use map accuracy. ALOS was launched by the Japan Aerospace Exploration Agency in January 2006 and has an effective resolution of 2.5m for the panchromatic channel and 10 m for the multispectral channels (Table 1).

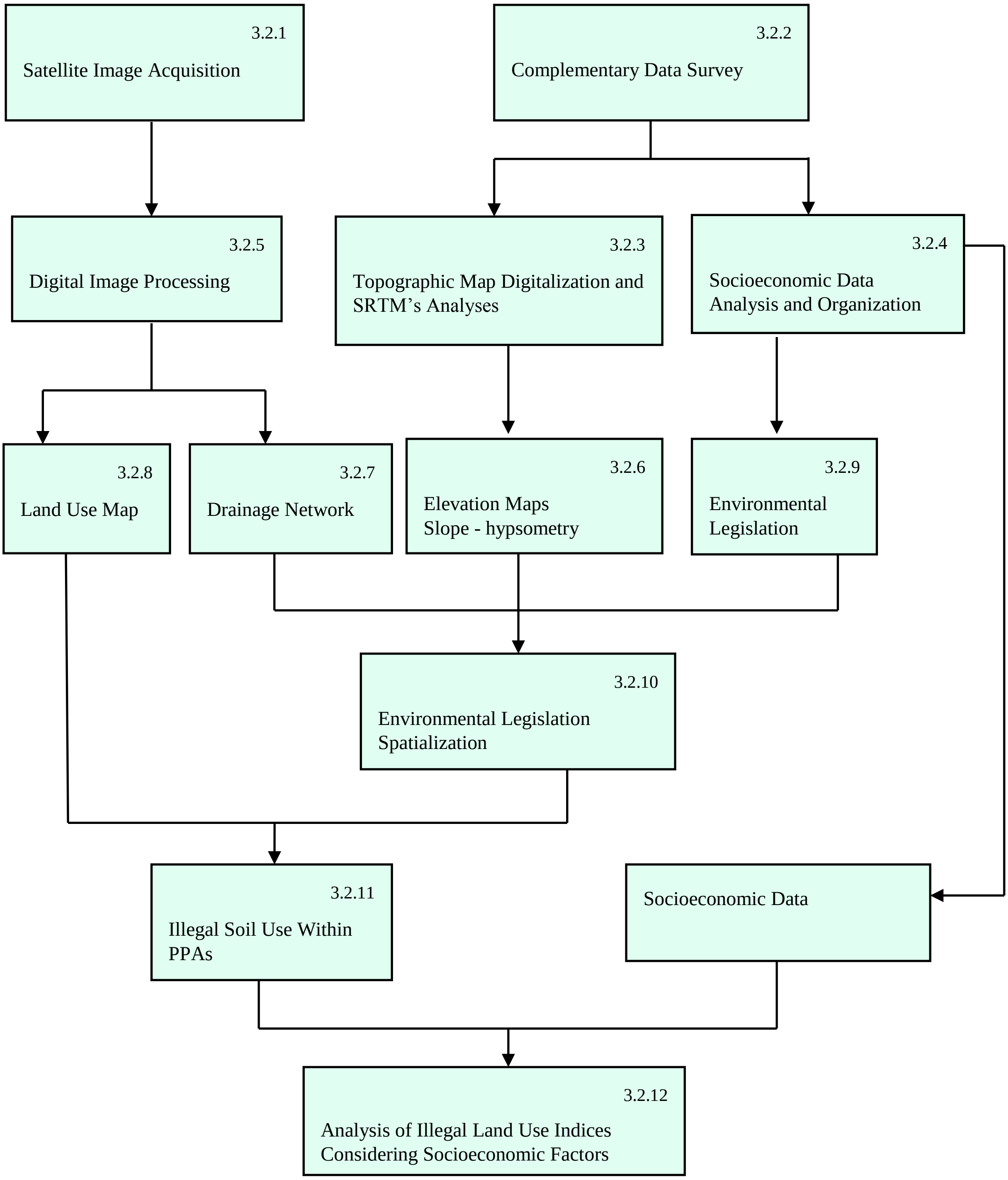

Figure 4 Methodological Flowchart

Table 1 Major Characteristics of ALOS sensor

	PRISM	AVNIR-2
Number of Bands	1 (Panchromatic)	4
Wavelength	0.52 to 0.77 micrometers	Band 1: 0.42 to 0.50 micrometers Band 2: 0.52 to 0.60 micrometers Band 3: 0.61 to 0.69 micrometers Band 4: 0.76 to 0.89 micrometers
Number of Optics	3 (Nadir; Forward; Backward)	
Base-to-Height ratio	1.0 (between Forward and Backward view)	
Spatial Resolution	2.5m (at Nadir)	10m (at Nadir)
Swath Width	70km (Nadir only) / 35km (Triplet mode)	70km (at Nadir)
Pointing Angle	-1.5 to +1.5 degrees(Triplet Mode, Cross-track direction)	- 44 to + 44 degree (Triplet Mode, Cross-track direction)
Bit Length	8 bits	8 bits
Number of Detectors		7000/band

ALOS images were acquired from the IBGE which is responsible for distribution to non commercial Federal Government and research institutions in Brazil. In order to cover the entire Palmeiropolis Municipality four panchromatic images and one multispectral image were necessary. Two of the panchromatic images were acquired on 14th April 2007 and two on 30th May 2007. The multispectral image was acquired on 14th April 2007. These images were merged to create a colour image with 2.5m resolution. These images were acquired with L12B-G processing level, which provides pixels aligned with the grid of the UTM projection. Radiometric calibration was applied and the images were geocoded using a a UTM projection (WGS84, Zone 22). Existing IBGE topographic maps at 1:100 000 scale, environmental legislation applicable to that geographic area, and other available geographic and socioeconomic information, were also collated.

Digital Image Processing

The digital image processing was conducted in three stages. The first was geometric correction in order to correct possible distortion of the satellite images. However, when overlaid over the IBGE topographic map the images showed a perfect match with the map and therefore further geometric correction was not deemed necessary. Actually, several studies have shown that pre-processed ALOS images have a geometric quality better than 1:50.000 scale and, when orthorectified, this accuracy increases to 1:25.000.

The second stage of image processing consisted of merging the panchromatic and multispectral images. Two methods were evaluated, namely Principal Components and Intensity Hue Saturation (IHS). The principal components method performed a better enhancement of the features of interest and was therefore employed to generate the coloured images with 2.5 m spatial resolution. The third stage was the application of image enhancement and equalization techniques to improve interpretation of land use within PPAs.

Topographic Analysis

Existing topographic maps were digitized to generate a cartographic base to support the acquisition of control points for the geo-referenced satellite images. The use of a digital elevation model (DEM) produced from the topographic maps gave lower elevation accuracy compared to the SRTM dataset which was subsequently employed (Zyl 2001; Junior et al. 2007). The Shuttle Radar Topography Mission (SRTM) is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA), which obtained the elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth (www2.jpl.nasa.gov/srtm/). The SRTM data used in this study was downloaded from USGS EROS Data Center which is available free of charge at a spatial resolution at 3 arc-seconds (90 m approximately). For this purpose the data were refined to 30 m of resolution by re-sampling. Santos (2006) evaluated the vertical precision of the SRTM DEM which was compared with the IBGE/DSG topographic map and with GPS points, (scale 1:100.000), in the Amazon. The SRTM DEM was better than the DEM produced by topographic map information. Other studies (Barros et al. 2005; Rodriguez et al. 2005), have shown that the SRTM DEM precision is close to 1:50.000 precision.

SPRING GIS software was used for the generation of the DEM as well as for the necessary GIS operations. SPRING is a state-of-the-art GIS and image processing system with an object-oriented data model which provides for the integration of raster and vector data representations in a single environment. SPRING is a product of Brazil's National Institute for Space Research (INPE/DPI - Image Processing Division) with assistance from others Brazilian Agencies and Companies. This software is available free of charge and can be downloaded from the internet. Further information about SPRING's features can be found at the INPE Site (http://www.dpi.inpe.br/spring/english). ArcGIS 9.2 software was used for some spatial operations, such as the generation of mandatory PPA maps.

Slope and elevation maps were generated from the SRTM DEM within SPRING GIS. The DEM was employed to delineate the water catchments that formed the spatial units for this study. The drainage network was extracted through manual interpretation of the ALOS colour satellite imagery with ancillary information from the elevation map. This information was particularly important for identification of relief low-points to determine the drainage network.

Quick Bird images available from Google Earth were initially used to check and adjust interpretation of the drainage network. Due to its high spatial resolution Quick Bird images allow the identification of smaller features. For example, it was observed that some sections of drainage were dislocated from their actual position when compared to the drainage extracted from Quick Bird images. This was the case especially for narrow waterways and for waterway sections where there was no vegetation. Another difficulty encountered in the process of drainage extraction was in areas of flat relief where drainage channels could not be identified and the altimetry did not help, due to spatial resolution of the SRTM data and the level of its precision i.e. c. 15 meters (Santos, 2006).

Land Use

Land use was mapped using ALOS multi-spectral imagery at 10 m spatial resolution. It was found that there was no improvement in the quality and interpretability of the mapping using the image merged (at 2.5 m resolution), since the panchromatic images were of different dates. The automatic supervised classification method called 'MAXVER' implemented in SPRING was used. Classification resulted in the mapped land cover classes shown in Figure 5. The land use classes pasture and bare soil were aggregated into a broad class agriculture, since there is no difference between them. In total 98% of the area was classified. The remaining unclassified 2% were distributed proportionally across the other classes,

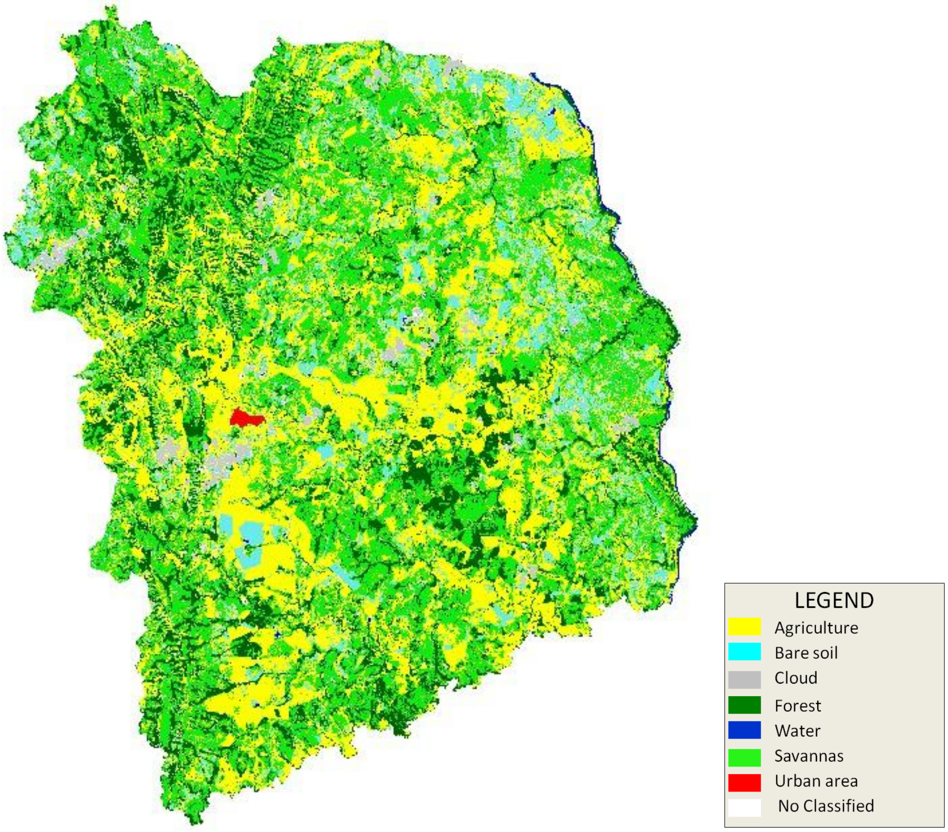

Figure 5 – Land use Map

2.5 Mapping the PPAs Legislation

The mapping of land affected by the PPA e legislation implemented within each sub-catchment, mapped using the drainage network. .

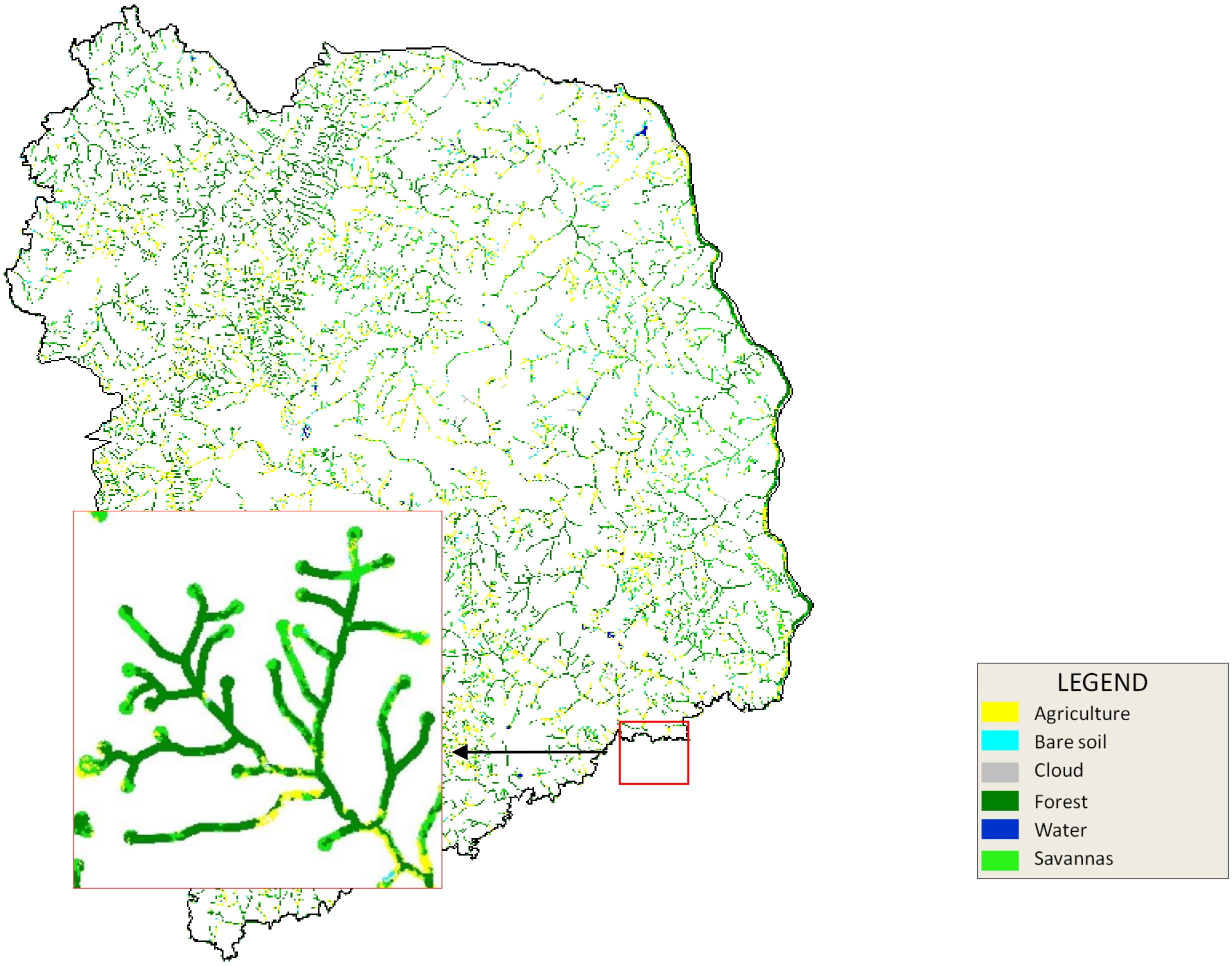

Figure 6. PPAs mandatory map for rivers, springs and lakes

Figure 7 is the map of slope and hilltop surfaces generated from the SRTM Digital Elevation Model. The spatial mapping of PPA parameters to generate hilltop and slope surfaces is a controversial issue because of the difficulty in defining their limits without carrying out fieldwork. Given the environmental importance of PPAs some studies have focused on understanding and developing methods that do not require field validation (Costa et al. 1996; Ribeiro et al. 2002; Schimith et al. 2004). In this sense, Hott (2004) developed an automated method using ArcGIS 9.2, for the generation of hilltop and hilltop ridges from the SRTM DEM. This study showed that the automatic generation of hilltop PPA areas is possible and it emphasized that the level of DEM accuracy directly influences the size of the area to be defined. It was suggested that there should be a definition by the Government regarding map scale and altimetry accuracy suitable to generate PPA maps which could be used for law enforcement.

Ribeiro et al. (2006) developed a study to generate a methodology for automated mapping of PPAs from STRM data in the Amazon region. This study introduced some interesting procedures for the automated mapping of PPAs but the absence of fieldwork to confirm the level of accuracy of the results does not allow adoption for legal enforcement. Nevertheless it is in a major step towards the automation of the mapping of PPAs.

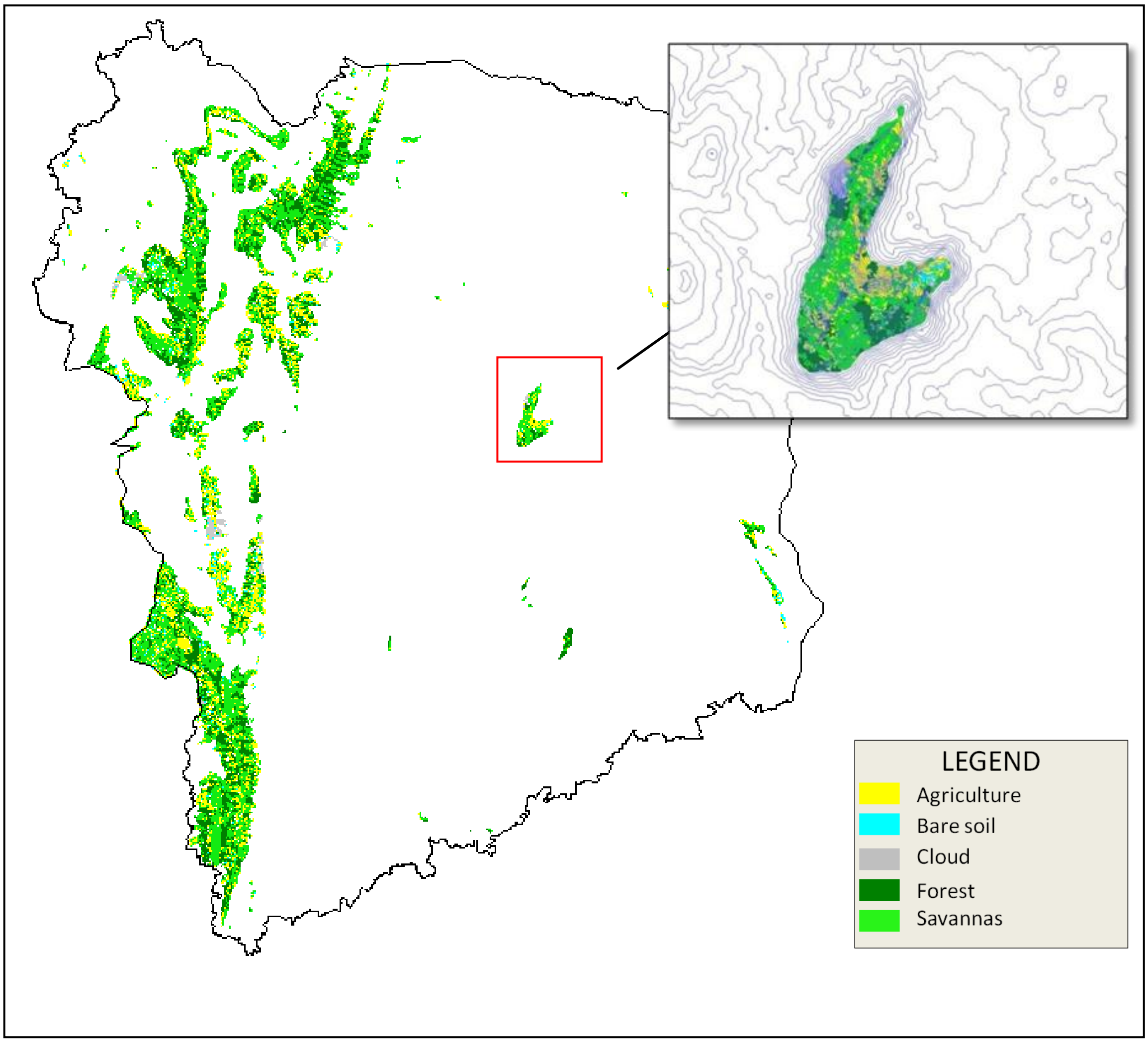

Figure 7 PPAs mandatory map for slope and hilltop

RESULTS

Illegal land use within PPAs

The areas of illegal use were obtained by overlaying the land cover map onto the designated PPA areas. The results showed that out of a total of 379.62 hectares of PPA inside the Municipality, 104.59 hectares (27.55%) of native vegetation had been lost (Table 2).

Table 2 Land cover results

	LAND COVER		
	TOTAL Municipality	**TOTAL PPA km2**	**TOTAL PPA %**
FOREST	**282.72**	128.59	**33.87**
CERRADO	640.77	141.51	37.28
AGRICULTURE	598.77	92.66	24.41
BARE_SOIL	148.97	11.93	3.14
WATER	8.64	0	0
URBAN	1.79	0.01	0
CLOUD	26.11	4.92	1.3
TOTAL Km2	1707.77	379.62	100
AGRIC+B_SOIL (PPA Illegal use)		104.59	27.55%

The results presented in Table 3 show that more than 98% of the PPA areas are found on hilltops or close to waterways and springs. The areas of illegal use are spread almost equally in these three PPA categories with 25.6% distributed on hilltops and 27.56% distributed around rivers and springs. Table 4 shows the results distributed by micro basins (Figure 8). It was found that some micro basins (number 5, 7, 26, 31, 40, 49) with a high percentage of PPA designated, displayed levels of illegal use below the Municipality average. Most of these micro basins are located in hilly/mountainous regions.

Moreover, some micro basins (13, 14, 15, 23, 24, 33, 39) with a relatively low concentration designated as PPA land showed high rates of illegal use, i.e. above the average for the Municipality. These micro basins were located in areas of flat relief mainly under intensive agriculture.

Table 3 Land cover results within PPA category

PPA / LANDCOVER	FOREST	CERRADO	AGRICULTURE	BARE_SOIL	WATER	URBAN	CLOUD	TOTAL Km2	TOTAL %
Waterways & springs	93.39	58.12	52	6.5	0	0.01	2.17	212.19	52.7
Hill top	47.93	86.52	42.26	4.97	0	0	2.77	184.45	45.81
Slope	0.03	0.24	0.07	0.01	0	0	0.01	0.36	0.09
Lakes	0.03	1.41	2.65	0.76	0	0	0.16	5.64	1.4
TOTAL Km2	142	146.29	96.98	12.24	0	0.01	5.11	402.64	100
TOTAL %	35.27	36.33	24.09	3.04	0	0	1.27		

Table 4 Land cover results for Microbasin within PPA

MICROBASIN AREA	1	2	3	4	5	6	7	8	9	10
TOTAL	36.29	14.55	42.88	19.96	59.29	16.88	34.33	69.24	67.60	82.41
PPA Km2	5.60	2.77	13.42	3.27	30.82	2.62	21.00	20.06	27.03	13.23
PPA %	15.44	19.04	31.30	16.38	51.98	15.52	61.17	28.97	39.98	16.05
Illegal Use %	14.1	19.49	21.91	30	18.04	15.65	21.52	33.6	28.41	20.56
MICROBASIN AREA	11	12	13	14	15	16	17	18	19	20
TOTAL	15.26	36.81	54.64	31.42	62.37	32.31	66.85	20.72	13.00	76.76
PPA Km2	6.52	5.29	4.77	4.63	5.17	5.00	9.00	2.90	2.25	9.13
PPA %	42.73	14.37	8.73	14.74	8.29	15.48	13.46	14.00	17.30	11.89
Illegal Use %	21.2	25.52	36.05	49.02	33.07	20.2	36	22.41	34.22	25.41
MICROBASIN AREA	21	22	23	24	25	26	27	28	29	30
TOTAL	12.76	23.95	33.46	23.83	45.09	13.93	20.11	8.69	27.51	13.02
PPA Km2	2.39	2.83	3.04	1.79	7.61	5.16	6.81	2.90	5.68	4.29
PPA %	18.73	11.82	9.09	7.51	16.88	37.04	33.86	33.37	20.65	32.95
Illegal Use %	28	27.21	43.09	44.13	34.16	28.1	35.98	40	37.32	46.39
MICROBASIN AREA	31	32	33	34	35	36	37	38	39	40
TOTAL	8.45	11.76	23.00	20.98	102.19	41.30	99.14	54.44	49.63	51.34
PPA Km2	5.97	1.21	2.13	2.44	14.41	9.17	12.98	8.09	3.91	31.26
PPA %	70.65	10.29	9.26	11.63	14.10	22.20	13.09	14.86	7.88	60.89
Illegal Use %	38.4	32.23	31.46	23.36	23.66	29.88	28.81	30.04	29.92	26.01
MICROBASIN AREA	41	42	43	44	45	46	47	48	49	
TOTAL	11.27	17.11	43.07	13.70	12.43	18.12	10.24	12.61	30.59	
PPA Km2	4.26	4.91	6.17	2.13	2.10	3.60	1.69	3.07	22.46	
PPA %	37.80	28.70	14.33	15.55	16.89	19.87	16.50	24.35	73.42	
Illegal Use %	11.7	16.09	20.26	24.41	14.76	23.61	29.58	17.26	20.79	

Microbasin Total area		1707	
PPA Total area		379	22.20%
Microbasin Average area		34.84	
PPA Illegal use	105.4	27.82%	

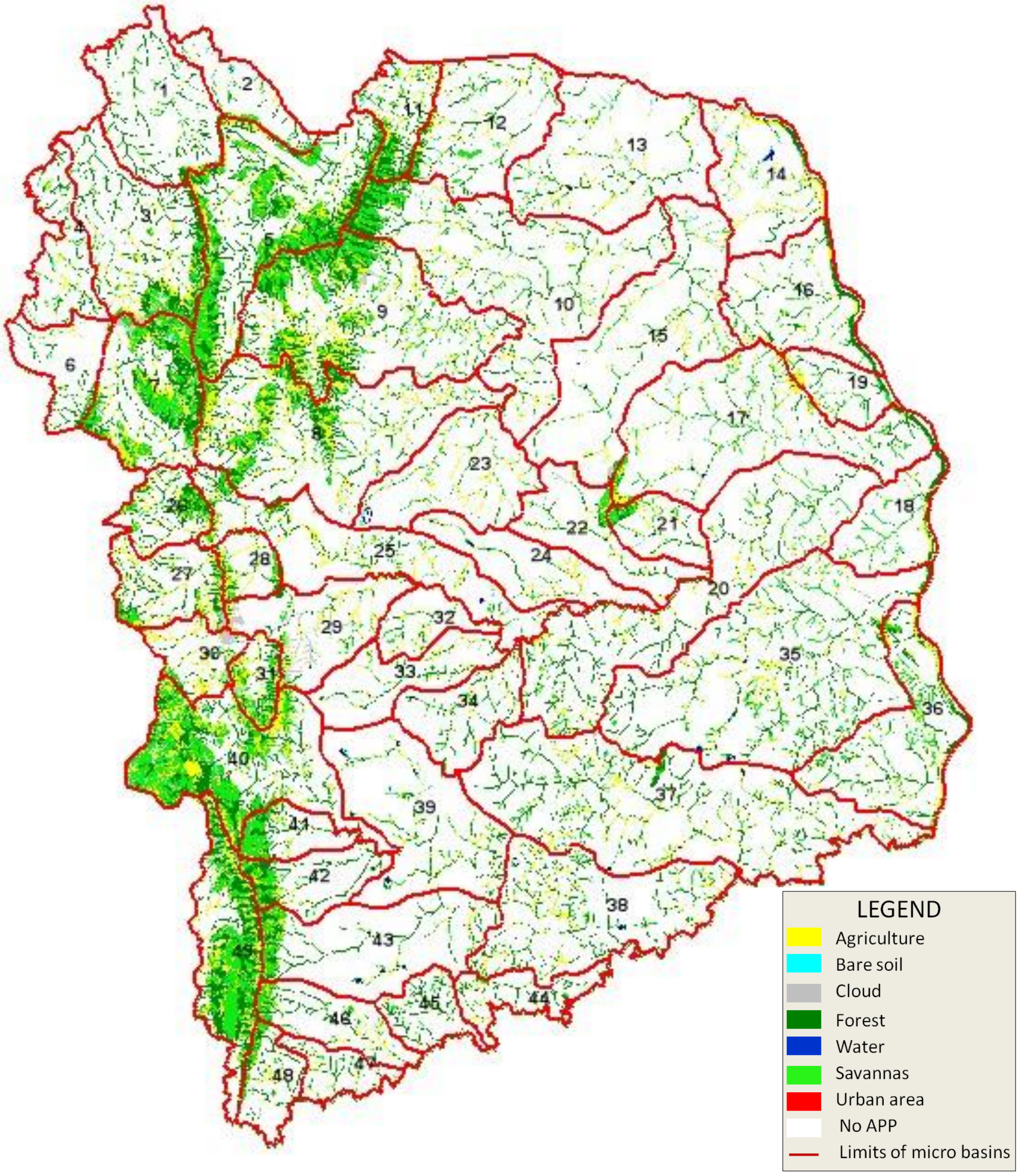

Figure 8 Map of PPA and limits of micro basins

Illegal Use & Socioeconomic Factors

The results show that the municipality of Palmeiropolis still has a significant cover of native vegetation (approximately 54%). Part of that native vegetation is in the process of degradation, mainly due to selective extraction of timber, or in the process of regeneration. In this work we chose not to differentiate between areas of primary of secondary vegetation due to lack of field validation. Another factor to be considered is that although the percentage of vegetation cover appears to be significant, much of it is concentrated in mountainous regions where intensive mechanized agriculture is not possible.

DISCUSSION & CONCLUSION

The municipality of Palmeiropolis has a large area of remaining native vegetation (54%), mostly located in the western part, where the relief is mountainous. The total area of land designated as PPA is 22.20% of the Municipality, a significant percentage especially when considering that an extra 35% of the Municipality area must be protected as a result of Legal Reserve (RL) legislation. However, its distribution proved to be quite varied, with a large concentration in the western part of the municipality. Despite a significant percentage cover of PPA land in the Municipality (i.e. 22.2%), it is difficult to suggest without further studies whether this is sufficient to maintain ecosystem functioning including the protection of biodiversity at a range of spatial scales and other ecosystem goods and services. A significant part of the Permanent Preservation Area within the municipality has been used illegally (27.55%).

The methodology used for mapping the PPAs proved to be appropriate for the purpose of this study. However, it needs to be automated for application at a large scale. The ALOS images with spatial resolution of 2.5 m were shown to be suitable for the mapping of PPAs, although there was difficulty in identifying springs/water courses in areas of flat relief. Moreover, the low price of these images combined with availability for the entire Brazilian territory encourages their use as an essential tool in support of effective environmental policy. According to Ribeiro et al. (2006), the lack of appropriate topographic datasets and the expertise needed for manually mapping PPAs means that it is virtually impossible to enforce the Brazilian Forest Code over an area of c.8.5 million Km^2

4.1. Future Work

The following steps are considered appropriate in order to refine the methodology and identify needs for future research:

- Validation of land cover map, with fieldwork, differentiating between primary and secondary native vegetation;
- Validation, through fieldwork, of PPAs mapped on hilltops generated from the SRTM DEM;
- Implementation in SPRING of a routine for automatic generation of a buffer for water course and springs;
- Development of further studies about the fauna of the region and their displacement, thus seeking more information on the effectiveness of the PPAs as ecological corridors.
- Establishment of a database of PPAs, through a partnership between Federal Government, States and municipalities, to assist with the development of an effective strategy for forest protection and restoration.

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ANNEX I

CONAMA Resolution No. 303, March 20, 2002 - Published in DOU on 90 of May 13, 2002, Section 1, page 68

Correlations:

Complemented by Resolution N^{o} 302/02

Amended by Resolution N^{o}. 341/03 (add new paragraphs)

Repealing Resolution 4 / 85

Provides on parameters, set limits and definitions of Permanent Preservation Areas THE NATIONAL COUNCIL ON THE ENVIRONMENT-CONAMA, in the use of powers as conferred by Law No. 6938 of August 31, 1981, regulated by Decree No. 99,274, from June 6, 1990, and in view of the provisions of Laws in 4771, from September 15, 1965, 9433, to Jan. 8, 1997, and its rules of procedure, and;

Considering the socio-environmental function of property provided for in art. 5, item XXIII, 170, item VI, 182, Paragraph 2, 186, item II and 225 of the Constitution and the principles of prevention, the precautionary and polluter payer; Considering the need to regulate art. 2 of Law No. 4771 of September 15 of 1965, regarding the permanent preservation areas;

Considering the responsibilities assumed by Brazil under the Convention of Biodiversity, 1992, the Ramsar Convention from 1971 and the Convention of Washington, from 1940, as well as the commitments derived from the Declaration of Rio de Janeiro, from 1992;

Considering the desirability of regulating the arts 2nd and 3rd of Law nr 4771, from September 15, 1965, regarding the permanent preservation areas, (considering added by Resolution No. 341/03);

Whereas it is the duty of public authorities and private individuals to preserve biodiversity, notably the flora, fauna, water resources, the natural beauty and ecological balance, preventing water pollution, soil and air, recognizing the intrinsic assumption and the right to property, pursuant to arts. 5th, caput (right to life) and item XXIII (social function of property), 170, VI, 186, II, and 225, all of the Federal Constitution, as well as of art. 1299, the Civil Code, which requires the owner and the settlers comply with the administrative regulations; (paragraph added by Resolution No 341/03);

Considering the fundamental function of dunes in the dynamic coastal zone, in Control of erosive processes and training and recharge of aquifers; (paragraph added by Resolution No. 341/03);

Considering the exceptional scenic beauty and landscape of dunes, and the importance the maintenance of their attributes for sustainable tourism; (paragraph added by Resolution No. 341/03);

Whereas the permanent preservation areas and other territorial spaces especially protected, as instruments of relevant environmental interest, incorporating sustainable development objective of the present and future generations, resolves:

Art 1st It is the object of this resolution the establishment of parameters, definitions and limits concerning the areas of permanent preservation.

Art 2nd for the purposes of this resolution, are adopted the following definitions:

I - the highest level: level reached during the full seasonal flood of perennial or intermittent waterways;

II - spring: where water wells up naturally from an underground source, even so intermittent;

III - vereda: swampy space or soaked, which contains springs or seepage, where there is occurrence of soil hydromorphic, characterized predominantly by Buritis of the swamp (Mauritia flexuosa) and other forms of typical vegetation;

IV - hill: elevation of the land with difference of altimetry quota between the top and the base from 50 to 300 meters and hillsides with a slope greater than thirty percent (approximately seventeen degrees) in the line of maximum slope;

V - mountain: elevation of the land with difference of altimetry quota between the top and the basis more than three hundred meter;

VI - base of hill or mountain: horizontal plane defined by plain or surface of water from adjacent waterways, or in relief wavy the lowest elevation quota of depression around it;

VII - the ridge line: a line linking the highest points of a sequence of hills or mountains, being in the crossover waters;

VIII - restinga (sandbanks): sandy deposit parallel to the shoreline, so generally elongated, produced by processes of sedimentation, where different communities receiving marine nfluence, also considered soil communities depending on the nature of the substrate more than the climate. The vegetation cover in sandbanks occurs in mosaic, and is on beaches, sandy ridges, dunes and depressions, showing, according to the next stage, herbaceous layer, shrub and tree, the latter more internalized;

IX – manguezal (mangroves): coastal ecosystem that occurs in low land, subject to tide action, formed by soaked and mud soil or sandy, which is predominantly associated to the natural vegetation known as mangroves, that receive river-sea influence typical of alluvial soils of estuarine areas and spread along the discontinuous Brazilian coast, between the Amapá and Santa Catarina States;

X - dune: geomorphologic unit of predominantly sandy formation, with appearance of hill, produced by the action of the winds, located on the coast or in interior of the continent and may be covered, or not, for vegetation;

XI - tray or plateau: landscape of flat topography, with average slope less than ten percent (approximately six degrees) and an area of more than ten hectares, ended abruptly at the escarpment, the plateau is characterized by large areas to more than six hundred meters high;

XII - escarpment: ramp slope of land equal to or exceeding forty-five degrees, which delimit reliefs of plates and elevated plain, being limited at the top by the rupture of positive slope (line of cliff) and at the foot by breaking negative slope, covering the deposits of runoff soil which is located near the foothills the escarpment;

XIII - consolidated urban area: one that meets the following criteria:

a) Legal definition by the government;
b) there are at least four of the following infrastructure urban equipment:

1. Loop road with rainwater drainage;
2. Water-supply system;
3. Sewage network;
4. Distribution of electricity and public lighting;
5. Collection of municipal solid waste;
6. Treatment of municipal solid waste and population density of more than five thousand inhabitants per km2;

Art 3rd Permanent Preservation Areas are formed by the following area:

I - in marginal track, measured from the highest level in horizontal projection, with minimum width of:

a) Thirty meters for the waterways with less than ten meters wide;

b) fifty meters for the waterways with ten to fifty meters wide;

c) Hundred meters for the waterways with water fifty to two hundred meters wide;

d) two hundred meters to waterways of two hundred to six hundred meters from width;

e) five hundred meters for the waterways with more than six hundred meters in width;

II - around the spring, even if intermittent, with minimum radius fifteen meters in such a way that protects, in each case, the its whole hydrographic basin;

III - around lakes and natural ponds on track with footage of:

a) Thirty meters, for those who are situated in urban areas consolidated;

b) Hundred meters, for they are in rural areas, except the bodies water less than twenty hectares of area, whose range is fifty meters marginal;

IV - on track path and in marginal, in horizontal projection, with minimum width of fifty meters from the edge of space swampy and weathered floodplain;

V - on top of hills and mountains, in areas from the altimetry level corresponding to two thirds of the minimum height of elevation on the base;

VI - the ridge lines in the designated area from the curve at the level of two thirds of the time, from the base, the lowest in the peak ridge, setting up the curve level for each segment of the ridge line equivalent to one thousand meters;

VII - in hillside or part thereof, with slope of more than one hundred per cent or forty five degrees on the line of maximum gradient;

VIII - the cliffs and the edges of the trays and plateau from the line of collapse track at no lower than a hundred meters in horizontal projection towards the other side of the escarpment;
IX - the restinga (sandbanks):

a) at least three hundred meter track, measured from the line of maximum flood;

b) at any location or extension, when covered with vegetation with light fixative of stabilizing the dunes or mangroves;

X - in mangrove, throughout its length;

XI - in dunes;

XII - in altitude over eighteen hundred meters, or, in states that have not such elevations, at the discretion of the relevant environmental authority;

XIII - in places of refuge or reproduction of migratory birds;

XIV - in places of refuge or reproduction of wildlife threatened with extinction out of a list drawn up by governmental agencies federal, state or municipal;

XV - on the beaches in places of nesting and breeding of wildlife;

Single paragraph: The occurrence of two or more hills or mountains whose tops are separated from each other by distances of less than five hundred meters, the permanent preservation area standing cover the range of hills or mountains, bounded from the curve of level equivalent to two thirds of the time at the base of the hill or mountain of lesser height of the set, according to the following:

I - are grouped hills or mountains whose proximity is up to five hundred meters from their tops;

II - identifies with the smaller hill or mountain;

III - moth is a line in the curve of level equivalent to two thirds of this, and

IV - a permanent preservation of the whole area above this level.

Art 4th CONAMA shall, in particular resolution, the parameters of permanent preservation areas of reservoirs and artificial arrangements for use of its surroundings.

Art 5th resolution enters into force on the date of its publication, revoking to CONAMA resolution paragraph 4, of September 18, 1985.

Jose Carlos Carvalho - President of the Council

This does not replace the text published in DOU, from May 13, 2002.

ANNEX II

Agriculture IBGE census 2006

Municipality/ State	Total establishments	Total Area (ha)	Land use for agricultural establishments					
			Crops		Pasture		Woods and forests	
			Establishments	Area (ha)	Establishments	Area (ha)	Establishments	Area (ha)
Palmeirópolis	479	135399	144	3114	471	66316	414	60512
Tocantins	**56896**	**16825737**	**26490**	**811874**	**50072**	**10290856**	**39545**	**5250649**

Municipality/ State	Total establishments	People employed at the farm on 31.12			
		Total	Family members		
			Establishments	Total	Total
Palmeirópolis	479	1620	479	1120	500
Tocantins	**56896**	**175405**	**56896**	**149405**	**25987**

Municipality/ State	Total establishments	Number of tractors in agricultural establishment	
		Establishments	Total
Palmeirópolis	479	85	118
Tocantins	**56896**	**5419**	**9547**

Municipality/ State	Total establishments	Number of animals in agricultural establishments in 31.12					
		Bovine		Swine		Birds	
		Establishments	Total	Establishments	Total	Establishments	Total
Palmeirópolis	479	411	58776	276	4425	364	19660
Tocantins	**56896**	**42857**	**6093118**	**22389**	**249350**	**40698**	**4478687**

Municipality/ State	Total establishments	Animal Productions			
		Cow's milk		Chicken eggs	
		Establishments	Total (1 000 l)	Establishments	Total (1000 dozen)
Palmeirópolis	479	133	1465	170	255
Tocantins	**56896**	**15053**	**144903**	**22775**	**4064**

Agriculture IBGE census 1996

Municipality/ State	Establishment that received technical assistance in 1996					
	Technical assistance	Fertilizer and correctives	Plague and affection controls	Soil Preservation	Irrigation	Electrical energy
Palmeirópolis	9	54	465	16	6	65
Tocantins	5 759	6 581	36 400	1 056	568	4 976

Municipality/ State	Number of establishments according to their size (ha)						
	Less than 10	Between 10 and 100	Between 100 and 200	Between 200 and 500	Between 500 and 2000	More than 2000	No declaration
Palmeirópolis	28	158	119	115	60	9	x
Tocantins	2 614	17 283	7 790	8 234	5 589	1 427	1 976

GDP and GDP per capita 2002-2005 (IBGE survey)

Municipality/ State	Gross Domestic Product and current prices and gross domestic product per capita 2002-2005							
	2002		2003		2004		2005	
	Current Prices (1 000 R$)	*Per capita* (R$)	Current Prices (1 000 R$)	*Per capita* (R$)	Current Prices (1 000 R$)	*Per capita* (R$)	Current Prices (1 000 R$)	*Per capita* (R$)
Palmeirópolis	27670.921	4308.1	34902.187	5657.67	36745.186	6055.57	38084.168	6728.65
Tocantins	**5607172.803**	**4576.41**	**7241146.844**	**5783.53**	**8277815.509**	**6555.94**	**9083623.82**	**6956.75**
Brazil	**1477821769**	**8378.1**	**1699947694**	**9497.69**	**1941498358**	**10692.19**	**2147239292**	**11658.1**

Populational Census 2007

Municipality/ State	Population census 2007
Palmeirópolis	8 120
Tocantins	1 243 627