VEGETATION COVER OF THE UPPER PARAGUAI BASIN IN MATO GROSSO DO SUL STATE: COMPARISON BETWEEN PANTANAL WETLAND AND THE PLATEAU

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Abstract

This paper presents spatial and quantitative information of the vegetation cover and land use in the Upper Paraguay Basin (BAP – Portuguese acronym) in 2007 and a comparison between the Plateau and Pantanal Wetland. Images from CBERS-2 Satellite were used in a Geographic Information System and for a hybrid interpretation (segmentation by region and visual interpretation), supported by field work. The mapping was done at levels 1, 2, and 3, considering the Brazilian Classification System. The quantitative data are presented separately for both Plateau and Pantanal Wetland. At level 1 areas with natural vegetation, as well as anthropic and water covered areas were mapped. Sixteen classes were mapped at level 2 and sixty-two classes at level three. Savannahs (*Cerrado* and *Chaco*) are natural vegetation typologies that occur extensively in the BAP, especially in the Pantanal Wetland. Planted pasture is the anthropic physiognomy of largest occurrence in BAP, especially on the Plateau. Altogether the Pantanal Wetland is preserved, however the Plateau is already at a critical level of conservation, requiring special attention from environmental agencies due to new deletions of vegetation. It is emphasized that Level 3 mapping contributes with important information for the identification of areas with restricted use, established by the Brazilian Forest Code from 2012.

Keywords: Areas with restricted use. Geo-technology. Deforestation, Forest Code.

Resumo

Cobertura vegetal da Bacia do Alto Paraguai em Mato Grosso do Sul: comparação entre Pantanal e Planalto

Este artigo apresenta informações espaciais e quantitativas da cobertura vegetal e uso da terra na bacia do alto Paraguai (BAP) do ano de 2007 e uma comparação entre o planalto e Pantanal. Foram utilizadas imagens digitais do satélite CBERS-2 processadas num sistema de informações geográficas e interpretação híbrida (segmentação por região + visual), apoiada em verificações a campo. O mapeamento foi efetuado nos níveis 1, 2 e 3 adotando-se o sistema brasileiro de classificação da vegetação, sendo que os dados quantitativos são apresentados por planalto e Pantanal. No nível 1 foram mapeadas áreas de vegetação natural, área antrópica e água. Foram mapeadas 16 classes no nível 2 e 62 no nível 3. As Savanas (Cerrado e Chaco) são tipologias de vegetação natural de maior ocorrência na bacia, principalmente no Pantanal e, a pastagem plantada é a fisionomia antrópica de maior ocorrência, principalmente no planalto. De forma geral o Pantanal encontra-se conservado, porém o planalto da bacia já se encontra em níveis críticos de conservação, necessitando de atenção especial dos órgãos ambientais quanto a novas supressões da vegetação. Destaca-se ainda, que o mapeamento no nível 3 traz subsídios importantes para a identificação das áreas de uso restrito previstas no Código Florestal de 2012.

Palavras-chave: Áreas de uso restrito. Geotecnologia. Desmatamento. Código Florestal.

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INTRODUCTION

Mato Grosso do Sul State is formed partially by two major river basins: the Paraná River to the East (47.7%) and the Upper Paraguay River to the West (52.3 %) and, according to IBGE (2004) [Brazilian Institute for Geography and Statistics], parts of three following biomes cover the State: *Cerrado* , *Pantanal* and Atlantic Forest. The Pantanal is located in the Upper Paraguay River Basin (BAP) and occupies areas in Brazil, Bolivia and Paraguay. Around 80 % of the BAP (361,666 Km^2) is located in Brazil as well as the continuous *Pantanal* flood plain (138,183 Km^2), according to Silva and Abdon (1998).

Regional maps are always performed by the Government and, in the 1980s and 1990s there were three major initiatives in this regard. The RadamBrasil program (BRASIL, 1982a; BRASIL, 1982b and BRASIL, 1982c) produced the first regional mapping from this area, using airborne radar imagery; Mato Grosso do Sul State (1989) produced, among others, the Vegetation and Land Use map at 1:250,000 scale, which included the southern part of the Pantanal, located in this State, using analog satellite Landsat 5 images of 1994. Pott et al. (1997) mapped the vegetation of the BAP, also at 1:250,000 scale in the frame of PCBAP - the Upper Paraguay Basin Conservation Plan. In the early 21st century, two important mapping initiatives occurred in the region. The first, described by Abdon et al. (2007), Abdon and Silva (2006) and Silva et al. (2007a; 2007b), refers to the Pantanal mapping with digital Landsat satellite images of 2002, at 1:250,000 scale, induced by the Ministry for Environment (MMA) through the edict "Mapping the remaining vegetation of the Brazilian biomes", as part of PROBIO actions - Project for Conservation and Sustainable Use of the Brazilian Biological Diversity.

Using digital CBERS satellite images of 2007, the Government of Mato Grosso do Sul State, aiming to start monitoring of deforestation and to provide the environmental regularization of rural properties, executed mapping of Land Cover/ Land Use at 1:100,000 scale. For details see Silva et al. (2011a ; 2011b) .

These studies constitute the knowledge basis of the spatial distribution from vegetation, and served to overthrow the former denomination "Pantanal Complex" that has long appeared on Brazilian maps. It is known today that the BAP is formed by the intersection of four major phyto-ecological regions, namely: Deciduous Seasonal Forest, Semi-deciduous Seasonal Forest, Savannah (*Cerrado*) and Steppic Savannah (*Chaco*). Furthermore there are the Floristic Contacts and Pioneer Vegetation, which must be added to these regions. The identification, mapping and quantification of different types of Vegetation, both natural and anthropic from a basin, constitute an important set of information for managers and decision makers. This can for example serve to get knowledge about the Vegetation itself, such as the presence of endemic species; to identify the anthropic level globally or by phyto-physiognomy; to identify the existence of Areas for Permanent Preservation on the banks of waterways or to select areas with conservation potential.

To provide an input for these issues, this paper aims to present the mapping of vegetation and land use of year 2007, of part from BAP in the Mato Grosso do Sul (MS) State and make a comparison between the Pantanal and the adjacent Plateau.

The area of BAP in MS State comprises 187,429 Km^2, wherein 48.6% refers to the Pantanal and 51.4% to the adjacent Plateau. It is noteworthy that for the purposes of analysis in this study, all the western part of the MS State was considered Pantanal, including in the area the hills at the western edge.

MATERIAL AND METHODS

To execute this mapping, the following images from CBERS-2 satellite, 2007 were used: bands 2 (0.52 - 0.59 µm (green)), 3 (0.63 - 0.69 µm (red)) and 4 ((0.77 - 0.89 µm (near infrared) at a spatial resolution of 20 meters, with least cloud cover. For the total coverage of the BAP area, 34 images were needed. This working step was followed by: the selection of satellite images, format conversion, GRIB, geo-referencing, enhancement, segmentation, interpretation, classification and field checks totaling 11 expeditions. Additionally, as a support, the information of Vegetation Indices time series provided by INPE (http://www.dsr .inpe.br/laf/series/) were used, whose technical details can be found in Lauro and Shimabukuro (2008) and Freitas et. al.(2011). High-resolution images from Google Earth were also used when available.

With the impossibility to obtain the digital and updated cartographic base, CBERS-2 images were geo-referenced to a UTM projection system, Datum SAD-69, based on the mosaic of LANDSAT images from NASA available at http://zulu.ssc.nasa.gov/mrsid/ . For the geometric transformation the polynomial transformation model at first grade, with bilinear interpolation, was used. Nine control points were collected on each image, the maximum planimetric error was 1.5 pixel (30 meters). This procedure was performed using the Geo-referenced Information Processing System (SPRING). Thus, the error accepted for the record was within the acceptable accuracy of the mapping error (PEC – acronym for Brazilian Cartographic Accuracy) admitted for maps on the scale 1:100,000, which is 50 meters. Besides the project in UTM, another one was created in Albers projection, with Datum SA-D69, to facilitate the calculation of areas, since the BAP encompasses two zones.

In each image mosaic corresponding to the cutout of 1:250,000 (6 maps at 1:100,000 each), the segmentation threshold was applied to 20 x 625 or 30 x 625 pixels, depending on the homogeneity / heterogeneity of the area. The objective of this procedure was to differentiate homogeneous targets in the vegetation cover and a minimum area for mapping of 25 ha. The interpretation was done visually (addition or elimination of vectors), and considered the elements texture, color, pattern, shape and location (geographic distribution). Such interpretations and classifications were based on field-testing with sample areas, using the Brazilian System for Vegetation Classification (IBGE, 1992) and the Technical Land Use Manual (IBGE, 2006), with some adjustments. In composite classes, such as Savannah Tree + Savanna Woodland (Sa + Sd), the first one is the dominant physiognomy of the mapped polygon. Maps are displayed on levels 1, 2 and 3.

RESULTS AND DISCUSSION

Mapping at level 1 – At this level natural areas, anthropic areas and water masses were mapped and quantified. One observes at figure 1 the predominance of natural areas (85,5%) in the Pantanal, unlike the situation on the plateau, dominated anthropic areas (57.8%). Spatially this can be seen at figure 2, where one observes in the West, in green, the wide distribution of natural vegetation and to the East, in gray, the wide distribution of anthropic areas. Findings in this regard were identified in studies from Abdon et al. (2007) and Silva et al. (2007a, 2011c) in their analysis of vegetation cover and deforestation in the region.

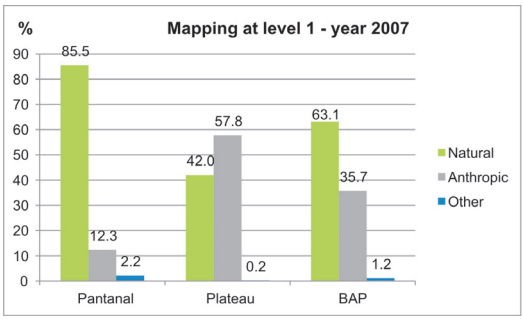

Figure 1 - Quantification of mapping from vegetation cover on the Pantanal, Plateau and BAP

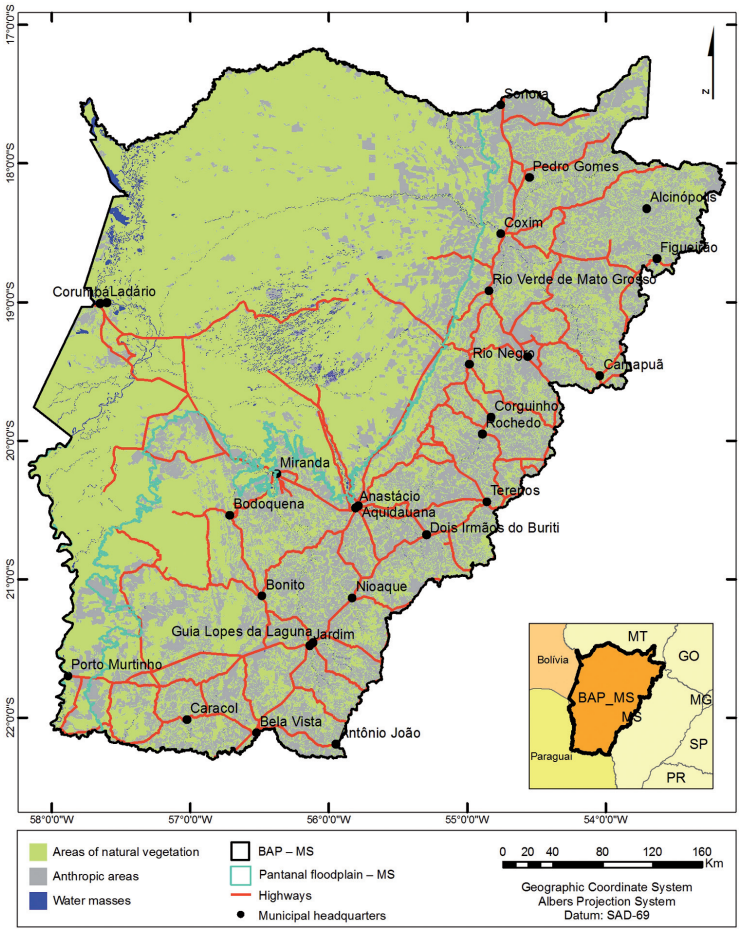

Figure 2 - Distribution of physiognomies mapped at level 1 at BAP, in 2007

Considering the total area of BAP, one verifies that it is covered by natural physiognomies at 63.1%, by anthropic physiognomies at 35.7% and by water at 1.2%. In analogy to the Forest Code, allowing deforestation of up to 80% of the original coverage subtracted from the Permanent Preservation Areas (APP), namely: banks of waterways, slopes (slope >45) and hilltops, one notes that the original vegetation cover is within the parameters established by law, with a good margin for its use.

However, this type of analysis, when considering the entire BAP, may cause bias in the interpretation. It is necessary to analyze both environments (Pantanal and the Plateau) separately, since the production system and the pressure for deforestation are completely different. So the Pantanal can be considered as a quite conserved region, with 85.5% of its' area as natural, while the Plateau presents only 42% of natural area, including already the Areas of Permanent Preservation, namely rivers, slopes and hilltops.

Mapping at Level 2 - At level 2, sixteen physiognomies were mapped: 8 natural ones, 7 anthropic and 1 related to water masses, whose values are shown on table 1. At the Natural areas, Savannah (*Cerrado* and *Chaco*) are the most frequent types of vegetation in the region, occupying 42.3% of the BAP surface. When only the Plateau is considered, this value falls to 21.4%, and considering only the Pantanal, the figure rises to 64.3%. Considering only anthropic areas with pasture plantation for cattle raising, which predominates at BAP, it occupies 32.5% from the area considered.

On the Plateau pasture occupies 52% of the area, while in the Pantanal, it occurs only on 11.9% of the floodplain. Semi-deciduous Seasonal Forests and Vegetation Refuges occur only in the Pantanal and are absent on the Plateau.

Similarly, there is no occurrence of Semi-evergreen Agriculture and Forestry in the Pantanal. Using percentage data of table 1, the graphs of figures 3 (Natural areas), 4 (Anthropic areas and Water) and 5 (Aggregation of areas mapped with larger occurrence) were constructed. To facilitate visualization, in figure 5, Semi-deciduous Seasonal Forests were aggregated to Deciduous Forests; *Chaco* and *Cerrado* were added to Savannah; Pioneer Formations and Vegetation Refuges were added to other natural vegetation and all anthropic areas, except for Planted pasture were aggregated into other uses. At figure 6, the reader can observe the spatial distribution of physiognomies mapped at level 2.

Table 1 - Physiognomies mapped and quantified in the Pantanal, Plateau and BAP at level 2, year 2007

Phyto-ecological region, Formation or Type of land use	Area (km^2)			%		
	Pantanal	Plateau	BAP	Pantanal	Plateau	BAP
AREAS OF NATURAL VEGETATION						
Riparian Woodland	3166.5	10470.0	13636.5	3.48	10.87	7.28
Semi-deciduous Seasonal Forest	87.7	1.2	88.9	0.10	0.00	0.05
Deciduous Seasonal Forest	1331.3	2501.5	3832.8	1.46	2.60	2.04
Savannah (*Cerrado*)	46654.5	16640.4	63294.9	51.22	17.27	33.77
Savannah Steppic (*Chaco*)	11916.5	4021.5	15938.0	13.08	4.17	8.50
Pioneer formations	3399.8	7.3	3407.1	3.73	0.01	1.82
Floristic contacts	11285.3	6830.8	18116.1	12.39	7.09	9.67
Vegetation refuge (Relics Communities)	28.5	0.0	28.5	0.03	0.00	0.02
ANTHROPIC AREAS						
Secondary vegetation	114.9	527.7	642.6	0.13	0.55	0.34
Annual agriculture	101.2	3502.7	3603.9	0.11	3.64	1.92
Livestock and agriculture	169.8	866.0	1035.8	0.19	0.90	0.55
Semi-evergreen agriculture	0	424.6	424.6	0.00	0.44	0.23
Forestry	0	53.8	53.8	0.00	0.06	0.03
Livestock (Planted pasture)	10806.9	50054.8	60861.7	11.86	51.95	32.47
Other anthropic areas	41.8	242.3	284.1	0.05	0.25	0.15
OTHER						
Water	1980.4	199.3	2179.7	2.17	0.21	1.16
TOTAL	91085.1	96343.9	187429	100	100	100

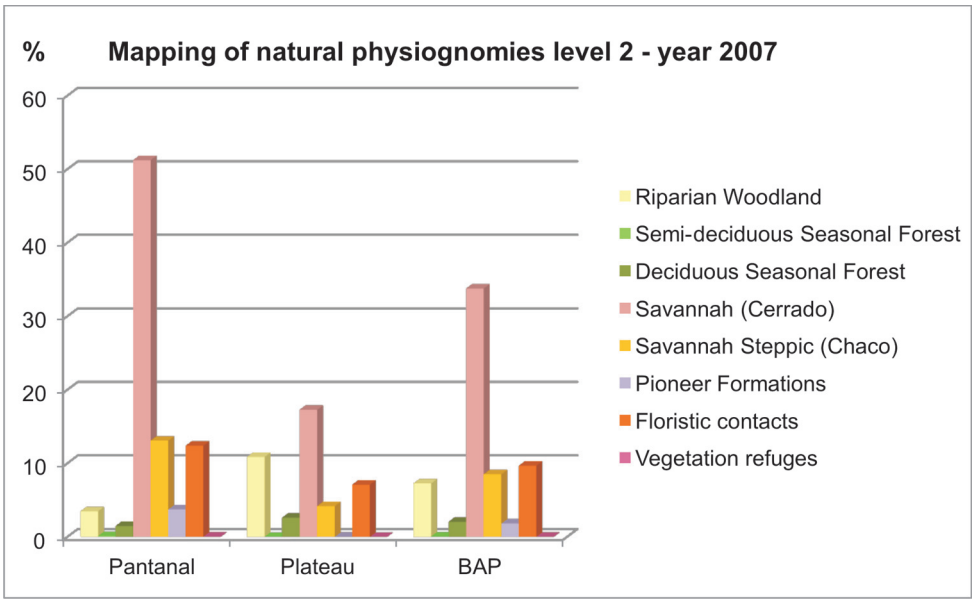

Figure 3 - Types of Natural Vegetation mapped in 2007 at BAP, at level 2

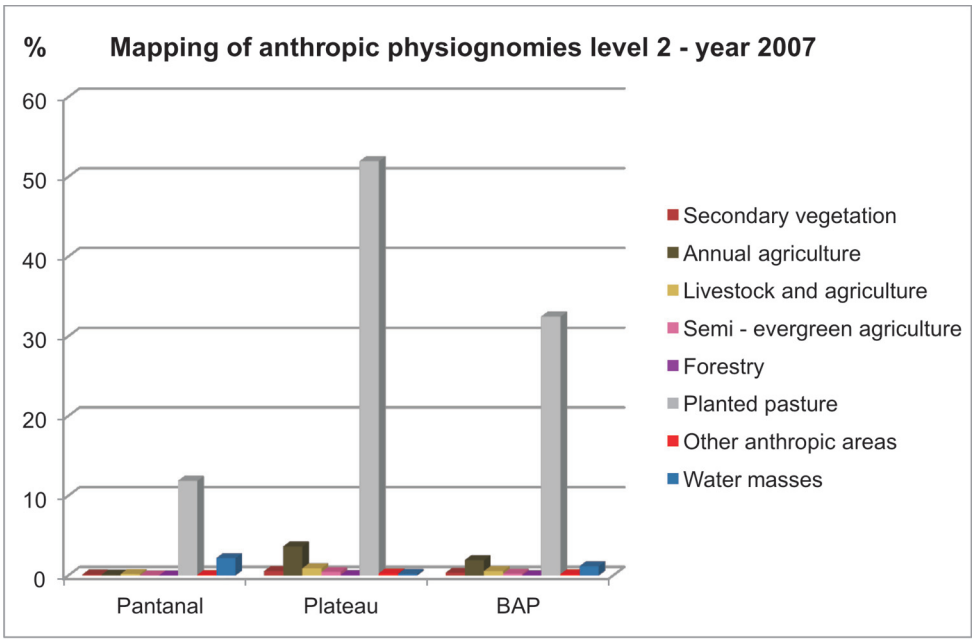

Figure 4 - Anthropic areas and water masses mapped in 2007 in the Pantanal, Plateau and BAP, at Level 2

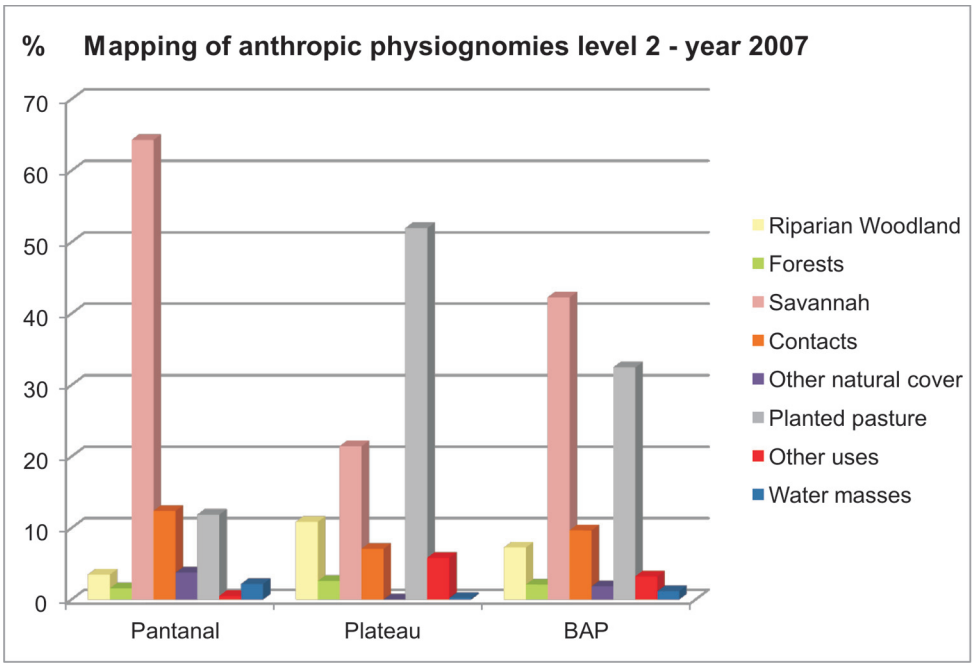

Figure 5 - Physiognomies with higher occurrences mapped in 2007 in the Pantanal, Plateau and BAP, at level 2

The Riparian Vegetation is localized along water courses and includes herbaceous, bush and arboreal vegetation, because for the mapping purpose it was not necessary to separate them. It occurs at 7.3% from BAP, 10.9% of the Plateau and 3.5% of the Pantanal area (Table 1 and Figure 3), with a wide distribution (Figure 6). According to Silva et al. (2009), the Riparian Vegetation in Mato Grosso do Sul State suffered impacts or is non-existent at almost all observations made on 368 points from this study. This problem occurs at BAP, because it occupies more than half the surface from the State.

The Semi-deciduous Seasonal Forest located at the Santa Cruz Hills, near Corumbá and Ladário (Figure 6) on iron ore and manganese deposits, occupies only 0.05% of the area of BAP or 0.1% of the Pantanal (Table 1 and Figure 3).

The Deciduous Seasonal Forest occurs mainly on the Bodoquena Mountains, in the *Soldado* Woods, in Kadiweu Indian Lands and on the western edge of the basin, in areas known as Amolar Mountain and Urucum-Jacadigo Hills (Figure 6), covering an area of 2.0% from BAP, 2.6% of the Plateau and 1.5% of the Pantanal (Table 1 and Figure 4). Except for the *Soldado* Woods, other forests are usually on calcareous soils.

According to Pott et al. (2001), in general forests should be preserved, considering that these are the surroundings of the Pantanal and the animals use it as a refuge. There are unique species of the Brazilian Flora, recorded in these places. The forests on limestone have many hardwood trees and a good commercial value. These are areas with great potential for forest management, coupled with livestock. Mauro and Campos (2001) point out that the forests close to Corumbá are rich in primates with 5 kinds of monkeys, so these habitats must be preserved.

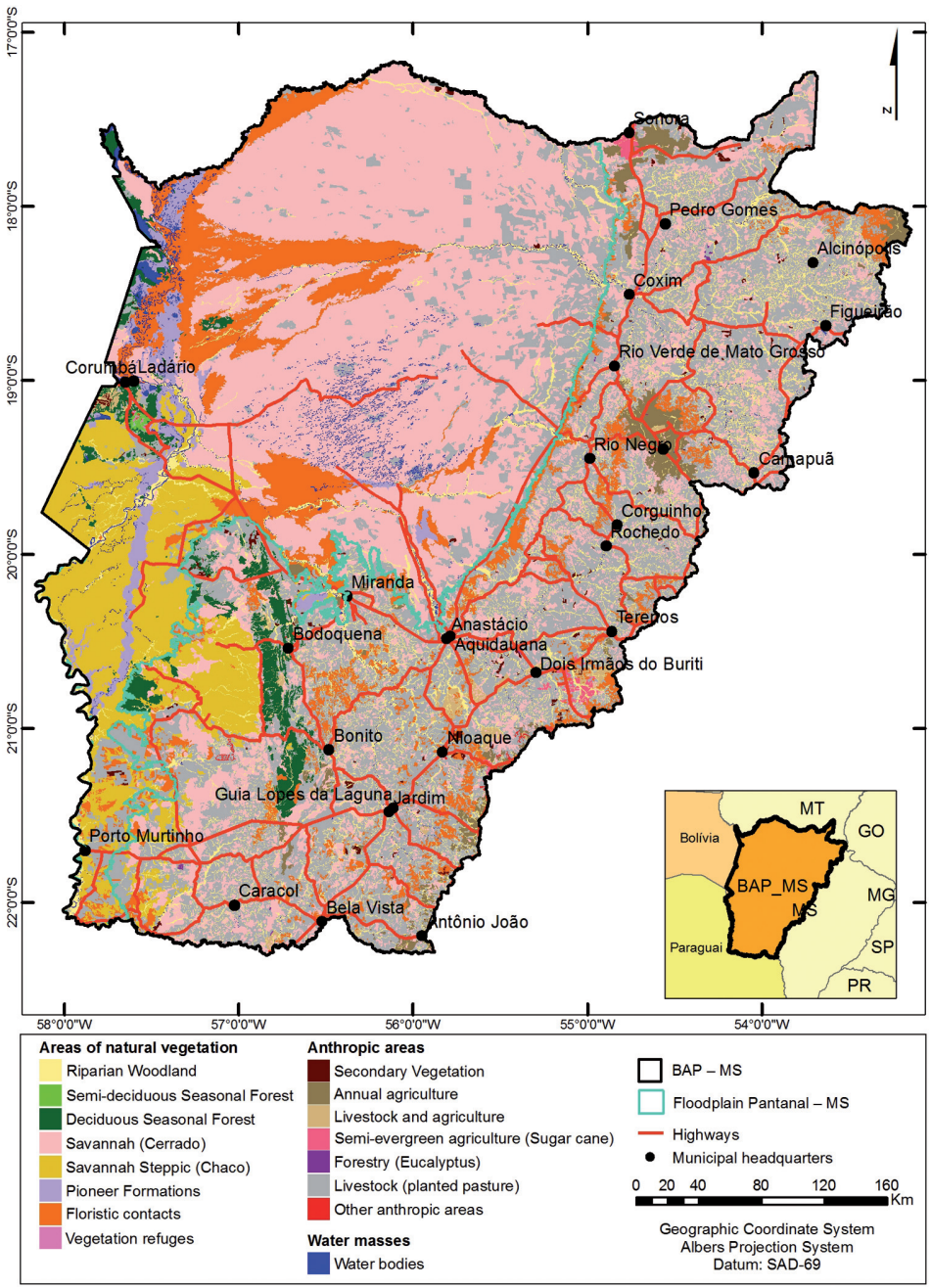

Figure 6 - Distribution of physiognomies mapped at level 2 in BAP, in 2007

Cerrado is the physiognomy with largest extension (33.8%) occurring in the BAP. It occupies 17.3 % of the area from the plateau and 51.2 % of the Pantanal (Table 1 and Figure 3), with a wide distribution in the region (Figure 6). It is distributed on the plateau and occupies most of the Pantanal, interspersing with the Chaco, at the Southwest.

Chaco is concentrated in the southwestern section of the basin (Figure 6), between Corumbá and the Apa river, after the city of Porto Murtinho and between the Paraguay River and the Bodoquena Mountains, near the homonym city. It occupies 8.5% of the BAP, 4.2% of the Plateau and 13.1% of the Pantanal (Table 1 and Figure 3). It is a physiognomy which needs special attention from the Government, as pointed out by Abdon et al. (2007), when she reports that this physiognomy is becoming fragmented, especially near the city of Porto Murtinho. In spite the fact that this vegetation is classified as Chaco, it is mostly composed of Floristic Contacts with the presence of Deciduous Forests and also Cerrado.

The Pioneer Formations are physiognomies associated to the periodic flooding of the Pantanal rivers and consist of arboreal vegetation (*Cambarazal*), Shrub (*Espinheiral, Saranzeiro*, *Macega, Pateiral, Pimenteiral*) and herbaceous (*Pirizal*, *Caetezal*, swamp and *Bacero*) formations. They occupy 1.8% of the basin area (Table 1 and Figure 3) and occur only in the Pantanal (Figure 6), mainly along the rivers Paraguay, Paraguay Mirim and Nabileque, where they occupy 3.7 % of the area.

The floristic Contacts are areas where two or more phyto-ecological regions meet and intermingle constituting the floristic transitions of Ecotone type - where species are mixed or are of type Enclave - where species do not mix (SILVA et al, 2011a). This physiognomy covers 9.7% of the BAP, 7.1% of the Plateau and 12.4% of the Pantanal (Table 1 and Figure 3). It occurs in various soil and altimetry conditions.

On the plateau the remains found are associated to the existing mountains, while in the Pantanal, as it is noted in Figure 6, from North to South, there are two major sectors in the floodplain. The first one is under the influence of the rivers Cuiabá, São Lourenço, Paraguay, Paraguay Mirim and Taquari, and the second is under the influence of rivers Negro and Miranda, constituting the Negro River Swamp.

The vegetation refuges are small areas, completely different from its surroundings and occur only at the top of the iron ore and manganese mountains near the cities of Corumbá and Ladário (Figure 6), occupying less than 0.1 % of the basin (Table 1 and Figure 3), occurring only in the Pantanal. According to Pott et al. (2001) there are endemic species in these areas which must be studied and preserved.

Regarding the Anthropic Areas, the type of land use mapped was associated with original vegetation, a procedure followed in the previous regional mapping (BRASIL, 1982a, 1982b, 1982c; MATO GROSSO DO SUL, 1989; POTT, 1997; SILVA et al , 2007a). As an example, the type of land use mapped as Planted Pasture in the Region of Submontane Deciduous Seasonal Forest, means that in the past this area was covered by Submontane Deciduous Seasonal Forest.

The predominant land use in the basin is Livestock with Planted pasture, occupying 32.5% of the BAP, 52% of the Plateau and 11.9 % of the Pantanal (Table 1 and Figure 3), concentrated on the Plateau and more dispersed in the Pantanal (Figure 6). As already pointed out by Abdon (2007), the pressure for the implementation of Planted pasture in the Pantanal occurs at the eastern boundary of the floodplain, since flooding in this region is fast and not very deep.

The Annual Agriculture, generally Soybeans and Corn, occupies 1.9% of BAP, 3.6 % of the Plateau and 0.1 % of the Pantanal (Table 1 and Figure 4), with some areas of concentration (Figure 6). These areas are associated with the municipalities

of São Gabriel do Oeste, Sonora and at the NE of the Alcinópolis city, already in the municipality of Costa Rica, with a section from the Paraná River basin.

Other Anthropic areas: (Figure 6): Secondary Vegetation (0.3%), Livestock and Agriculture (0.6%) a mixture between culture and pasture, Semi-evergreen agriculture (0.2%) consisting of sugar cane, Forestry (<0.1%) including Eucalyptus and others (0.2%). Urban influence, Mining and Occupied Floodplains have a minimal share in the BAP and, except for the cities and mining, they are virtually nonexistent in the Pantanal (Table 1 and Figure 3) .

The water masses, formed by dams, ponds, rivers, and several types of lakes and salt marshes, occupy 1.2% of the BAP, 0.2 % of the Plateau and 2.2 % of the Pantanal (Table 1 and Figure 3), with highlights to the lakes and floodplain ponds (Figure 6).

Mapping at level 3 - At level 3, detailed until the Vegetable sub-formation, 62 physiognomies of vegetation cover and land use have been mapped. At Table 2 these physiognomies can be verified, discriminated for BAP, Plateau and Pantanal, with regional names of plant type, if applicable, shown in brackets. Mappings at this level of detail are important because they provide the manager and the farmers with useful information to assist in decision making, whether the area identification for conservation by the manager or the allocation of use by the producer. In addition, this detail brings is beneficial to the Forest Code from 2012 (BRASIL, 2012), especially regarding the identification of areas for restricted use in the Pantanal region.

Depending on the structure and density, the Cerrado was mapped as Woodland Savannah, Wooded Savannah, Park Savannah or Grass-Woody Savannah. Furthermore, composed classes were mapped where the individualization of physiognomies was not been possible. Therefore classes were mapped of type Wooded Savannah + Woodland Savannah or regionally known as *Cerrado + Cerradão*. It is noteworthy that the Wooded Savannah (Cerrado) was mapped together with Riparian Vegetation, when the Riparian Vegetation was not separately identified in the enclosed polygon, and without Riparian Vegetation, when there was discrimination between Riparian Vegetation and Savannah. Twelve vegetation types were mapped in the Cerrado (Table 2), especially the classes of Wooded Savannah and Grass-Woody Savannah, occupying both large areas on the Plateau, and in the Pantanal. Relevant classes are still predominantly Grass-Woody, but presenting occurrences with Woodland Savannah (Sg + Sd) and Wooded Savannah (Sg + Sa), which have wide distribution in BAP, especially in the Pantanal.

Such as at the Cerrado, Chaco was also mapped as Woodland, Wooded, Park and Grassy-woody, in composite classes and, with and without Riparian Vegetation, totaling 10 classes (Table 2), highlighting the *Carandazal* Park, Meadow of *Carandá* and *Paratudal*, which occupy the largest area of the Chaco, mainly in the Pantanal.

The Floristic Contacts were mapped as nine classes, wherein and 6 are of the Ecotone type and 3 Enclave type. Noteworthy is the Ecotone Savannah/Pioneer Formations (*Cerrado*, *Campo Sujo*, *Cambarazal*), occurring only in the Pantanal, generally associated with wetlands or in areas of Cerrado being invaded by *Cambara* trees. At the enclave the following vegetation formations stand out: Savannah Woodland/ Submontane Semi-deciduous Seasonal Forest and the Savanna Woodland/Submontane Deciduous Seasonal Forest, both predominating on the Plateau (Table 2).

The Secondary Vegetation was mapped as 6 classes, highlighting the secondary type, denominated before as "Cerrado", occurring almost entirely on the plateau (Table 2). From the 3 classes mapped as "Annual Agriculture", one stands out which was implanted on an earlier Cerrado area, especially on the Plateau (Table 2). Planted pastures were mapped as 8 classes, especially the pasture in the Cerrado region (Table 2), predominantly on the Plateau.

Table 2 - Physiognomies of vegetation cover and land use mapped at BAP, level 3, scale 1:100,000, year 2007

Nr.	Phytoecological region, Formation or Sub-formation	Code	Pantanal	Plateau	BAP
	AREAS OF NATURAL VEGETATION	-			
	I – Riparian Vegetation				
1	Alluvial (Arboreal, Bush, Herbaceous) - along rivers	Fa	3166.5	10470.0	13636.5
	II – Semi-deciduous Seasonal Forest	F			
2	Submontane (Woods)	Fs	87.7	1.2	88.9
	III – Deciduous Seasonal Forest	C			
3	Lowlands (Woods, Dry Forest)	Cb	387.8	373	760.8
4	Submontane (Woods, Dry Forest, Limestone Forest)	Cs	943.5	2128.5	3072.0
	IV – Savannah (*Cerrado*)	S			
5	Woodland (*Cerradão*)	Sd	4513.0	2688.7	7201.7
	Wooded (*Campo Cerrado*, Cerrado, *Cerrado Aberto*)	Sa			
6	Without Riparian Vegetation	Sas	8725.6	4060.1	12785.7
7	With Riparian Vegetation	Saf	2223.9	4239.1	6463.0
	Park Savannah	Sp			
8	Park Savannah without Riparian Vegetation	Sps	249.9	358.2	608.1
	Grassy-woody (*Campo, Campo Limpo, Campo Sujo, Caronal* and *Campo Alagado*)	Sg			
9	Without Riparian Vegetation	Sgs	5738.0	755.7	6493.7
10	With Riparian Vegetation	Sgf	1450.2	234.5	1684.7
11	Woodland + Wooded	Sd+Sa	3298.7	1520.1	4818.8
12	Woodland + Grassy-woody	Sd+Sg	1162.3	72.7	1235.0
13	Wooded + Woodland	Sa+Sd	4440.5	1548.5	5989.0
14	Grassy-woody + Woodland	Sg+Sd	2639.5	70.9	2710.4
15	Wooded + Grassy-woody	Sa+Sg	2390.5	512.5	2903.0
16	Grassy-Woody + Wooded	Sg+Sa	9822.4	579.4	10401.8
	V – Savannah Steppic (Chaco)	T			
	Wooded (Chaco)	Ta			
17	Without Riparian Vegetation	Tas	312.6	1035.2	1347.8
18	With Riparian Vegetation	Taf	71.3	387.8	459.1
	Park (*Carandazal, Campina de Carandá, Paratudal*)	Tp			
19	Without Riparian Vegetation	Tps	1924.2	58.5	1982.7
20	With Riparian Vegetation	Tpf	5007.5	21.1	5028.6
	Grassy-woody (*Campo, Campo Limpo, Campo Sujo, Campina* and *Campo Alagado*)	Tg			
21	Without Riparian Vegetation	Tgs	1158.3	200.3	1358.6

22	With Riparian Vegetation	Tgf	2563.9	0.5	2564.4
23	Forested + Wooded	Td+Ta	0.0	1345.4	1345.4
24	Wooded + Forested	Ta+Td	68.9	532.5	601.4
25	Wooded + Grassy-woody	Ta+Tg	271.9	123.8	395.7
26	Grassy-woody +Wooded	Tg+Ta	537.9	316.4	854.3
	VI – Pioneer Formations	P			
27	Vegetation with fluvial and/or lacustrine-arboreal (*Cambarazal*), Bush (*Espinheiral, Saranzeiro, Macega, Pateiral, Pimenteiral*), Herbaceous (*Pirizal, Caetezal, Brejo* and *Bacero*) influence.	Pa	3399.8	7.3	3407.1
	VII – Areas of Ecological tension or Floristic Contacts	SN			
	Ecotone				
28	Savannah / Deciduous Seasonal Forest (Woods)	SNt(SCt)	0.0	69.3	69.3
29	Savannah / Semi-deciduous Seasonal Forest (Woods)	SNt(SFt)	344.8	0.0	344.8
30	Semi-deciduous Seasonal Forest / Pioneer Formations (Woods)	NPt(F+Pa)	1291.2	0.0	1291.2
31	Savannah / Pioneer Formations (*Cerrado, Campo Sujo, Cambarazal*)	SPt(S+Pa)	8065.7	0.0	8065.7
32	Savannah Steppic / Pioneer Formations (*Chaco, Campo Sujo*)	TPt(T+Pa)	752.0	26.4	778.4
33	Savannah / Wooded Steppic Savannah	STt(Ta+Sa)	68.9	203.5	272.4
	Enclave				
34	Savannah / Submontane Deciduous Seasonal Forest (Woods)	SNc/(Sd+Cs)	0.0	2364.5	2364.5
35	Savannah / Submontane semi-deciduous Seasonal Forest (Woods)	SNc/(Sd+Fs)	133.8	3798	3931.8
36	Steppic / Savannah/ Lowlands Deciduous Seasonal Forest (Woods)	TNc/(Td+Cb)	628.9	369.1	998.0
	VIII – Vegetation Refuges (Relics Communities)	r			
37	Herbaceous montane refuge (*Campo*)	rmh	28.5	0.0	28.5
	IX – Anthropogenic Areas	AA			
	Secondary Vegetation	Vs			
38	Savannah Secondary Vegetation	Vs.S	43.3	480.5	523.8
39	Secondary Vegetation of Lowlands Deciduous Seasonal Forest	Vs.Cb	2.3	0.0	2.3
40	Secondary Vegetation of Submontane Deciduous Seasonal Forest	Vs.Cs	44.6	31.3	75.9
41	Secondary Vegetation of Submontane Semi-deciduous Seasonal Forest	Vs.Fs	0.0	2.2	2.2
42	Secondary Vegetation of Forested Steppic Savannah	Vs.Td	24.7	12.3	37.0
43	Secondary Vegetation of Park Steppic Savannah	Vs.Tp	0.0	1.4	1.4
	Annual Agriculture	Ac			
44	Agriculture at the Submontane Deciduous Seasonal Forest region	Ac.Cs	54.0	20.0	74.0
45	Agriculture at the Savannah region	Ac.S	32.8	3339.9	3372.7
46	Agriculture (Indian lands)	Ac_ti	14.4	142.8	157.2
	Livestock and agriculture	Ag			
47	Livestock and agriculture (small holdings)	Ag	0.0	9.5	9.5
48	Livestock and agriculture (rural settlements)	Ag_ar	169.8	856.5	1026.3

49	Sugar cane	Cana	0.0	424.6	424.6
	Forestry	-			
50	Reforestation (Eucalyptus)	R	0.0	53.8	53.8
	Livestock (Planted pasture)	Ap			
51	Planted pasture in the Lowlands Deciduous Seasonal Forest region	Ap.Cb	132.1	0.0	132.1
52	Planted pasture in the Submontane Deciduous Seasonal Forest region	Ap.Cs	378.5	877.2	1255.7
53	Planted pasture in the Alluvial Semi-deciduous Seasonal Forest region	Ap.Fa	5.5	6.1	11.6
54	Planted pasture in the Submontane Semi-deciduous Seasonal Forest region	Ap.Fs	6.3	14.7	21.0
55	Planted pasture in the Savannah region	Ap.S	8593.3	46219.3	54812.6
56	Planted pasture in the Steppic Savannah region	Ap.T	1580.4	2574.6	4155.0
57	Planted pasture (Indian lands)	Ap_ti	101.6	325.6	427.2
58	Planted pasture (Rural settlements)	Ap_ar	9.2	37.3	46.5
	Other Anthropic Areas	OA			
59	Urban Influence	Iu	33.9	172.3	206.2
60	Areas degraded by mining	Im	7.9	2.1	10.0
61	Occupied floodplains	Fa_Ag	0.0	67.9	67.9
	IX – Other				
62	Water masses (dams, reservoirs, rivers, streams, saline marshes)	Agua	1980.4	199.3	2179.7
	TOTAL		91085.1	96343.9	187429.0

CONCLUSIONS AND SUGGESTIONS

The information of the different vegetation types mapped at Level 3 provide useful information to identify the areas of restricted uses established by the Forest Code from 2012.

The information generated allow the user to perform a comprehensive analysis of the basin showing the location and quantification of physiognomies that occur in the basin, providing the basis for decision making by State Government agencies, especially regarding the monitoring of vegetation, since it follows the same methodology of previous mappings.

The main phytoecological regions found in this study area are, in descending order, Savannah (*Cerrado*), Savannah (*Chaco*), Deciduous Seasonal Forest and Semi-deciduous Seasonal Forest, making the Pantanal an important biome, where these physiognomies intersect creating mosaics in the landscape.

The Pantanal floodplain, although quite intact, is naturally fragmented, merging forested physiognomies, wooded and Grass-Woody, favoring the biological diversity and wildlife habitats.

The BAP plateau is highly fragmented by human uses, especially due to replacement of native vegetation for planted pasture for extensive livestock, a fact that should be considered in Government Plans. Due to a constant pressure for the removal of vegetation in BAP, it is suggested to create a system for monitoring the vegetation cover in the State, supported by geo-technology products and tools.

The need to create Conservation Units in the areas of Floristic Contacts, Forests and Savannah Steppic (*Chaco*) is reinforced.

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REFERENCES

ABDON, M. M.; SILVA, J. S. V. **Fisionomias da vegetação nas sub-regiões do Pantanal brasileiro**. São José dos Campos: INPE; Campinas: Embrapa Informática Agropecuária, 2006. 1 CD-ROM.

ABDON, M. M.; SILVA, J. S. V.; SOUZA, I. M.; ROMON, V. T.; RAMPAZZO, J.; FERRARI, D. L. Desmatamento no bioma Pantanal até o ano 2002: relações com a fitofisionomia e limites municipais. **Revista Brasileira de Cartografia,** Rio de Janeiro, v. 59, n. 1, p. 17-24, 2007.

BRASIL. Lei Nº 12.651, de 25 de maio de 2012. Diário Oficial [da] República Federativa do Brasil. Brasília, DF, 28 maio 2012. Dispõe sobre a proteção da vegetação nativa.

BRASIL. Ministério das Minas e Energia. Projeto Radambrasil. **Folha SD.21 Cuiabá**: geologia, geomorfologia, solos, vegetação e uso potencial da terra**,** Rio de Janeiro: DNPM, 1982a. 544 p. (levantamento de recursos naturais, v.26).

BRASIL. Ministério das Minas e Energia. Projeto Radambrasil. **Folha SE.21 Corumbá e parte da Folha SE.20:** geologia, geomorfologia, solos, vegetação e uso potencial da terra, Rio de Janeiro: DNPM, 1982b. (levantamento de recursos naturais, v.27), 452 p.

BRASIL. Ministério das Minas e Energia. Projeto Radambrasil. **Folha SF.21 Campo Grande:** geologia, geomorfologia, solos, vegetação e uso potencial da terra, Rio de Janeiro: DNPM, 1982c. 416 p. (levantamento de recursos naturais, v.28).

FREITAS, R. M.; SHIMABUKURO,Y. E. Combining wavelets and linear spectral mixture model for MODIS satellite sensor time-series analysis. **Journal of Computational Interdisciplinary Sciences**, 2008 v. 1, n. 1, p. 51-56, 2008. Doi: 10.6062/jcis.2008.01.01.0005. Available at: <http://www.epacis.net/jcisHYPERLINK>.

FREITAS, R. M.; ARAI, E.; ADAMI, M.; SOUZA, A. F.; SATO, F. Y.; SHIMABUKURO, Y. E.; ROSA, R. R.; ANDERSON, L. O.; RUDORFF, B. F. T. Virtual laboratory of remote sensing time series: visualization of MODIS EVI2 data set over South America. **Journal of Computational Interdisciplinary Sciences**, 2, n. 1, p. 57-68, 2011. Doi: 10.6062/jcis.2011.02.01.0032. Available at: <http://www.epacis.net/jcis>.

IBGE. **Mapa de Biomas do Brasil**: primeira aproximação. Rio de Janeiro: IBGE. 2004.

IBGE. **Manual técnico da vegetação brasileira adaptada a um sistema universal**. Rio de Janeiro, 1992. 92 p.

IBGE. **Manual técnico de uso da terra**. 2 ed. Rio de Janeiro, 2006. 91p.

MATO GROSSO DO SUL. Secretaria de Planejamento. **Macrozoneamento geoambiental do Estado de Mato Grosso do Sul**. Campo Grande: SEPLAN/FIPLAN, 1989. 242 p.

MAURO, R. de A.; CAMPOS, Z. Fauna. In: SILVA, J. S. V. (Org.) **Zoneamento Ambiental da borda Oeste do Pantanal:** Maciço do Urucum e adjacências. Brasília, DF: Embrapa Comunicação para Transferência de Tecnologia, 2000. cap. 9, p. 133-151. Acompanha 8 mapas.

POTT, A.; SILVA, J. S. V.; SALIS, S. M.; POTT, V. J.; SILVA, M. P. Vegetação e uso da terra. In: Silva, J.S.V. (Org). **Zoneamento Ambiental da borda Oeste do Pantanal**: Maciço do Urucum e adjacências. Brasília, DF: Embrapa Comunicação para Transferência de Tecnologia, 2000. p. 111-132. il. Acompanha 8 mapas.

POTT, A.; SILVA, J. S. V.; ABDON, M. M.; POTT, V. J.; RODRIGUES, L. M. R.; SALIS, S. M.; HATSCHBACH, G. G. Vegetação. In: PROGRAMA NACIONAL DO MEIO AMBIENTE (Brasil). **Plano de Conservação da Bacia do Alto Paraguai - PCBAP**: diagnóstico dos meios físico e biótico. Brasília, DF: Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal, p. 1-179, 1997. v. 2. t.1. Subcomponente Pantanal.

SILVA, J. dos S. V. da; POTT, A.; ABDON, M. de M.; POTT, V. J.; SANTOS, K. R. dos. **Projeto GeoMS**: cobertura vegetal e uso da terra do Estado de Mato Grosso do Sul. Campinas: Embrapa Informática Agropecuária, 2011. 64 p.

SILVA, J. dos S. V. da; SPERANZA, E. A.; VENDRUSCULO, L. G.; ESQUERDO, J. C. D. M.; MAURO, R. de A.; BIANCHINI, S. L.; FLORENCE, R. de O. **Projeto GeoMS**: melhorando o sistema de licenciamento ambiental do Estado de Mato Grosso do Sul. Campinas: Embrapa Informática Agropecuária, 2011. 64 p.

SILVA, J. dos S. V. da; ABDON, M. de M.; SILVA, S. M. A. da; MORAES, J. A. de. Evolution of deforestation in the Brazilian Pantanal and surroundings in the timeframe 1976 – 2008. **Geografia**, Rio Claro, v. 36, Número Especial, p. 35-55, jun. 2011.

SILVA, J. dos S. V. da; ABDON, M. de M.; ROSSI, M. Identificação de padrões de vegetação ciliar em imagens CBERS e respectivo estado de conservação. **Geografia**, Rio Claro, v. 34, Número especial, p. 629-641, dez. 2009.

SILVA, J. dos S. V. da; ABDON, M. de M.; BOOCK, A.; SILVA, M.P. da. Fitosionomias dominantes em parte das sub-regioes do Nabileque e Miranda, sul do pantanal. **Pesquisa Agropecuaria Brasileira**, Brasilia, DF, v.33, Numero especial, p.1713-19, out.1998.

SILVA, J. S.V.; ABDON, M. M; POTT, A. Cobertura vegetal do Bioma Pantanal em 2002. In: CONGRESSO BRASILEIRO DE CARTOGRAFIA, 23., 2007, Rio de Janeiro. **Anais...** Rio de Janeiro: SBC, 2007. p.1030 -1038. 1 CD – ROM.

SILVA, J. S. V.; ABDON, M. M.; SILVA, A. M.; SOUZA, L. A. Banco de dados de vegetação do projeto Probio-Pantanal. In: CONGRESSO BRASILEIRO DE CARTOGRAFIA, 23., 2007, Rio de Janeiro. **Anais...** Rio de Janeiro: SBC, 2007b. p. 1643 - 1652. 1CD – ROM.