SUBSIDIES FOR MONITORING RIVERCROSSINGS AND FISHING BOAT POINTS ON A SECTION OF THE APA RIVER, AT THE BRAZILIAN/PARAGUAYAN BORDER

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Summary

The occupation of the Apa River transborder basin occurred in an unorderly form, causing several environmental problems. The erosion processes increased and, associated to the livestock activities and products crossing the river, from one country to the other, are probably causing the degradation of riparian forests, the silting of the river and water pollution. This work presents the mapping of crossing the ford points of bovine cattle, market goods and products from country to country; professional fishing venues with infrastructure on the riparian forests; navigation characteristics - white waters, speed, depth and width. The data was acquired on a section of the Apa river, starting in the city of Bela Vista, municipality of Bela Vista, up to the mouth of the Perdido river, municipality of Caracol, totalling 214km along the Brazilian/Paraguayan border, Mato Grosso do Sul State. A database was produced on ArcGis 9.3, with the localization of the points, attribute description and photographs. This information can be electronically visualized on the Landsat 7 TM+ image, generated from the multispectral R5G4B3 band fusion, from point/orbit 226/75 and panchromatic band 8, with a final resolution of fourteen meters. A map with the characterization of this section was created at 1:250,000 scale.

Key words: Apa river. Fishing. Cross points. Mapping.

Resumo

Subsídios para o monitoramento de pontos de travessia e pesqueiros em trecho do Rio Apa, fronteira do Brasil e Paraguai

A ocupação da bacia transfronteiriça do rio Apa, vem ocorrendo de maneira desordenada, determinando sérios problemas ambientais. Ampliaram-se os processos erosivos que associados à atividades como a passagem de gado e mercadorias através do rio, de um país para o outro, podem estar causando a degradação das matas ciliares, o assoreamento do rio e a poluição das águas. Este trabalho apresenta o mapeamento de pontos de travessia – passagens a vau - de rebanhos bovinos, mercadorias e produtos de um país para outro; pesqueiros com infraestrutura nas matas ciliares; características de navegabilidade – corredeiras, velocidade, profundidade e largura. Os dados foram obtidos em trecho do rio Apa, com inicio na cidade de Bela Vista, município de Bela Vista até a foz do rio Perdido, município de Caracol, totalizando 214 km na linha de fronteira do Brasil com o Paraguai, Estado do Mato Grosso do Sul. Produziu-se uma base de dados no ArcGis 9.3, com a localização dos pontos, descrição de atributos e fotografias. Estas informações poderão ser visualizadas eletronicamente na imagem Landsat 7 TM+, gerada a partir da fusão R5G4B3 multiespectral, do ponto/órbita 226/75 e pancromática banda 8, com resolução final de catorze metros. Produziu-se mapa de caracterização do trecho em escala de 1:250.000.

Palavras-chave: Rio Apa. Pesqueiros. Pontos de travessia. Mapeamento.

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INTRODUCTION

In social and environmental terms, the occupation of the Apa river basin in Mato Grosso do Sul State, at the border between Brazil and Paraguay, is occurring chaotically since the very beginning of the colonization from this region, and it is still determining significant negative impacts. From the 1950s onwards, livestock activities expanded and in the 1970s and 1980s the same happened to mechanized plantations of soybeans and rice. Consequently erosive process increased, causing a high soil loss rate, with damaging effects on water resources (ANA,2003).

The behavior of water resources involves the erosion, whose process includes the removal and transportation of soil particles and/or rock fragments, starting and propagating by intrinsic nature mechanisms on the space where it occurs, resulting in sedimentation, where the topographic and hydraulic agents are weaker (WALLING, 1983). The Apa River basin is localized in areas of strongly rolling terrain, draining its water to the Pantanal wetlands. So the exploitation of natural resources within this basin must be done very carefully, in order to cause minimum changes to the Pantanal floodplain.

Approximately 50% of the lands from the Apa river basin are formed by Rhodic Hapludox-type soil which, although it presents low erosion rates due to its texture, there are erosion problems due to its occurrence in strongly rolling hills. The trampling due to cattle accelerates the erosion process (ANA, 2003).

The beef cattle practiced extensively is responsible, in terms of polluting loads, for the generation of 82.39% of the total fecal colliforms (CIDEMA, 2002).

The free transit of cattle along the Brazilian-Paraguayan border arean, risking the health of the herd in both countries is largely divulged in the region and all around Brazil (TOMAZELA, 2008). The High Vigilance Zone (ZAV, in Portuguese) was created in 2008, after the occurrence of Foot-and-Mouth disease (FMD) in a 750km area along the Paraguayan border. The fresh beef produced in the ZAV cannot be exported, and this caused an impact on the economy of several municipalities in the Pantanal region (FAMASUL, 2010). There is still a suspicion, after an outbreak of FMD occurred in 2005, that resulted in the sanitary slaughter of over six thousand animals in this region and in high losses for the Brazilian Beef exports, that it may have originated from animals being smuggled from Paraguay. Nevertheless, according to Tomazela (2008), there is no way to prevents Paraguayan cattle from entering in Brazil.

The Brazil/Paraguay border areas in Mato Grosso do Sul State with more intensive commerce are *Isla Marguerita* (Alto Paraguay Dept.) with Porto Murtinho-MS, *Bella Vista* (Amambay Dept) with Bela Vista-MS, *Pedro Juan Caballero* (Amambay Dept.) and Ponta Porã-MS, *Salto del Guairá* (Canindeyú Dept.) with Mundo Novo-MS (MENEGOTO, 2004).

During 10 months, a team from the Brazilian Revenue Union (Sindireceita) drove over 15,000km on federal and state highways, riverside roads and rivers along the border zone between Brazil and Uruguay, Argentina, Paraguay, Bolivia, Peru, Colombia, Venezuela, Guyana, Suriname and French Guyana. In these points of the country, trucks loaded with charcoal, timber, beverages and agricultural products enter daily in Brazil, without any surveillance. Boats cross rivers in the Brazilian borders in the Northern, Central-Western and Southern regions without any inspections. Rivers along the border are routes for drug traffickers and smugglers who use clandestine ports to enter in Brazil without any harassment (SINDIRECEITA, 2010).

The riparian forest is cut to build cattle direction fences and roads for the passage of goods, vehicles, timber and charcoal in the section under study.

In this context, this study identified and mappped the passage points for bovine livestock, goods and products without due environmental and health clearance or inspection, along the border between Brazil and Paraguay, which is a threat for the degradation of the

riverbed and contamination of the Apa river water; the fishing areas with infrastructure built in the Permanent Preservation Areas; the characteristics of navigability of the river, which could also avoid the river crossing of bovines several times during the year. We produced a characterization map, with the satellite image as background in the river section of Bela Vista/Caracol/MS, considering the points originated from the field survey; a database on GIS environment that. Furthermore we cooperate with the law enforcement and customs agencies for the control and prevention of transnational felonies. We are able to inform to the governmental agencies in MS State, the environmentally critical points and make environmental information available, pointing out the possible impacts caused by the occupation process of the points mapped.

The remote sensing data provide a global view of a region from the perspective that is very similar to other sources, such as maps or Geographic Information Systems - GIS. This opens the possibility to make integrated use of satellite imagery and other sources of spatial information (CENTENO, 2004).

According to Folving & Denegre (1994), *apud* Centeno (2004), the information derived from remote sensing could be combined with information obtained from other sources and found also as a thematic image or as the result of a visual interpretation generating products with no interpretation in the background, where vector information from other sources are overlapped.

The municipalities that integrate the Apa River basin (BHRA) in Brazilian territory, in the State of Mato Grosso do Sul are: Ponta Porã, Antônio João, Bela Vista, Caracol, Porto Murtinho, Bonito and Jardim. In Paraguay, the BHRA includes areas from the departments of Concepcion and Amambay contemplating the municipalities Bella Vista, Concepción, Pedro Juan Caballero, San Carlos and San Lázaro.

The Apa River basin is inserted in the southern part of the Brazilian Pantanal in the geotectonic unit known asMetamorphic Belt Paraguay-Araguaia, on Pre-Cambrian structures from the older groups of these structures. It is placed on Time Zone 21, which has the Central Meridian of 57ºW.

The headwaters of Apa river is located South of the municipality Antônio João, folowing an East-West direction, crossing the municipalities of Bela Vista, Caracol and Porto Murtinho, constituting the border line between Brazil and Paraguay.

Figure 1 shows the section of the Apa river being studied, starting in the city of Bela Vista till the Perdido river, including the municipalities of Bela Vista and Caracol in the State of Mato Grosso do Sul (Brazil) and *Bella Vista, Concepción* and *San Carlos* (Paraguay).

The State of Mato Grosso do Sul has predominantly a tropical climate, with the rainy season in summer and dry season in winter, and average temperatures ranging from 25ºC in the Paraguay lowlands to 20ºC in the plateau. The avearage rainfall rate is approximately 1,500mm/year. In the extreme south, a sub-tropical climate occurs, due to a higher latitude and the plateau relief. The predominant vegetation type is the *Cerrado* (savannah).

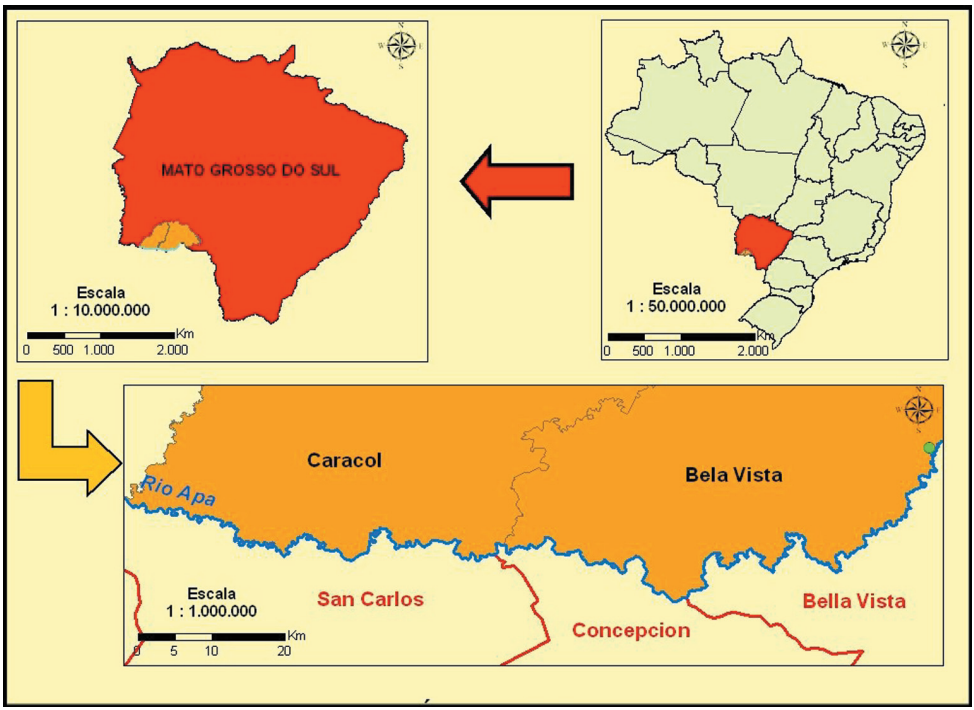

Figure 1 - Locale of the studied portion on Apa river, municipalities of Bela Vista and Caracol in the State of Mato Grosso do Sul

OBJECTIVES

- To identify and characterize points related to the livestock and crossing of goods unauthorized by environmental, sanitary and custom authorities between Brazil and Paraguay.
- To identify and characterize points that may cause the degradation of riparian forests due to the construction of infrastructures on the margins of a section from of the Apa river.
- To produce a characterization map and a database on GIS (Geographic Information System) and make it available for electronic queries.

MATERIAL AND METHODS

DESCRIPTION OF THE SURVEY FOR ENVIRONMENTAL TARGETS

The information used on this work were obtained by a patrol constituted by military personnel from the Bela Vista 10th Regiment of Mechanized Cavalry (10th. RCMec), with the support of the Environmental Police of Mato Grosso do Sul. The recognition survey was carried out in three days, starting on June 21st, 2004 in the Apa river. A survey was done on

navigation capabilities, riparian vegetation, white waters, fishing venues and ford crossings that could be used for drug trafficking and illegal flow of livestock, timber and other products in the border area.

For the acquisition of D-GPS control points, three Military grade Garmin GPS 80 precise positioning receivers were used for navigation and recognition. The system adopted was the UTM and DATUM Sad 69 for the survey.

The targets - fishing venues and ford crossings – in the area under study were chosen because they presented degradation potential due to the installation of infrastructure in Permanent Preservation Areas (PPA) and livestock and product crossings without any sanitary control or environmental authorization and also due to the characteristics that prejudice crossing and river navigation, such as speed, width, depth and rapids.

SOFTWARE AND DATABASE USED

The database used was produced on GIS environment, using a Landsat 7 image from the ETM+ (Enhanced Thematic Mapper) sensor, Orbit/Point 226/75 from August 8th, 2001 obtained at the Brazilian Space Research Institute (INPE); data from the Brazilian Institute for Geography and Statistics (IBGE), National Water Regulatory Agency (ANA) and data obtained during field survey by the 10th. RCMec.

For the image processing, we used the software ENVI 4.2 (Environment for Visualizing Images) produced by ITT Visual Information Solutions. For the Geographic Information System (GIS), the software ArcGis ver. 9.3, produced by ESRI - Environmental Systems Research Institute, was used.

REMOTE SENSING IMAGE PROCESSING

The satellite image was inserted using the ENVI 4.2 software. The first processing carried out was the composition choice to be used: R5G4B3. Afterwards the IHS image merge technique was applied. The images used were a panchromatic (Band 8) and a multispectral one. The combination of both created a new image, with new information on a higher spatial resolution (15 meters), colored and with a three-band spectral resolution. After the image merging, the area under study was cut out.

SPATIAL DATA PROCESSING

The spatial data obtained at ANA, hydro-referenced base, graphical representation of the hydrological network present in the Brazilian systematic mapping to the millionth, considering the sections of rivers, encoded by *Otto Pfasftetter's* methodology and toponyms from that mapping - were inserted on a GIS together with other data obtained at IBGE: Cidade_shp, Mun_Brasil_shp, UF_Brasil.shp and the *shapefile* IHS_R5G4B3_L7_225_076_08082001_rec, and the cut out of the thematic image (area under study).

On ArcGis, the following shapefiles were created:

- Municipal Rivers: the layers were adjusted in the same projection; the hydrography of the municipality limits was cut out, defining the rivers within the municipalities of interest.
- MS_Municipalities, locating the municipalities of the MS State.
- Municipality Placement: to locate the cities of Bela Vista and Caracol.
- Municipal Limit - municipality limits of Bela Vista and Caracol, Mato Grosso do Sul – Brazil. To correct distortions, the municipal limits were edited on ArcCatalog, to coincide with the Apa river over the satellite image.
- Rio_Apa: The ArcCatalog was used to create a new polyline-type shapefile named Rio_Apa, due to the very large distortion between the water course seen in the image and what is drawn on the hydrographic base (HIntegrada). It was edited, and the hydrography was redesiged to adjust it to the image on ArcMap.

From the primary data, the following shapefiles resulted: Corredeira, Passagem a Vau, Pesqueiro (Chute, Ford crossing, Fishing Venue).

All layers were adjusted and reprojected to the same parameters of the project.

Each layer was edited in order to add fields to locate and characterize the points and axis surveyed during the field reconnaissance.

All data used and/or created on ArcGis were electronically stored on a CD for further queries.

RESULTS AND DISCUSSION

The Apa river is presently suffering strong silting in several sections of its extension. The amount of sediments which came from its margins is concentrated in those points where the river is much shallower, making the navigation even more difficult. The huge amount of tree trunks stuck on the river bed is very dangerous for smaller boats, as seen on picture 1.

Picture 1 - Underwater tree branch

This work was carried out when the Apa river was in mid-depth level, varying from 2 to 3 meters, and reaching 30cm on ford crossings and chutes, and around 8m in its rare pockets.

The average width is 10 meters and varies according to the time of the year, but it never overpasses 50 meters during the rainy season.

The average velocity was 0.4m/s and the highest 1.8m/s in those points of chutes. Such a speed, considered low, does not bring any hardships to cross it with any products.

Sixty-two chute portions were mapped on the studied section, which difficults the navigation practically year-round. We also mapped nine fishing venues characterized on table 1 and 12 ford crossings on both Paraguayan andr Brazilian sides. All points mapped are represented on figures 2A, 2A1 and 2B, 2B1.

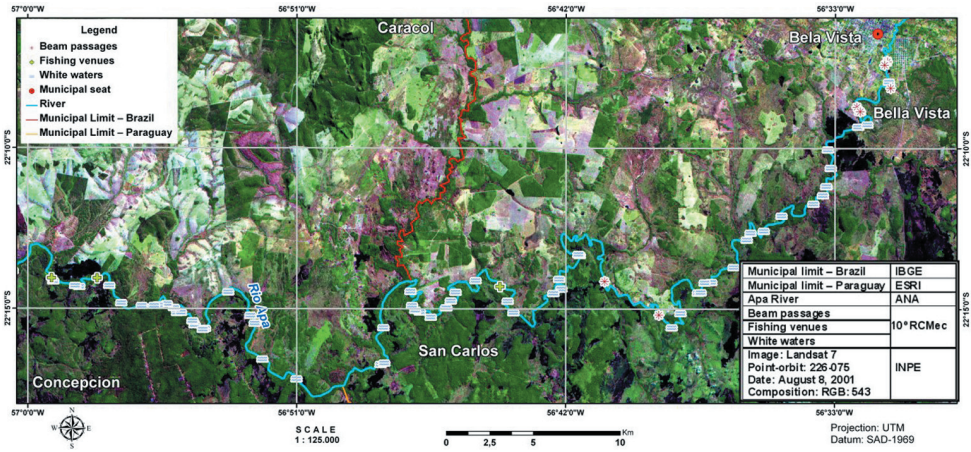

Figure 2A - Characterization map of the Apa river, from the point outside the city of Bela Vista, MS, up to longitude 57°0'0"W

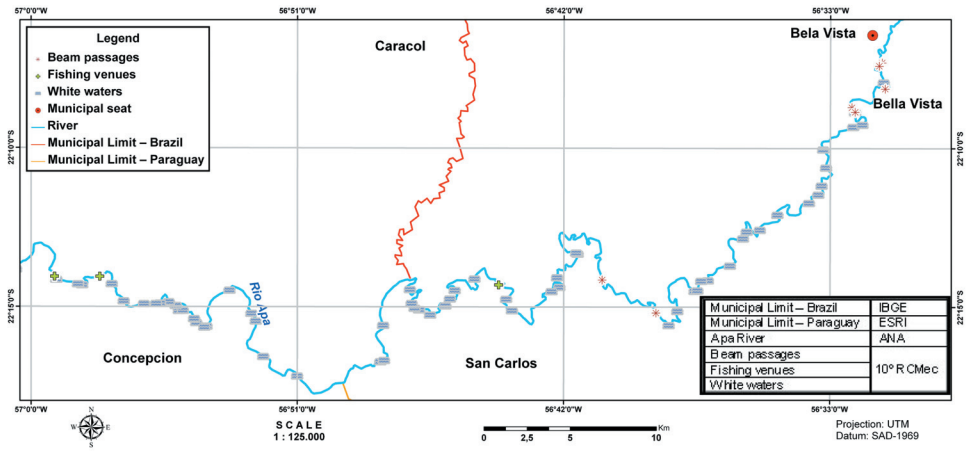

Figure 2A1 - Characterization map of the Apa river, without orbital imagery, from the point outside the city of Bela Vista, MS, up to longitude 57°0'0"W

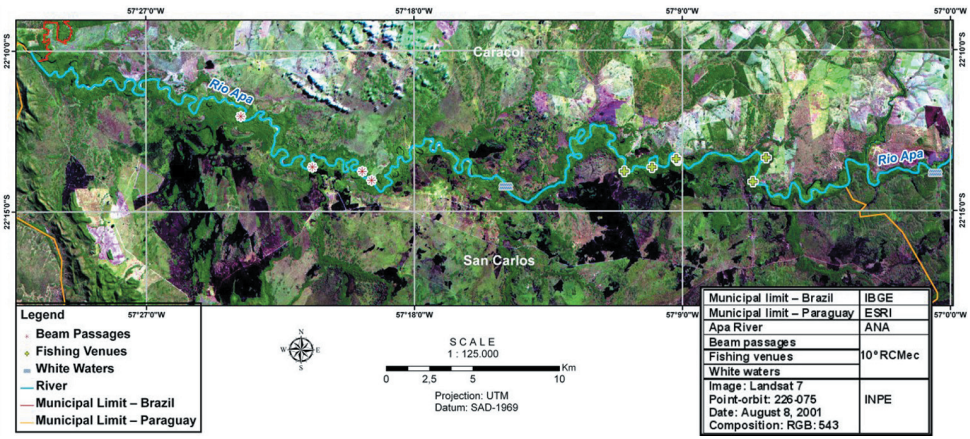

Figure 2B - Characterization map of the Apa river, from longitude 57°0'0"W to the Perdido River, municipality of Caracol, MS

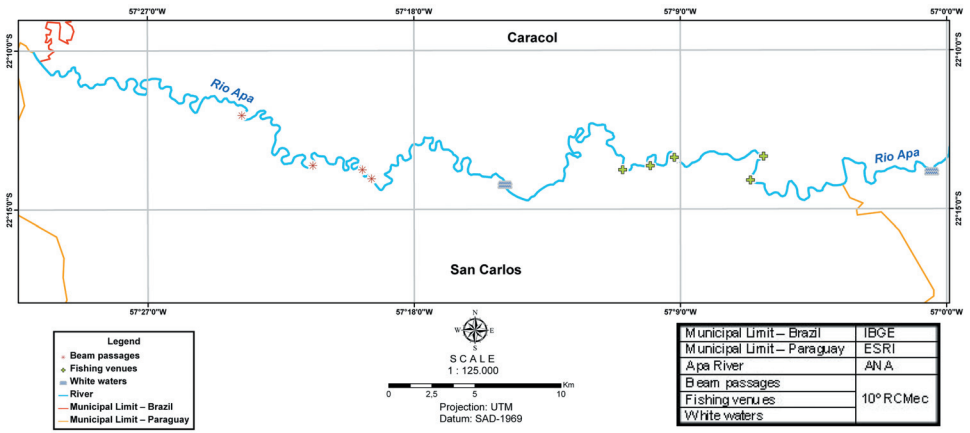

Figure 2B1 - Characterization map of the Apa river, without orbital imagery, from longitude 57°0'0"W to the Perdido River, municipality of Caracol, MS

It is necessary to verify the legality from the facilities of all fishing venues, in order to avoid degradation of natural resources and the responsible authorities must take actions to enforce Law Nr.4771 from Sept.15th 1965, directing actions which could become recovery projects of degraded sections from Permanent Preservation Areas of Apa river (article 2, indent I to X and article 4, indents I to VIII from Law #6938 from 08/21/1981). It is known that any changes or suppressions in these areas, constitutes a delict according to Articles 30 to 53 of the Environmental Crimes Act (Law Nr. 9605 from Feb. 12th, 1998).

Some areas where fishing venues are placed are highly damaged due to the construction of facilities in the Permanent Preservation Areas as seen on figure 2.

Table 1 - Fishing venues on a portion of the Apa river

Fishing venues name	Latitude	Longitude	Infrastructure
Fazenda Primavera	22°14'33.59" S	56°44'12.89"W	Wharf
Paulão	22°14'21.20" S	56°57'40.55"W	Twenty masonry houses
Belo Apa	22°14'5.35" S	56°59'26.83"W	From ten to fifteen masonry houses.
Zagaia	22°13'30.74" S	57°6'37.43"W	Three wood constructions.
Rancho dos Amigos	22°14'32.09" S	57°6'21.45" W	Wharf
Campina Verde	22°13'35.84" S	57°9'19.35" W	Two construction, caretaker house with phone and power.
Campina Verde	22°13'35.84" S	57°9'19.35" W	Six masonry constructions, phone and power.
Califa	22°13'38.80" S	57°9'55.58" W	Some constructions wiht power generator.
Baía Negra	22°13'46.96" S	57°11'0.07" W	Power generator, landing airstrip, phone. In front of human settlement of Paraguay.

Picture 2 - Baía Negra Fishing Venue, Brazilian margin

The existing board passages on Apa river, with data presented on table 2, are the places where the lower depth of the river occur on the study portion.

Table 2 - Beam passages on a portion of the Apa river

Name	GSC- SAD 69 (Lat/Long)	Wide (m)	Depth (m)	Vel. (m/s)	Kind of riverbed	Kind of bank
Macaco	22°15'13,3"S 56°31'10"W	10	1,0	0,5	Shingle	Prepared
Nameless	22°7'17,61"S 56°35'54,55"W	10	1,0	0,3	Shingle	Prepared
Davi	22°7'11,8"S 56°31'21,55"W	11	0,1	0,5	Shingle	Prepared
Getúlio Lima	22°8'18,83"S 56°31'8,81"W	11	0,1	0,7	Shingle / muddy	Slanted
Nameless	22°8'47,3"S 56°32'20,47"W	15	1,3	0,4	Shingle	Slanted
Fumaça	22°8'52,26"S 56°32'26,07"W	10	0,5	0,6	Rocky	Slanted
Farm Santa Cruz	22°15'13,3"S 56°39'1,76"W	15	1,2	0,4	Shingle	Slanted
Farm Piúva	22°14'9,6"S 56°42'8,33"W	12	1,0	0,4	Shingle	Slanted
Farm Barranco Part	22°14'1,45"S 57°19'47,49"W	12	1,0	0,4	Shingle	Slanted
Farm Barranco Part	22°13'44,7"S 57°20'1,21"W	12	3,0	0,4	Sandy	Slanted
Farm Barranco	22°13'35,29"S 57°21'26,21"W	10	1,5	0,3	Shingle	Slightly slanted
Nameless	22°12'5,78"S 57°23'48,1"W	25	1,3	0,3	Sandy	Slightly slanted

Considering these observations, a constant monitoring, inspections and control of the ford crossings as seen on figure 3, where peppertree timber is piled on the Paraguayan margin of the river ready to be shipped by boat to cross to the Brazilian margin; and fishing venues. Such places must be recovered according to the present legislation.

The river crossing of bovines, besides risking the health of the herds from both Brazil and Paraguay, are contributing to the silting of the riverbed, due to the livestock trampling in the margins as seen on figure 4. The picture was taken on the Brazilian margin, a few minutes after crossing of a bovine herd from Paraguay. The Brazilian margin was wet, with recent paw prints from the animals.

Picture 3 - Beam passage, with piled up peppertree on the Paraguayan margin

Picture 4 - Beam passage with recent livestock crossing tracks on the Brazilian margin

CONCLUSIONS AND SUGGESTIONS

The results and products obtained in this work may be used as an instrument to help the Public Administration to monitor, control and surveil the natural resources of the border area, along the Apa river portion, considering especially livestock, goods and illegal product from crossing illegally from one country to the other. On the mapped points it was observed countless evidences of livestock crossing and also goods and illegal products (lacking authorization from competent authorities) such as timber and vehicles.

Apa is a plateau river, with chutes in several points: totally sixty two were mapped on the studied section, difficulting the navigation during all months of the year. Nevertheless, the water flow speed, considered low, does not bring any hardships to cross any products, from Paraguay to Brazil.

The bovine river crossing, due to its trampling, is a factor that is causing the silting of the riverbed, causing lower water depths in the section studied. The riparian forests are also being destroyed due to the construction of directioning fences for bovines. The withdrawal of this vegetation was observed on those points of river crossing of other goods, such as timber and vehicles.

The Permanent Preservation Areas of the mapped and photographed fishing venues are very damaged, mainly due to the construction of infrastructures, such as brick houses, power generators and docks. Some have small airfields for smaller airplanes and are placed close to a rural settling area, on Paraguayan territory, facilitating the border crossing between both countries.

At the cartographic presentation, the user can obtain, using the mouse pointer, for instance, the localization of each cross point (ford crossing), of each fishing venue and each chute section with its characteristics and attributes. The map is a visualization tool and indirectly facilitates the data analysis process. Nevertheless, the real analysis is made by the computer, which retrieves the information directly on the Database, used to elaborate the map, including the layers created from the data obtained during the field survey, considering the environmentally critical points.

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