

# ANALYSIS OF THE CONSERVATION STATE FROM THE PERMANENT PROTECTION AREAS AT THE SPRINGHEADS AND OF THE WATER FROM CABAÇAL RIVER DRAINAGE BASIN, MATO GROSSO STATE, BRAZIL

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## Abstract

The objective of this paper is to evaluate the conservation status of the Permanent Protection Areas (APPs) at the springheads and of the water from Cabaçal river drainage basin, in Mato Grosso state. The methodological procedures were digital image processing in a GIS and laboratory analysis of water, followed by quantification of Water Quality Indices and water conservation. The areas covered by vegetation within the drainage basin correspond to 22%, while agricultural/livestock activities use 76% of the area and less than 2% remain for reforestation. From the 6.034 springheads, 78% are in disagreement with the legislation. From the 5 sub-basins, 4 present Water Quality Indices classified as "High", and the sub-basin of Cabaçal river presented the worst Index, during both hydrologic seasons. The best Index was obtained by Branco river sub-basin. The sampling periods (dry and rainy season) did not show a seasonal influence on the results. One concludes that the losses of vegetation cover at the springheads of the drainage basin influenced negatively on the conservation indices of the water samples analyzed, although its physical-chemical and biological parameters were in accordance with the current legislation.

**Keywords:** Geo-technologies. Environmental Conservation. Pantanal. Upper Paraguai basin. Water Quality Index.

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## Resumo

### **Análise do estado de conservação das apps de nascentes e da água da bacia hidrográfica do rio Cabaçal, Mato Grosso-Brasil**

Objetivou-se avaliar o estado de conservação das Áreas de Preservação Permanente (APPs) das nascentes e da água da bacia hidrográfica do rio Cabaçal, Mato Grosso. Os procedimentos metodológicos foram constituídos por processamento digital de imagem em Sistema de Informação Geográfica e análises laboratoriais de água, com posterior quantificação dos Índices de qualidade da água e conservação da água. As áreas com cobertura vegetal na bacia correspondem a 22% enquanto as atividades agropecuárias a 76% e áreas de reflorestamento a menos de 2%. Das 6.034 nascentes 78% encontram-se em desacordo com a legislação. Das 5 sub-bacias 4 apresentaram Índices de Conservação da Água classificados como Alto, sendo que a sub-bacia das nascentes do rio Cabaçal apresentou o pior Índice, em ambos os períodos sazonais, enquanto que o melhor foi o da sub-bacia rio Branco. Os períodos de amostragem (seco e chuvoso) não apresentaram influência sazonal nos resultados. Concluiu-se que as perdas da cobertura vegetal das nascentes da bacia influenciam de maneira negativa nos índices de conservação das coleções hídricas analisadas, ainda que seus parâmetros físico-químicos e biológicos estejam em atendimento à legislação vigente.

**Palavras-chave:** Geotecnologias. Conservação Ambiental. Pantanal. Bacia Alto Paraguai. Índice de Conservação da Água.

## INTRODUCTION

The landscapes are submitted constantly to changes due to human actions which transform the scenarios. This action however is surpassing all plausible limits of land use, because:

The environments built up or transformed by human action occupy the largest part of the continents. Man transforms the space by felling forests, implantation of pastures and cultures, construction of roads, seaports, airports, water reservoirs, rectification and channelization of water flows, implantation of industries and urban areas (FLORENZANO, 2002, p. 81).

At the perspective to do a territorial and ecological analysis of the geographic space, the drainage basin is being considered as the basic unit for analysis and planning. According to Freitas & Kerr (1996, p. 44), a drainage basin "includes an area of natural formation, drained by a water course and its tributaries, upstream of a transversal section considered, where there is a convergence of the water from the basin". In this context the springheads are superficial manifestations of groundwater sheets which originate the water bodies (VALENTE; GOMES, 2005). Its conservation is directly related to the protection of the vegetation existing at its margins.

There is an environmental legislation which must be observed during land use, aiming to preserve the vegetation along water bodies, such as Law Nr. 12.651/2012 (BRASIL, 2012), which in its 3<sup>rd</sup> article defines the Permanent Protection Areas (APPs). These areas have the environmental function to preserve the water resources, the landscape, the geologic stability, the biodiversity, the genetic flow of fauna and flora, to protect the soil and assure the wellbeing of human population.

The CONAMA – *Conselho Nacional do Meio Ambiente* (National Environmental Council) resolution Nr. 303 from 2002 confirmed the Permanent Protection Areas around springheads, reiterating the missing protection of these environments and regulating the requirements of the Forest Code in force. As for the springheads, this code specifies a 50 m protection radius at its surrounding. It is understood that its physical importance in springhead areas affects the action of vegetation as a damper of the rain, impeding its direct impact on the soil and its gradual compaction (SILVA *et al.*, 2012, p .1501). More recently the Decree Nr. 7.830 from 2012, which refers to the Rural Environmental Cadastral and foresees at Article 19 the recovery of Permanent Preservation Areas, observing the minimum width for the restoration of marginal sections along water courses, when referring to rural properties (BRASIL, 2012).

In this sense, the need to monitor the APPs of the springheads is mandatory for planning the adequate land use of the area, minimizing the environmental damage. Santos *et al.* (1981) inform that there is a need for constant upgrading of land use information, so that its tendencies and scenarios can be analyzed. The use of Geo-technologies allow an adequate knowledge of environmental/geographical characteristics, strongly increasing the management of natural resources and easing the historical evaluation of deforestation (MARTINS; SILVA, 2007). In the environmental context, the spatial technologies have been largely used for mapping and analyzing the APPs, especially referring to land use conflicts and to the conservation of vegetation and water quality (NASCIMENTO *et al.*, 2005; OLIVEIRA *et al.*, 2008; SOARES *et al.* 2007; GRIPP JUNIOR *et al.*; 2010).

In this frame, the objective of this study is to evaluate the conservation status of the vegetation in Areas of Permanent Conservation (APPs) and of the water from the Cabaçal River Watershed, Mato Grosso state, due to its importance for the maintenance of the Pantanal biome, which depends on the inundation pulse for the establishment of its cycle. This is because the water which inundates the floodplain originates not only from in situ rainfall and from Paraguai river, but also from springheads and its sub-basins, located on the plateau.

## MATERIAL AND METHODS

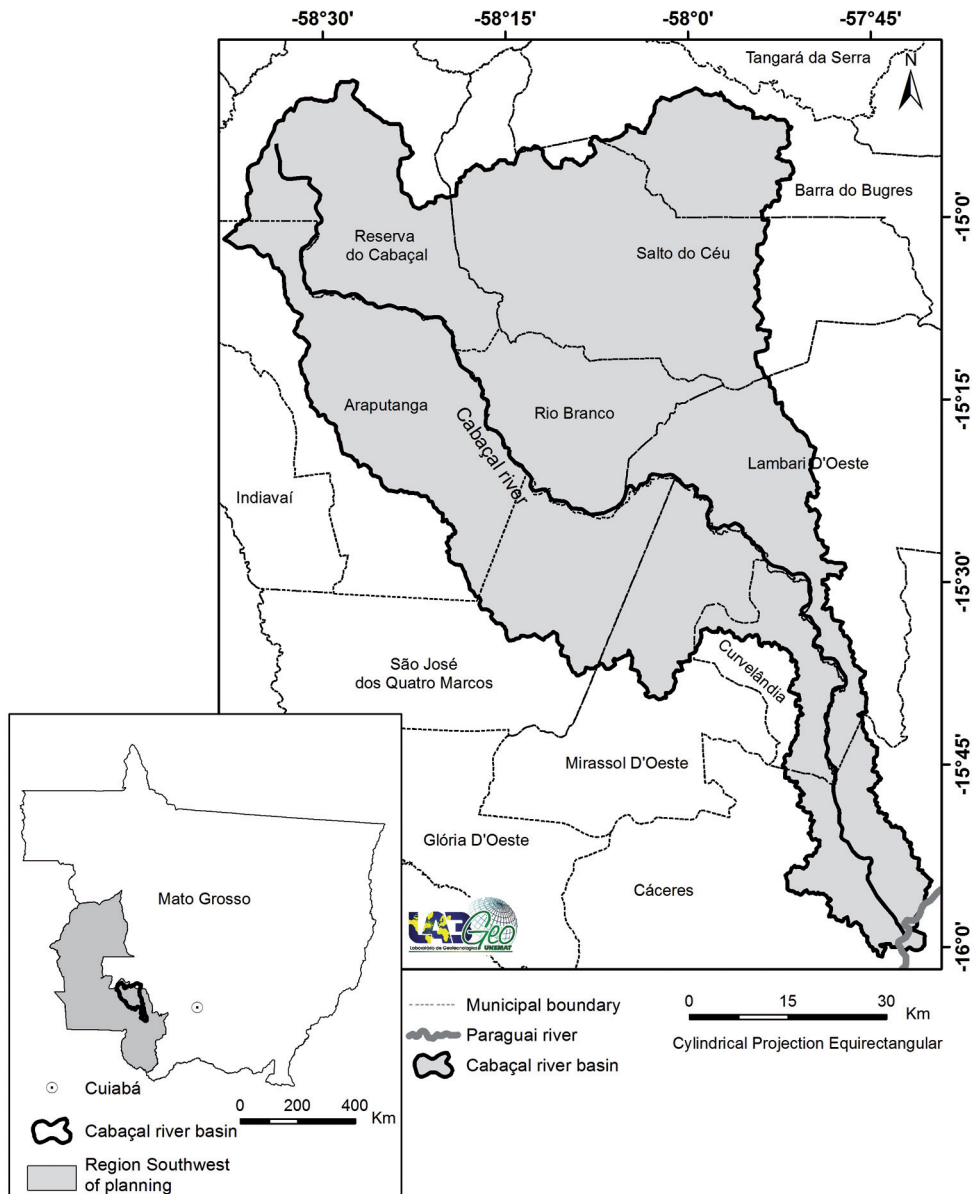
### *Study Area*

This study was done in the Cabaçal River Watershed covering an area of 6.042 km<sup>2</sup> (Figure 1), which is one of the sub-units of the Upper Paraguai Watershed (BAP). Its territory is distributed among 11 municipalities, which totalize 201,587 inhabitants (IBGE, 2015), whose main economic activity is livestock.

The cities within the area under study are: Araputanga, Barra do Bugres, Cáceres, Curvelândia, Lambari D'Oeste, Mirassol D'Oeste, Reserva do Cabaçal, Rio Branco, São José dos Quatro Marcos and Salto do Céu.

The average IDHM (Index of Municipal Human Development) of the above mentioned municipalities in this region is 0.615, demonstrating a growth of 25% compared to the same index from 2000 (PNUD, 2013).

The climate of the watershed under study is tropical humid, with well-defined yearly stations: a dry one from April to September and a rainy one from October to March (ANDRADE *et al.*, 2013).



**Figure 1 - Localization of the watershed under study in the Upper Paraguai Watershed and the respective municipalities in Mato Grosso state**

Source: Labgeo Unemat (2015).

## METHODOLOGY

For the land use and land cover analysis Landsat-8 - OLI (Operational Land Imager) images of frames 227/71, 228/70 and 228/71, 30 m resolution, dated Aug. 21<sup>st</sup> 2013 were acquired from the USGS Catalogue (2013).

A Geographic Databank (GDB) was created at software SPRING, version 5.2.6, from INPE (CÂMARA *et al.*, 1996), considering System UTM, 21 S and Datum SIRGAS 2000. The satellite images were imported to the GDB for the preparation of a mosaik and a mask of the area under study. Afterwards segmentation was performed, using the method of region growth with similarity 800 and pixel area of 1.200, sample collection for training, supervised classification (Bhattacharya classifier) and matrix/vector edition.

During the supervised classification, ten classes were identified for the elaboration of the land use/land cover map of the watershed after an analysis from the reports of the Project "Conservation and Sustainable Use of the Brazilian Biologic Diversity - PROBIO (BRASIL, 2004) and of the Technical Handbook on Vegetation and Land Use (IBGE, 2012).

In order to perform mapping of the springheads, software ArcGIS, version 9.2 (ESRI, 2007) was used, considering the method of visual RapidEye satellite image interpretation, with 6.5 m spatial resolution and made available by the Brazilian Ministry for Environment.

The validation of the springhead map was done by ground truth points, whose coordinates were registered by GPS, photographs and verification on high spatial resolution images available at Internet (Google Earth), for those places with difficult access.

On the springhead map, the tool Buffer, available at ArcGIS, was used for the delimitation of Permanent Protection Areas (APPs). To do that, a radius of 50 m was defined around the springhead, in accordance with the actual Brazilian Forest Code (BRASIL, 2012).

After the springhead map of the APPs was generated, it was used as a mask for the land use/land cover map, where the quantification and analysis on which land use/land cover classes exists at the springheads was made, identifying those areas with environmental degradation and conflict zones. Finally a layout of the map was elaborated as well as the quantification using the calculation of attributes from ArcGIS.

The Water Conservation Index, elaborated for the evaluation of the water conservation status in Mato Grosso do Sul state (VIEIRA *et al.*, 2013), was considered in this study. It was however modified for the calculation of coefficients from each municipality and divided by the state coefficient, which was generated by the sum of the municipal coefficients. In this study it was obtained by the calculation of the coefficient from each sub-basin divided by the coefficient from the entire basin. Since the sample collection points are located at the outlets of the sub-basins, the values reflect the water conservation status of each hydrographic sub-unit.

In just one of the sub-basins there are 3 water collection points due to the existence of a sugar mill, whose first point is located before the mill, the second one after the mill and the third one at the outlet from the sub-basin.

In order to obtain the CCA (Water Conservation Index) the following calculus was performed:

$$CCA = (IQA/100 + CMC)/2$$

where:

CCA = Water Conservation Coefficient;

IQA = Water Quality Index;

CMC = Coefficient of Riparian Forest: the value is 1, if  $SMC_{ex} > SMC_{leg}$  or  $SMC_{ex}/SMC_{leg} = 1$  ( $SMC_{ex}$  = Surface of existing Riparian Forest;  $SMC_{leg}$  = Surface of Riparian Forest specified in Legislation).

If CMC does not fit in the previous situation, the quartiles are applied, where the coefficients were defined, considering the subdivision of minimum width of riparian forest (50 m) required by the actual Forest Code, as follows: 0,25 (0 to 12,5); 0,5 (12,5 to 25); 0,75 (25 to 37,5) and 1 (>37,5 to 50).

The IQA classification adopted in this study was defined by the National Water Agency for the Mato Grosso state (BRASIL, 2015).

**Table 1 - Classes of Water Quality Index**

<b>IQA values</b>	<b>IQA evaluation</b>
91-100	Excellent
71-90	Good
51-70	Fair
26-50	Poor
0-25	Bad

Considering these values, the final equation of ICA is applied as follows:

$$ICA = (CCAsb/CCAb) * 100$$

Where:

ICA = Water Conservation Index;

CCAsb = Coefficient of Water in the sub-basin;

CCAb = Coefficient of Water Conservation calculated for all sub-basins of the watershed.

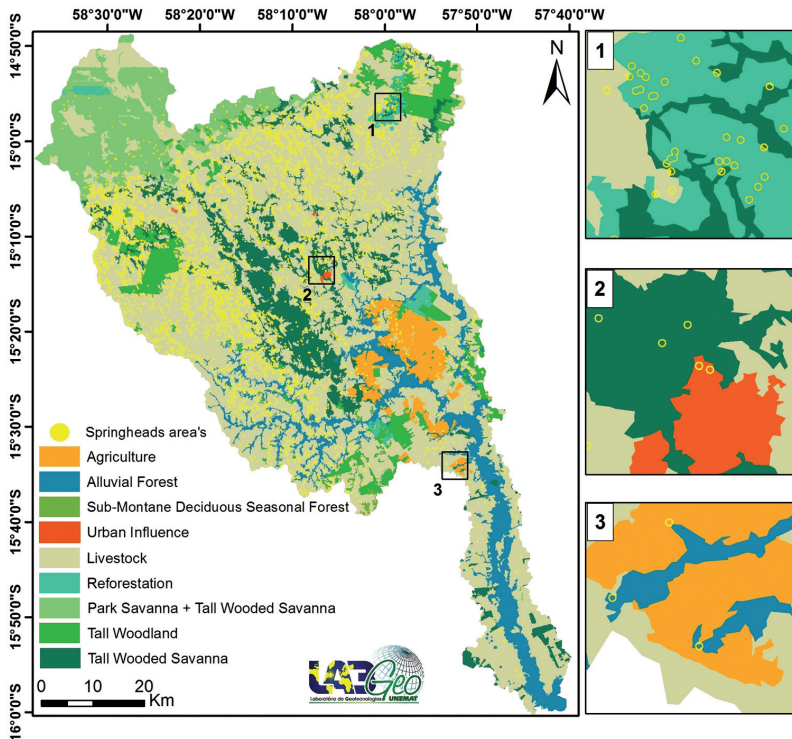
The ICA values obtained were ranked, in a scale from 1<sup>st</sup> to 5<sup>th</sup> place, due to the quantity of sub-basins and classified in the following intervals: 0-5 (Low), 5-10 (Medium) and >10 (High).

## RESULTS AND DISCUSSION

The Cabaçal River Watershed has 6.034 springheads, whose APPs of springheads correspond to 49,5 km<sup>2</sup> and 22% of this total (Table 1 and Figure 2) corresponds to vegetation cover.

**Table 2 - Thematic classes of vegetation cover in APPs of springheads from the Cabaçal River Watershed**

Classes of vegetation cover	Area (km <sup>2</sup> )
Ecotone between Savanna and Deciduous Seasonal Forest	0.54
Alluvial Forest	3.97
Sub-Montane Deciduous Seasonal Forest	0.28
Sub-Montane Deciduous Seasonal Forest + Secondary Vegetation	0.52
Sub-Montane Semi-Deciduous Seasonal Forest	0.11
Secondary Vegetation	0.03
Tall Wooded Savanna without riparian Forest	0.05
Tall woodland	0.31
Tall woodland + Tall Wooded Savanna	4.01
Park Savanna + Tall Wooded Savanna	0.92
<b>Total</b>	<b>10.81</b>



**Figure 2 - Land use, vegetation cover and APPs at the springheads of the Cabaçal River Watershed /Mato Grosso state**

Source: Labgeio Unemat (2015).

Those classes which present the largest areas of forest cover were Forest Savanna + Tall Woodland, which correspond to 37% and the Alluvial Forest with 36%. These physiognomies are characteristic for the Cabaçal River Watershed which taken together, correspond to 73% of the vegetation cover from the APPs of the springheads within the watershed.

The phyto-ecological classes corresponding to Secondary Vegetation, Tall Wooded Savanna without riparian Forest, Tall Woodland and Ecotone between Savanna and Deciduous Seasonal Forest perform jointly 8.61% of the total forest cover physiognomies. Similarly, the classes Sub-Montane Deciduous Seasonal Forest, Sub-Montane Deciduous Forest + Secondary Vegetation and Sub-montane Semi-Deciduous Seasonal Forest correspond to 8.42%. These are typical forests of places with higher slope gradients. According to Gouveia *et al.* (2013, p. 1050), based on the precepts from Almeida *et al.* (2010, p. 298), studies at secondary forests in the Brazilian Amazon region demonstrate that, as the occupation of a region is consolidated with the increase of deforestation and land use by livestock, the abandonment of land and consequently the formation of secondary vegetation is reduced.

The land use corresponds to 78% of the APPs from the area under study. A similar situation was identified by Passos *et al.* (2010, p. 37), who verified the advancement of agriculture in areas with predominant original vegetation, due to edaphic-climatic and economic favorable conditions in the region. The same precepts were pointed out by Pessoa *et al.* (2013, p. 18), demonstrating that the native vegetation at the middle course from the Paraguai river was reduced to 19.85% of its area in 2001 and 3.79% in 2011.

Livestock activities predominate at the springhead APPs, corresponding to 97% of land use. It is a plausible result because the economy of the municipalities within the basin under study is based on this activity (Table 2 and Figure 2). According to Santos *et al.* (2013, p. 880), livestock at the springheads of Cabaçal river, in medium-sized properties, has contributed to silting of rivers in the region, especially with the appearance of large gullies and the consequent loss of soil.

**Table 3 - Thematic classes of land use at the APPs on the springheads of Cabaçal River Watershed**

<b>Classes of land use</b>	<b>Area (Km<sup>2</sup>)</b>
Agriculture	0.44
Urban influence	0.04
Livestock + Secondary vegetation	37.55
Reforestation	0.61
<b>Total</b>	<b>38.64</b>

The occurrence of pasture, characterized by the presence of grass, destined to animal nutrition does not guarantee an efficient soil cover, constituting a problem for the municipalities of the region, due to its degradation, as pointed out in the Long-Term Plan of Mato Grosso state (MATO GROSSO, 2012) and by Neves *et al.* (2011, p. 423). This document confirms that the increasing occupation of southwest Mato Grosso state caused the deforestation of a large portion from the natural vegetation for livestock



activities without adequate land use and management, originating areas with high environmental fragility and susceptibility to erosion.

Pastures covered with grass suffer under soil compaction caused by animal trampling causing the extinction of springheads. Calheiros *et al.* (2004, p. 26), inform that trampling compacts the soil surface close to the springheads, reduces the infiltration capacity, causing laminar erosion, causing water contamination by soil particles and also silting. In the Paraguai/Jauquara (Mato Grosso state) watershed, one of the Upper Paraguai Basin sub-units, Casarin *et al.* (2008, p. 37), verified that the riparian forests along rivers were degraded due to land use/land cover, generally by cultivated pasture, besides other types of human actions.

Class "Agriculture" totalizes 1.13% of the area under study, with predominance of sugar cane, an increasing and worrying activity in southwest Mato Grosso state, because cultures with high utilization of chemical products must be further away from water bodies to avoid contamination. Armas *et al.* (2007), identified in their studies in São Paulo state that the occupation of the above mentioned watershed with sugar cane is worrying, because the chemical products used, present high toxicological levels, with a strong tendency to reach the water bodies.

The reforestation areas totalize 1.57% in APPs and must be analyzed carefully because, depending on the species used, its quantity and localization, it can interfere on the conservation of biodiversity. However its benefits must be considered, because reforestation is efficient for the protection of the drainage net in regions with erosion processes occurring (CARDOSO, 1988, p. 109), besides attending the economic needs for the substitution of forest felling, whose regeneration is slow.

Among the sub-basins of the area under study, the one of Bugres river presents most springheads with conflicts of its use, mainly due livestock activities in the municipalities of Araputanga, Mirassol D'Oeste and São José dos Quatro Marcos (Table 3). According to Avelino (2006, p. 252), most tributaries of Cabaçal river, are suffering silting due to inadequate land use wherein at Bugres river, affluent of Cabaçal river, in spite of its margins are a little more preserved, the silting process originated at its springheads is intense.

**Table 4 - Conserved APPs and those in conflict of land use at the sub-basins of Cabaçal River Watershed**

Sub-basin	Area Basin	Conserved APPs		APPs with conflict of land use		APP	Municipalities	
		Km <sup>2</sup>	%	Km <sup>2</sup>	%			
Springheads river	Cabaçal	829,32	6.02	90.43	0,64	9.57	6,66	Araputanga (24.66%) and Reserva do Cabaçal (75.34%)
Branco river		886,67	2.58	22.26	9,01	77.74	11,59	Lambari D'Oeste (0.95%), Reserva do Cabaçal (8.41%), Rio Branco (35.62%) and Salto do Céu (55.02%)
Bugres river		1.182,08	1.24	11.37	9,63	88.18	10,93	Araputanga (42.29%), Curvelândia (0.50%), Lambari D'Oeste (0.08%), Mirassol D'Oeste (24.41%) and São José dos Quatro Marcos (32.72%)
Vermelho river		1.353,38	1.67	16.95	8,16	83.05	9,82	Barra do Bugres (26.28%), Lambari D'Oeste (21.73%), Rio Branco (1.51%) and Salto do Céu (50.48%)
Inter-basin of Cabaçal river		1.416,77	2.01	27.23	5,36	72.77	7,37	Araputanga (10.13%), Cáceres (22.72%), Curvelândia (14.96%), Lambari D'Oeste (21,6%), Mirassol D'Oeste (6.27%), São José dos Quatro Marcos (5.39%), Reserva do Cabaçal (2.99%) and Rio Branco (15.97%)

The Araputanga municipality presents most APPs of springheads with land use conflict (25.38%) related to the thematic class Livestock + Secondary Vegetation followed by Salto do Céu, São José dos Quatro Marcos, Rio Branco and Reserva do Cabaçal which represent 24.23%; 7.27%; 7.05% and 5.73% respectively (Table 4). According to Nunes *et al.* (2013, p. 191), in the municipality Salto do Céu/Mato Grosso state), even in places of reduced human activity and with little medium height vegetation, if the soil is extremely susceptible to erosion, the potential to erosion is high. The results found by Pessoa *et al.* (2013, p. 20), Grossi (2006, p. 25) and Serigatto (2006, p. 93), on the land use at the inter-basin of the Paraguai river inter-basin (Mato Grosso state), Queima Pé river basin (MT) and Sepotuba River basin (MT) respectively, agree with those found in this study, because they verified that there was an increase of land use related mainly to livestock and agriculture.

**Table 5 - Areas in Km<sup>2</sup> of thematic land use and land cover classes in APPs in the municipalities of Cabaçal River Watershed**

Municipalities	Ag	SNT	SNT+Vs	Fa	Fs+Vs	Iu	Ap+Vs	Rf	Sd	Sd+Sa	Tp+Sa	Vs	Vs+Fs	Land Use (%)
Araputanga	...	0,268	...	0,809	0,119	...	12,563	...	...	0,783	0,089	...	...	12.563
Barra do Bugres	...	0,043	0,227	0,387	...	...	1,991	0,548	0,164	0,000	...	0,038	...	2.539
Cáceres	...	...	...	0,010	...	...	0,116	...	...	...	...	...	...	0.116
Curvelândia	0,024	...	...	0,033	...	...	0,217	...	...	...	...	...	...	0.241
Lambari D'Oeste	0,240	0,031	...	0,239	...	...	0,622	0,013	0,106	0,023	...	...	...	0.875
Mirassol D'Oeste	0,042	0,032	...	0,176	...	...	0,524	0,012	...	0,014	...	...	...	0.578
Reserva do Cabaçal	...	...	...	0,293	...	...	2,842	...	...	0,442	0,580	...	...	2.842
Rio Branco	...	...	...	0,341	...	0,016	3,491	0,016	...	1,438	...	...	...	3.522
São José dos Q. Marcos	0,033	0,060	...	0,558	...	...	3,763	...	...	0,097	...	...	...	3.795
Salto do Céu	...	0,293	0,074	0,753	...	...	11,995	...	...	1,251	0,255	...	0,228	11.995

**Legend:** Ag: Agriculture; SNT: Ecotone between Savanna and Deciduous Seasonal Forest; SNT+Vs: Ecotone between Savanna and Deciduous Seasonal Forest with Secondary Vegetation; Fa: Alluvial Forest; Fs+Vs: Sub-Montane Semi-Deciduous Seasonal Forest with secondary vegetation; Iu: Urban influence; Ap+Vs: Livestock with Secondary Vegetation; Rf: Reforestation; Sd: Tall Woodland; Sd+Sa: Tall Woodland + Tall Wooded Savanna; Tp+Sa: Park Savanna + Tall Wooded Savanna; Vs: Secondary Vegetation; Vs+Fs: Secondary Vegetation with Sub-Montane Deciduous Seasonal Forest.

In this context, the information obtained by the Water Conservation Index (ICA) verified during the rainy period for the sub-units of Cabaçal River watershed, demonstrate that the Branco river (2) sub-basin presents the best ICA (Table 5), showing the intimate relation between the conservation state of the riparian forest, which is in consonance with what is foreseen in the legislation and in the Water Quality Index (IQA).

A similar fact was pointed out at the Bugres river basin (3) which attended the width of the riparian forest required by legislation and IQA, classified as "Good", which ranked it the second place. Ferreira and Dias (2004, p. 618), emphasized in their study that the presence of riparian forest reduces significantly the possibility of water contamination in rivers by sediments conducted in surface water flow. Although it occupies the 2<sup>nd</sup> position, the Bugres river sub-basin (3) pointed an ICA above 21, due to a forest extract around the springhead and to the IQA of 73.4. In spite of presenting a BOD (Biochemical Oxygen Demand) at the acceptable minimum by the CONAMA Resolution Nr. 357/2005 (BRASIL, 2005), the low turbidity value was one of the parameters which contributed for the "Good" classification.

**Table 6 - Water Conservation Index of sub-basins from the Cabaçal river watershed in the rainy period**

Sub-basin	Altitude	IQA	Class. IQA	Riparian Forest	CMC	CCAsb	ICA	Classification	Ranking
1	285,90	78	Good	Doesn't attend	0,25	0,5130	12,9316	Medium	5 <sup>th</sup>
2	170,34	81,1	Good	Attends	1	0,9055	22,8258	High	1 <sup>st</sup>
3	144,63	73,4	Good	Attends	1	0,8670	21,8553	High	2 <sup>nd</sup>
4	157,62	67,1	Reasonable	Attends	1	0,8355	21,0612	High	4 <sup>th</sup>
5	114,61	69,2	Reasonable	Attends	1	0,8460	21,3259	High	3 <sup>rd</sup>
<b>CCAb</b>						3,967			

Sub-basins = 1 Springheads of Cabaçal river; 2 Branco river ; 3 Bugres river; 4 Vermelho river and 5 Inter-basin of Cabaçal river.

Almeida and Schwarzbold (2003, p. 88), emphasize this tendency, demonstrating that the existence of a large area with pasture cover contributes strongly to the increase of turbidity, and much more if forests would predominate there.

On the other hand, the sub-basin Springheads of the Cabaçal River (1) presented the worst ICA, possibly because the APP is in violation of the Law, although IQA was classified as "Good". The inter-basin of Cabaçal river (5), which includes the mouth of Cabaçal river, in spite the width of its APP is larger than defined by Law, was classified with one of the lowest IQA values. This can be attributed to the high level of dissolved oxygen found in the samples, possible due to the presence of a sugar-energy plant located in this inter-basin. Data from the Environmental Institute of Mato Grosso do Sul - IMASUL (MATO GROSSO DO SUL, 2013, p. 37), demonstrate that those areas covered with sugar cane where vinasse is applied, originated from the industrial area during the rainy season, may cause the depletion of dissolved oxygen in the river with the entrainment of this residue.

The Vermelho river sub-basin (4) presented a high ICA and, even though its riparian forests attend to the current legislation, it was ranked at the penultimate position, due to the worst IQA value. The low concentrations of dissolved oxygen can be attributed to the high values of fecal coliforms in the water, which may be related to an input of domestic sewage. Alberto and Ribeiro Filho (2012, p. 176), warned that the reduction of OD concentrations are an indicator for the presence of domestic sewage. Analogous precepts were pointed out by CARVALHO *et al.* (2000), who affirmed that the excess of organic material in the water caused the reduction of OD content in the water and that during the decomposition process there is oxygen consumption in an aquatic environment.

All analyzed sub-basins during the humid period, except for the springhead sub-basins of Cabaçal river, had high ICA values, as it was found by Vieira *et al.* (2013), who reported that the ICA from all municipalities of the state were classified as "High".

For the dry season the ICAs in general presented a high level of classification (Table 6). Except for the sub-basin Springheads of Cabaçal river (1) which exhibited for both wet and dry seasons an "Average" classification, presented the worst ICA.

The sub-basin of Branco river remained at the 1<sup>st</sup> ranking position of ICA, classified as "High", with a "Good" classification for its water quality, in accordance with the criteria of Mato Grosso state (BRASIL, 2015). In this hydrographic unit, the rivers present riparian vegetation, with little deforestations. According to Jardim (2010, p. 25), the riparian forests have a high absorption capacity and adsorption which work as filters of the water that flows from the highest parts to the water courses.

The second position of the ICA classification was occupied by the sub-basin of Bugres river (3), which presented good water quality and riparian forests at its water courses in conformity with the legal precepts.

**Table 7 - Index of Water Conservation at Cabaçal river basin during the dry period**

Sub-basins	Altitude	IQA	Class. IQA	Riparian forest	CMC	CCAb	ICA	Classification	Ranking
1	285,90	81,10	Good	Doesn't attend	0,25	0,5305	12,9595	Average	5 <sup>th</sup>
2	170,34	81,00	Good	Attends	1	0,9050	22,1082	High	1 <sup>st</sup> o
3	144,63	80,80	Good	Attends	1	0,9040	22,0837	High	2 <sup>nd</sup> o
4	157,62	74,70	Good	Attends	1	0,8735	21,3387	High	4 <sup>th</sup> o
5	114,61	76,10	Good	Attends	1	0,8805	21,4987	High	3 <sup>rd</sup> o
<b>CCAb</b>						4,0935			

Sub-basins = 1 Springheads of Cabaçal river; 2 Branco river ; 3 Bugres river; 4 Vermelho river and 5 Inter-basin of Cabaçal river

Similar situations were found at hydrographic sub-units which occupied the 3<sup>rd</sup> and 4<sup>th</sup> positions of ICA, although presenting the lowest IQA values.

One perceives a tendency of parameter equivalence for the dry season, which obtained similar values in all sub-basins. A difference was noted for the sub-basin Springheads of Cabaçal river, due to the inexistence of APP in some rivers of this sub-basin, which interfered in the conservation coefficient of the riparian forest (CMC), influencing its ICA. Piasentin *et al.* (2009, p. 311), report that the associated changes in landscape and vegetation interfere in the hydrologic balance and on the water quality controlling processes and that the small scale human effects are relevant for the entire hydrographic basin. This explanation corroborates to understand the average performance of the ICA.

Curiously one notes that there was no seasonal influence on the ranking of the sub-basins which kept up similarly during the wet and dry seasons, contrary situation to that one pointed out by Almeida & Schwarzbold (2003), who report a clear seasonal interference on the water quality in their studies in Rio Grande do Sul state.

Due to the ICA presented by the sub-basins, the Water Conservation Coefficient from the basin (CCAb) from Cabaçal river was lower during the rainy period, although

there was a higher water volume in the rivers. This denouement can be attributed to the IQA values which, when compared with those from the dry period, present a lower performance.

## **FINAL CONSIDERATIONS**

The evaluation of the conservation status of the Permanent Protection Areas (APPs) at the Cabaçal river watershed, demonstrated that there were losses of vegetation cover, hampering the conservation of this type of water body, in disagreement with what was established by Law 12.651/2012.

Among the sub-basins of Cabaçal river watershed, the one of Bugres river presents most APPs at springheads with conflicts on its use, located at municipalities Araputanga, Curvelândia, Lambari D'Oeste, Mirassol D'Oeste and São José dos Quatro Marcos. Among these municipalities Araputanga has most APPs in conflict to its use, within the Cabaçal river hydrographic basin.

The Water Conservation Index for the five hydrographic sub-units under study demonstrates that for both wet and dry periods, the worst status was the one of Inter-basin Springheads of Cabaçal river, a worrying situation, because in this sub-basin the springheads of Cabaçal river are localized. On the other hand, the best ranking was for the Sub-basin of Branco river, presenting high indices during both periods.

The degradation of the APPs at the springheads of Cabaçal watershed, may carry a risk to the biome and the Pantanal floodplain, because it affects the regional hydrologic dynamics, with consequences for the inundation pulse at the Upper Paraguai Basin.

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