ASSESSMENT OF THE ARBOREAL SPECIES DIVERSITY AND CORRELATION BETWEEN THE SPECIES DISTRIBUTION AND SOIL CHARACTERISTICS AMONG PARAGUAY RIVER ISLANDS, SECTION BETWEEN CACERES AND TAIMÃ ECOLOGICAL STATION, PANTANAL, BRAZIL

Solange Kimie IKEDA CASTRILLON[1]
Carolina Joana DA SILVA[2]
José Ricardo Castrillon FERNANDEZ[3]
Ronaldo José NEVES[4]
Ingrid LEITE[5]

Abstract

This study assessed the diversity of trees in six islands of Paraguay River, between Caceres and Taimã Ecological Station in Pantanal, Brazil. These islands originated from two geomorphologic processes: meander neck rupture and sedimentation, which were compared. A Canonical Correspondence Analysis and a Cluster and Discriminant Analysis were used to determine the correlations between the abundance of tree species and the variables of soil attributes (chemical and textural properties). Geo-technologies such as remote sensing imagery and GPS were important tools used during this work. The group formed by the most frequent and abundant species in the islands *Sapium obovatum*, *Psidium nutans* and *Laetia americana* was positively correlated with soil properties that presented high values in the islands, such as magnesium and saturation of magnesium, aluminum, clay and silt.

Key words: Diversity. Soil. Fertility. Flood.

Resumo

Avaliação da diversidade arbórea e correlação entre a distribuição das espécies e as caracteristicas dos solos em ilhas do Rio Paraguai entre Cáceres e Estação Ecológica de Taiamã, Pantanal Matogrossense, Brasil

Este estudo avaliou a diversidade da vegetação arbórea em seis ilhas do rio Paraguai, entre Cáceres e a Estação Ecológica de Taiamã, Pantanal Matogrossense. Foram comparadas ilhas formadas por dois processos geomorfológicos: a partir do rompimento do colo do meandro do canal e de sedimentação. Análise de Correspondência Canônica, Análise de Cluster e Discriminante foram utilizadas para verificar as correlações entre a abundancia das espécies arbóreas e as variáveis dos atributos do solo (propriedades químicas e texturais). Geotecnologias como imagens de sensoriamento remoto e GPS foram ferramentas importantes na execução deste trabalho. O grupo formado pelas espécies mais freqüentes e abundantes nas ilhas: *Sapium obovatum*, *Psidium nutans* e *Laetia americana*, correlacionou positivamente com atributos do solo que nas ilhas apresentaram altos valores, como magnésio e saturação por magnésio, alumínio trocável, argila e silte.

Palavras-chave: Diversidade. Solos. Fertilidade. Inundação.

[1] Mato Grosso State University, Cáceres *Campus*, Assistant Professors at the Department of Biological Sciences. Av. São João s/n. Bairro Cavalhada. CEP: 78200-000. Cáceres-MT, Brasil. E-mail: solangeikeda@gmail.com

[2] Mato Grosso State University, Cáceres *Campus*, Assistant Professors at the Department of Biological Sciences. Av. São João s/n. Bairro Cavalhada. CEP: 78200-000. Cáceres-MT, E-mail: ecopanta@terra.com.br

[3] Federal Institute of Education, Science and Technology of Mato Grosso - Cáceres *Campus*. Assistant Professor. Av. dos Ramires S/N, Distrito Industrial - CEP: 78200-000. Cáceres-MT, Brasil. E-mail: jrcastrillon@gmail.com

[4] Mato Grosso State University, Cáceres *Campus*, Assistant Professors at the Department of Geography. Av. São João s/n. Bairro Cavalhada. CEP: 78200-000. Cáceres-MT. E-mail: rjneves@terra.com.br

[5] Mato Grosso State University, Cáceres *Campus*, Expert in Agrarian Residency. Av. São João s/n. Bairro Cavalhada. CEP: 78200-000. Cáceres-MT, Brasil. E-mail: ingleite@gmail.com

INTRODUCTION

The diversity of the Pantanal can only be understood considering a continental approach, since it is located among three large morpho-climatic and phyto-geographic domains in South America: *Cerrado*, *Chaco* and *Pre-Amazonia*, and it behaves, from a phyto-geographic point of view, as a fragile zone of ecological tension (AB'SABER, 2006, p.65).

In Mato Grosso, Pantanal also has a flooded area characterized by a rich diversity of habitats, species and processes. The ecology of this region is determined by the flood pulse which depends on the geometry of the system, including the total quantity and periodicity of river discharges and its flow on flooded plains, the form of riverbeds, and the sedimentary load (JUNK; DA SILVA, 1999, p.25).

The fluvial-morphological peculiarities of several rivers result in different intensities, flood durations, soil features and vegetation types, leading to the formation of distinct Pantanal regions (ADÁMOLI, 1986, p.105). Additionally, Silva & Abdon (1998, p.1706) considered the geopolitical division to propose eleven sub-units named sub-watersheds or sub-regions: "*Pantanal de Cáceres*", the region of this study; "*Poconé*"; "*Barão de Melgaço*"; "*Paraguai*"; "*Paiaguás*"; "*Nhecolândia*"; "*Aquidauana*"; "*Miranda*"; "*Abobral*"; "*Nabileque*" and "*Porto Murtinho*".

Among the studies relating floristic and phyto-sociological composition to soil and vegetation at the Pantanal in Mato Grosso, those ones of Duarte (2007, p.110), carried out at "*Pantanal de Barão de Melgaço*", and of Soares & Oliveira (2009, p.276), at "*Pantanal de Miranda*", related edaphic factors to "*paratudais*", formations with mono-dominance of *Tabebuia aurea* Benth. & Hook.f ex. S. Moore. In addition, Salis (2006, p.239) studied the abundance and the distribution of tree species, as well as their correlations to soil fertility in areas of *Cerradão* (savanna woodland) at the Pantanal in Mato Grosso do Sul State, while Cardoso *et al*. (2010, p.1034) reported that the conversion of native forests into pastures cultivated at Pantanal reduces carbon storage in the soil.

Pantanal soils are generally influenced in their formation since they are originated from the upland where Latosols, weathered soils and soils rich in aluminum oxides predominate (COUTO; OLIVEIRA, 2009, p.75). These soils have peculiarities due to its topographical location and the water regime to which they are subjected; these pedologic characteristics must be considered for their use and management (SOARES *et al*. 2006).

A geomorphologic partitioning of "*Pantanal de Cáceres*" was carried out by Assine and Silva (2009, p.190) and Silva (2010, p.19) using satellite images to recognize the morphological elements (active channels, point bars, levees, abandoned meanders, oxbow lakes, paleo-channels, channel rupture sites, avulsion etc.) that are important to understand the diversity of soils and plant species in the area under study. Between the urban area of Cáceres and Taiamã Ecological Station at Paraguay River, Souza *et al.* (2007, p.35) verified islands formed from the meander neck rupture and from the sedimentation process.

The six islands investigated on the Paraguay River, between Cáceres and Taiamã Ecological Station, constitute morphological elements composing the Pantanal landscape at Cáceres, where Eutrophic Gley soil predominate, with clay presenting high cation exchange capacity (SOARES *et al.*, 2006).

OBJECTIVE

To compare the arboreal diversity among islands formed due to a meander neck rupture and sedimentation process, analyzing the correlations between arboreal species distribution and variables of soil attributes.

MATERIAL AND METHODS

The area under study includes six islands located in Paraguay River between the urban area of Cáceres city, Mato Grosso State, and Taiamã Ecological State at Pantanal in Mato Grosso, between geographical coordinates S 16º08'05.3" S W 57º43'49.3" W and S 16º48'57.4" and W 57° 37'46.9" W (Figure 1).

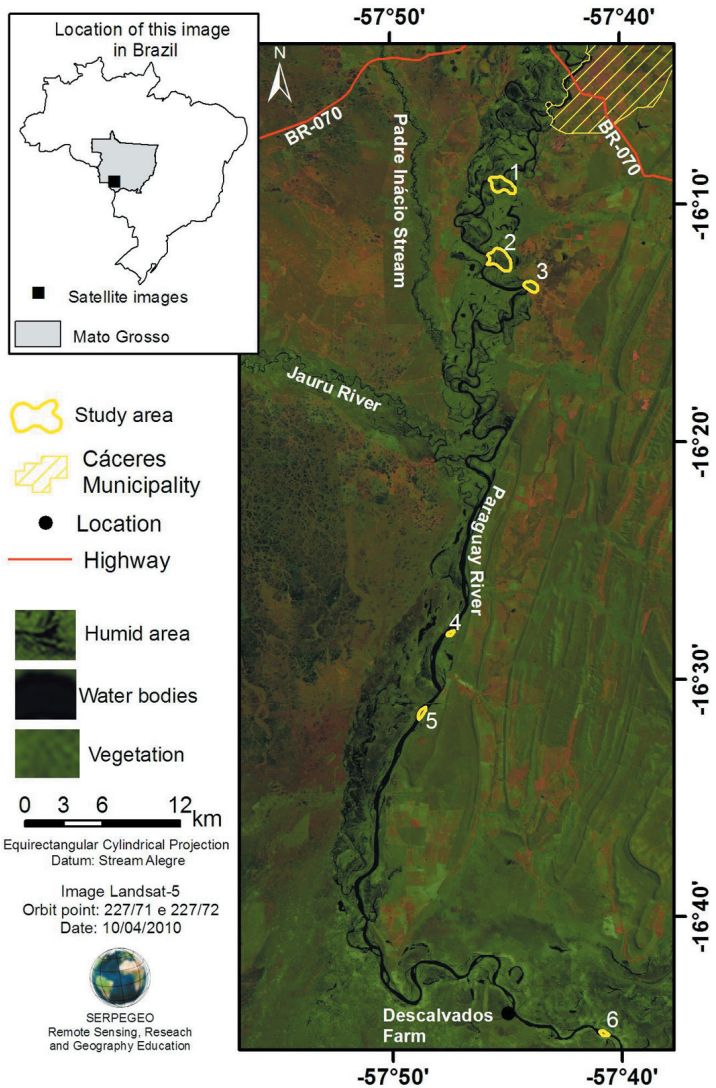

Figure 1 – Location of the study areas constituted of islands situated in Paraguay River between Cáceres and Taiamã Ecological Station at Pantanal in Mato Grosso, Brazil

These islands are submitted to inundation during the flooding period and are situated within the following geomorphologic compartments of Pantanal at Cáceres: Meander plain with meandering channel, Meander plain with straight channel and Current depositional lobe of the Paraguay fan (SILVA, 2010, p.20).

Islands 1, 2 and 3, with coordinates in the central area between S 16°09'02.5" and W 57°45'16.3"W, S 16°12'08.7" and W 57°45'23.9"W, and S 16°13'24.7" and W 57°43'59.4" respectively, are located in the compartment Meander plain with meandering channel and show a sinuosity index ranging from 1.5 to 2.2. The islands in this compartment were formed as a result of the meandering dynamics of abandonment and creation of a new channel by the Paraguay River from the rupture of the channel neck.

Islands 4 and 5 (geographical coordinates: S 16°27'59.5" and W 57°47'33.4", and S 16°31'18.1" and W 57°48'49.5"W) are located in the Meander plain with straight channel, where Paraguay River channel differs from the previous compartment due to its low sinuosity (index ≤ 1.1) and the island formation is due to the deposition process.

Island 6 (geographical coordinates: 16°44'50.8"S and 57°40'59.3"W) is located in the current depositional lobe of the Paraguay, where the Paraguay River is meandering but differently from that one of Meander plain with meandering channel, due to the lower sinuosity of the former. Its formation process is the same as that of islands 4 and 5, sediment deposition and consequent colonization by vegetation. Therefore the islands were grouped in two categories due to its geomorphologic formation processes: channel neck rupture (islands 1, 2 and 3) and deposition (4, 5 and 6).

The digital processing of the images from TM Landsat 5 and HRC of CBERS 2B were carried out using SPRING 4.3.3 (CÂMARA *et. al*., 1996) software, involving the steps of recording, color space transformation (RGB-IHS-RGB) according to Tu *et al*. (2001), cutting of the areas under study, segmentation and classification of the investigated areas, discriminating three classes: Arboreal vegetation, Flooding fields and Water. Layouts were prepared in ArcGis of Esri. A field survey was carried out to validate the classification of images, and check those classes which raised doubts during the interpretation step, using a GPS.

The thematic maps generated supported the selection of sites for the establishment of 22 plots, distributed in edge and central areas, occupied by arboreal vegetation, as exemplified in figure 2. Plots had a size of 10m x 20m, totaling 200m^2 per plot, considering for this study all trees with DBH (Diameter at Breast Height) ≥ 5cm.

The floristic similarity among the islands was analyzed by an agglomerative classification using UPGMA (Unweighted Pair Groups Method using Arithmetic Averages) (JAMES; McCULLOCH, 1990, p. 129). The classification through UPGMA resulted in dendrograms based on simple clustering and Euclidean distance of Sorensen's similarity indexes, which indicates the hierarchies among the groups formed.

A hand auger was used to collect random samples from 15 points per plot at 0 to 20 cm depth for analysis of the chemical and granulometric characteristics of the soils. For waterlogged soils, cuts were done using a machete at the established depth to allow collections. Soil samples from each plot were homogenized to obtain a composite sample of around 500 g.

Soil samples were stored in plastic bags which were labeled and sent to "Agro Análise" Lab (Cuiabá, Mato Grosso) for the determination of the following attributes: hydrogen potential (pH in water), levels of potassium (K) (mg/dm^3), phosphorus (P) (mg/dm^3), calcium (Ca) (cmol$_c$/dm^3), magnesium (Mg) (cmol$_c$/dm^3), hydrogen (H) (cmol$_c$/dm^3), aluminum (Al) (cmol$_c$/dm^3), sum of bases (SB) (cmol$_c$/dm^3), cation exchange capacity (CEC) (cmol$_c$/dm^3), base saturation (S) (%), organic matter (OM) (g/dm^3), calcium (Ca) (%), magnesium (Mg) (%), potassium (K) (%), hydrogen (H) (%) and aluminum (Al) (%), and proportions of sand, silt and clay (g/Kg). The laboratory procedures followed the protocol of EMBRAPA (1997, p.3-180).

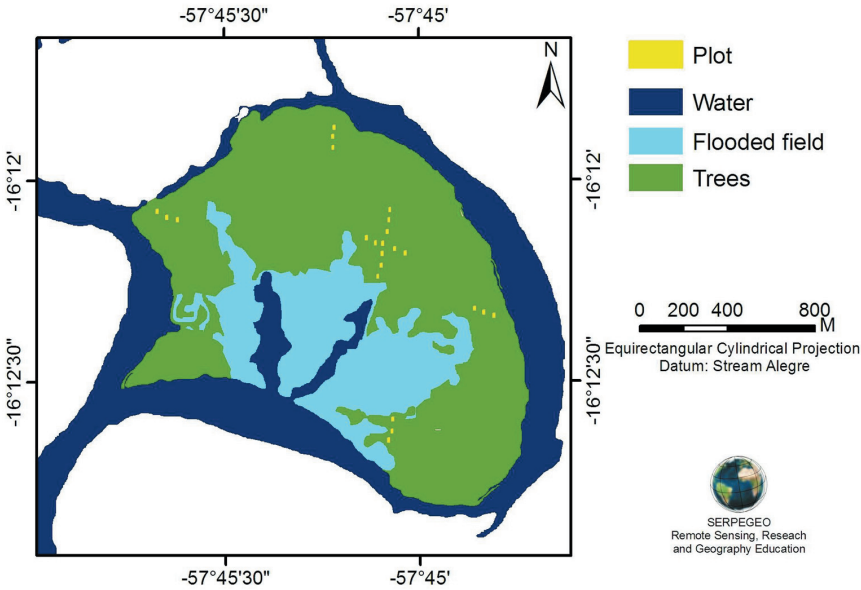

Figure 2 - Distribution of plots for surveying the tree species

Soil attributes among the islands were subjected to Lilliefors' normality test and evaluated by ANOVA (Analysis of Variance) and multiple comparison among means using Tukey's test. After logarithmization (P and H) and removal of outliers (O.M.), the variables without normal distribution (sand, silt and clay) were assessed using Kruskal-Wallis test, followed by Dunn's test, using the software BioEstat 5.0 (AYRES *et al*., 2003).

Correlations among arboreal species distribution and variables of soil attributes (chemical and textural properties) were established using a mixed gradient analysis and evaluated by means of a Canonical Correspondence Analysis – CCA (TER BRAAK, 1987, p. 170). Currently, this multivariate analysis has been recommended when the objective is to obtain a closer relationship between environmental variables and species abundance. The species matrix was constituted by the number of individuals per species in each plot, using species with five or more individuals.

The average of each variable was determined per species and considered an attribute associated with the number of individuals (TER BRAAK, 1987, p. 170). The average of variables per species were considered to perform a cluster analysis according to the minimum variance method, resulting in clusters of species based on dissimilarity, followed by discriminant analysis using the XLSTAT system, version 2009 (trademark Addinsoft). For multivariate analyses, data were standardized considering that the chemical and physical attributes of the soils studied in this work are constituted by units of different measures.

RESULTS AND DISCUSSION

The classifications of fused remote sensing imagery, with medium resolution, allowed the generation of thematic maps from the islands, distinguishing the classes Flooded field and Forest vegetation (Figures 3 and 4), and the estimate of the percentages of the areas in each mapped class, as shown in tables 1 and 2.

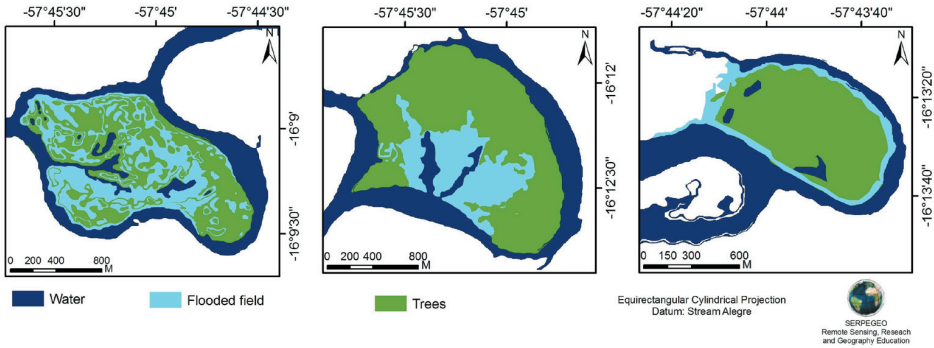

Figure 3 - Distribution of the classes flooded field and arboreal vegetation in islands 1, 2 and 3

Table 1- Percentage of vegetation classes in islands 1, 2 and 3

Island 1			Island 2			Island 3		
Classes	Areas		Classes	Areas		Classes	Areas	
	ha	%		ha	%		ha	%
Flooded field	72,85	45,87	Flooded field	54,26	26,86	Flooded field	13,17	19,72
Arboreal vegetation	85,97	54,13	Arboreal vegetation	147,76	73,14	Arboreal vegetation	53,61	80,28
Total	**158,82**	**100**		**202,02**	**100**		**66,78**	**100**

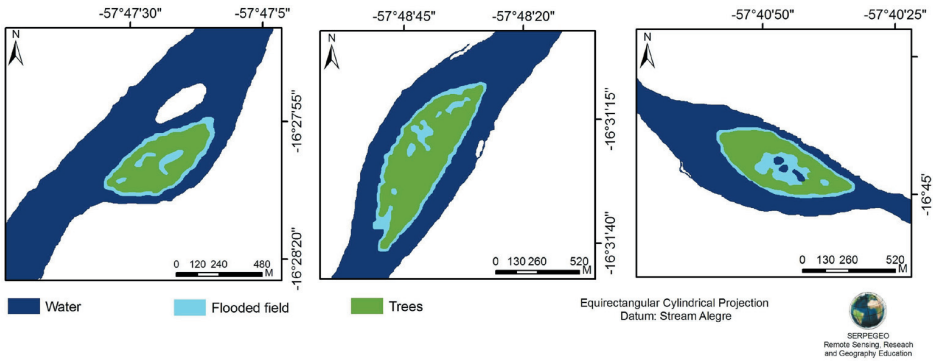

Figure 4 - Distribution of the classes flooded field and arboreal vegetation in islands 4, 5 and 6

Table 2 - Percentage of vegetation classes in islands 4, 5 and 6

Island 4			Island 5			Island 6		
Classes	Areas		Classes	Areas		Classes	Areas	
	ha	%		ha	%		ha	%
Flooded field	4,73	30,57	Flooded field	1,15	11,46	Flooded field	5,90	33,78
Arboreal vegetation	10,75	69,43	Arboreal vegetation	8,92	88,54	Arboreal vegetation	11,57	66,22
Total	**15,49**	**100**		**10,07**	**100**		**17,47**	**100**

In all six islands of Paraguay River, 40 species belonging to 34 genera and 21 families were found. Seventeen (17) species were exclusive of islands 1, 2 and 3 formed from the meander neck rupture. In islands formed from the sedimentation process, three species were exclusive. In general, the species had a wide occurrence and *Sapium obovatum* was the species of higher frequency in the islands and plots (Table 3). Seven species appeared in only one of the islands, which contributed to dissimilarity.

Considering the cluster (Figure 5), some islands have high floristic similarity indexes such as islands 1 and 3 which had Sorensen Index = 0.86. There was a division into two groups: islands 1, 2 and 3, formed from the channel meander neck rupture, and those formed from sedimentation (islands 4, 5 and 6), distinguishing the difference in the arboreal species composition among the islands with different formations.

In the Paraná River, studies carried out by Corradini *et al*. (2008 p.345) on islands formed due to processes of bar coalescence to the existing islands indicated that the geomorphology, specially the relief, has a control on vegetation, showing a sequence of riparian vegetation and a relationship with the surface morphology.

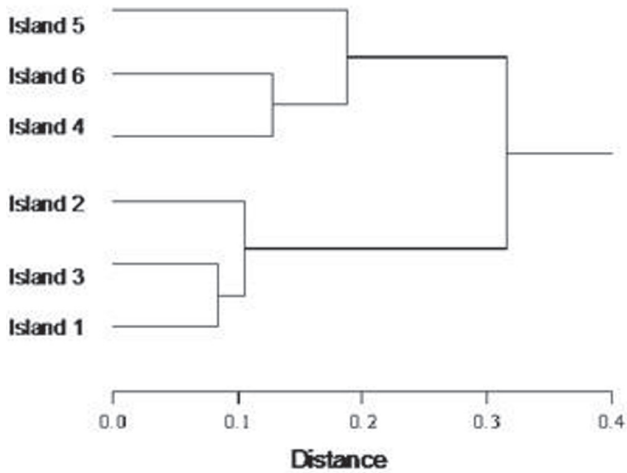

Figure 5 - UPGMA Cluster – Dendrogram with simple clustering, Euclidean distance, distinguishing by Sorensen's coefficient species difference among islands

The granulometric analysis of the soils in the islands indicated, on average, clayey to very clayey texture; however, there was a variation in the plots and some of them had sandy texture. Depending on their nature, the sediments that originated the Gley soils show great differences in characteristics like fertility and soil texture (COUTO; OLIVEIRA, 2009).

In general, most soils in the islands had a high acidity (average among islands from 4.2 to 4.6) and high exchangeable aluminum level (between 2.0 cmol/dm^3 and 3.1 cmol/dm^3) and average levels of phosphorus (% clay > 50% and phosphorus values between 4.4 cmol/dm^3 and 11.4 cmol/dm^3). They also had a high sum of bases (from 7.1 cmol/dm^3 and 8.8 cmol/dm^3) and mean base saturation (46.8% to 53%).

There was a significant difference for phosphorus levels in soils sampled from islands 4, 5 and 6 (from sedimentation) relative to island 2 and 3 (meander neck rupture); phosphorus levels were higher in islands from sedimentation, the means of which ranged from 8.8 mg/dm^3 to 11.4 mg/dm. Ribeiro *et al.* (1999, p.28) considered that these levels represent an average availability for the plants. Phosphorus is considered one of the most restrictive

elements to plant growth and development according to the low available levels in natural occurrence.

A difference in the exchangeable aluminum level (Al) was detected only for island 6 (from sedimentation), where the Al level was lower than in the remaining islands; however, exchangeable Al values were high in general. In Northern Pantanal, several studies on Gley soils have identified extensive areas showing a large quantity of exchangeable aluminum (COUTO; OLIVEIRA, 2009).

According to Soares & Oliveira (2009), in the soil of "*Pantanal de Miranda*" aluminum concentrations were high, causing toxicity; however, the negative effects of this element for vegetation are minimized by the presence of calcium and magnesium, present at high concentration in the area; the same pattern occurs in the islands studied. Deforestation in the Araguaia Watershed for extensive pasture implantation reduced the values of phosphorus, calcium and magnesium and increased the total acidity of soils (FARIA *et al*.,2010, p.523).

Gley soils at Pantanal occupy around 10% of the area along Paraguay, Taquari and smaller rivers. Their characteristics are highly diversified, presenting moderately to highly clayey textures and eutrophic, dystrophic and aluminate character (FERNANDES, *et al*., 2007). The soils in the islands are clayey and dystrophic.

From the 40 species found in the islands, after the removal of those with less than 5 individuals, 27 species, with 1833 arboreal individuals, were used for multivariate analyses (Table 3).

Table 3 – List of the 27 tree species, abbreviations used in the Canonical Correspondence and discriminant analyses, with total density (TD) and density per island in Paraguay River between Cáceres and Taiamã Ecological Station at Pantanal in Mato Grosso, Brazil

Spécies	Abrev.	D T	Density/Island					
			1	2	3	4	5	6
Albizia inundata (Mart.)	Alb inu	70	22	11	22	5	4	6
Alchornea discolor Poepp.	Alc dis	5	0	0	0	0	0	5
Alchornea sp.	Alc sp.	5	0	5	0	0	0	0
Banara arguta Briq.	Ban arg	55	7	9	16	9	9	5
Brosimum lactescens (S. Moore) C.C. Berg.	Bro lac	19	3	13	0	0	2	1
Buchenavia oxycarpa Eichler	Buc oxy	16	3	5	3	2	3	0
Buchenavia sp.	Buc sp.	17	9	0	8	0	0	0
Casearia aculeata Jacq.	Cãs açu	10	0	9	1	0	0	0
Campomanesia eugenioides (Cambess.) Legrand	Cam eug	14	0	0	7	0	7	0
Cróton sellowii Baill.	Cro sel	10	3	0	1	1	5	0
Crataeva tapia L.	Cra tap	53	26	11	2	9	0	5
Garcinia brasiliensis Mart.	Gar bra	51	2	5	43	0	0	1
Inga Vera Willd.	Ing ver	38	3	4	8	6	4	13
Laetia americana L.	Lae ame	170	102	15	52	1	0	0
Licania parvifolia Huber	Lic par	39	0	18	21	0	0	0
Mouriri guianensis Aubl.	Mou gui	27	1	5	20	0	0	1
Nectandra amazonum Nees	Nec ama	6	2	0	2	0	0	2
Ocotea diospyrifolia (Meisn.) Mez	Oco dio	45	10	15	13	3	0	4
Pouteria glomerata (Miq.) Radlk	Pou glo	17	5	2	6	0	4	0
Psidium nutans O. Berg	Pis nut	127	105	1	20	1	0	0
Sapium obovatum Klotzsch ex Müll. Arg.	Sap obo	773	210	170	43	123	218	9
Swartzia jorori Harms	Swa jor	10	0	0	4	6	0	0
Trichilia catigua A. Juss.	Tri cat	39	4	33	0	0	2	0
Triplaris americana L.	Tri ame	13	4	0	2	0	2	5
Vochysia divergens Pohl	Voc div	25	1	1	23	0	0	0
Zygia latifolia (L.) Fawc. & Rendle	Zyg lat	57	4	0	50	0	3	0
Zygia inaequalis (Humb. & Bonpl. ex Willd.) Pittier	Zyg ina	122	17	52	48	0	4	1

Based on the average of the soil chemical and textural attributes for each species, determined by Canonical correspondence analysis, the species were grouped by cluster analysis through hierarchical classification and canonical discrimination into three groups (Figures 6 and 7).

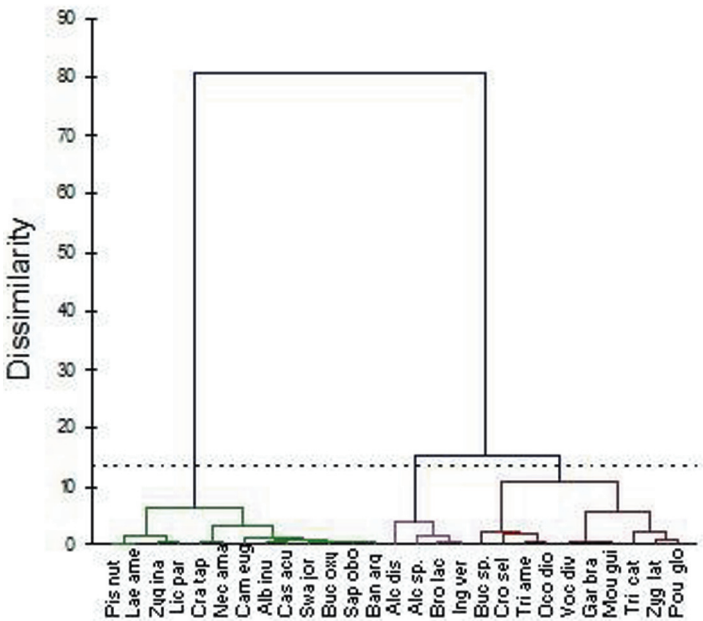

Figure 6 - Clustering dendrogram (Dissimilarity, Euclidean distance and minimum variation) related to the soil characteristics for each tree species in the islands sampled in Paraguay River, between Cáceres and Taiamã Ecological Station in Mato Grosso, Brazil

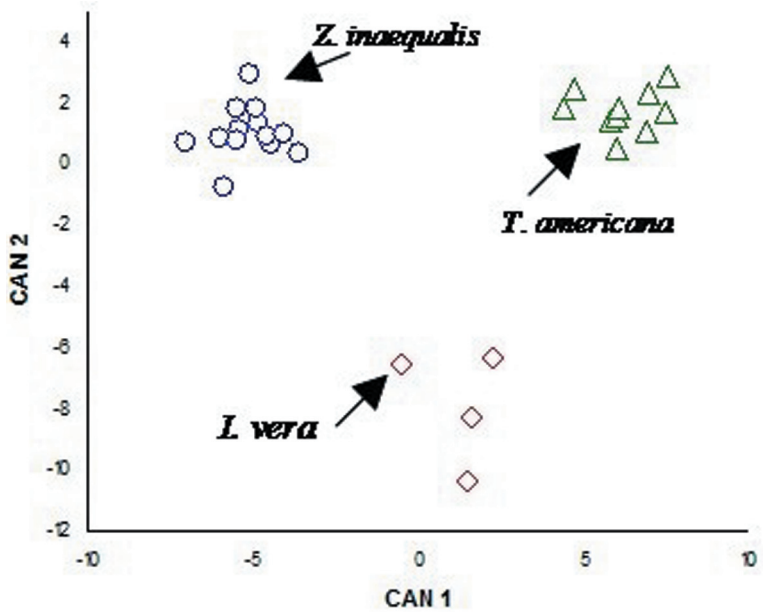

Figure 7 - Canonical variables 1 and 2 and groups 1 (○), 2 (△) and 3 (◊) formed by the tree species in the islands of Paraguay River at Pantanal in Mato Grosso, Brazil

Three groups were defined based on the high fitting probability (Pr j|X) using the a priori and a posteriori classification of species belonging to the respective designated groups. Canonical correspondence analysis indicated significance of correlations among the axes of species and the environmental variables, with values of 0.984 for axis 1 and 0.962 for axis 2 (Table 4).

Table 4 – Partial correlations between the original soil variables and Canonical variables 1 and 2 of tree species in the islands of Paraguay River at Pantanal in Mato Grosso, Brazil

Soil variables	Correlations	
	CAN 1 r^2= 0,984	CAN 2 r^2= 0,962
pH água	-0.122	**-0.614**
Fósforo	0.396	**-0.636**
Potássio	-0.579	0.102
Ca	**-0.917**	0.087
Mg	**-0.872**	0.219
Al	-0.211	**0.747**
H	**-0.641**	0.072
MO	**-0.811**	0.382
Areia	**0.794**	-0.327
Silte	**-0.659**	0.490
Argila	**-0.799**	0.260
SB	**-0.924**	0.142
CTC	**-0.862**	0.282
% Bases	**-0.899**	-0.152
% Ca	**-0.825**	-0.237
% Mg	**-0.763**	0.063
% Al	**0.605**	0.552
% K	0.296	-0.227
%H	**0.724**	-0.381

Class 1, with the group formed by the species *Sapium obovatum*, *Psidium nutans, Laetia americana*,*Crataeva tapia*, *Banara arguta*, *Nectandra amazonum, Zygia inaequalis*, *Buchenavia oxycarpa, Casearia aculeata*, *Licania parvifolia*, *Campomanesia eugenioides* and *Swartzia jorori*, had higher values of Mg percentage and Mg, Silt, Base and Al^+ Saturation, Sum of Bases and Clay (Table 5).

Table 5 – Standard means of pedologic-environmental variables for all three groups of tree species in the islands of Paraguay River between Cáceres and Taiamã Ecological Station at Pantanal in Mato Grosso, Brazil

Variables	Classes		
	1	2	3
pH água	-0.010	-0.186	**0.648**
Fósforo	-0.514	-0.273	**0.201**
Potássio	-0.055	-0.656	-0.528
Ca	0.077	-1.023	-0.675
Mg	**0.469**	-0.700	-0.570
Al	**0.305**	0.143	-0.892
H	-0.243	-0.554	-0.462
MO	0.006	-0.648	-0.771
Areia	-0.264	**0.772**	**0.882**
Silte	**0.371**	-0.534	-1.058
Argila	**0.232**	-0.791	-0.778
SB	**0.219**	-0.962	-0.677
CTC	0.100	-0.864	-0.855
% Bases	**0.329**	-0.841	-0.080
% Ca	0.087	-1.089	-0.155
% Mg	**0.589**	-0.239	0.037
% Al	0.096	**0.829**	-0.275
% K	-0.203	-0.008	0.112
%H	-0.496	0.179	**0.358**

The species in this class correlated to several attributes that, on average, were considered high in the islands probably due to the distribution and abundance of these species, the first three of which are more abundant. High Al^{3+} levels found in the soil surface layer of Northern Pantanal are explained by specific characteristics of this pedo-environment, which favors the ferrolysis process, releasing Al^{3+} (COUTO; OLIVEIRA, 2009, p.75). At Pantanal "Barão de Melgaço", Duarte (2008, p.135) verified that *Sheelea phalerata* (Mart.) Bur was the most abundant species in the area under study, keeping a positive correlation with Al^{3+}.

Class 1 had high values for silt and clay; this relation is expected due to the high abundance and frequency of species in this group such as *Sapium obovatum*, *Psidium nutans* and *Laetia americana*; in addition, Gley soils at Pantanal have, in general, moderately to high clayey texture (SOARES *et al*. 2006, p.283, FERNANDES, *et al*., 2007,p.5).

Class 2, with the group formed by *Zygia latifolia*, *Pouteria glomerata*, *Trichilia catigua*, *Croton sellowii*, *Ocotea diospyrifolia*, *Garcinia brasiliensis*, *Mouriri guianensis*, *Buchenavia* sp., *Vochysia divergens* and *Triplaris americana*, had higher values for the variables percentage of aluminum and sand.

Some studies on *V. divergens*, present in group 2 with values related to sand and aluminum saturation, determined the presence of this species in sandy soils (NUNES DA CUNHA; JUNK, 2004, p.105), whereas other works have classified it as an aluminum-accumulating species (HARIDASAN, 2000, p.61).

The groups of classes 2 and 3 had high values for sand. In general, the islands have clayey to highly clayey texture; however, sites with high sand levels are common, which are related to the species in these groups according to discriminant analysis (Figure 8). Areas with high sand concentrations imply an inundation-dependence for the maintenance of the soil fertility through the addition of nutrients by river water.

The group formed by *Alchornea* sp., *Alchornea discolor*, *Brosimum lactescens* and *Inga vera*, of class 3, had high values for the variables: pH of water, sand and H percentage. Variations in pH values at Pantanal between the horizons can be related to the hydromorphism to which the soil is subjected, a consequence of reduction reactions that tend to increase pH (COUTO; OLIVEIRA, 2009.p.75), which may also have determined different and higher values, relating species of class 3.

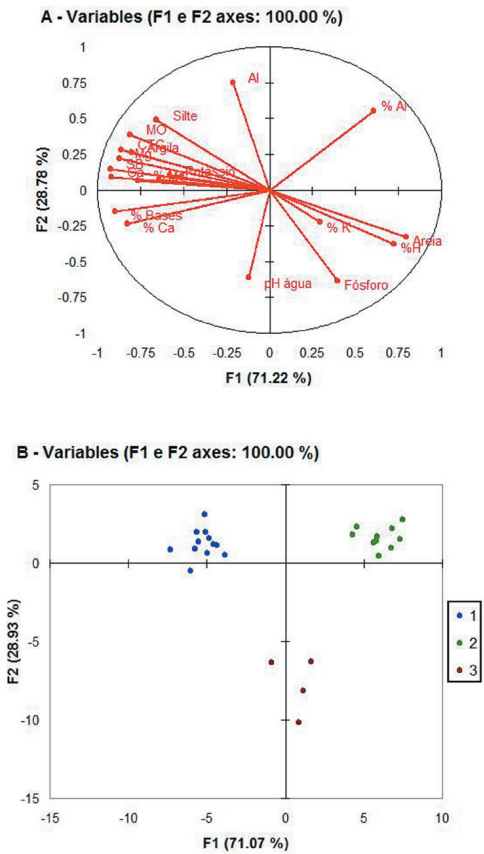

Figure 8 - (A) Bi-plot of correlation among chemical and textural attributes of the soil and (B) discriminant variables 1 and 2 and groups of species 1(△), 2 (◊) and 3 (○) formed by means of soil attributes in the islands of Paraguay River at Pantanal in Mato Grosso, Brazil

Nutrient interactions in the ATTZ (Aquatic Terrestrial Transition Zones) were emphasized by Junk *et al*. (1989, p.110) and Junk and Da Silva (1999, p.25). According to these authors, the productivity of flooded areas is the sum of aquatic and terrestrial productivity. Based on the concept of flood pulse, growing plants in the terrestrial phase absorb nutrients from the soil and store them as organic matter. During the aquatic phase, the organic matter and the nutrients are transferred, serving as food base for aquatic organisms, while the nutrients are absorbed by algae and aquatic macrophytes. The nutrients return to the soil, fertilizing it for the terrestrial phase.

There is a lack of information about the specific correlations among different types of soils and diverse variations in forest formations. Variations in the structure and floristic composition related to the soil type were already detected in several studies (JACOMINE, 2000, p.27). In the Pantanal studies correlating the species to the soil attributes are still needed; however, other factors may interfere synergistically with the distribution of these species, such as for instance flooding.

CONCLUSIONS

Referring to floristic similarity, there was a division into two groups, originated from two geomorphologic processes: the meander neck rupture in islands 1, 2 and 3, and sedimentation in islands 4, 5 and 6.

Most soils in the islands had a high acidity and a high exchangeable aluminum level, medium phosphorus levels, a high sum of bases and medium base saturation. The soils in these islands are clayey and dystrophic.

The group formed by the most abundant species in the islands *Sapium obovatum*, *Psidium nutans* and *Laetia americana*, was correlated to the soil attributes that present high values such as magnesium and saturation by magnesium, exchangeable aluminum, clay and silt.

NOTES

This paper is part of the Doctoral Thesis CASTRILLON, S. K. I. **Avaliação da diversidade arbórea das ilhas do rio Paraguai, entre Cáceres e a Estação Ecológica de Taiamã, Pantanal Matogrossense, Brasil,** 2010, 94 f. Thesis (Doctorate) Graduate Program in Ecology and Natural Resources, Universidade Federal de São Carlos, São Carlos/SP, 2010.

ACKNOWLEDGEMENTS

To "Fundação de Amparo a Pesquisa do Estado do Mato Grosso" (FAPEMAT) for supporting this study (Process: 045/2007).

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