UPPER PARAGUAY RIVER BASIN NATURAL VEGETATION COVER

Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin Brazilian Portion

Period of Analysis: 2002 to 2008

Bacia do Alto Paraguai

Conservação e Sustentabilidade

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Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin

Brazilian Portion

Period of Analysis: 2002 to 2008

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1. Foreword

The purpose of the present report is to present the results of monitoring changes in vegetation and land use in the Brazilian part of the Upper Paraguay River Basin (Bacia do Alto Paraguai) - BAP considering the period from 2002 to 2008. The detailed definition and identification of the alterations have been represented on the scale of 1:50,000, based on Programme for the Sustainable Use of Brazilian Biological Diversity – Probio, mapping done in 2002 and using visual interpretation methodology applied to Landsat-5 TM satellite images (available at the site of the INPE) displayed on computer monitors. The satellite images used represent the period from March to July 2008.

The area of the Basin that was analysed encompasses the headwaters and source areas and downstream as far as the confluence of the Apa and Paraguay rivers on the border between Brazil and Paraguay. The Paraguay river commands an extensive drainage network formed by the Cuiabá, São Lourenço, Itiquira, Correntes, Taquari, Negro, and Aquidauana rivers and their tributaries. The entire basin area is approximately 600,000 km^2 of which 360,000 are in Brazilian territory divided between the Brazilian states of Mato Grosso and Mato Grosso do Sul. The area includes two large geo-physical regions: the Pantanal itself, or Pantanal floodplain with an area of roughly 150,000 km^2, and the Pantanal Highlands with an area of around 217,000 km^2. (Source: Map of Brazilian biomes, IBGE-2004 and Map of Level 3 Sub-basins of the National Water Regulatory Agency).

The Pantanal flood plain is drained by the Paraguay River and its extensive network of tributaries with a hydrological pulse regime represented by seasonal flooding and certain other features that make the region unique and have given rise to a nomenclature peculiar to the region:

. baias - low-lying depressions, usually circular, filled with water that may be salty and varying in size from dozens to hundreds of metres across;

. cordilheiras - small stretches of higher ground between the baias that almost never go under water although they are usually as little as 2 metres above water level. They are an important refuge for the region's cattle and are the sites of the farm installations and farmhouses;

. vazantes - much larger depressions set among the cordilheiras and function as intermittent drainage channels (Pott & Pott, 2000);

. corixos, small seasonal water courses with clearly defined beds (Pott & Pott, 2000).

In the Pantanal the rivers regularly inundate the plain, and it encompasses large lakes, a great number of watercourses and other drainage areas subject to seasonal flooding. The Brazilian Constitution of 1988 formally classified it as a National Heritage and in 2000 Unesco established it as a Biosphere Reserve area.

The Highland region is relatively higher, ranging from altitudes of 500 to 1,500 metres and is situated in the northern and eastern portions of the Basin which is where the springs and headwaters of the BAP rivers are to be found. In addition to the natural fragility imposed by the relief of the terrain and the nature of the soils, the highland region has suffered greatly from human intervention in the form of generalized deforestation and land clearing that includes the destruction of gallery forests, all resulting from the expansion of agricultural and cattle-raising activities into the area.

Deprived of any adequate management that takes into account their intrinsically fragile nature, the areas of pasture and croplands have become the sources of enormous quantities of sediments washed into the rivers and accompanied by residues of fertilizer and agro-chemical applications.

When the rivers get down onto the plain their waters can no longer transport such material and it is deposited, leading to a generalized silting up of the lower courses of the rivers.

According to the IBGE (Brazilian Institute for Geography and Statistics) Biomes Map (first approximation, 2004) the BAP is covered by three large biomes: Amazon, Cerrado, and Pantanal. There are also small enclaves of Atlantic Forest (as shown on the IBGE Map of 2008 delimiting the area covered by Law nº 11.428 enacted in 2006).

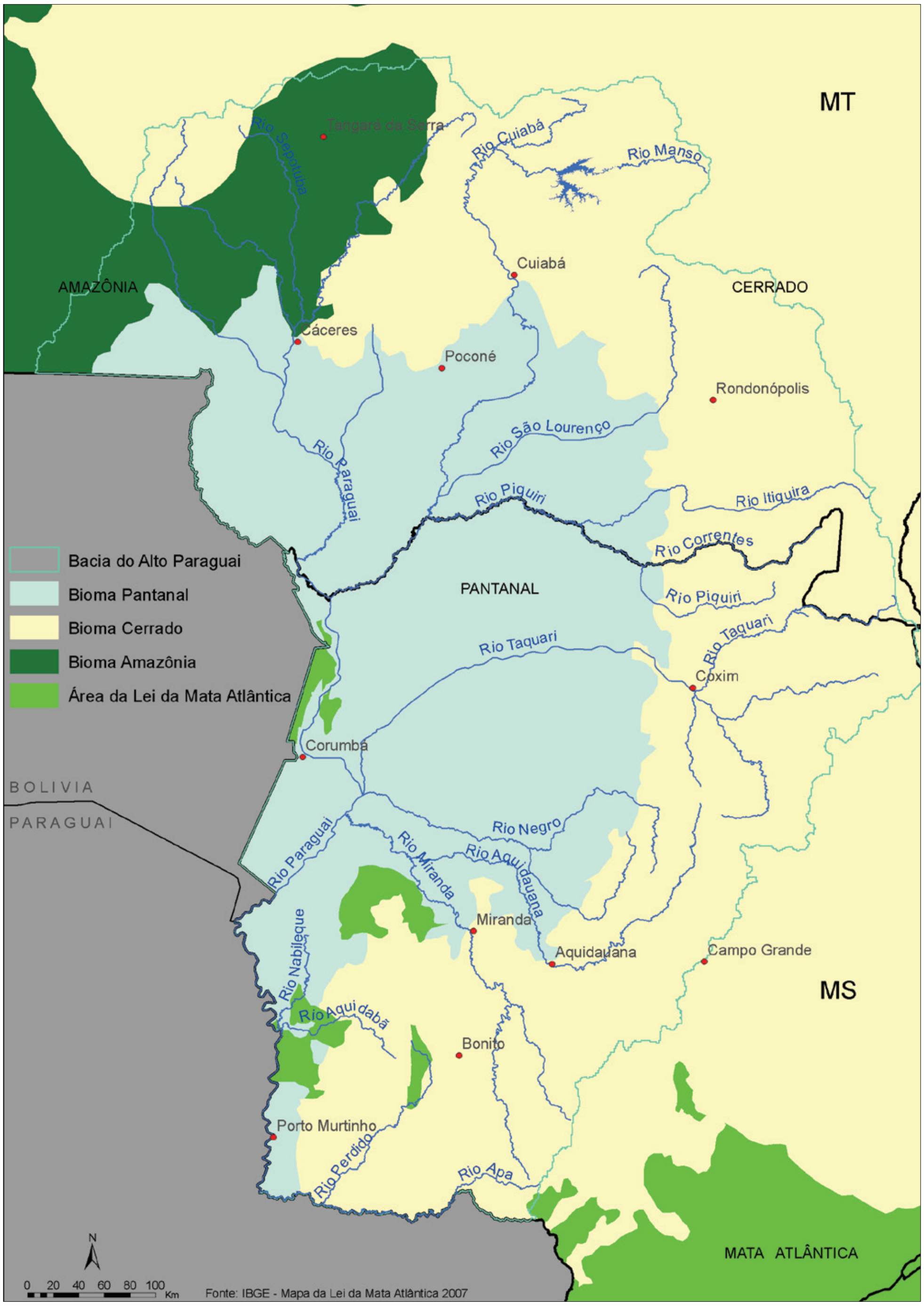


Figure 1. Hydrological Basin of the Upper Paraguay River (Brazilian portion).

In terms of withstanding the effects of regional economic development tendencies, the BAP ecosystems are extremely fragile. The traditional modes of fishing and ranching have been substituted by forms of intensive exploitation that produce alterations in the natural areas.

Over the last three decades the region has been suffering the consequences of the expansion of cattle ranching and agricultural activities especially in the Highland region, and they have left their mark in the form of huge environmental impacts on the low lying areas of the Pantanal. One outstanding example of that is the case of the Taquari River which has had its main course completely deformed and has now fanned out over a huge area as a result of silting up caused by erosion processes taking place upstream in the highland areas, site of its springs and headwaters and those of its tributaries, the Jauru and Coxim Rivers.

There has been an intense environmental impact that has altered the natural cycle of vegetation succession and many species have been extinguished due to the presence of water, as well as a large social-economic impact due to the abandoning of many small cattle farms as the area is no longer suitable for that activity.

Figure 2. Huge quantities of sediments from upstream have blocked the former bed of the Taquari River and caused its waters to fan out over the lower regions of a large part of the plain.

Abdon et al offer an explanation of the degradation process occurring in that region of the Pantanal analysing the geological and geo-morphological conditions of the highland area where the presence of Botucatu and Botucatu + Pirambóia formations in 64% of the Basin area indicates susceptibility to erosion processes considering that the soils usually associated to such formations have high erosion potential. Indeed, de-characterization of the relief has already been occurring due to rapid erosion especially in the Municipalities of Camapuã, in the sub-basin of the Coxim River, and Alcinópolis, in the sub-basin of the Jauru River. Loss of soil occurs through the process of ravine and voçoroca formation especially in highly erosion-prone soils like the Quartz Sands and Litholitic soils that occupy 59% of the highlands. Red and yellow Podzolic soils which are medium to highly erosion-prone, according to how sandy or clayey their composition is, occupy 23% of the highland areas of the Basin (source: PCBAP). Figures 3, 4, 5 and 6 show 2 areas on the 2002 maps that were subjected to correction and higher definition and their respective locations in the BAP.

2. Databases used

Probio

Probio is the Programme for the Sustainable Use of Brazilian Biological Diversity (Programa de Conservação and Utilização Sustentável da Diversidade Biológica Brasileira) and is under the coordination of the Ministry of the Environment.

With the aim of updating data on the Brazilian vegetation cover, it has been promoting the mapping of the remaining stands of vegetation of all the main Brazilian biomes including the Pantanal, Amazon and Cerrado. Embrapa Informática Agropecuária (Agriculture and Livestock Information Division of the Agriculturel Research Corporation-Embrapa) based in the city of Campinas, has been coordinating the project for mapping the Pantanal biome and it has been carried out through a partnership arrangement with Embrapa Beef Cattle (Campo Grande), the Brazilian Space Research Institute (São José dos Campos) and the Pantanal Environmental Institute (Campo Grande). The institutions responsible for executing the project determined the mapping methodology, which varied somewhat according to the peculiarities of each biome. The data used refers to the entire Pantanal biome and part of the Cerrado and Amazon biomes. The Brazilian Geography and Statistics Institute – IBGE gave support to the process of determining the technical standards to be adopted and the legend conventions to be used in the mapping process.

Altered Areas in the Pantanal 2000 and 2004 - Embrapa Pantanal

Data was made available in shapefile format together with the Landsat satellite image mosaics for the years 2000 and 2004 (Padovani et al, 2004).

Deforestation in the State of Mato Grosso MT – SEMA (2003, 2004, 2005, 2007)

Areas of deforestation in shapefile format available at the site:

http://monitoramento.sema.mt.gov.br/simlam/

Prodes/ Inpe

Files in shapefile format referring to Forest Areas especially in the Amazon Biome for the year 2007.

3. Methodology

After reviewing the available databases it was decided to adopt the Probio database (shapefile format and satellite images) as reference material because: it offered be the best cartographic base available covering the entire BAP (highland and Pantanal), it was compatible with a scale of 1:250,000, and because of the methodology used for delimiting polygons and the degree of detail in the legends (identifying the various categories of vegetation cover and land use).

The other databases were to provide auxiliary data in the validation process. Before undertaking the monitoring of Vegetation Cover and Land Use for the period 2002 to 2008 the mapping for the year 2002 had to be corrected and the degree of definition heightened. Probio base reference material was duly adjusted (where necessary) to a scale of 1:50,000 and elaborated in greater detail. That was done visually on a computer screen using Landsat TM satellite images of the area of the reference mapping.

Revision and Detail Enhancement of the Probio mapping

The Probio files in shapefile format were separated according to the articulations of the IBGE maps on a scale of 1:250,000 and also by biomes. For the purpose of elaborating the continuous cartographic base for mapping the vegetation cover and land use in the Upper Paraguay River Basin, the !:250,000 maps were set edge to edge and adjusted.

The same process of joining together and adjusting the edges was applied to the divisions of the three biomes: Pantanal, Cerrado and Amazon.

As part of the process of revising the continuous cartographic base, it proved necessary to conduct a topographical analysis of the shape file to eliminate overlapping of polygons and the presence of gaps in the mapping. During the process of verification of the vector map (on the scale of 1:50,000) it proved possible to improve the quality of the reference mapping by correcting displacement errors and the attributes of polygons, reclassifying them in the light of the satellite images and the classification key that had been established for the mapping process. The legend conventions were also unified for the entire BAP area.

The minimum area for mapping polygons adopted by the Probio was 40 hectares. In the present project the Probio polygons were sub-divided into smaller areas, sometimes as little as 3 hectares. That made it possible to separate the various classes of vegetation on the 2002 maps, which made verification of alterations by 2008.

Figures 3, 4, 5 and 6 show 2 areas on the original Probio 2002 maps that were subjected to correction and higher definition and their respective locations in the BAP.

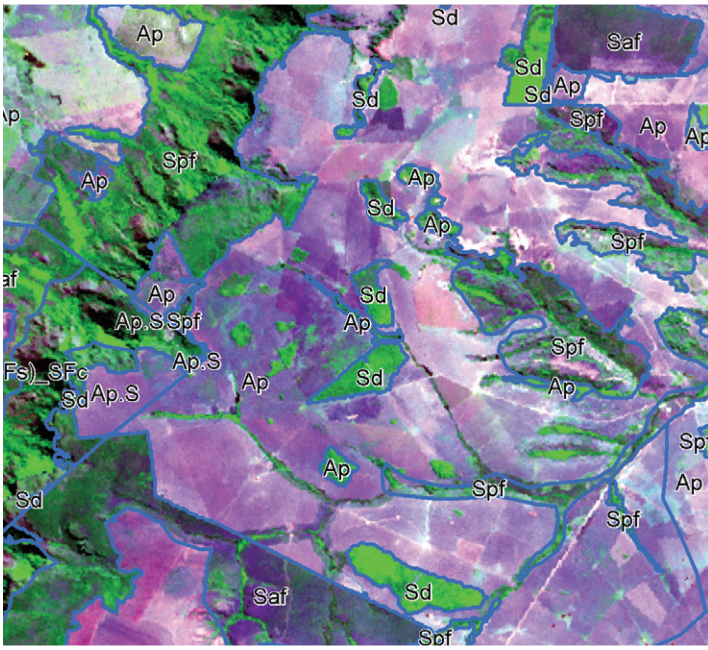
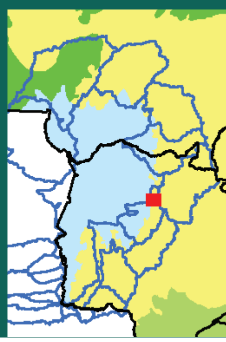


Figure 3. 2002 image with Probio polygons outlined in blue and vegetation identifications in black letters.



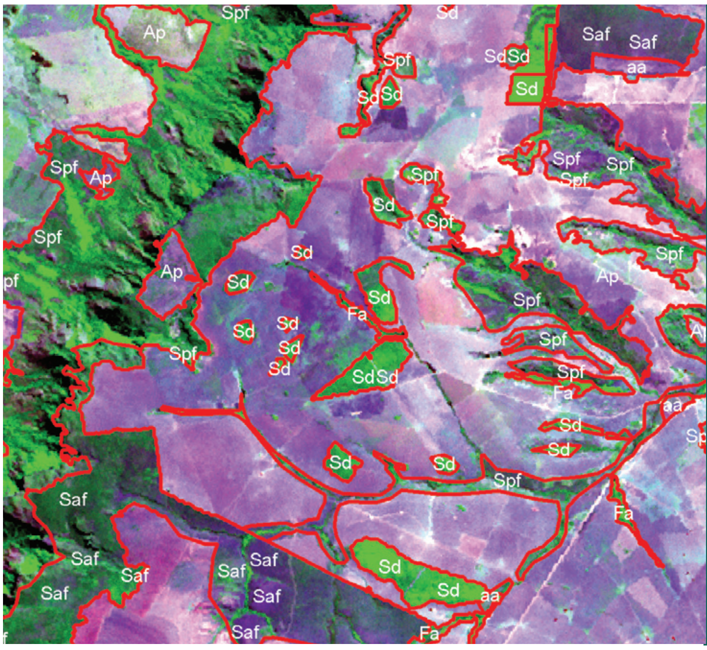


Figure 4. Same 2002 image used by Probio with enhanced detail and correction of classification -polygons outlined in red.

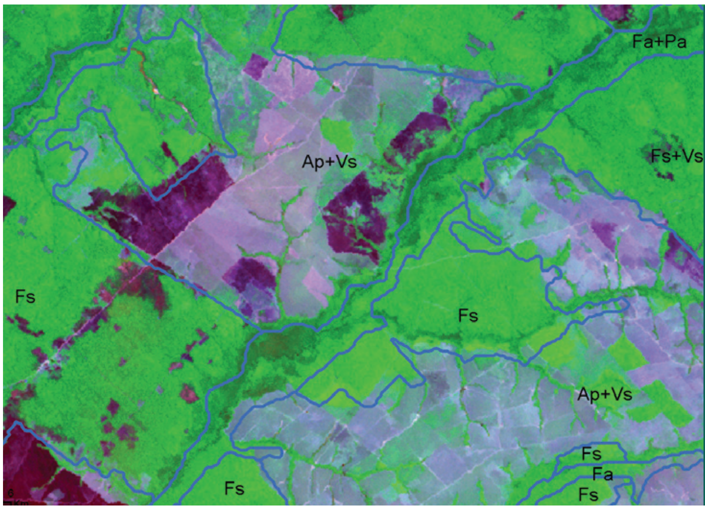
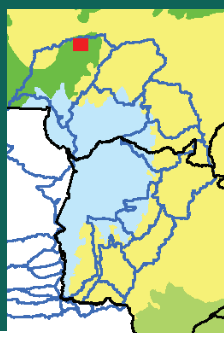


Figure 5. 2002 image with polygons interpreted by the Probio outlined in blue.



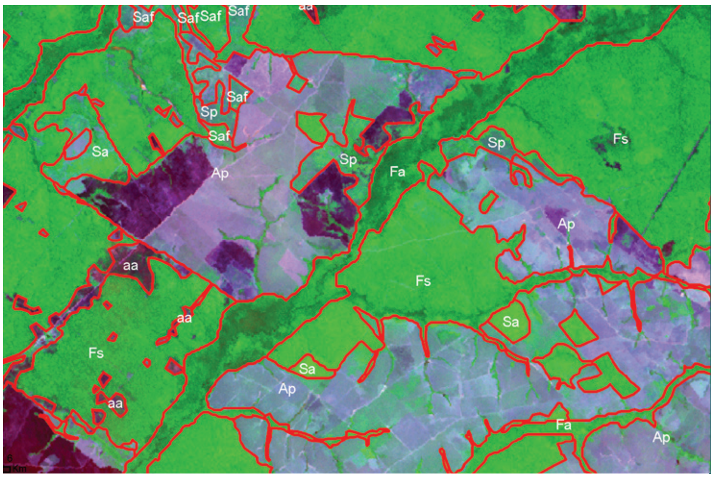


Figure 6. Same 2002 image showing polygons outlined in red after detail enhancement and corrections of classifications using a a scale of 1:50,000.

The Map legends used in the interpretation process obey the standards established by the IBGE, also adopted by the Probio.

After interpretation had been completed, the 52 categories of natural vegetation were grouped into 7 classes to simplify matters, facilitate understanding and avoid confusion. In the case of certain specific analyses, the 5 categories of anthropic intervention were grouped as a single class.

The simplification of categories adopted for legend purposes was intended to facilitate the analyses made for the purpose of classifying the vegetation. Grouping was done according to phytogeographic affinities of the vegetation taking into account similarities in the habit (herbaceous, shrubby, arboreal) and was defined during the technical meetings to validate the mapping.

There now follows a detailed explanation of the composition of the respective physiognomies (according to IBGE classification in Veloso et al, 1991) for each of the classes into which the categories were grouped:

Simplified Natural Class: Forest Formations

Ca	Seasonal Deciduous Alluvial Forest
Cb	Seasonal Deciduous Lowland Forest
Cs	Seasonal Deciduous Sub-montana Forest
Fa	Seasonal Semi-deciduous Alluvial Forest
Fb	Seasonal Semi-deciduous Lowland Forest
Fs	Seasonal Semi-deciduous Sub-Montana Forest
SN	Forested Savannah/ Seasonal Forest
SNc (Sd+Fs)	Forested Savannah/ Seasonal Semi-deciduous Forest (contact)
SNc (Sd+Cs)	Forested Savannah/ Seasonal Deciduous Forest (contact)

Simplified Natural Class: Woodland Savannah (Cerradão)

Sd	Woodland Savannah
Sd+Cs	Woodland Savannah /Seasonal Deciduous Woodland
Sd+Fs	Woodland Savannah /Seasonal Semi-deciduous Woodland
Sd+Sa	Woodland Savannah /Wooded Savannah
Sd+Sg	Woodland Savannah /Gramineous Savannah
Sd+Spf	Forest Savannah /Parkland Savannah

Simplified Natural Class: Shrubby Savannah (Cerrado)

SNt (SCt)	Savannah/Seasonal Deciduous Forest (transition)
SNt (SFt)	Seasonal Semi-deciduous Forest (transition)
Sa	Shrubby Savannah
Sa+Sd	Shrubby Savannah/Woodland Savannah
Sa+Sg	Shrubby Savannah/Gramineous Savannah
Sa+Sp	Shrubby Savannah/Parkland Savannah
Saf	Shrubby Savannah with Gallery Forest
Sas	Shrubby Savannah with no Gallery Forest

Simplified Natural Class: Grassland Savannah

Sg	Grassland Savannah-Shrubby
Sg+Sa	Grassland Savannah-Shrubby/Woodland Savannah
Sg+Sd	Grassland Savannah-Shrubby/Woodland Savannah
Sgf	Grassland Savannah- Shrubby with Gallery Forest
Sgs	Grassland Savannah-Shrubby with no Gallery Forest
Sp	Parkland Savannah
Sp+Sa	Parkland Savannah/Woodland Savannah
Sp+Sg	Parkland Savannah/Grassland Savannah
Spf	Parkland Savannah with Gallery Forest
Spf+Sd	Parkland Savannah/Woodland Savannah
Sps	Parkland Savannah with no Gallery Forest
Vs	Secondary Vegetation
rsh	Refuge

Simplified Natural Class: Steppe-type Savannah (Chaco)

Td	Forested Steppe-type Savannah
Ta	Steppe-type Savannah with Trees
Tps	Steppe-type Savannah without Gallery Forest

Simplified Natural Class: Steppe-type Savannah/Chaco wetland

Ta+Td	Steppe-type with Trees/ Steppe-type Forested
Ta+Tg	Steppe-type with Trees/ Steppe-type Grassland
Tg+Ta	Steppe-type Shrubby Grassland/ Steppe-type with trees
Tgf	Steppe-type Grassland Savannah-Shrubby with Gallery Forest
Tgs	Steppe-type Grassland Savannah-Shrubby without Gallery Forest
Tpf	Steppe-type Parkland Savannah with Gallery Forest

Simplified natural Class: Vegetation with fluvial influence

NPt (F+Pa)	Seasonal Forest /Pioneer (transition)
P	Pioneer Formations
Pa	Pioneer Formations with fluvial or lacustral influences
SP	Savannah/Pioneer
SPt (S+Pa)	Savannah/Pioneer Formations (transition)
TPt (T+Pa)	Steppe-type Savannah/Pioneer Formations (transition)

Forest Formations – FF

This class of vegetation includes seasonal deciduous and semi-deciduous forests typified by their seasonality.

The sub-class Fa corresponds to an alluvial formation found on the flatlands and along the courses of the rivers. This group of formations consists of tall trees with shrubs in the lower stratum.

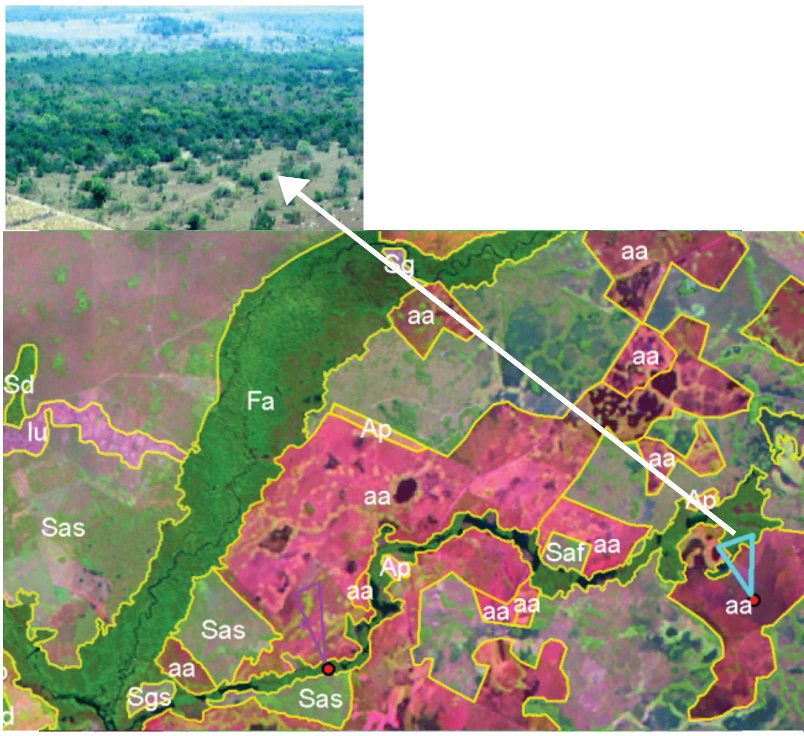
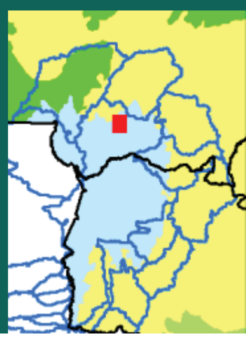


Figure 7. Aerial photograph (top) of Class FF, sub-class Fa vegetation corresponding to the blue triangle in the satellite image.



Woodland Savannah – SF (Cerradão)

This class consists of a dense distribution of trees smaller in size than those identified in the class 'Forest Formations'.

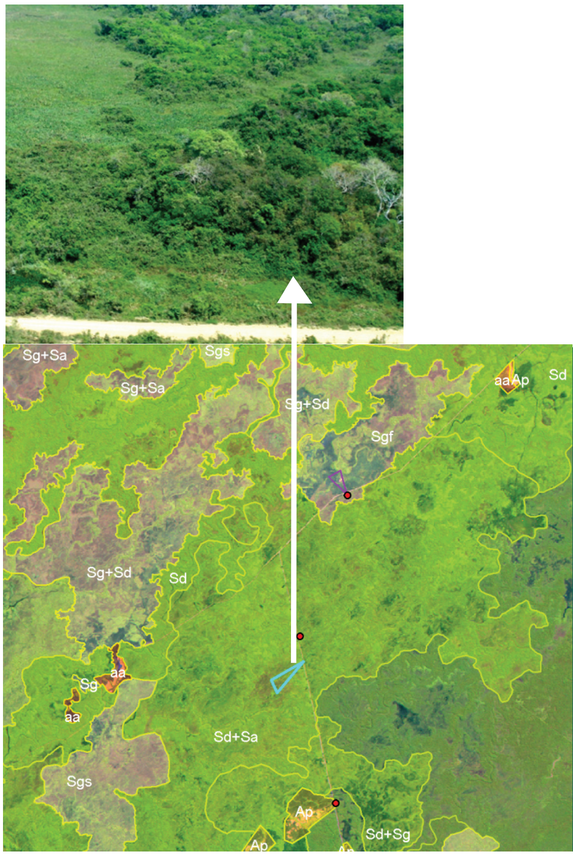
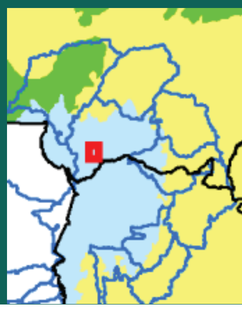


Figure 8. Aerial photograph (bottom) of Class SF vegetation, sub-class Sd+Sa corresponding to the blue triangle in the satellite image.



Shrubby Savannah – SA (Cerrado)

This class corresponds to trees of relatively small stature sparsely distributed in a continuous vegetation consisting of shrubs and herbaceous species.

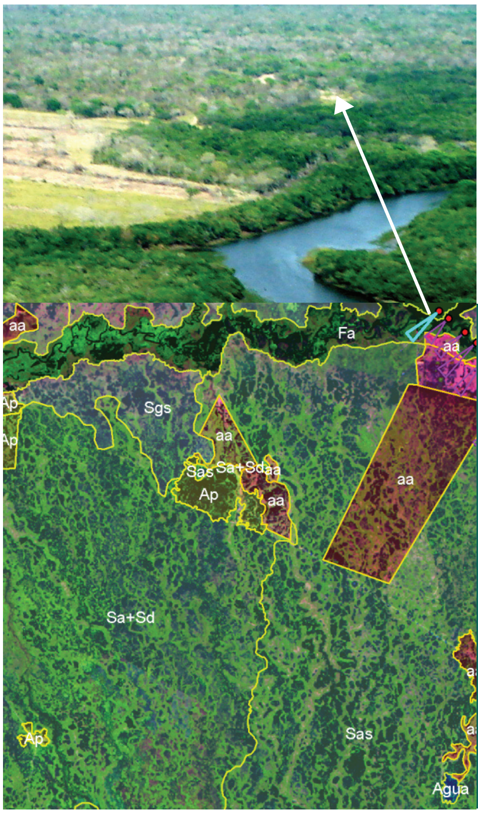
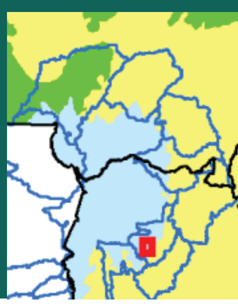


Figure 9. Aerial field photograph (bottom) of Class SA vegetation, sub-class Sa+Sd corresponding to the blue triangle in the satellite image.



Grassland Savannah – SG (Grassland)

This class of vegetation has a sparse distribution of arboreal species but its main aspect is gramineous and it is usually found in areas subject to periodic or permanent.

The herbaceous vegetation is mixed with erect or decumbent shrubs.

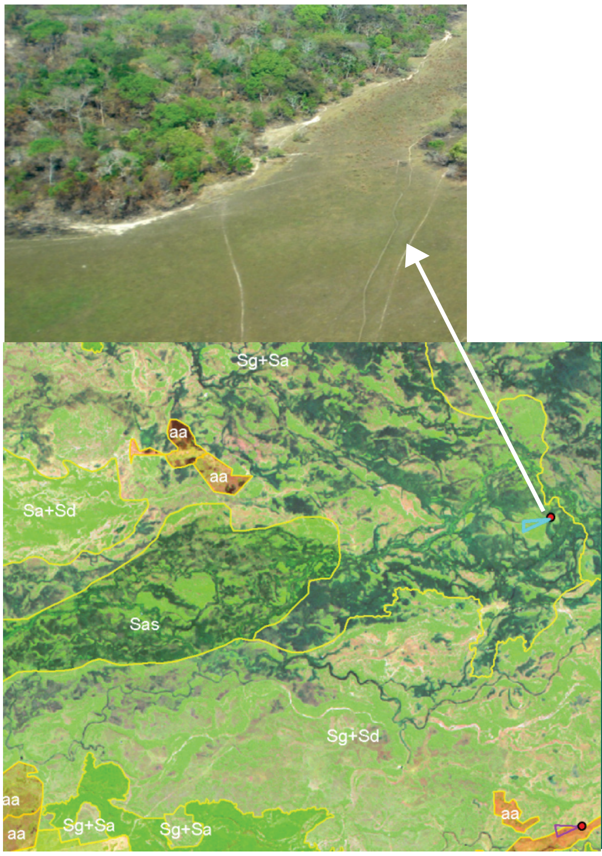
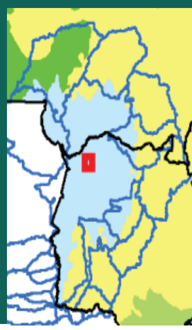


Figure 10. Aerial photograph (bottom) of Class SG vegetation subclass Sg+Sa corresponding to the blue triangle in the satellite image.



Steppe-type Savanna – SEC (Chaco)

This class corresponds to a mixed herbaceous/shrubby vegetation with a lower density of distribution than is found in shrubby savannah (Cerrado).

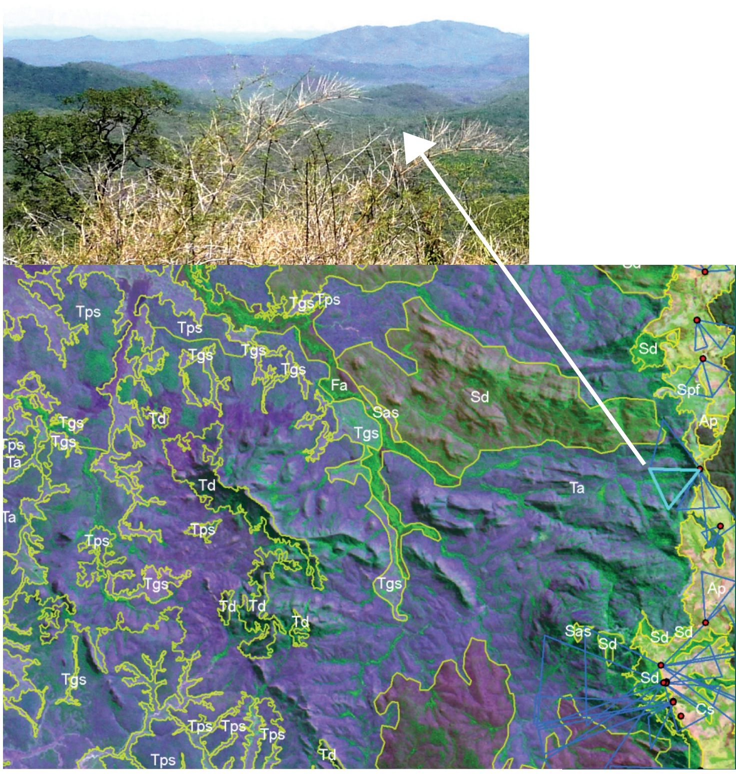
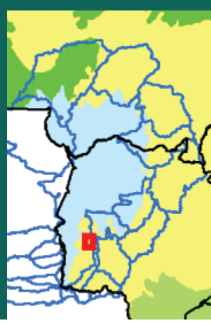


Figure 11. The field photo (bottom) shows Class SEC vegetation, sub-class Ta and corresponds to the blue triangle in the satellite image.



Steppe-type Savanna – SEU (Wetland Chaco)

This class consists of a type of herbaceous/shrubby vegetation with a lower distribution density than that of the Shrubby Savannah (Cerrado) areas. It usually occurs in wet areas of the flatlands subject to periodic or permanent inundation.

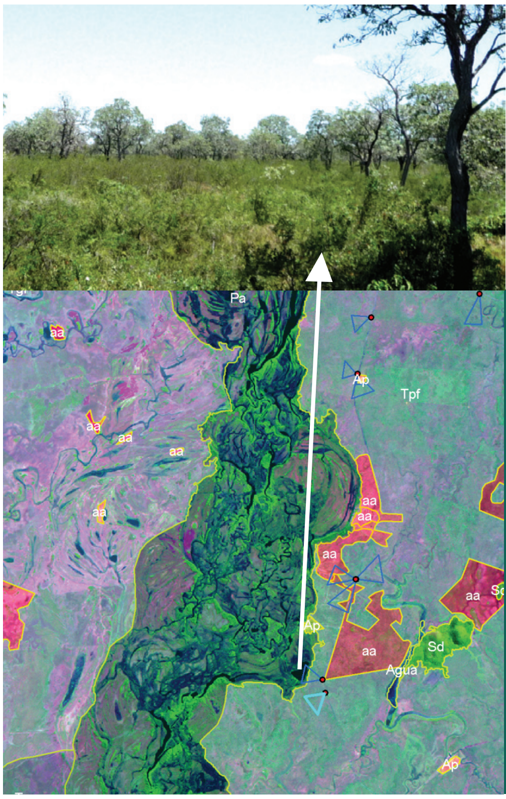
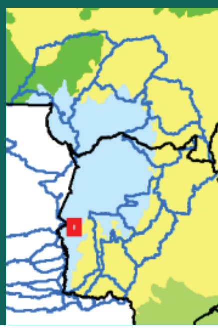


Figure 12. The field photo (bottom) shows Class SEU vegetation, sub-class Tpf and corresponds to the blue triangle in the satellite image .



Vegetation under Fluvial Influence – VF

This class of vegetation consists of arboreal species and pioneer formations (e.g. marshes and stands of Cambará and Paratudo trees and Carandá palms along water courses and in low-lying areas that accumulate water).

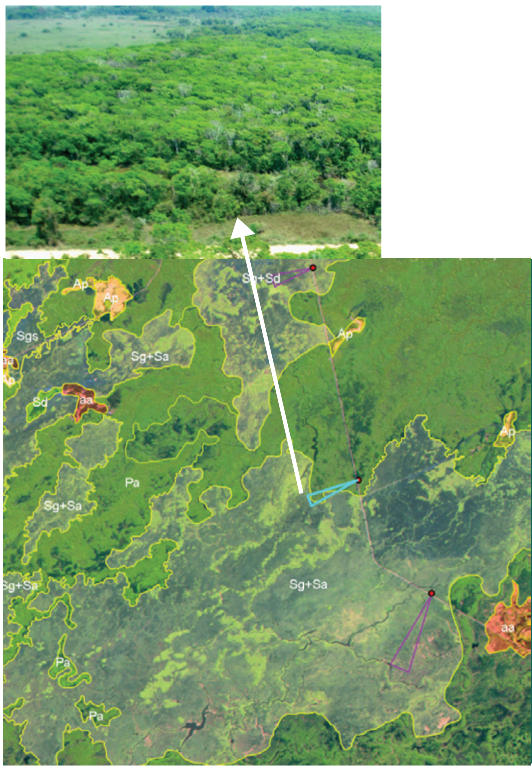
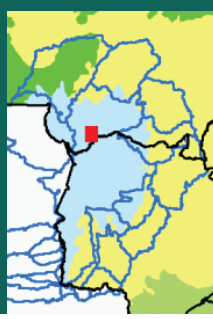


Figure 13. The field photo (bottom) shows Class VF vegetation, sub-class Pa and corresponds to the blue triangle in the satellite image.



Natural Alterationl/Management – anm

The polygons that have been mapped as Natural Alteration/Management refer to categories of vegetation that can be used as natural pasture for cattle and in the methodology adopted they have been considered as areas of natural vegetation.

Such areas show spectrum variations in the satellite images that may be due to seasonal differences or differences stemming from the management of the natural pastureland which are a characteristic of the traditional models of cattle-raising in the Pantanal biome.

They are mainly found in the Pantanal's floodplain region and show signs of seasonal recovery of the vegetation according to the time of year and the management techniques used in cattle farming.

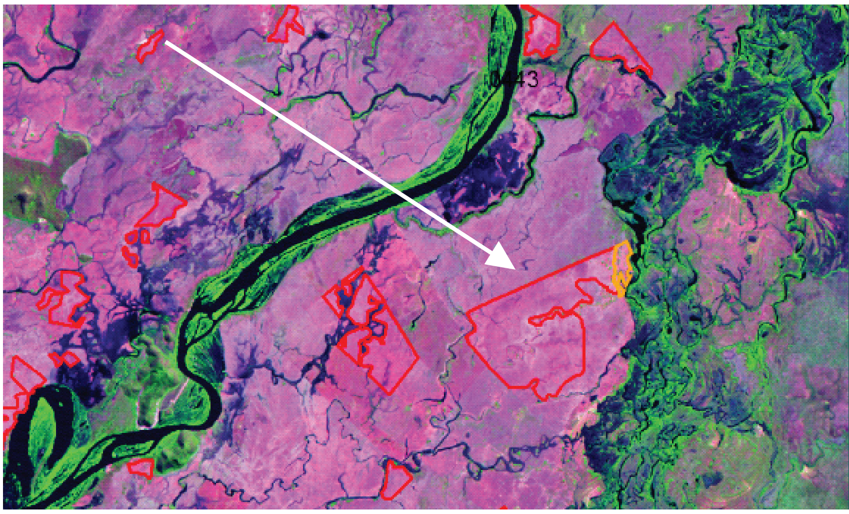
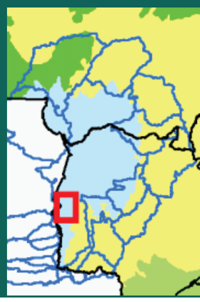


Figure 14. Satellite image of the sub-class Natural Alteration/Management .



To avoid losing any information on the original vegetation cover as it was in 2002, a separate field in the shape attribution table was created to store it

Rivers, streams, corixos, vazantes, baías and salinas – Water

The water categories were delimited and individualised as a specific formation. Special attention was paid to delimiting the bodies of water found in the middle of anthropic-use areas (separating areas represented by lakes in the middle of pastureland for example).

In some cases, vegetation subject to fluvial influence may include masses of water that are not individualised. This occurs most commonly in the most low-lying areas where the Pantanal's natural hydrological regime exercises great influence over the flooded areas. In the case of the rivers, baías and Salinas, only the bigger ones were mapped.

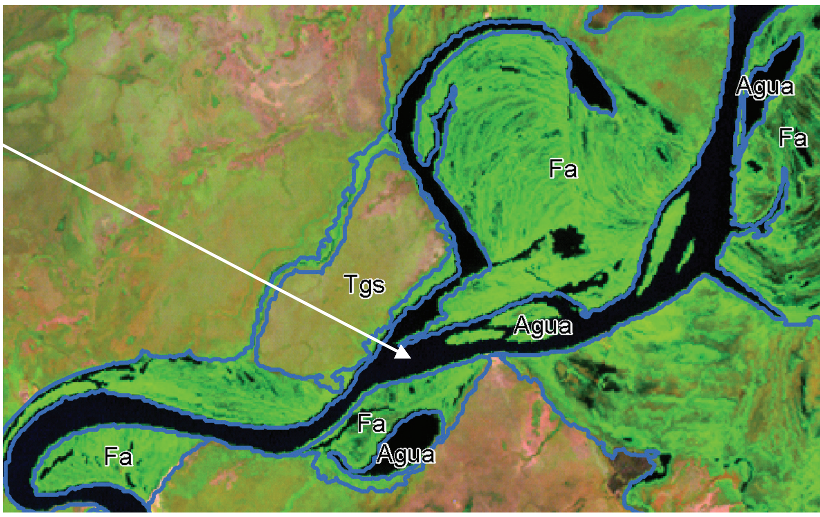
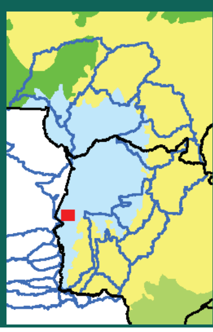


Figure 15. Satellite image of the Class 'Water'.



Anthropic Use – UA

Areas where anthropic use has been consolidated and the ecological function of the original vegetation has been completely lost.

Ac	Agriculture
Ap	Pastureland
Im	Degraded by Mining
Iu	Urban Influence
R	Reforestation

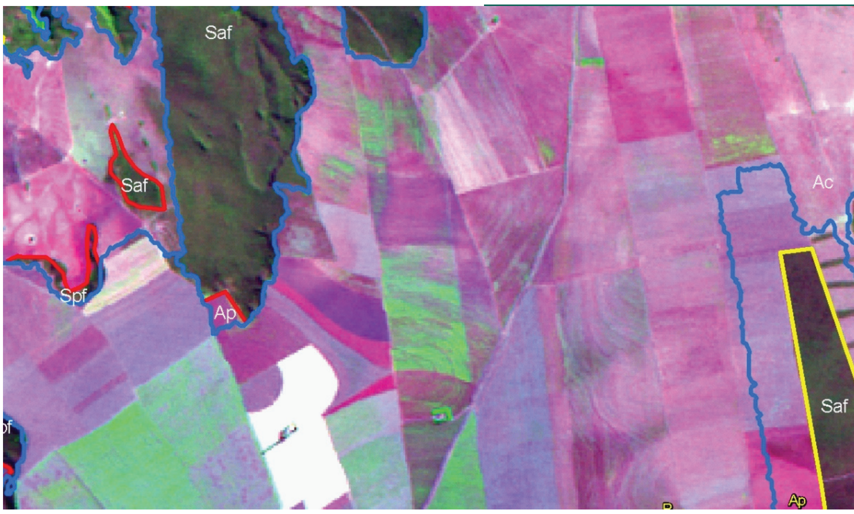
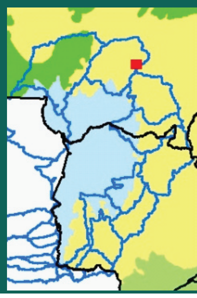


Figure 16. Satellite image showing the class Anthropic Use.



Anthropic Alteration – aa

Areas where the original native vegetation shows signs of alteration in the natural cover but complete conversion to other use, such as for agriculture or for pasture, has not yet occurred. For example:

- cerrado areas where the density of the vegetation cover has been reduced;
- forest areas with clearings in them or where the larger trees have been removed.

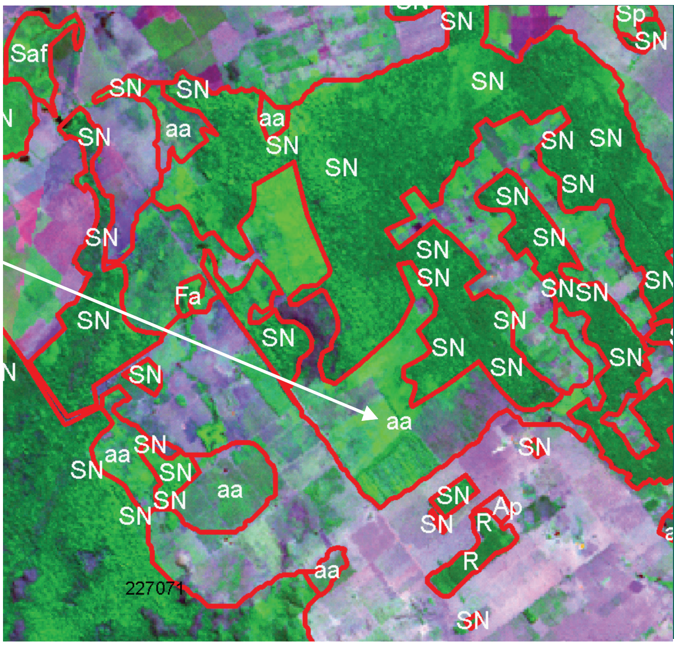
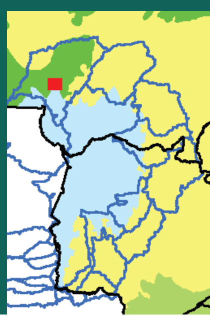


Figure 17 a) Satellite images showing examples of Anthropic Alteration.



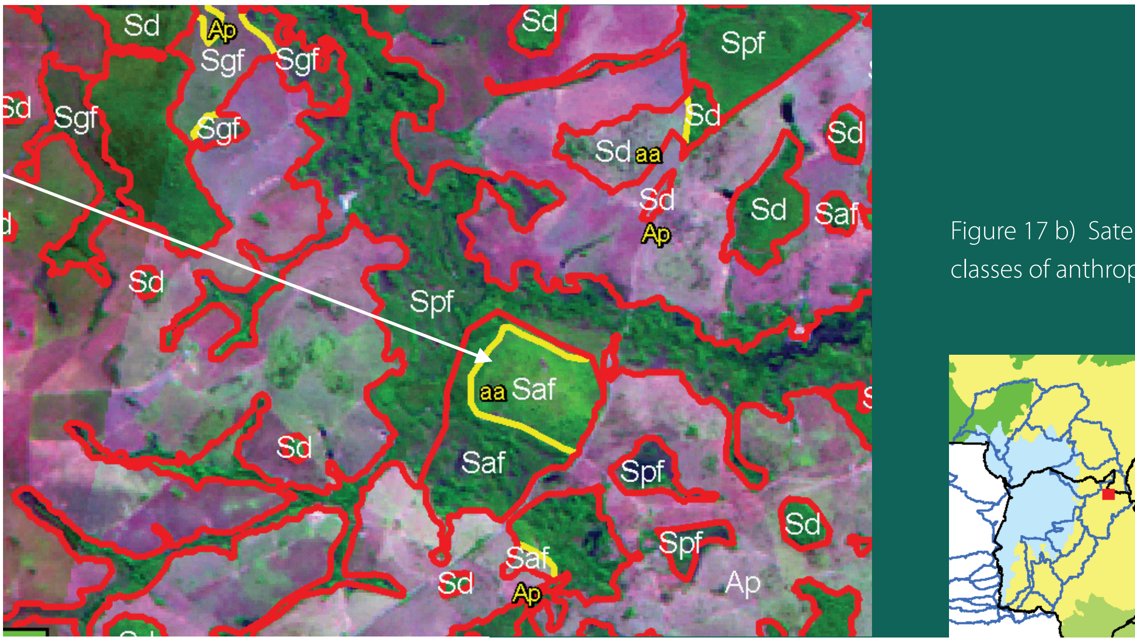


Figure 17 b) Satellite images showing classes of anthropic alterations.

Updating and enhancing detail from 2002 to 2008

In order to update the altered areas for the period 2002 to 2008 the 2002 land use map was superimposed on the Landsat – TM images for 2008 duly geo-referenced on the basis of the 2002 images. The polygons were then sub-divided and re-classified according to the alterations in land use detected in the 2008 images.

No kind of mask was employed for the already altered areas so that during the analysis of the alterations that occurred from 2002 to 2008 it was possible to subdivide and reclassify in greater detail the polygons of 2002 whenever it proved necessary.

The process of visual comparison of the 2002 and 2008 images and the subdivision of the polygons where there were alterations in the use of the land was carried out systematically for the entire BAP using the scale of 1:50,000. The figures that follow illustrate the alterations that were identified.

Natural areas in 2002 converted to anthropic use in 2008

In the images below it is possible to identify natural areas of open grassland with gallery forest (Saf) and areas of dense savannah (Sd) in 2002 converted to pasture by 2008.

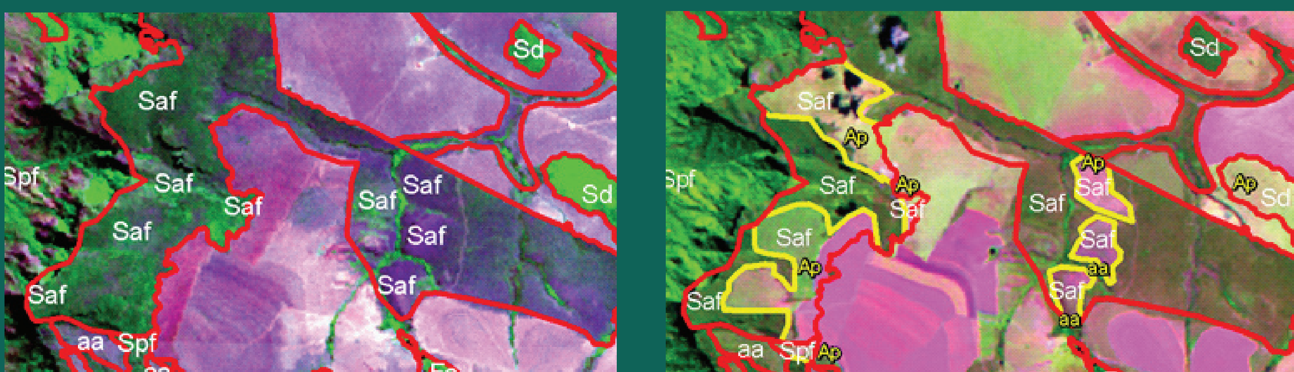


Figure 18. Comparison of images- areas SAF in 2002 (polygons in red) converted to Ap in 2008 (polygons in yellow).

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Natural areas in 2002 that were converted into pastures by 2008 or into areas of anthropic alteration.

In the two pictures below it is possible to identify natural areas of forest formations that were converted into pasture (Ap) by 2008 or show signs of Anthropic Alteration (aa).

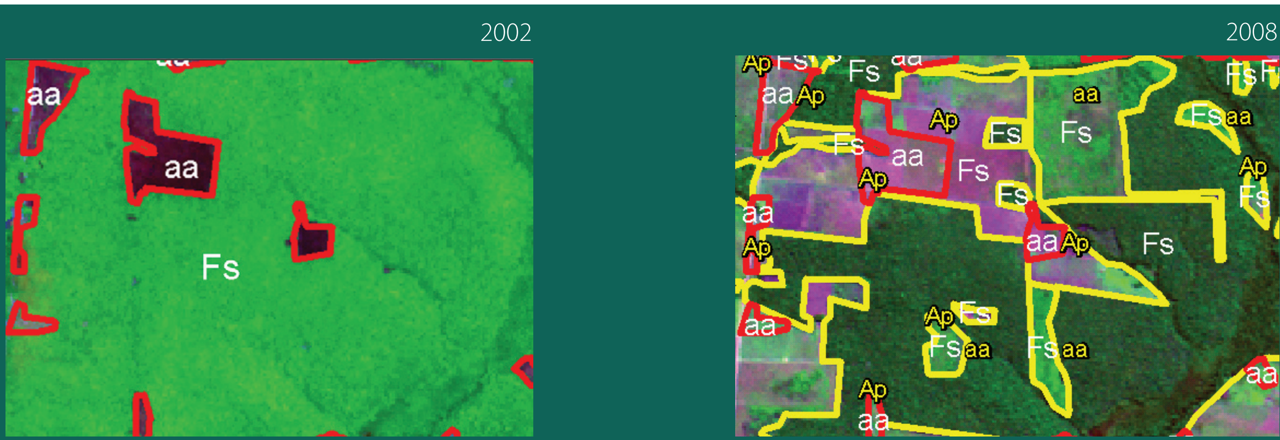

Figure 19. Comparison of images for 2002 and 2008. Fs areas in 2002 converted to Ap or aa by 2008.

Natural areas in 2002 that were re-classified as Natural Alteration/Management areas.

In the images it is possible to identify natural areas of gramineous savannah that show signs of Natural Alteration/Management in 2008.

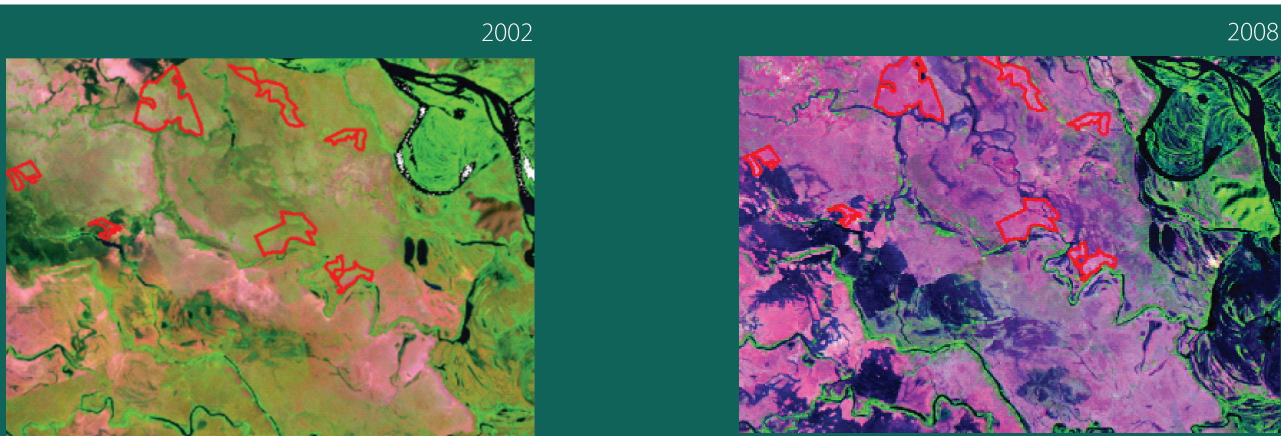

Figure 20. Comparison of images for 2002 and 2008 –areas that were Sg in 2002 showing signs of alteration in 2008 characterizing the sub-class Natural Alteration/Management (polygons in red). Note the differences in tone inside the polygons as compared to their surroundings.

During the process of comparing the land use maps for 2002 and 2008 the identification of alterations in some of the patterns that were visualised in the images led to doubts and uncertainties in their interpretation. Such situations were addressed by using CBERS HRC images with a resolution of 2.5 metres, together with Google Earth images and fieldwork on the ground

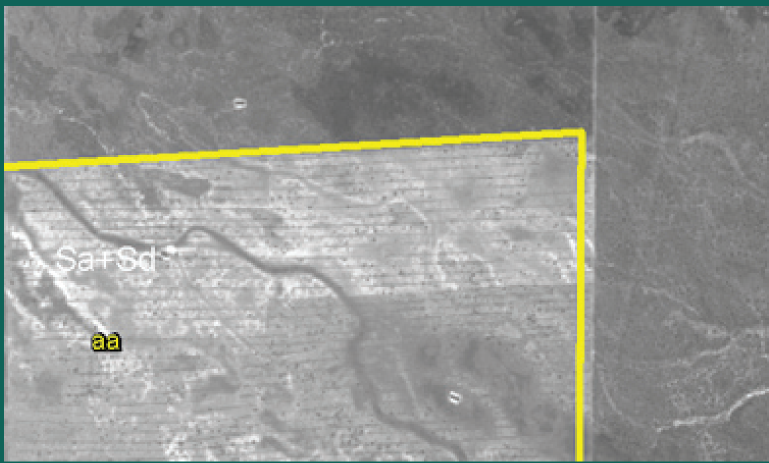

Figure 21. A polygon that had been re-classified from As+Sd to Anthropic Alteration (aa) based on the 2008 Landsat images but which the validation process using CBER HRC images proved to be areas of pastureland (Ap). It is possible to discern horizontal rows in the images that are the piled up remains of the original vegetation.

Doubtful polygons were also superimposed on *Google Earth* images, especially in those areas where high resolution images were available which includes a good part of the BAP and they provided important information on the class of vegetation observed.

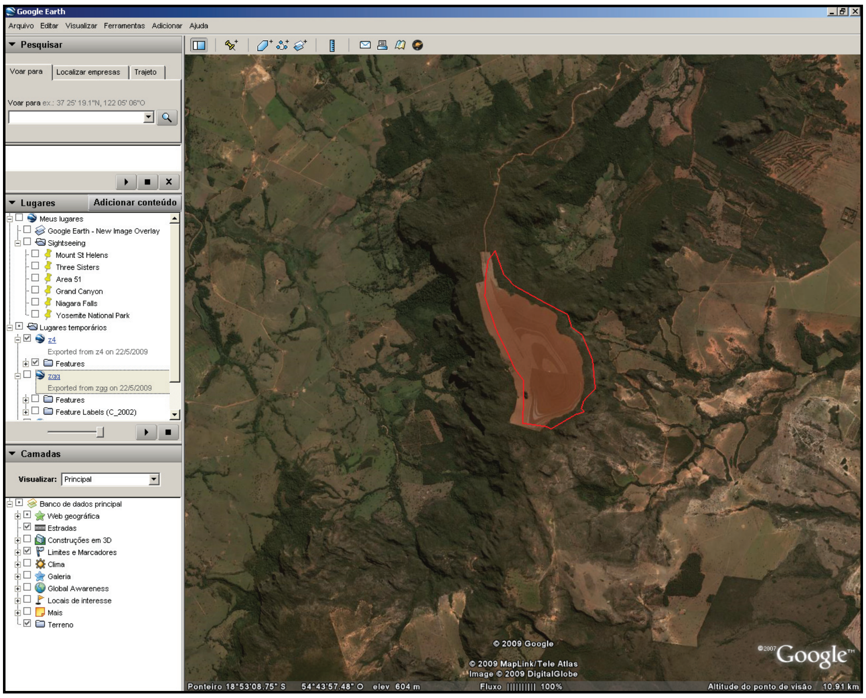

Figure 22. High resolution *Google Earth* image. The polygon outlined in red identifies one of the areas analyzed.

Legend conventions in the Final Vector File

The final vector file in shapefile format displays following fields of information in the corresponding table of attributes:

C_ORIG = classes of vegetation and land use in 2002 according to Probio;

C_2002 = classes of vegetation and land use in 2002 according Probio after adjustment;

C_2008 = classes of vegetation and land use in 2008.

All the classifications adopted obeyed IBGE legend standards which were considered to be the primary level of grouping vegetation types.

Two other fields were added to accommodate the secondary level of grouping the classes of natural vegetation as can be seen in item 3.2 - Legend, of this document:

SIMPL02 = classes of vegetation and land use in 2002, according to the simplified form of the legend conventions;

SIMPL08 = grouping of natural vegetation and use categories in 2008 according to the simplified legend

To facilitate data processing, the analysis of the 2008 situation and the alterations that occurred from 2002 to 2008, field representing a third level of simplification were contemplating the following classes:

- ***NATURAL*** = Areas of natural vegetation in 2002 that continued to be natural in 2008 (including here in the class Natural Alterations/Interference;
- ***ANTHROPIC*** = Areas of Anthropic vegetation in 2002 and in 2008 (including the class Anthropic Alterations)

The fields where such information is registered are:

- ***SITUA02*** = 3rd level of simplification of the legend for 2002;
- ***SITUA08*** = 3rd level of simplification of the legend for 2008.

Another field was added to accommodate a summary of information obtained by monitoring the period from 2002 to 2008 in regard to areas of natural vegetation in 2002 (including the category Natural Alteration/ Management) converted to anthropic use by 2008 (including the category Anthropic Alteration) and such information was designated as "Alteration 2002 to 2008".

- ***MONIT02A08*** = field with information on the variation from 2002 to 2008 prepared by comparing the third level of simplification of the legend.

The table below shows how each polygon is identified in the final shapefile:

FID	Shape*	Objectid_1	C_ORIG	C_2002	C_2008	SIMPL02	SIMPL08	SITUA02	SITUA08	MONITO2A08	ÁREA_HA
2448	Polygon	2472	Ap	Ap	Ap	Ap	Ap	Antrópico	Antrópico	Antrópica	6.85
2449	Polygon	2473	Ap	Ap	Ap	Ap	Ap	Antrópico	Antrópico	Antrópica	34.76
2450	Polygon	2474	Sg+Sa	anm	anm	anm	anm	Alteração N	Alteração N	Natural	71.75
2451	Polygon	2475	Sg+Sa	Sg+Sa	anm	SG	anm	Natural	Alteração N	Natural	15.99
2452	Polygon	2476	Sg+Sa	anm	anm	anm	anm	Alteração N	Alteração N	Natural	37.7
2453	Polygon	2477	Sas	anm	anm	anm	anm	Alteração N	Alteração N	Natural	28.59
2454	Polygon	2478	Sas	anm	anm	anm	anm	Alteração N	Alteração N	Natural	30.56
2455	Polygon	2479	Sas	anm	anm	anm	anm	Alteração N	Alteração N	Natural	62.55
2456	Polygon	2480	Sas	Sas	anm	SA	anm	Natural	Alteração N	Natural	108.96
2457	Polygon	2481	Sa+Sd	anm	anm	anm	anm	Alteração N	Alteração N	Natural	10.63
2458	Polygon	2482	Sa+Sd	anm	anm	anm	anm	Alteração N	Alteração N	Natural	21.93
2459	Polygon	2483	Sas	Sas	aa	SA	aa	Natural	Alteração	Alteração 2002a	52.5
2460	Polygon	2484	Sas	anm	anm	anm	anm	Alteração N	Alteração N	Natural	191.22
2461	Polygon	2485	Sas	Sas	Sas	SA	SA	Natural	Natural	Natural	106.01
2462	Polygon	2486	Cs	Cs	Cs	FF	FF	Natural	Natural	Natural	1.93
2463	Polygon	2487	Cs	Cs	Ap	FF	Ap	Natural	Antrópico	Alteração 2002a	9.04
2464	Polygon	2488	Sas	Sas	Ap	SA	Ap	Natural	Antrópico	Alteração 2002a	336.92
2465	Polygon	2489	Sas	Sas	anm	SA	anm	Natural	Alteração N	Natural	1934
2466	Polygon	2490	Sas	Sas	Ap	SA	Ap	Natural	Antrópicol	Alteração 2002a	26.44

Figure 23. Table showing the attributes of the shapefile and the respective fields (columns).

4. Validation of the Mapping

The work of validation was essential to guarantee the high quality of the map being produced.
In this project all the mapping undertaken by a given interpreter was revised by another using an even larger set of information to validate the mapping and further qualify those areas that are liable to strong subjective influence in their classification.

In addition to the use of high resolution images, a considerable set of reference information was compiled to assist in the correct identification of the categories included in the mapped areas.

The map in figure 50 displays some of the information stemming from fieldwork of Embrapa Pantanal researchers who made their regional data available to the mapping process offering guidance in the identification of:

. Types of vegetation

. Areas of planted pasture

. Areas of natural pasture

. Deforested areas

. Farm buildings and installations

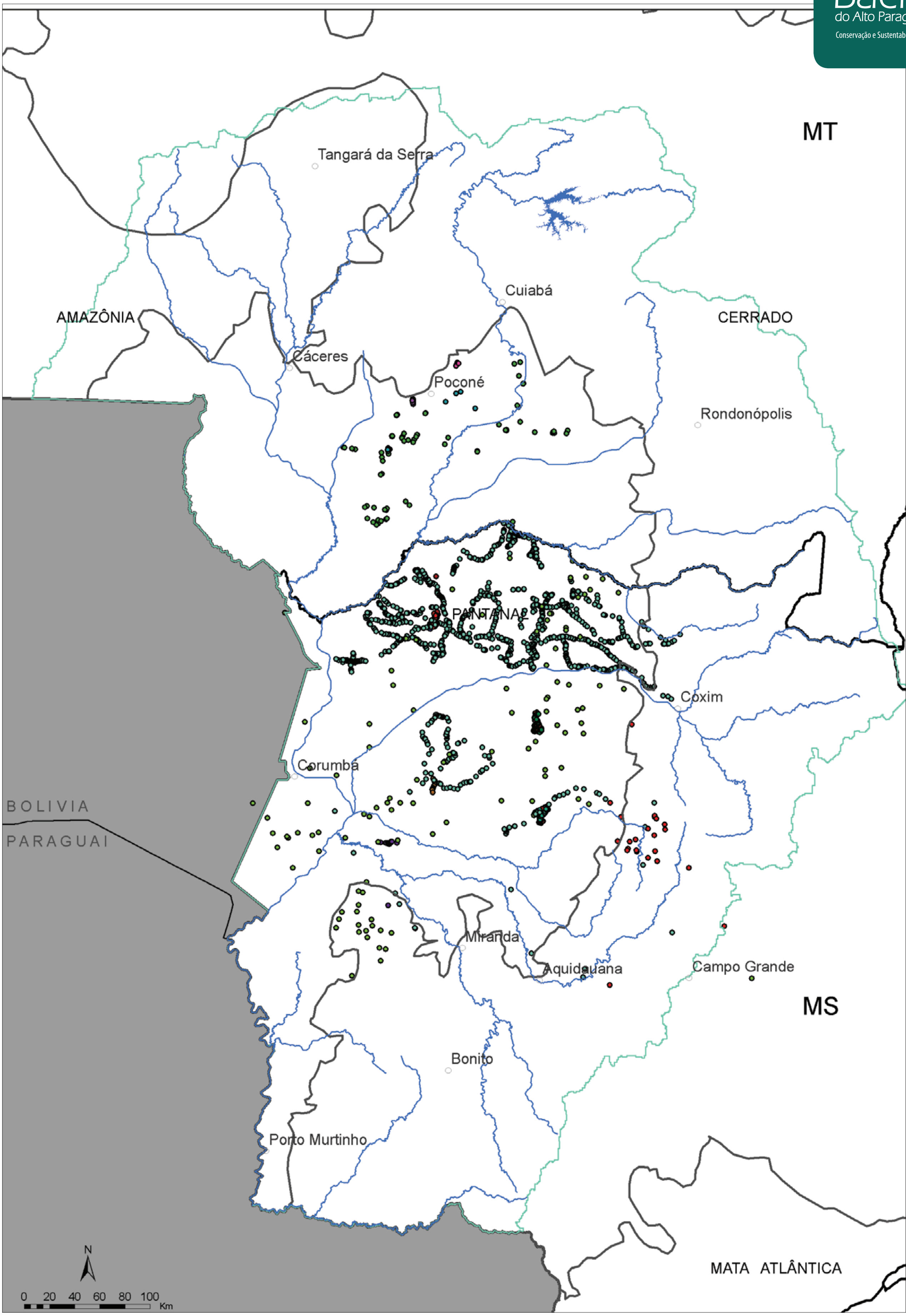

Figure 24. Some of the sites where information supplied by Embrapa Pantanal was used to validate the mapping.

With a view to incorporating the accumulated experience and field knowledge of Embrapa Pantanal staff that have been working in the region for years, meetings were held with those specialists that could assist in the validation of specific regions and in adjusting the standards used in interpretation and the legends adopted in the mapping process. The respective consultants were:

. Carlos Roberto Padovani

. Sandra Aparecida Santos

. Sandra Mara A. Crispim

. Suzana Maria Salis

. Walfrido Tomas

. Guilherme de Miranda Mourão

To further that same end, specialist Mario Barroso of Conservação Internacional, Brasília and cattle rancher Marcelo Pinto Figueiredo, president of the Cattle Farmers Union (Upan) for the Nabileque region were both consulted (Upan)

During the meetings questions were raised regarding specific well-known regions with characteristics being used in the process of interpreting the images. The resulting comments were noted and used to refine the pre-existing information and to adjust the standards being applied to the entire BAP.

After that the entire map was revised and elaborated in further detail incorporating the orientations and recommendations that were proffered during this stage of the work.

5. Analysis of the Results

The mapping made it possible to carry out a considerable set of analyses not only of the situation in 2008, but of the evolution of changes over the period from 2002 to 2008.

A continuous cartographic base in the form of a shapefile was produced (Vector File) that can be superimposed on various profiles in order to identify patterns and supply information to provide support to the planning of conservation actions and interventions in the BAP.

Analysis of the Results

The result of the project is a continuous map of that can be used to generate monitoring statistics for the period 2002 –2008 or of the situation of vegetation and land use in 2008.

To gain a better understanding of the dynamics of land occupation in the BAP and make adequate planning of actions and interventions in the Bacin feasible, the analyses of the results need to be regionalized.

Analysis of the results

Total area of the BAP: 368,640 km^2

Total natural vegetation cover: 221,690 km^2 = 60.1% of the BAP

Composition by class of natural vegetation in the BAP:

Classes of Natural Vegetation in the Bap in 2008	Area (km^2)	Percentage of the total Bap area
SA (Shrubby Savannah/Cerrado)	58,021	15.70%
SG (Gramineous Savannah/Grassland)	51,423	13.90%
SF (Woodland Savannah/Cerradão)	32,040	8.70%
FF (Forest Formations)	30,470	8.30%
VF (Vegetation under Fluvial Influence)	27,375	7.40%
SEU (Steppe-type Savannah/Wetland Chaco	12,077	3.30%
SEC (Steppe-type Savannah/Chaco)	5,039	1.40%
anm (natural alteration/management))	2,072	0.60%
Water	3,173	0.90%

Total anthropic area in 2008: 146,949 km^2 = 39.9%

Categories of anthropic use in the Bap in 2008	Area (km^2)	Percentage of the total Bap area
Pastureland	111,302	30.20%
Agriculture	22,083	6.00%
Anthropic Alteration	11,896	3.20%
Urban Influence	806	0.20%
Reforestation	804	0.20%
Influence of Mining	59	0.00%

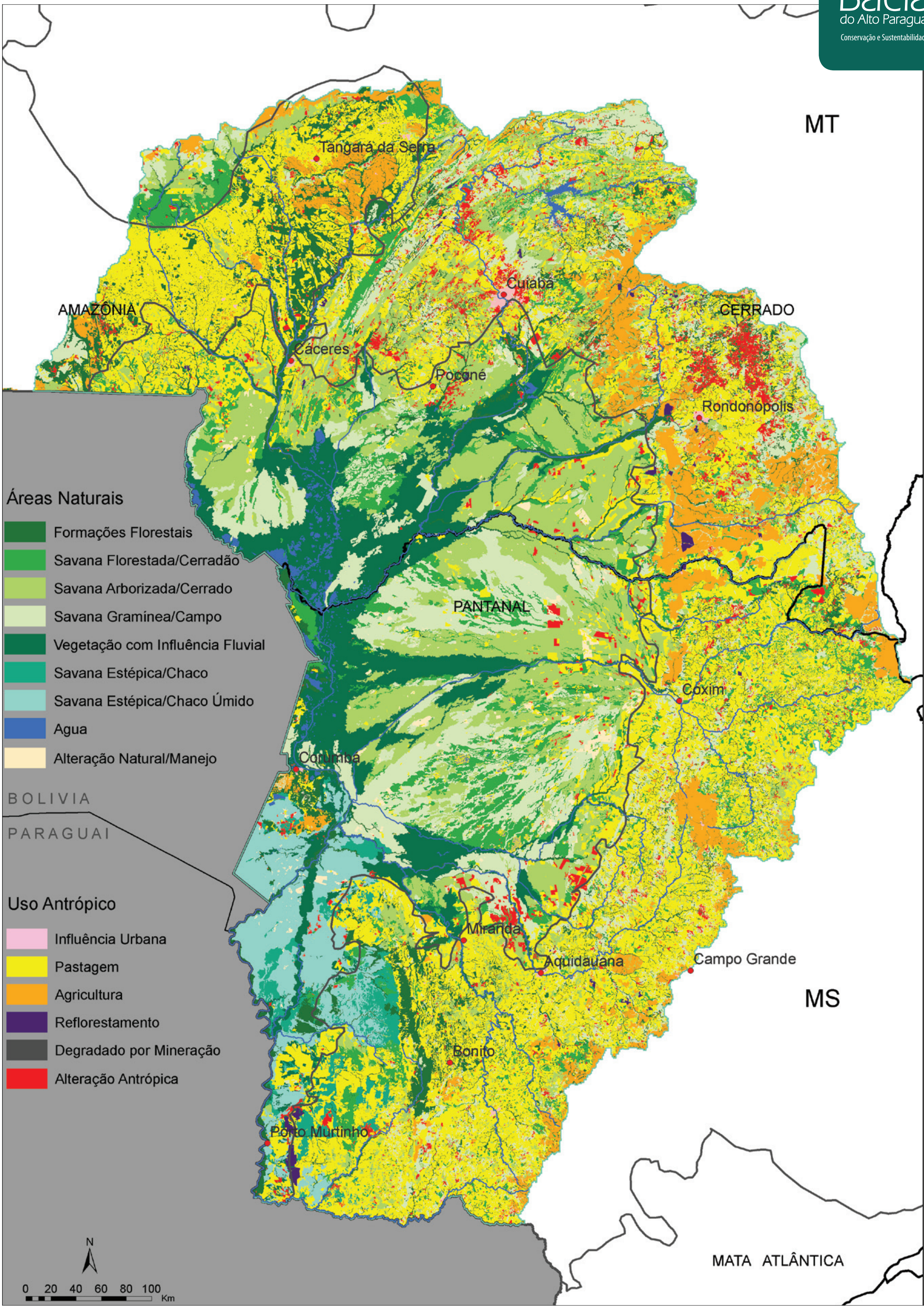

Figure 25. Map of natural vegetation and land use in the BAP - 2008 (simplified classification legend).

Analysis by biomes

This analysis cross-referenced the data obtained, with that of the IBGE's bioma map for the year 2004 on a scale of 1:5,000,000 (first approximation):

	% of Biome in BAP	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
		km²	%	km²	%	km²	%	km²	%
AMAZÔNIA	1%	10,793	3.6%	21	0.1%	20,136	62.7%	1,155	3.6%
CERRADO	9%	79,516	42.9%	545	0.3%	97,751	52.7%	7,642	4.1%
PANTANAL	100%	128,209	84.9%	2,606	1.7%	16,598	11.0%	3,667	2.4%

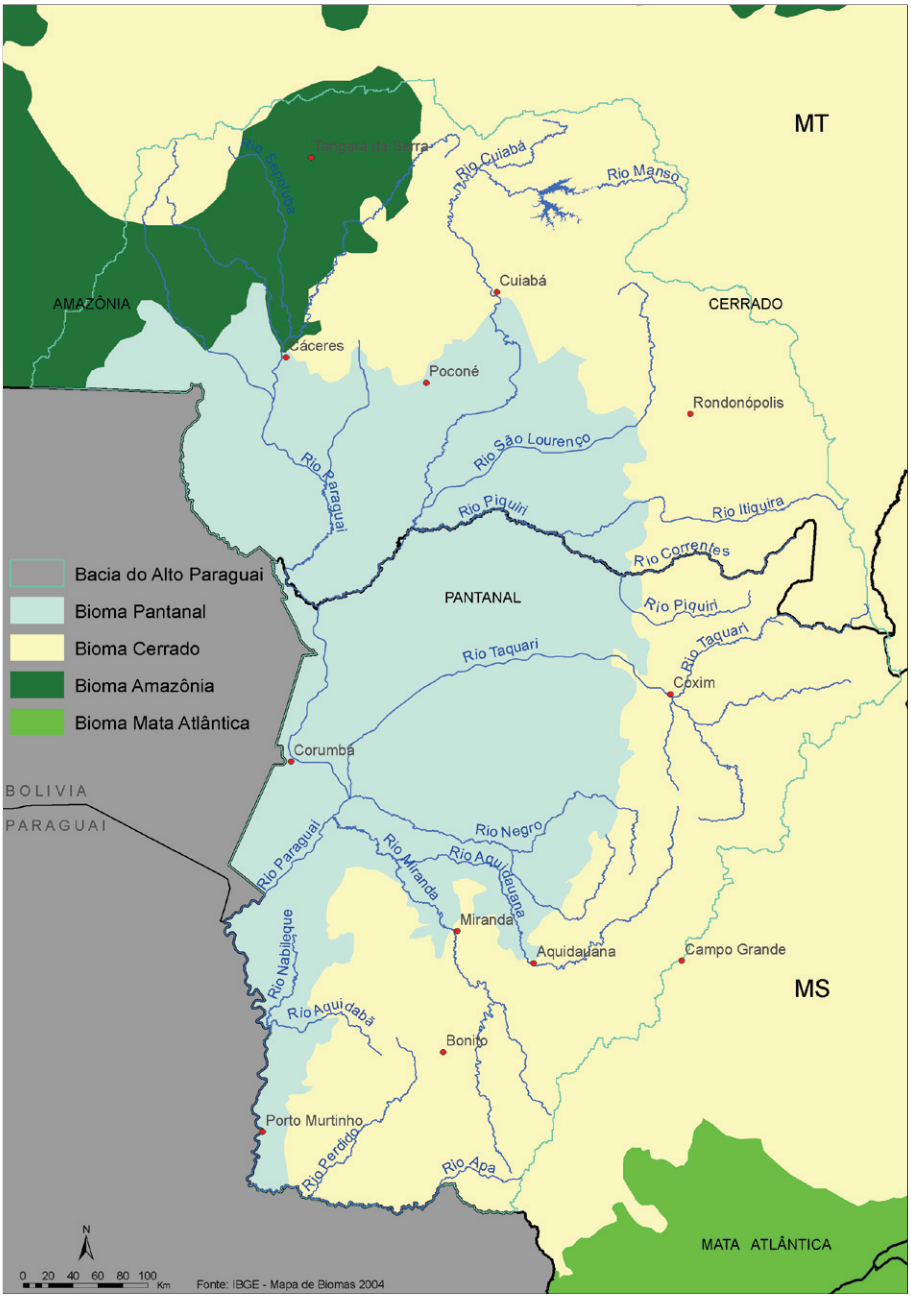

Figure 26. Map of BAP biomes.

Analysis by floodplain and highlands

The analysis of the BAP floodplain considered the Pantanal according to the limits delineated in the IBGE's Pantanal biome map of 2004 (first approximation). The rest of the BAP outside those limits was considered to be highlands.

	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
	km^2	%	km^2	%	km^2	%	km^2	%
Floodplain	128,209	84.9%	2,606	1.7%	16,598	11.0%	3,667	2.4%
Highlands	90,309	41.5%	566	0.3%	117,887	54.2%	8,797	4.0%

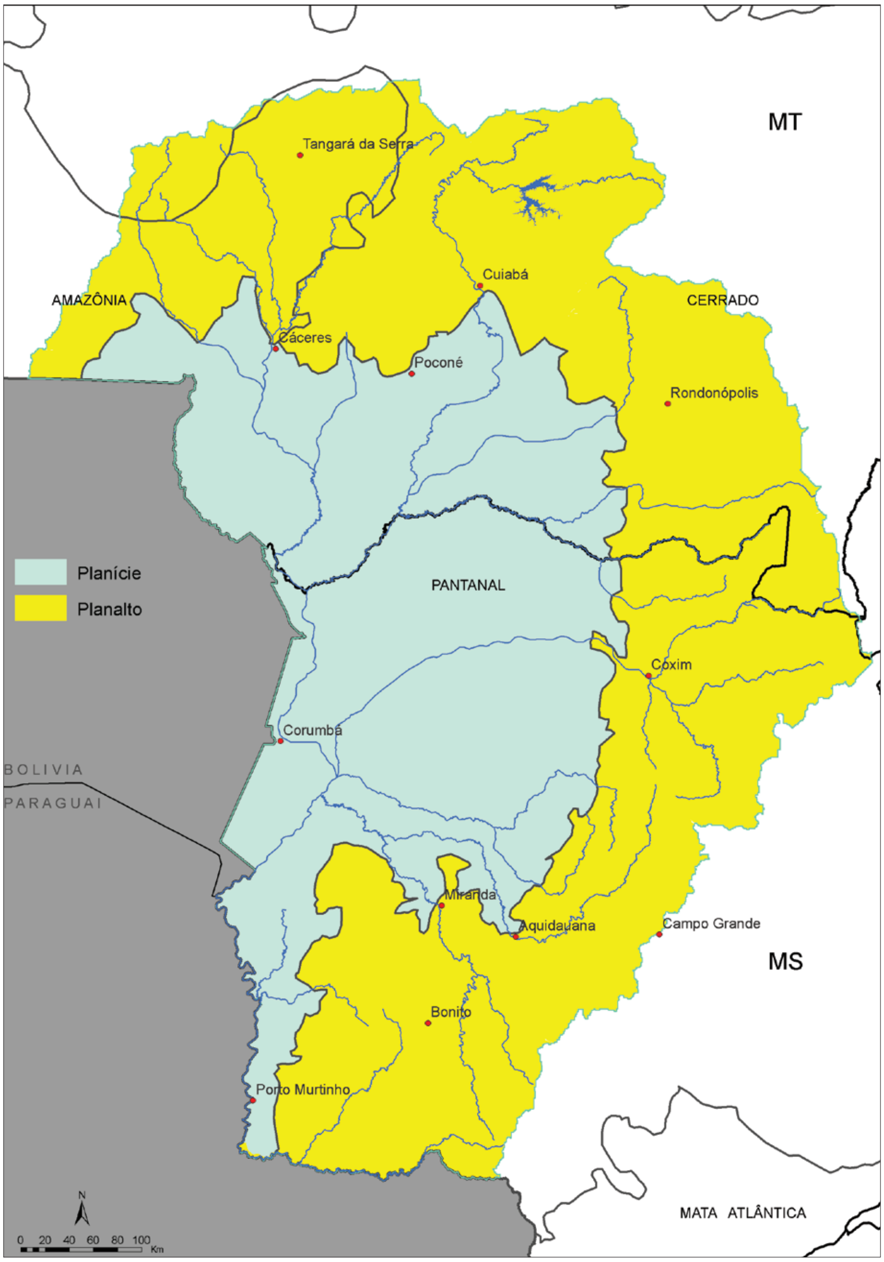

Figure 27. Area of the floodplain (turquoise) and the highlands (yellow) on the IBGE biomes map.

Area of the BAP floodplain: 151,080 km^2 = 41.0%

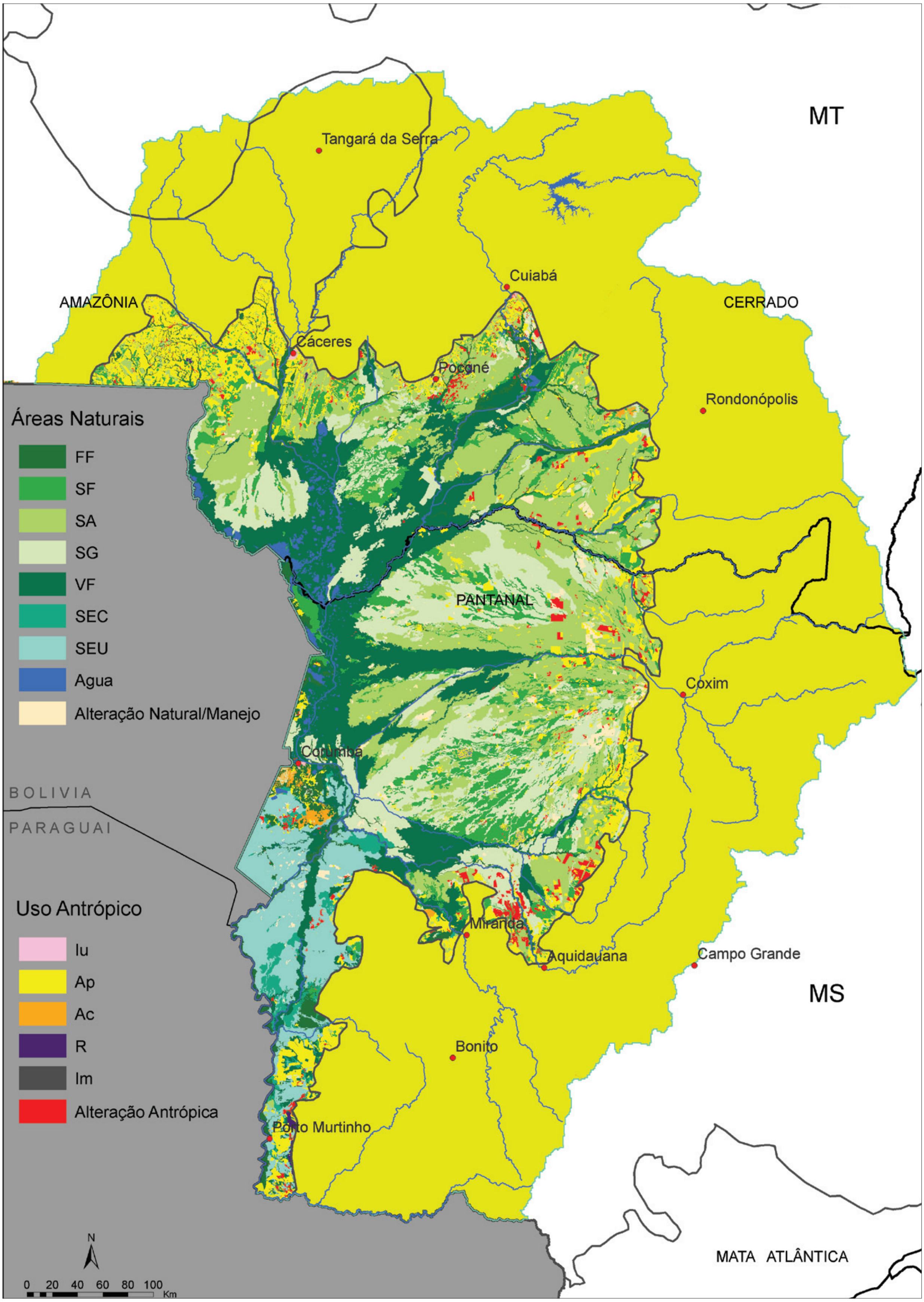

Figure 28. Map of natural vegetation and land use in the BAP floodplain - 2008 (simplified classification legend).

Natural vegetation cover in the floodplain – 2008

Total natural area: 130,815 km^2 = 86.6% of the floodplain

Composition by categories of natural vegetation in the floodplain:

Natural Vegetation Class	Area (km^2)	% of total floodplain area
SA (Shrubby Savannah/Cerrado)	37,606	24.90%
VF (Vegetation under Fluvial Influence)	27,222	18.00%
SG (Gramineous Savannah/Grassland)	25,884	17.10%
SF (Woodland Savannah/Cerradão)	16,015	10.60%
SEU (Steppe-type Savannah/Wetland Chaco)	9,700	6.40%
FF (Forest Formations)	7,876	5.20%
Water	2,606	1.70%
anm (natural alteration/management)	2,072	1.40%
SEC (Steppe-type Savannah/Chaco)	1,834	1.20%

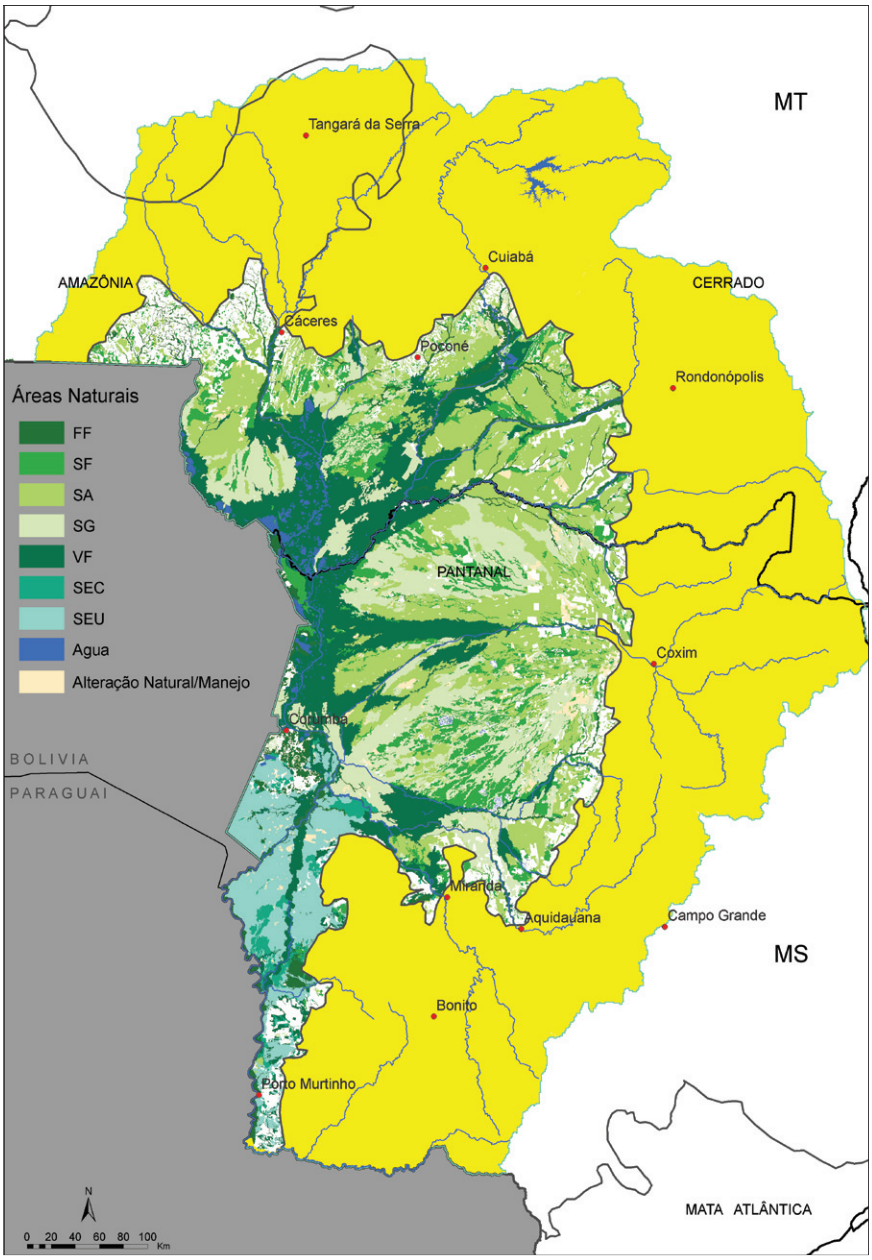

Figura 29. Natural vegetation types in the floodplain in 2008 – simplified classification legend

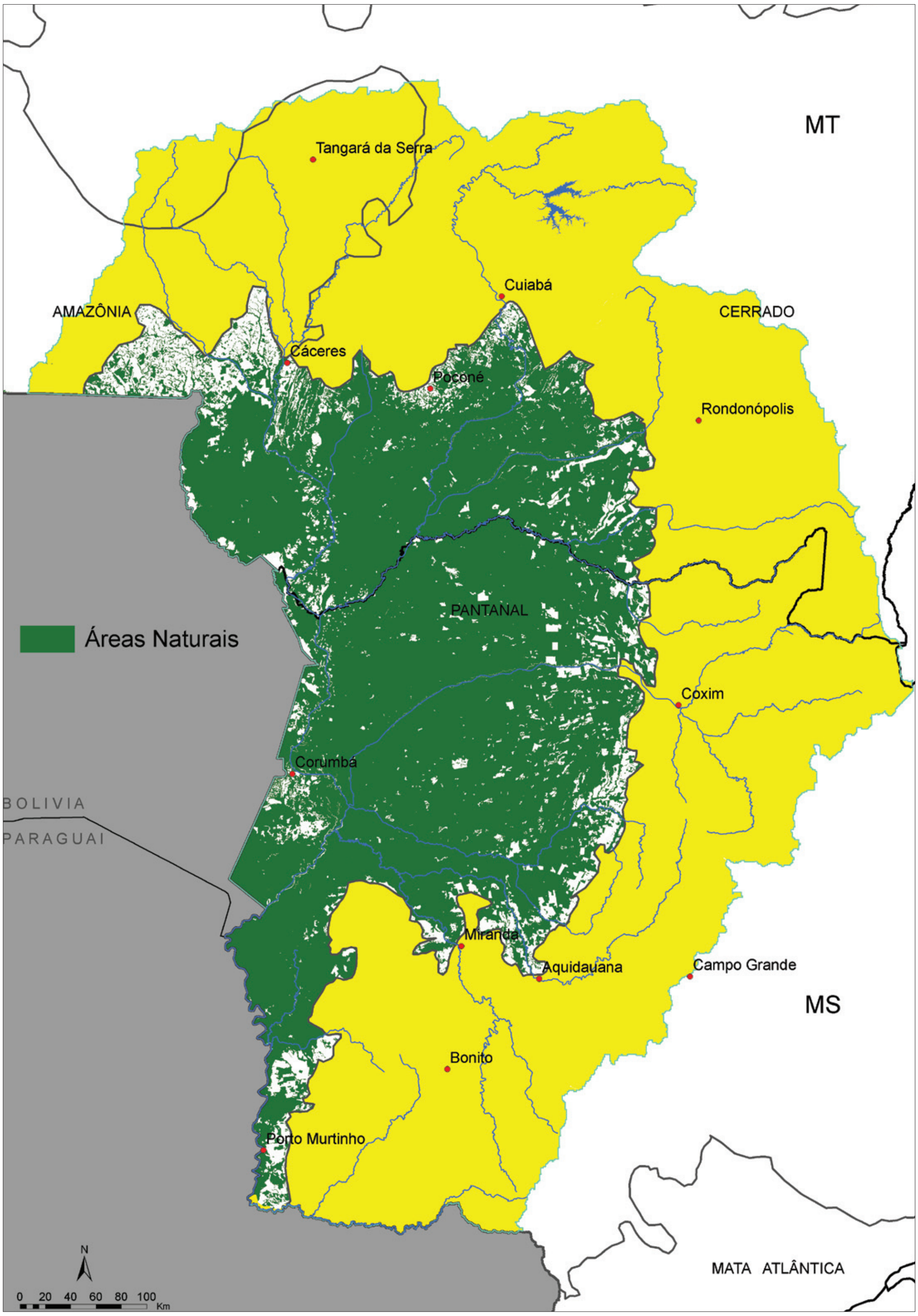

Figure 30. Map of natural vegetation in the floodplain not classified by types.

Areas of anthropic use in the floodplain – 2008

Total anthropic use area in 2008: 20,265 km^2 = 13.4%

Class of Use	Área (km^2)	% of total floodplain area
Pastureland (Ap)	16,737	11.10%
Anthropic Alteration(aa)	2,740	1.80%
Agriculture (Ac)	493	0.30%
Reforestation (R)	150	0.10%
Urban Influence (Iu)	116	0.10%
Degraded by mining (Im)	29	0.00%

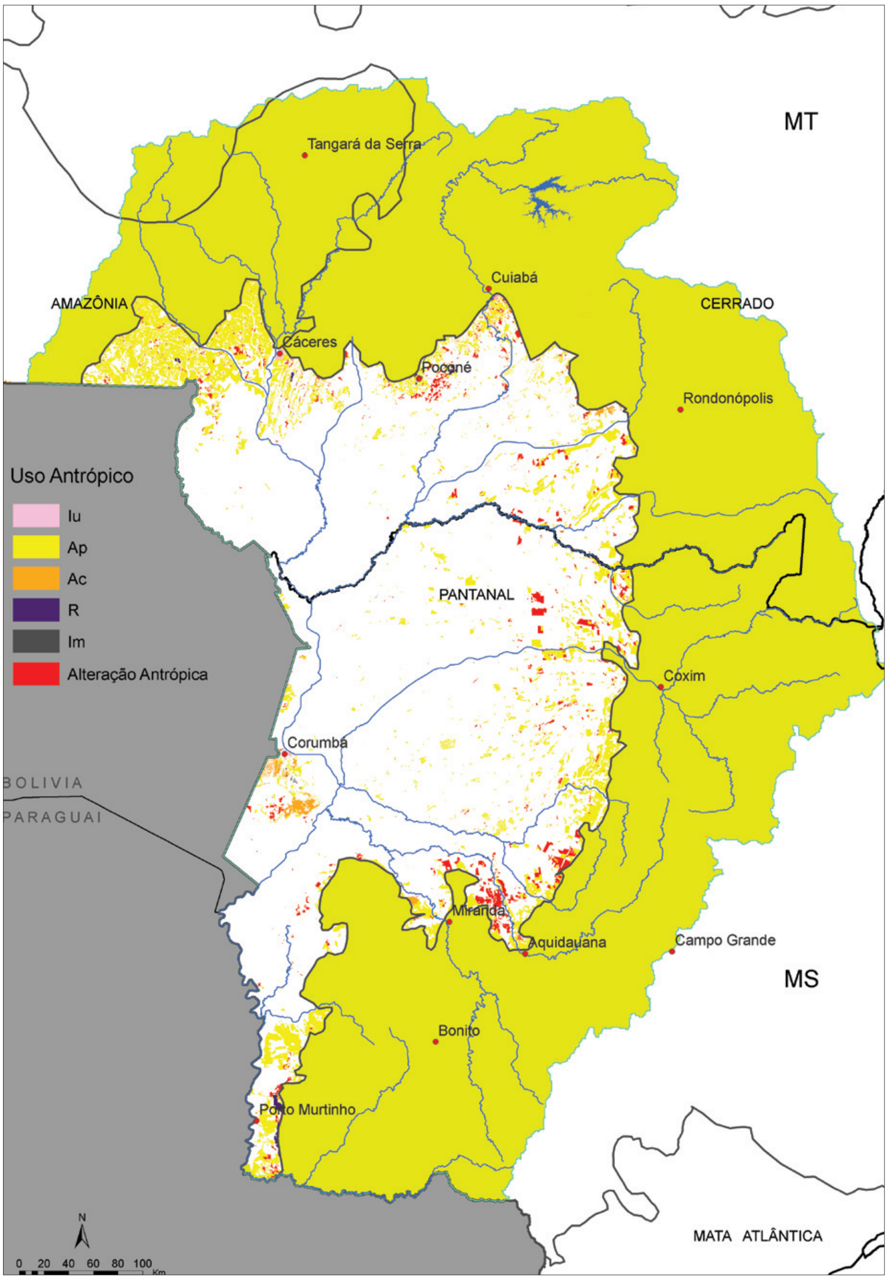

Figure 31. Classes of anthropic use in the floodplain - 2008.

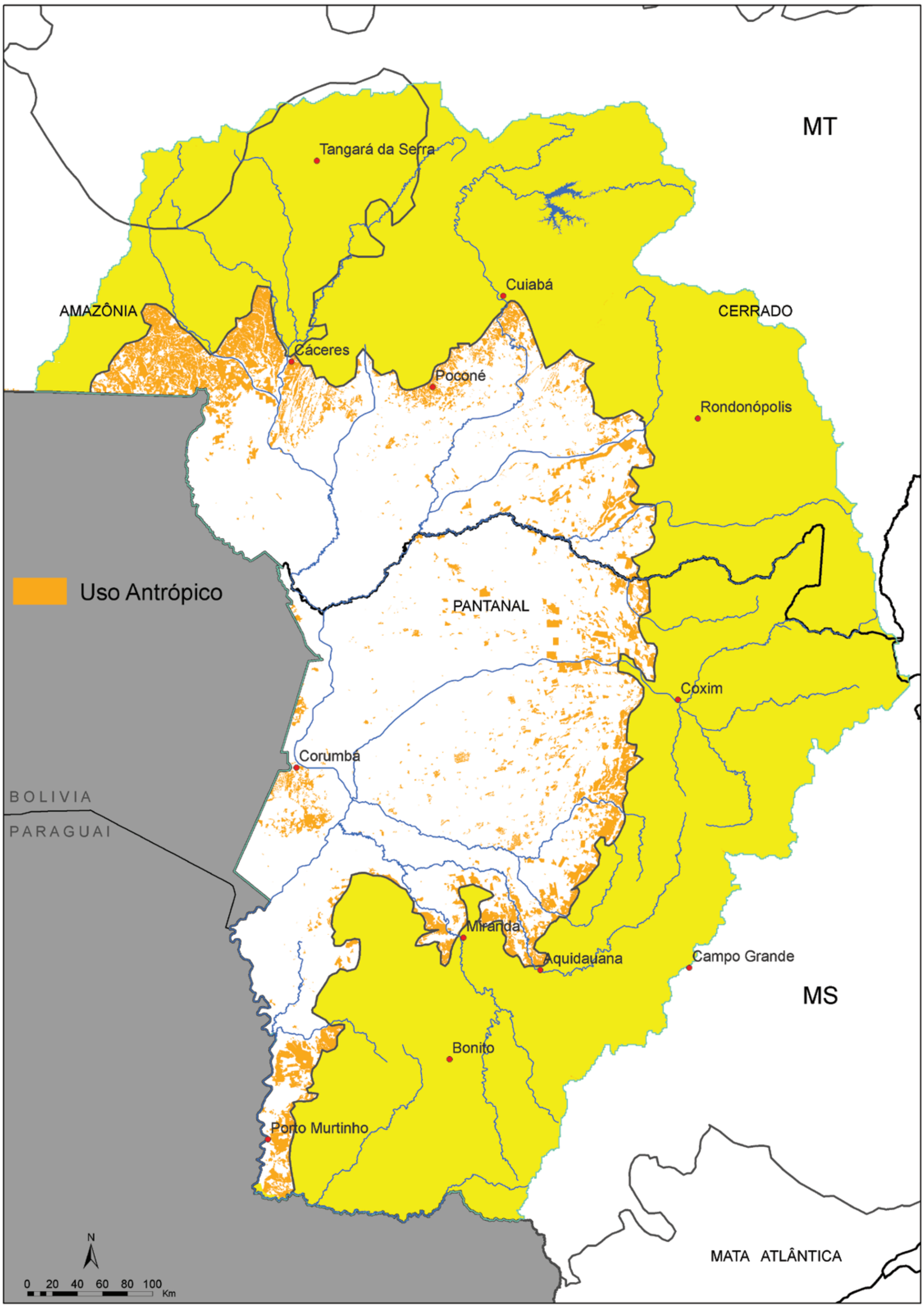

Figure 32. Map of anthropic use areas in the floodplain in 2008, not classified by types.

Analysis of pasture areas in the floodplain

Conversion to pastureland

Pastureland in 2002: 14,613 km^2

Pastureland in 2008: 16,737 km^2 = 11.1% of ther floodplain area.

Pastureland advanced into areas of:

SF (Woodland Savannah/Cerradão): 819 km^2

SA (Shrubby Savannah/Cerrado): 799 km^2

SG (Gramineous Savannah/Grassland): 193 km^2

FF (Forest Formations): 74 km^2

Anm (natural alteration/management): 67 km^2

aa (anthropic alteration): 55 km^2

SEU (Steppe-type Savannah/Wetland Chaco): 54 km^2

SEC (Steppe-type Savannah/Chaco): 50 km^2

VF (Vegetation under Fluvial Influence): 49 km^2

Pastureland lost area stops:

Reforestation: 27 km^2

Agriculture (at least): 5 km^2

Degradation by mining: 3 km^2

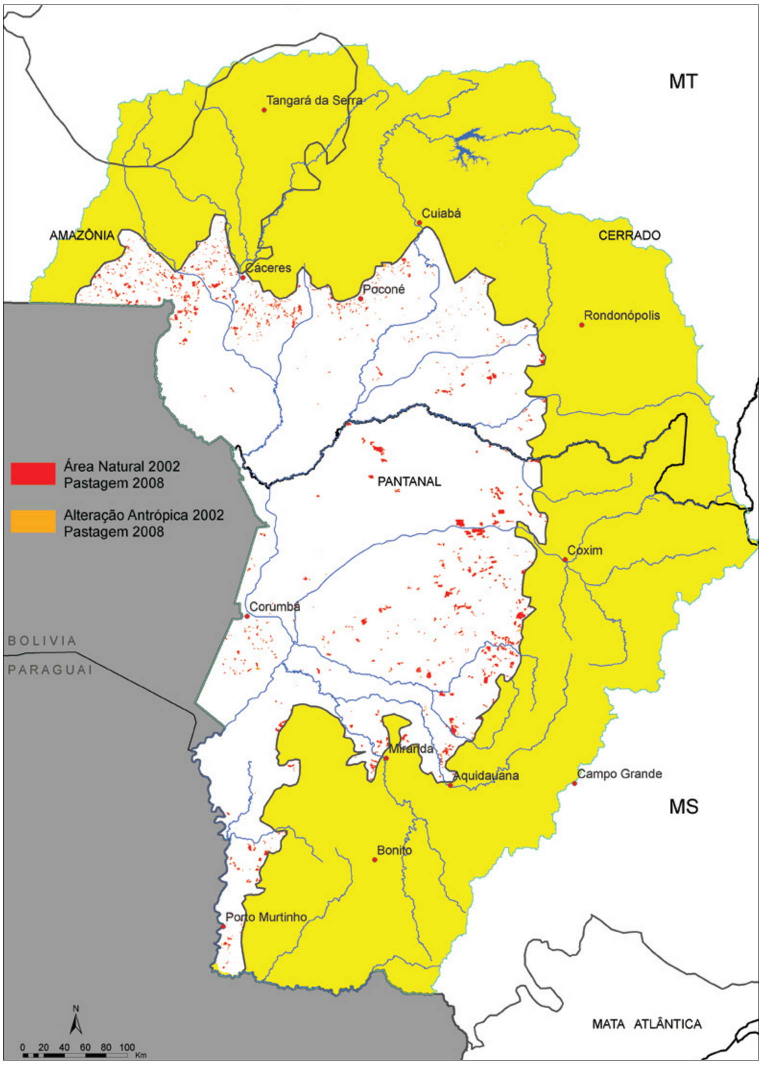

Figure 33. Natural areas in the floodplain in 2002 converted into pastureland by 2008.

Analysis of agriculture in the floodplain

Conversion to agriculture

Agriculture in 2002: 475 km²

Agriculture in 2008: 493 km² = 0.3% of the floodplain area

A agriculture advanced into areas of:

SG (Gramineous Savannah/Grassland): 5 km²

SEC (Steppe-type Savannah/Chaco): 5 km²

AP (Pastureland): 5 km²

SA (Shrubby Savannah/Cerrado): 1 km²

FF (Forest Formations): 2 km²

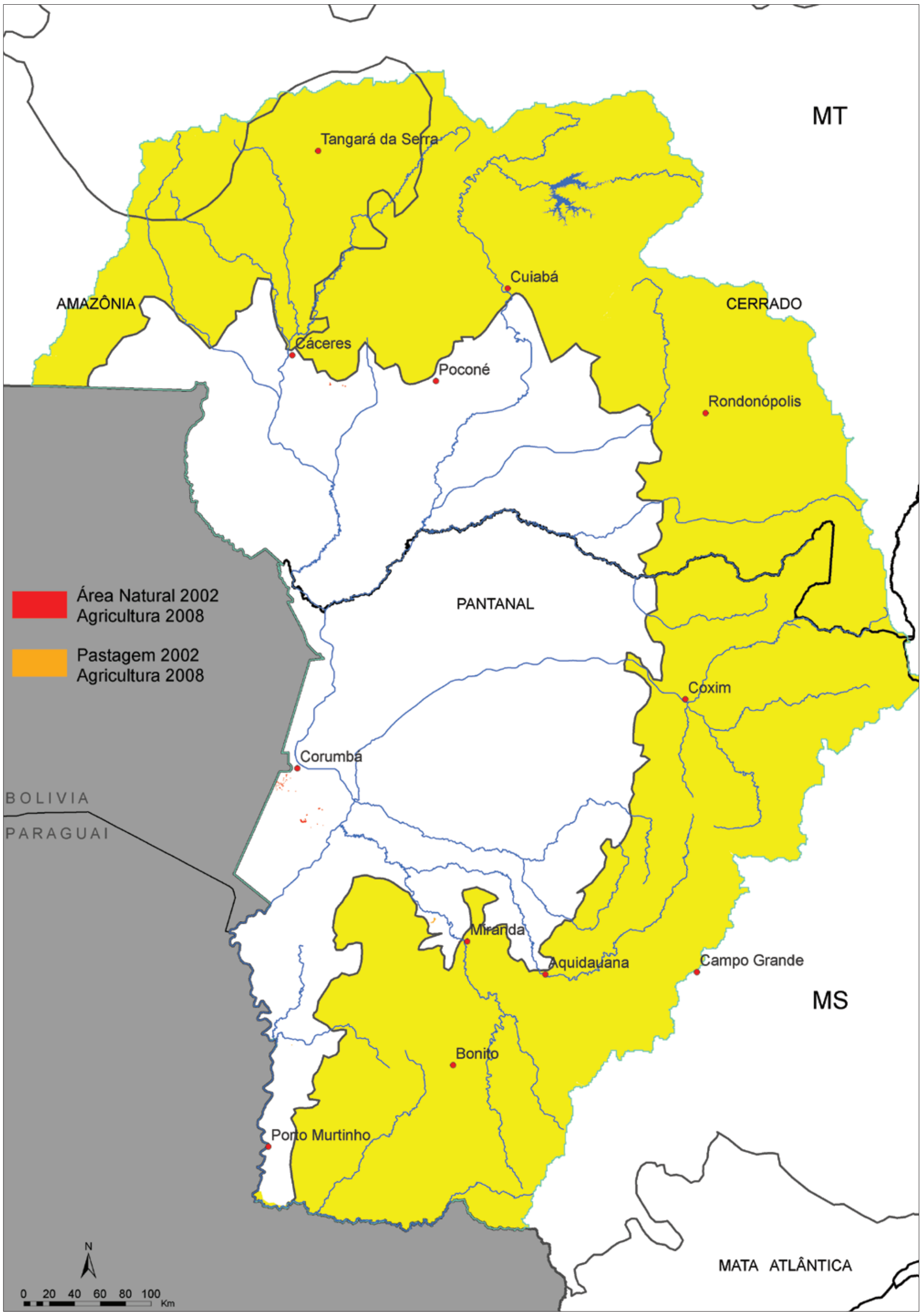

Figure 34. Natural areas and pasture in 2002 converted for agricultural use by 2008.

Areas of Natural Alteration/Management in the floodplain

Natural Alteration/Management in 2002: 1,798 km^2

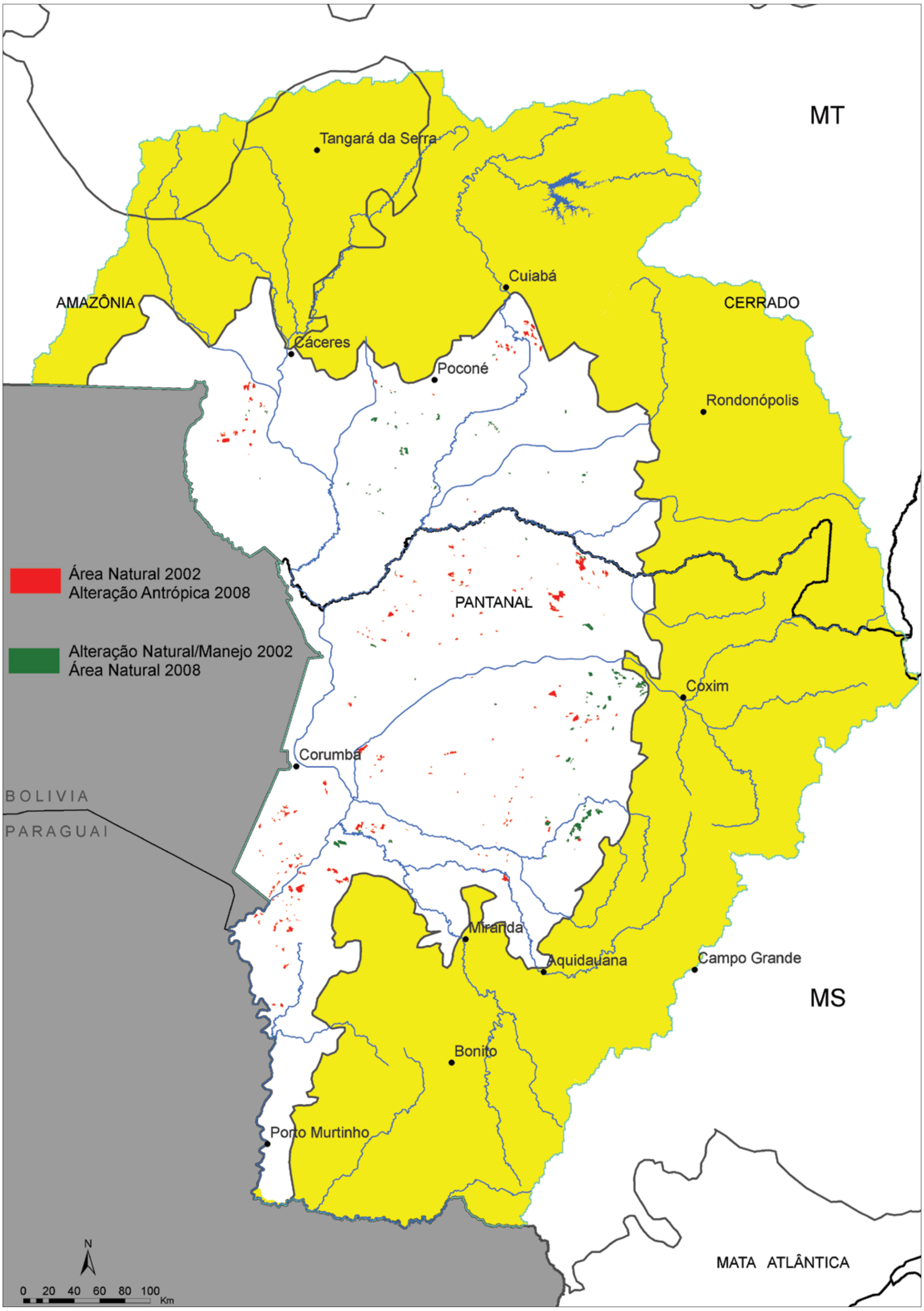

Figure 35. Areas mapped as Natural Alteration/Management in the floodplain in 2008.

Areas of the floodplain in the category Anthropic Alteration

Anthropic Alteration in 2002: 1,254 km^2

Anthropic Alteration in 2008: 2,740 km^2 = 1.8% of the total floodplain area.

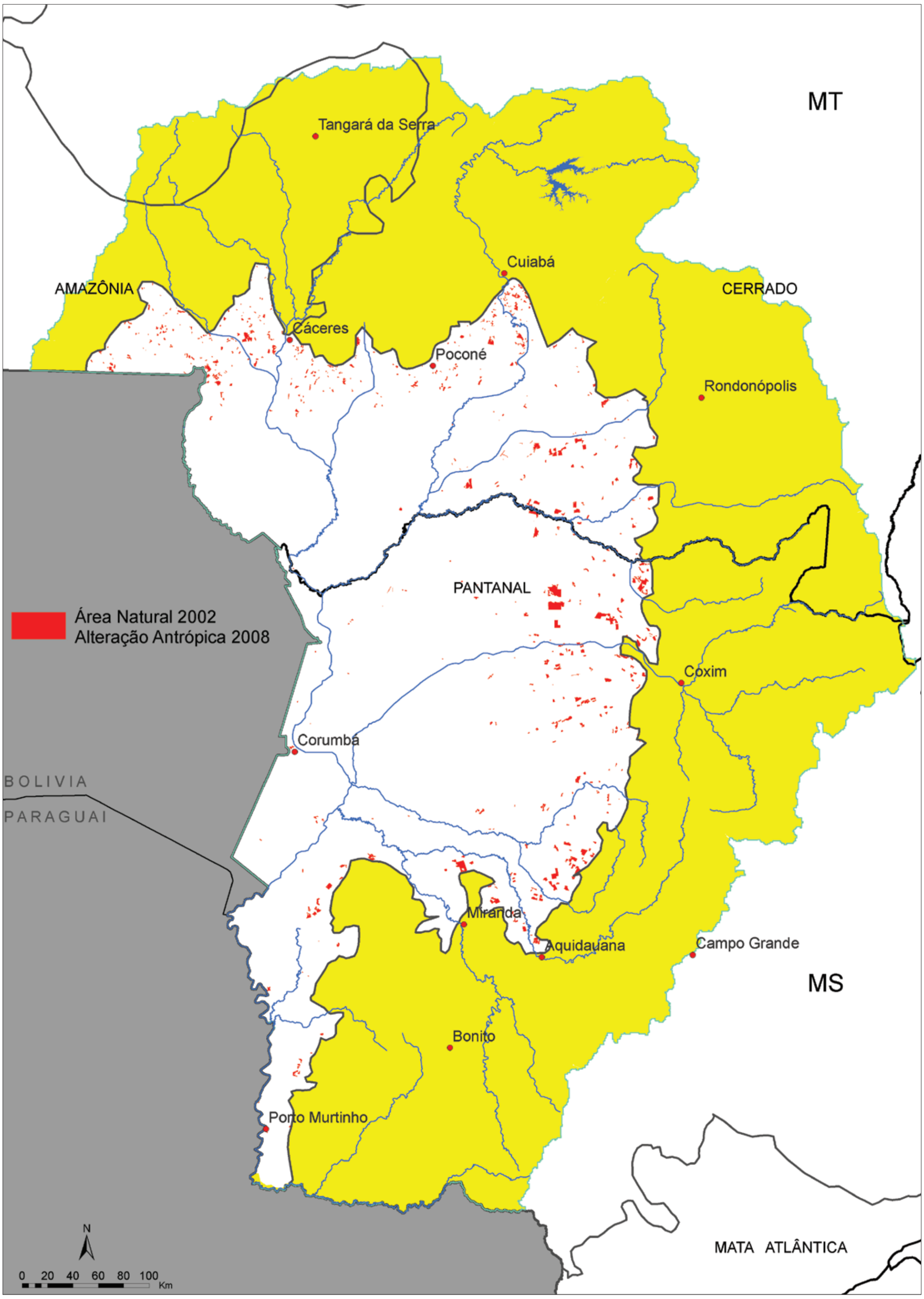

Figure 36. Natural areas in the floodplain in 2002 transformed into Anthropic Alteration areas by 2008.

Analysis of the highland area of the BAP

Highlands area of the BAP: 217,560 km²

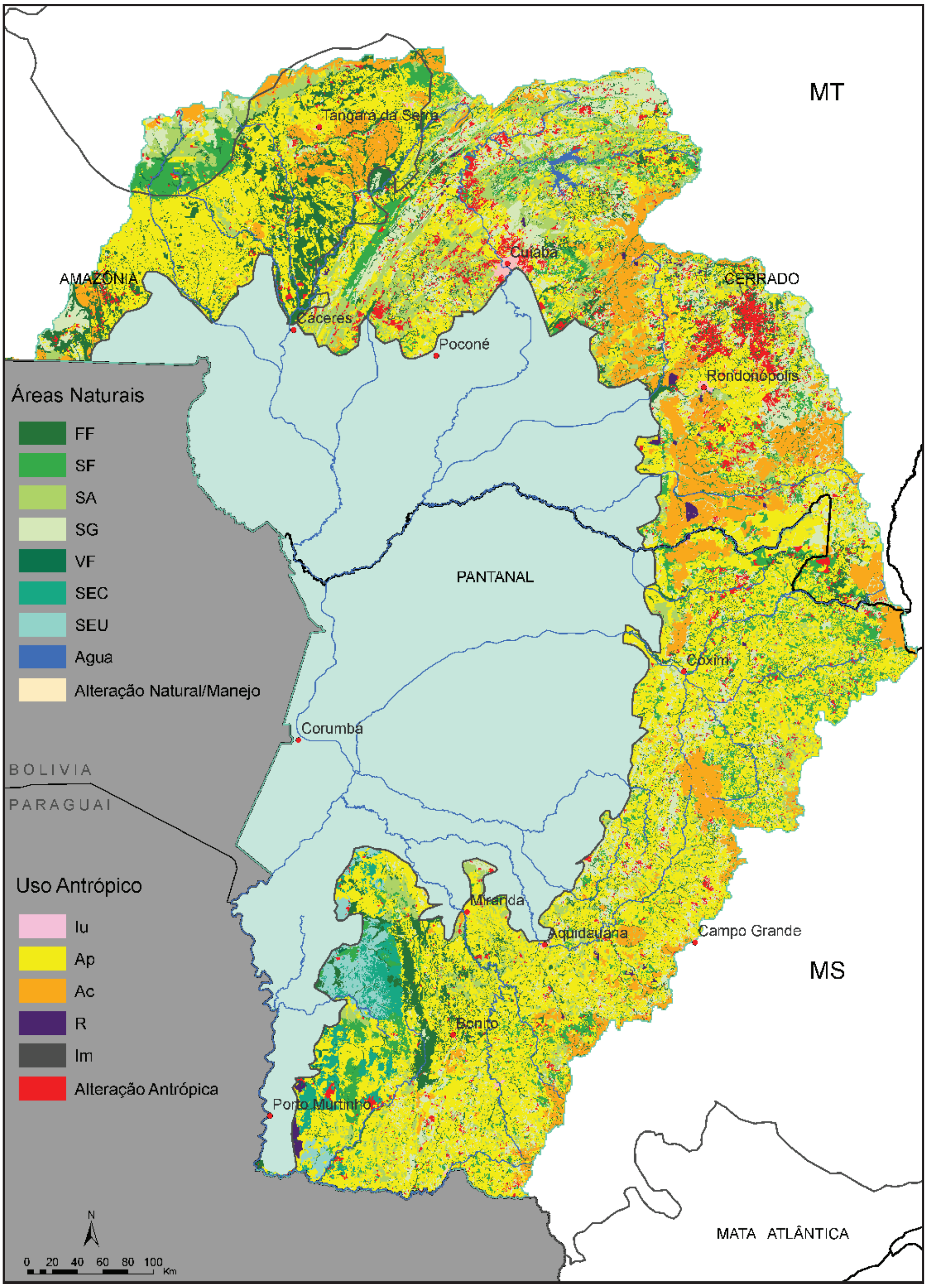

Figure 37. Map of natural vegetation and land use in the highlands region - 2008 (simplified classification legend).

Natural vegetation cover in the highlands – 2008

Total natural vegetation area: 90,876 km^2 = 41.8% of the highlands

Composition by natural vegetation classes in the highlands:

Natural Vegetation Class	Area(km^2)	% of the total highlands area
SG (Gramineous Savannah/Grassland)	25,539	11.70%
FF (Forest Formations)	22,594	10.40%
SA (Shrubby Savannah/Cerrado)	20,416	9.40%
SF (Forested Savannah/Cerradão)	16,026	7.40%
SEC (Steppe-type Savannah/Chaco)	3,206	1.50%
SEU (Steppe-type Savannah/Wetland Chaco)	2,376	1.10%
Water	567	0.30%
VF (Vegetation under Fluvial Influence)	153	0.10%

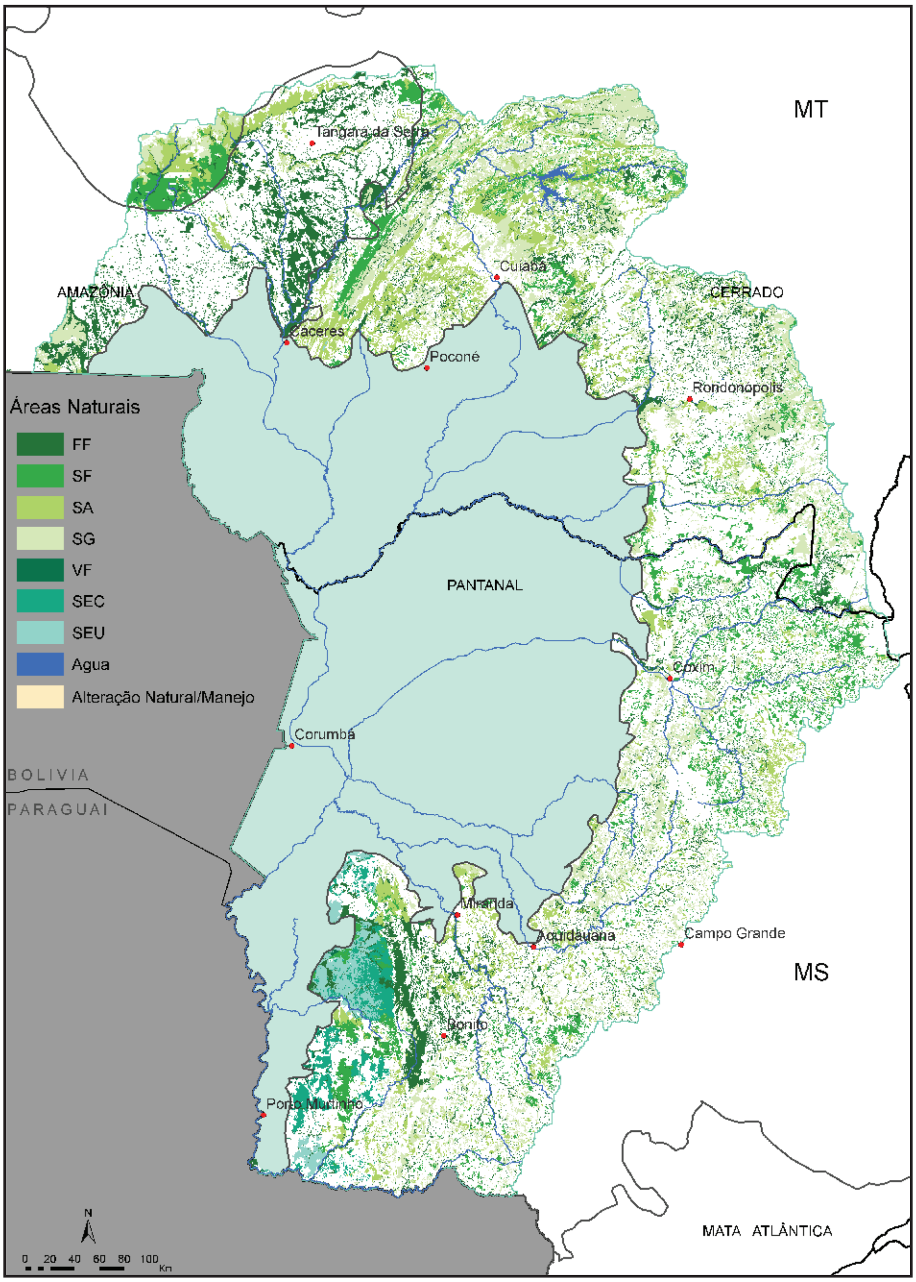

Figure 38. Natural areas in the highland region – 2008 (simplified classification legend).

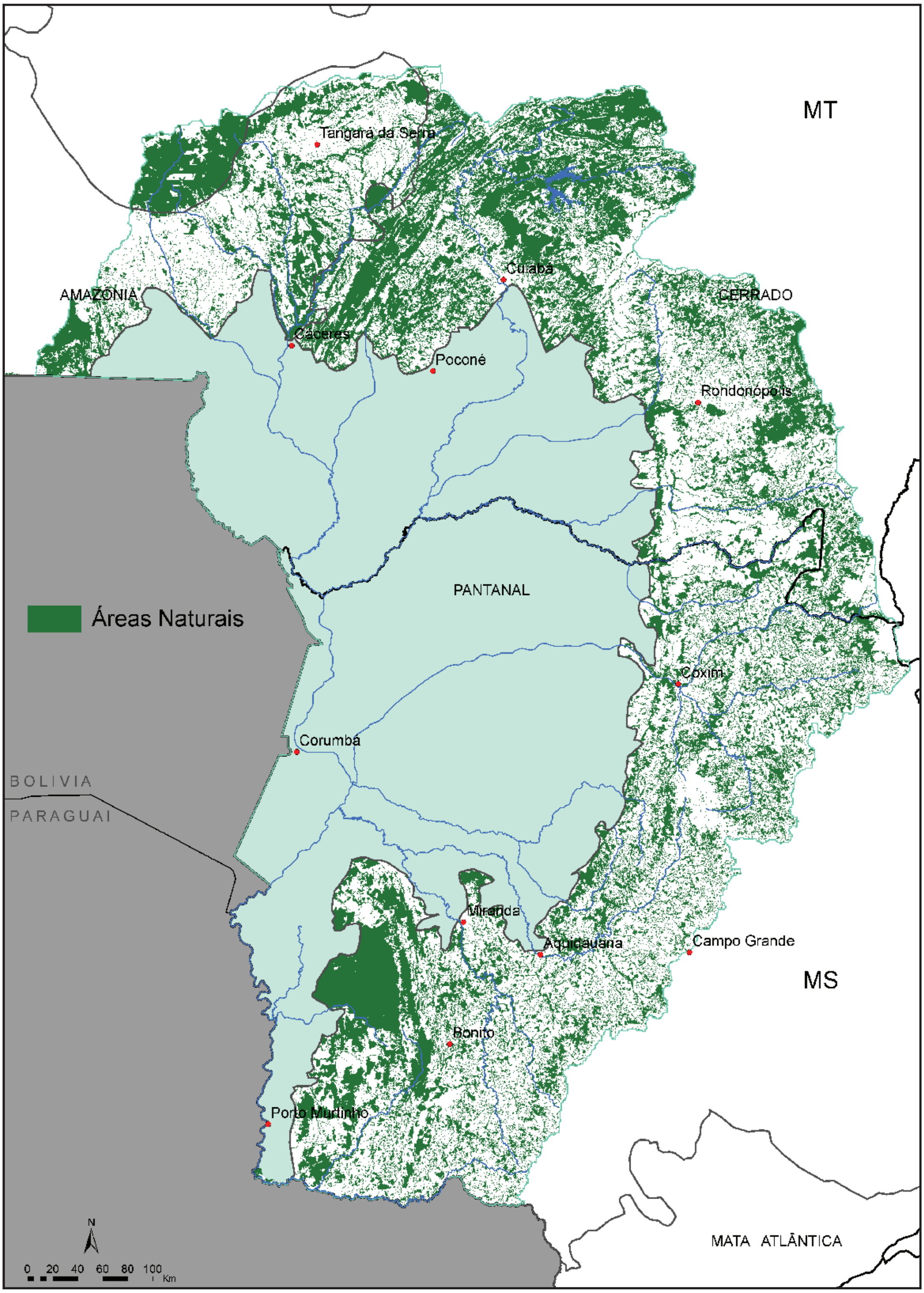

Figure 39. Map of natural areas in the highland region without classification into types.

Anthropic use in the highlands – 2008

Total anthropic use area in 2008: 126,684 km^2 = 58.2%

Category of use	Area (km^2)	% of total highlands area
Pastureland (Ap)	94,565	43.50%
Agriculture (Ac)	21,590	9.90%
Anthropic Alteration(aa)	9,156	4.20%
Urban Influence (Iu)	690	0.30%
Reforestation (R)	654	0.30%
Degraded by mining (Im)	30	0.00%

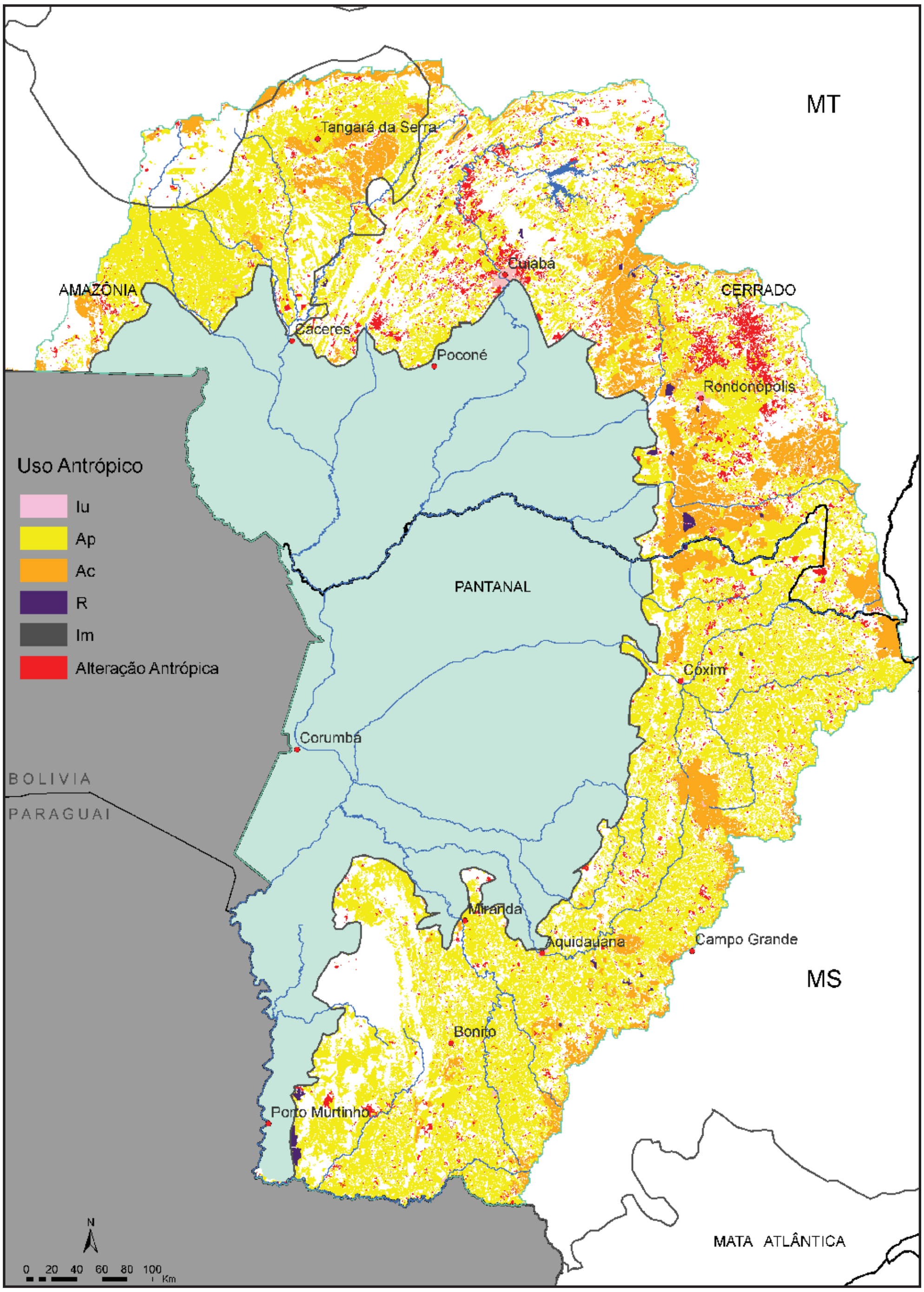

Figure 40. Classes of anthropic use in the highlands - 2008.

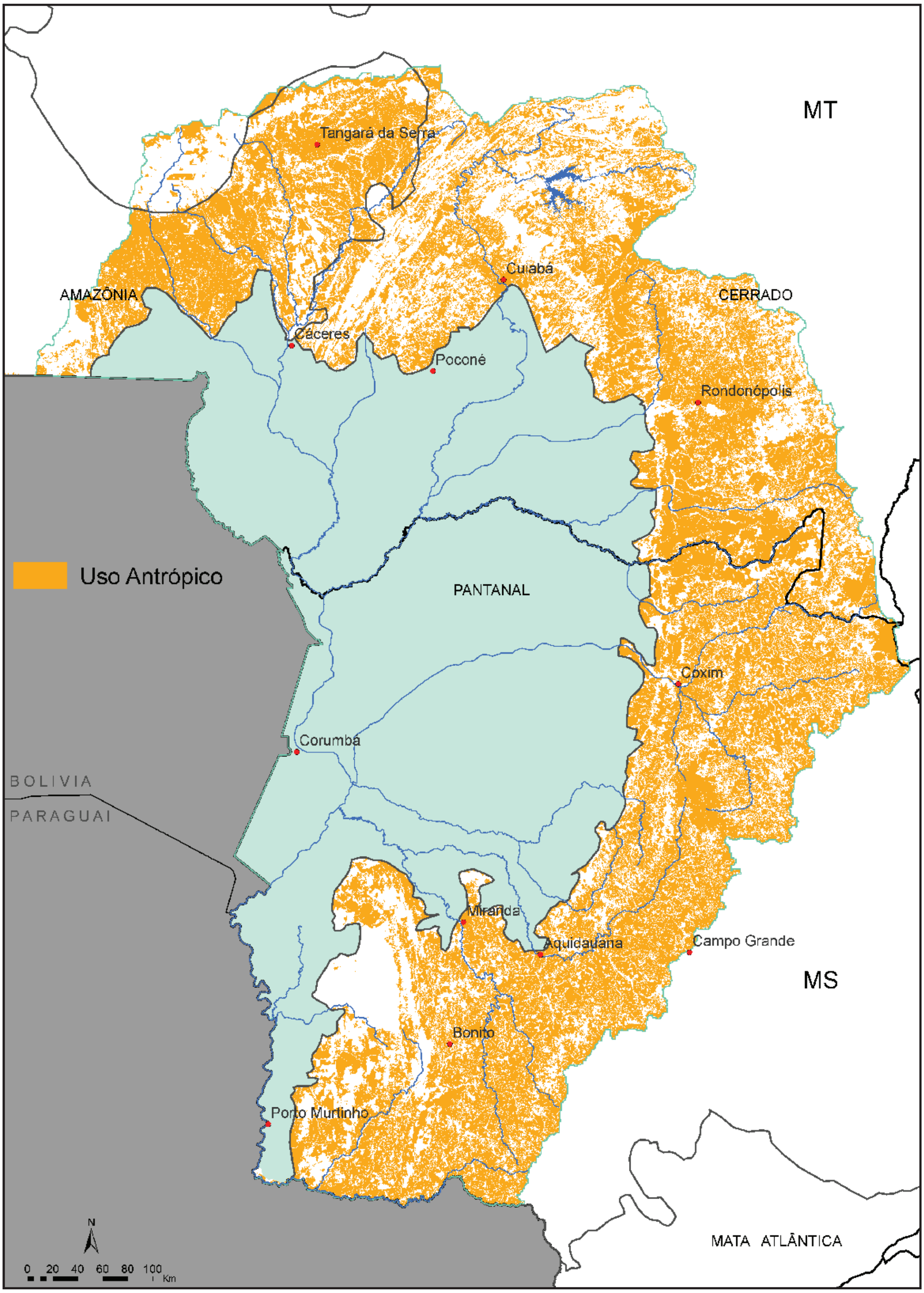

Figure 41. Map of areas of anthropic use in the highlands without distinction of sub-types - 2008.

Analysis of pastureland in the highlands

Conversion to pastureland

Pastureland in 2002: 89,159 km²

Pastureland in 2008: 94,565 = 43.5% of the highlands area

Pastureland advanced into areas of:

SG (Gramineous Savannah/Grassland): 1,589 km² / SA (Shrubby Savannah/Cerrado): 1,486 km²

aa (anthropic alteration): 1,139 km² / FF (Forest Formations): 1,032 km²

SF (Woodland Savannah/Cerradão): 940 km² / SEC (Steppe-type Savannah/Chaco): 289 km²

SEU (Steppe-type Savannah/Wetland Chaco): 54 km²/ VF (Vegetation under Fluvial Influence): 7 km²

Pastureland lost area to:

Agriculture (at least): 1,019 km² / Reforestation: 95 km² / Urban Influence: 9 km²

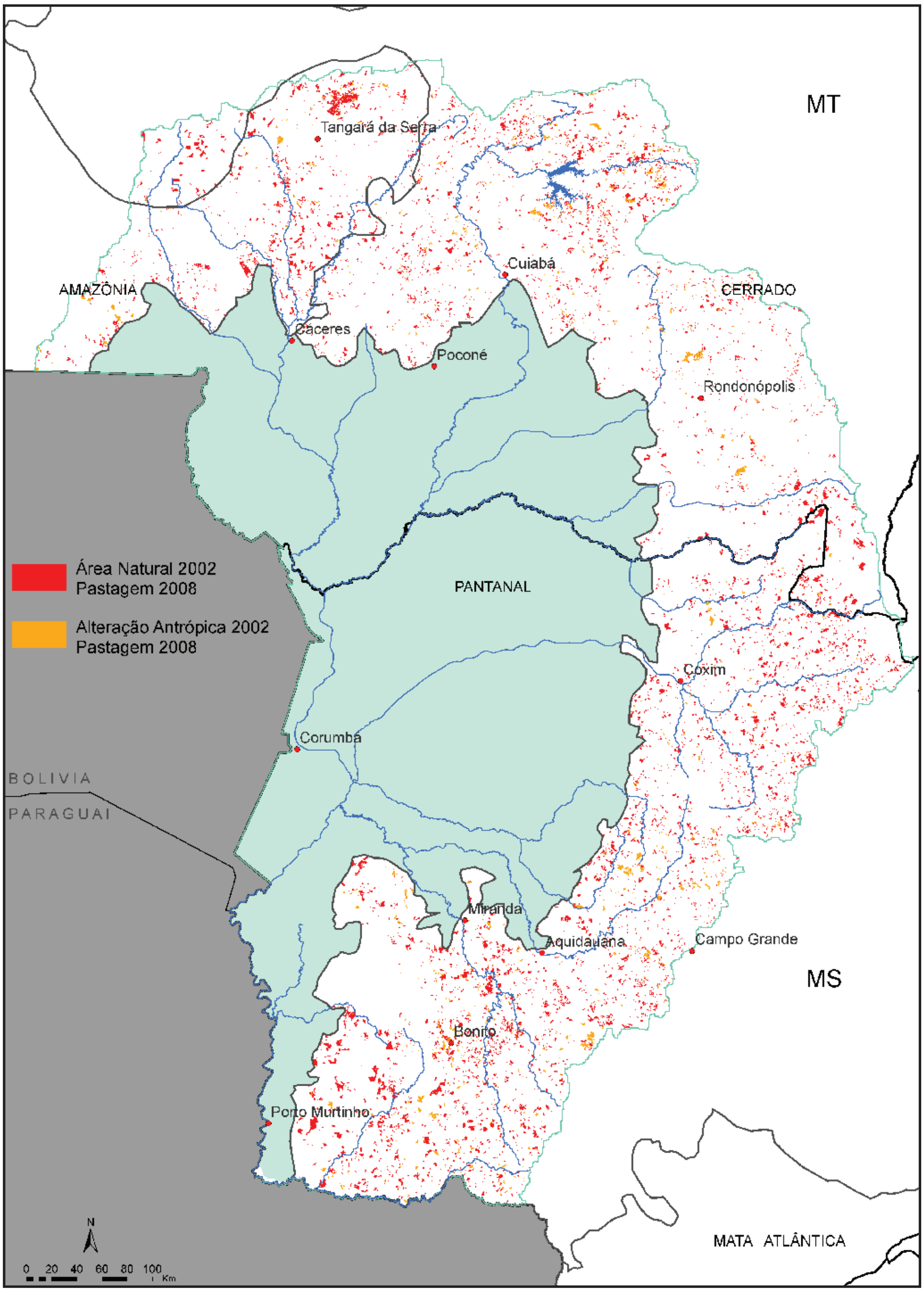

Figure 42. Natural areas in the highlands in 2002 transformed into pastureland by 2008.

Analysis of agriculture in the highlands

Conversion to agriculture

Agriculture in 2002: 20,164 km^2

Agriculture in 2008: 21,590 km^2 = 9.9% of the highlands area

Agriculture advanced into areas of:

AP (Pastureland): 1.019 km^2

SG (Gramineous Savannah/Grassland): 148 km^2

SA (Shrubby Savannah/Cerrado): 119 km^2

SF (Woodland Savannah/Cerradão): 93 km^2

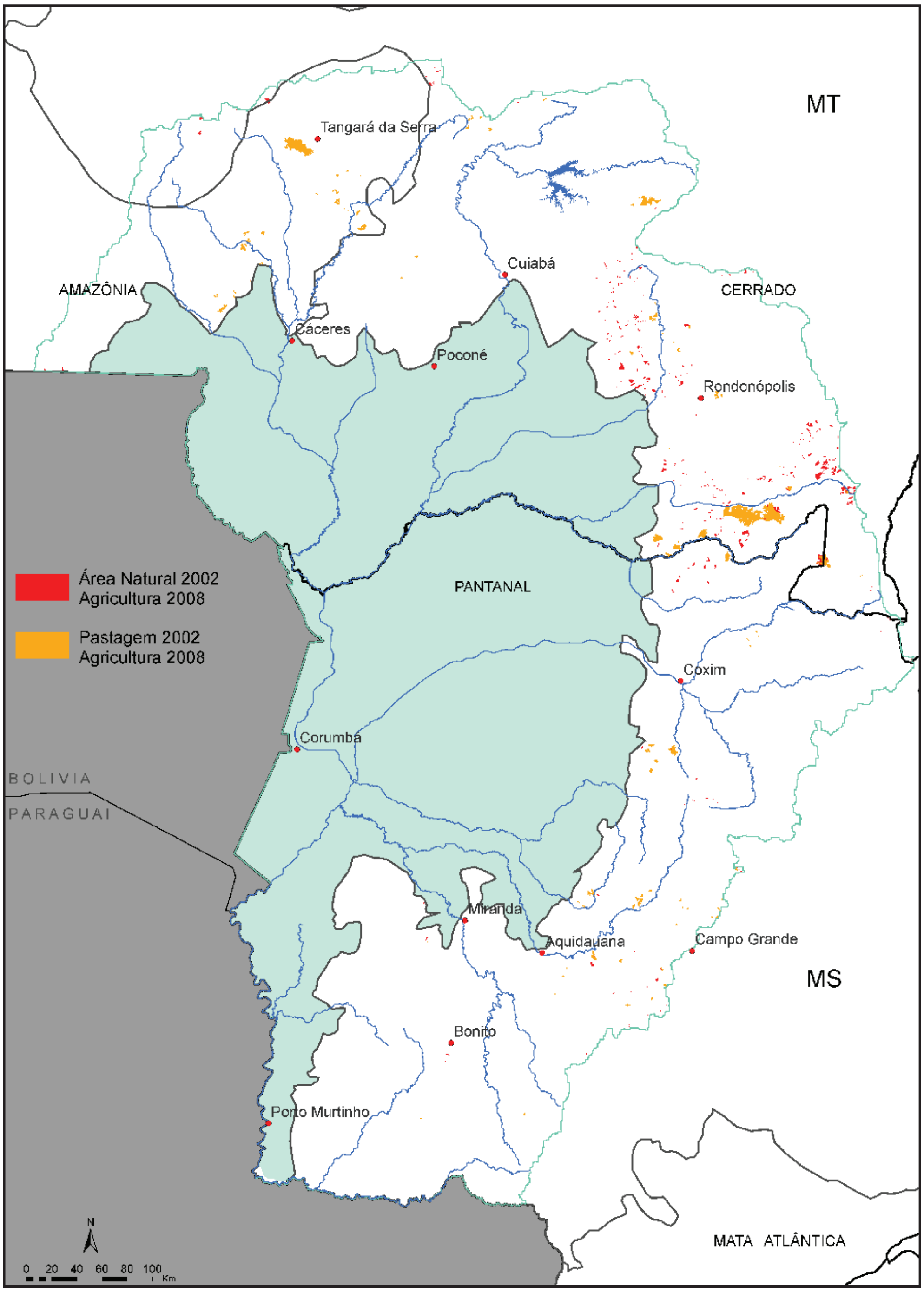

Figure 43. Natural areas and pastureland in the highlands in 2002 converted to agricultural use by 2008.

Areas of the highlands in the category Anthropic Alteration

Anthropic Alteration in 2002: 7,339 km^2

Anthropic Alteration in 2008: 9,156 km^2 = 4.2% of the highlands area.

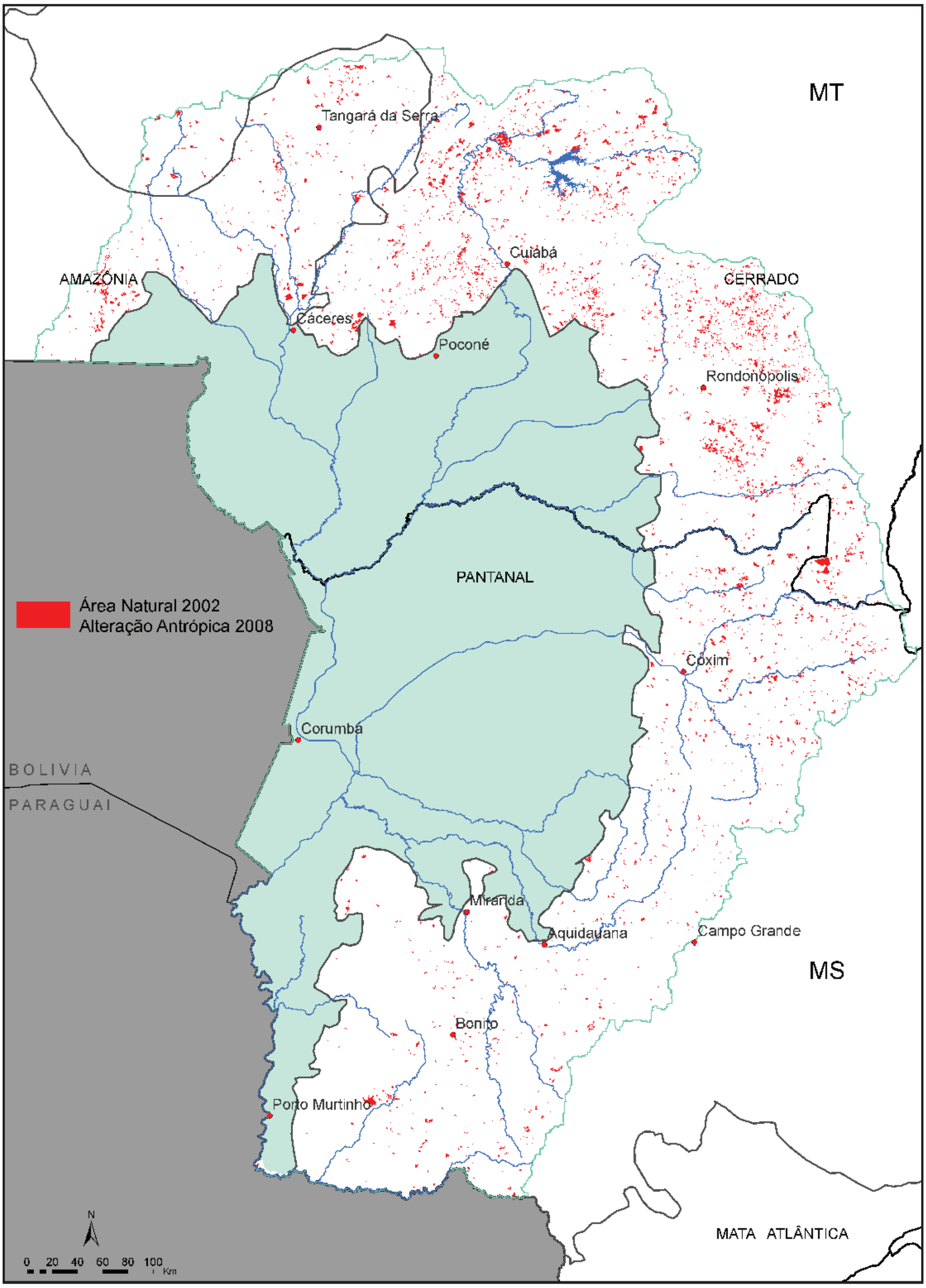

Figure 44. Natural areas in the highlands in 2002 transformed into altered areas by 2008.

Analysis by regions

This preliminary analysis was based on the map of regions provided by Embrapa - Pantanal:

	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
Region	km^2	%	km^2	%	km^2	%	km^2	%
Abobral	2,775	98.50%	21	0.70%	10	0.40%	12	0.40%
Nabileque	12,614	94.70%	184	1.40%	327	2.50%	189	1.40%
Poconé	14,713	92.60%	211	1.30%	763	4.80%	210	1.30%
Cáceres	10,754	87.00%	819	6.60%	655	5.30%	127	1.00%
Paiaguás	24,373	90.50%	43	0.20%	1.841	6.80%	662	2.50%
Paraguai	8,691	83.40%	995	9.50%	683	6.60%	48	0.50%
Nhecolândia	23,801	87.90%	130	0.50%	2.369	8.80%	769	2.80%
Barão de Melgaço	15,824	86.90%	141	0.80%	1.815	10.00%	421	2.30%
Aquidauana	3,630	71.80%	14	0.30%	1.008	19.90%	405	8.00%
Porto Murtinho	2,342	59.90%	35	0.90%	1.444	36.90%	90	2.30%
Highlands MT	58,873	45.10%	512	0.40%	65.408	50.10%	5.644	4.30%
HighlandsMS	40,130	39.20%	70	0.10%	58.164	56.90%	3.887	3.80%

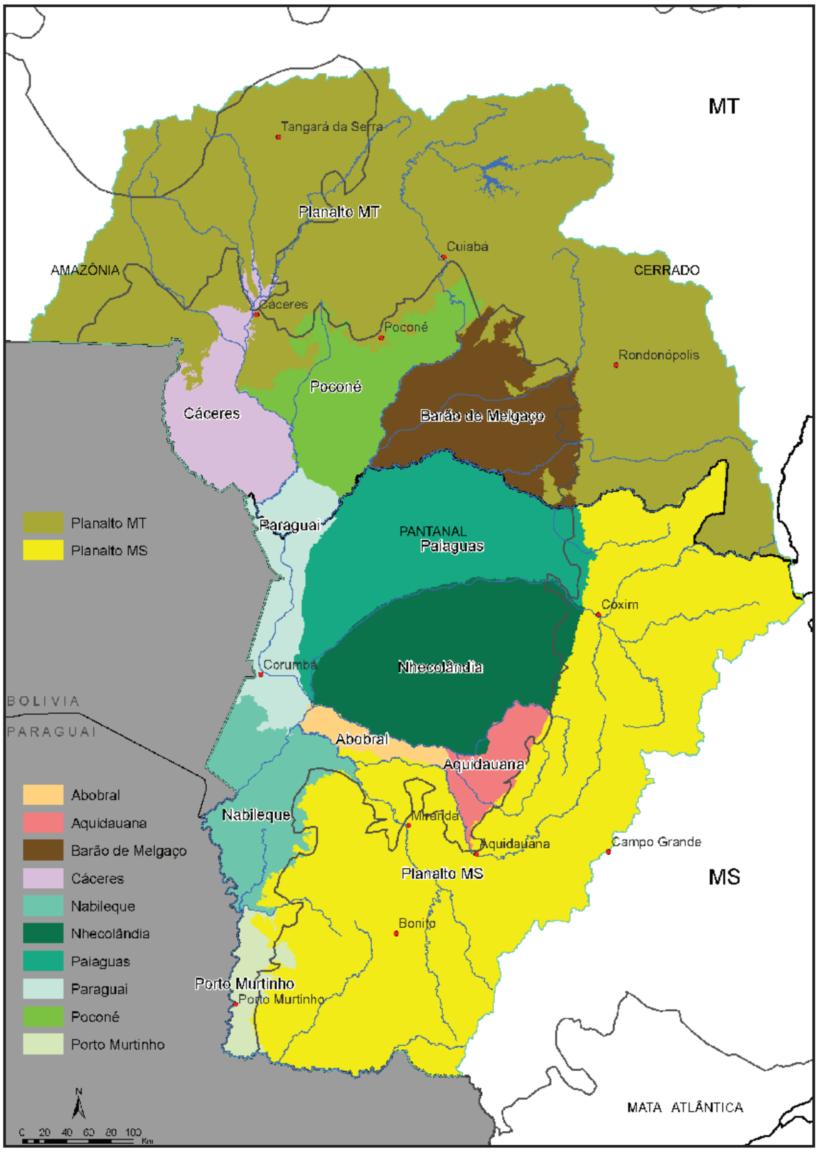

Figure 45. Sub-regions of the Pantanal according to Silva and Abdon (1998), and the division of the BAP between states.

Analysis by hydrographic basin

This preliminary analysis made use of the map of regions supplied by the National Water Regulatory Agency - ANA.

Sub-basins in the floodplain:

Sub-basins*	Natural Vegetation 2008		Water2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
	km^2	%	km^2	%	km^2	%	km^2	%
Apa	1,623	60.40%	31	1.20%	986	36.70%	47	1.80%
Aquidauana	2,499	72.10%	6	0.20%	806	23.20%	157	4.50%
Cuiabá 02	592	52.20%	20	1.70%	465	41.00%	57	5.10%
Cuiabá 03	11,990	92.70%	264	2.00%	506	3.90%	177	1.40%
Itiquira	15,836	86.60%	38	0.20%	1,769	9.70%	641	3.50%
Jauru	2,341	39.50%	12	0.20%	3,207	54.20%	363	6.10%
Miranda	2,708	82.30%	26	0.80%	490	14.90%	66	2.00%
Nabileque	13,547	88.40%	191	1.20%	1,361	8.90%	224	1.50%
Negro MS 01	24,642	87.40%	114	0.40%	2,434	8.60%	1,002	3.60%
Paraguai Pant 01	23,413	88.30%	1,349	5.10%	1,455	5.50%	312	1.20%
Santa Rita - Paraguai	1,202	35.10%	6	0.20%	2,001	58.50%	211	6.20%
São Lourenço	4,385	90.50%	31	0.60%	345	7.10%	84	1.70%
Taquari 02	23,406	93.60%	517	2.10%	756	3.00%	323	1.30%

Sub-basins in the highlands:

Sub-basins*	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
	km^2	%	km^2	%	km^2	%	km^2	%
Apa	5,380	36.60%	0	0.00%	8,661	59.00%	641	4.40%
Aquidauana	5,239	29.20%	5	0.00%	12,169	67.90%	519	2.90%
Cuiabá 01	10,052	58.60%	391	2.30%	5,833	34.00%	883	5.10%
Cuiabá 02	6,441	52.90%	45	0.40%	5,163	42.40%	537	4.40%
Cuiabá 03	1,040	54.60%	-	0.00%	771	40.50%	94	5.00%
Itiquira	4,913	31.40%	20	0.10%	9,997	63.90%	713	4.60%
Jauru	5,285	34.30%	9	0.10%	9,698	62.90%	418	2.70%
Miranda	6,617	36.00%	7	0.00%	11,009	59.90%	741	4.00%
Nabileque	6,014	70.40%	0	0.00%	2,214	25.90%	310	3.60%
Negro MS 01	2,779	41.00%	0	0.00%	3,734	55.10%	262	3.90%
Paraguai 01	8,655	50.00%	4	0.00%	8,109	46.90%	528	3.10%
Paraguai Pant 01	2,685	53.80%	0	0.00%	2,091	41.90%	213	4.30%
Santa Rita - Paraguai	1,199	62.30%	0	0.00%	643	33.40%	82	4.30%
Sepotuba	4,736	45.80%	10	0.10%	5,012	48.40%	588	5.70%
São Lourenço	8,926	36.80%	21	0.10%	14,425	59.40%	904	3.70%
Taquari 01	10,348	34.40%	53	0.20%	18,358	60.90%	1,362	4.50%

* The sums of the figures may show slight discrepancies (less than 0.1%) stemming from the adjustments to scale made in the sub-basins base map.

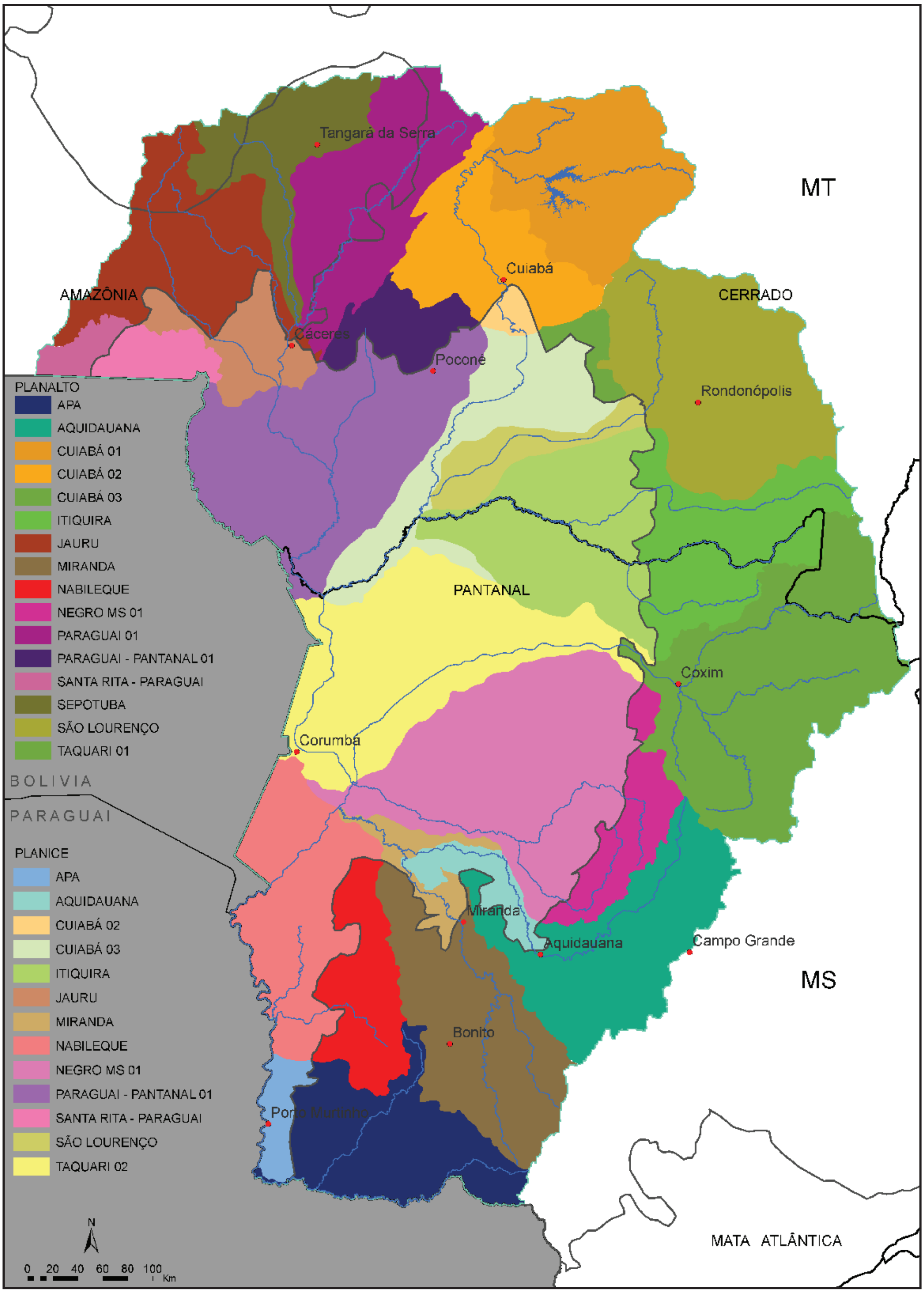

Figure 46. Level-3 Sub-basins of the ANA sub-divided by floodplain and highland

Analysis by municipality

To carry out the analysis by municipalities, the IBGE's 2007 map of municipal areas on a scale of 1:2,500,000 was used .

The second column of the table below (grey) shows the percentage of the municipal area that lies in the highland region of the BAP.

The following table sets out the results for the Highlands region in decreasing order of % of intact natural vegetation areas:

Municipality - State	% lying in the highlands	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
		km^2	%	km^2	%	km^2	%	km^2	%
Reserva do Cabaçal - MT	100%	965	72.10%		0.00%	313	23.30%	61	4.50%
Pontes e Lacerda - MT	6%	368	69.60%		0.00%	150	28.20%	12	2.20%
Rosário Oeste - MT	96%	4,857	67.80%	28	0.40%	1,877	26.20%	398	5.60%
Porto Murtinho - MS	69%	7,785	64.10%	0	0.00%	3,871	31.90%	483	4.00%
Nobres - MT	64%	1,532	63.60%	7	0.30%	764	31.70%	107	4.40%
Alto Paraguai - MT	100%	1,285	62.60%	1	0.10%	681	33.20%	85	4.10%
Cáceres - MT	15%	2,205	60.80%	2	0.10%	1,195	32.90%	227	6.20%
Nossa Senhora do Livramento - MT	66%	2.076	60.50%	1	0.00%	1,197	34.90%	160	4.70%
Porto Estrela - MT	100%	1,240	60.10%		0.00%	773	37.50%	51	2.50%
Planalto da Serra - MT	14%	196	58.00%		0.00%	130	38.50%	12	3.40%
Nova Brasilândia - MT	91%	1,683	56.40%	52	1.70%	1,073	36.00%	174	5.80%
Cuiabá - MT	96%	1,854	55.40%	10	0.30%	1,407	42.00%	77	2.30%
Chapada dos Guimarães - MT	100%	3,412	54.60%	323	5.20%	2,197	35.20%	315	5.00%
Guiratinga - MT	37%	1,075	53.90%		0.00%	836	41.90%	84	4.20%
Barra do Bugres - MT	100%	3,244	53.70%	8	0.10%	2,597	43.00%	195	3.20%
Nortelândia - MT	100%	715	52.90%	1	0.10%	600	44.40%	35	2.60%
Tangará da Serra - MT	48%	2,679	49.30%	3	0.10%	2,560	47.10%	196	3.60%
Alto Araguaia - MT	63%	1,694	48.60%	4	0.10%	1,479	42.50%	307	8.80%
Bodoquena - MS	97%	1,178	48.30%	2	0.10%	1,193	48.90%	65	2.70%
Acorizal - MT	100%	406	48.30%	6	0.80%	384	45.70%	44	5.30%

Municipality - State	% in the highlands	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
		km^2	%	km^2	%	km^2	%	km^2	%
Porto Esperidião - MT	59%	1,647	48.30%	0	0.00%	1,614	47.30%	152	4.40%
Santo Antônio do Leverger - MT	38%	2,228	47.60%	3	0.10%	2,241	47.80%	212	4.50%
Poxoréo - MT	70%	2,321	47.50%	1	0.00%	2,334	47.70%	232	4.70%
Aquidauana - MS	21%	1,708	47.20%	1	0.00%	1,789	49.40%	121	3.40%
Poconé - MT	16%	1,255	46.80%	0	0.00%	1,329	49.50%	99	3.70%
Jangada - MT	100%	454	44.50%	1	0.10%	517	50.70%	49	4.80%
Dom Aquino - MT	80%	779	44.20%		0.00%	925	52.50%	58	3.30%
Nova Marilândia - MT	100%	852	44.00%		0.00%	894	46.20%	189	9.80%
Miranda - MS	57%	1,320	42.40%	1	0.00%	1,711	55.00%	79	2.50%
Diamantino - MT	20%	670	41.90%		0.00%	864	54.00%	64	4.00%
Pedra Preta - MT	100%	1,700	41.30%		0.00%	2,180	53.00%	234	5.70%
Rio Negro - MS	98%	721	40.80%		0.00%	994	56.20%	53	3.00%
Bonito - MS	100%	1,927	39.10%	1	0.00%	2,771	56.20%	233	4.70%
São Pedro da Cipa - MT	100%	133	38.80%		0.00%	192	55.90%	18	5.30%
Curvelândia - MT	33%	46	38.60%		0.00%	68	56.30%	6	5.20%
Lambari D'Oeste - MT	100%	677	38.30%	0	0.00%	1,002	56.70%	87	4.90%
Nova Olímpia - MT	100%	586	37.80%	0	0.00%	935	60.30%	29	1.90%
Alcinópolis - MS	100%	1,643	37.30%	6	0.10%	2,528	57.40%	230	5.20%
Várzea Grande - MT	98%	337	36.70%	8	0.80%	528	57.40%	47	5.10%
Camapuã - MS	50%	1,140	36.20%	1	0.00%	1,871	59.40%	135	4.30%
Rio Verde de Mato Grosso - MS	57%	1.651	35,60%	7	0,10%	2.799	60,40%	174	3,80%
Corguinho - MS	100%	921	34.90%	0	0.00%	1,628	61.80%	86	3.30%
Salto do Céu - MT	100%	600	33.90%	1	0.00%	1,132	63.90%	39	2.20%
Pedro Gomes - MS	100%	1,228	33.60%	0	0.00%	2,247	61.50%	179	4.90%
Rio Branco - MT	100%	177	33.50%		0.00%	348	65.90%	3	0.60%
Sonora - MS	90%	1,229	33.50%	8	0.20%	2,307	62.90%	127	3.50%
Juscimeira - MT	99%	724	33.10%	1	0.00%	1,358	62.00%	106	4.90%
Coxim - MS	80%	1,685	32.90%	28	0.60%	3,231	63.10%	175	3.40%
Bela Vista - MS	100%	1,570	32.10%	0	0.00%	3,133	64.00%	192	3.90%
Figueirão - MS	87%	1,353	31.70%	6	0.10%	2,670	62.60%	239	5.60%
Bandeirantes - MS	38%	366	30.70%		0.00%	802	67.20%	26	2.20%
Ponta Porã - MS	18%	289	30.50%		0.00%	620	65.30%	40	4.20%
Jardim - MS	100%	659	29.90%	1	0.00%	1,437	65.30%	105	4.80%
Sidrolândia - MS	21%	326	29.70%		0.00%	737	67.20%	34	3.10%
Anastácio - MS	100%	869	29.50%	1	0.00%	1,969	66.70%	111	3.80%
Nioaque - MS	100%	1,152	29.40%	2	0.10%	2,604	66.40%	163	4.20%
Maracaju - MS	27%	412	29.30%	0	0.00%	955	67.90%	40	2.80%
Alto Garças - MT	55%	587	29.00%		0.00%	1,270	62.80%	165	8.20%
Itiquira - MT	78%	1,921	28.40%	12	0.20%	4,591	67.80%	246	3.60%
Costa Rica - MS	36%	540	27.60%	0	0.00%	1,342	68.60%	73	3.70%
Araputanga - MT	100%	443	27.60%	1	0.10%	1,151	71.80%	9	0.60%
Santo Afonso - MT	100%	322	27.60%		0.00%	775	66.30%	72	6.20%

Municipality - State	% in the highlands	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
		km^2	%	km^2	%	km^2	%	km^2	%
Caracol - MS	100%	805	27.40%		0.00%	1,976	67.30%	155	5.30%
Dois Irmãos do Buriti - MS	100%	635	27.10%	3	0.10%	1,605	68.50%	100	4.30%
São Gabriel do Oeste - MS	100%	1,048	27.10%	1	0.00%	2,738	70.80%	80	2.10%
Jaciara - MT	100%	435	26.20%		0.00%	1,186	71.60%	37	2.20%
Rochedo - MS	100%	398	25.40%	0	0.00%	1,126	72.10%	38	2.40%
Guia Lopes da Laguna - MS	100%	292	24.10%		0.00%	881	72.80%	37	3.00%
Jaraguari - MS	31%	213	23.90%		0.00%	663	74.50%	14	1.50%
Terenos - MS	99%	672	23.90%	0	0.00%	2,045	72.70%	96	3.40%
Rondonópolis - MT	100%	995	23.90%	17	0.40%	3,097	74.20%	62	1.50%
Campo Grande - MS	8%	151	23.30%		0.00%	492	75.50%	8	1.20%
Arenápolis - MT	100%	94	22.80%		0.00%	311	75.20%	9	2.10%
Campo Verde - MT	47%	507	22.60%		0.00%	1,669	74.30%	71	3.20%
Denise - MT	100%	280	21.50%		0.00%	1,008	77.50%	13	1.00%
Mirassol d'Oeste - MT	79%	175	20.60%		0.00%	624	73.50%	50	5.90%
Glória D'Oeste - MT	86%	146	20.00%		0.00%	565	77.70%	17	2.30%
Antônio João - MS	60%	129	18.90%		0.00%	534	78.20%	20	2.90%
Alto Taquari - MT	61%	157	18.50%		0.00%	688	81.10%	4	0.40%
Jauru - MT	93%	182	14.80%	3	0.30%	1,028	84.00%	10	0.80%
São José do Povo - MT	100%	65	14.70%		0.00%	368	82.80%	11	2.60%
São José dos Quatro Marcos - MT	100%	169	13.20%		0.00%	1,087	84.90%	24	1.90%
Indiavaí - MT	100%	61	10.20%	2	0.40%	533	88.90%	3	0.60%
Figueirópolis D'Oeste - MT	97%	86	10.00%		0.00%	759	88.20%	16	1.80%

% na Planície	Vegetação Natural 2008		Água 2008		Áreas de Uso Antrópico 2002		Conversão para Uso Antrópico 2002-2008	
	km^2	%	km^2	%	km^2	%	km^2	%
100%	10,492	93.90%	129	1.20%	368	3.30%	186	1.70%
97%	59,190	93.80%	874	1.40%	1,932	3.10%	1,097	1.70%
84%	13,358	91.70%	453	3.10%	654	4.50%	100	0.70%
22%	1,712	87.30%	4	0.20%	206	10.50%	39	2.00%
79%	10,730	80.50%	50	0.40%	1,937	14.50%	619	4.60%
34%	1,385	78.80%	4	0.20%	311	17.70%	58	3.30%
43%	1,829	77.30%	11	0.50%	462	19.50%	64	2.70%
62%	5,840	77.10%	39	0.50%	1,465	19.30%	229	3.00%
85%	15,262	73.70%	962	4.60%	3,844	18.60%	639	3.10%
43%	2,450	69.50%	9	0.20%	861	24.40%	205	5.80%
20%	855	66.00%	6	0.50%	364	28.10%	71	5.50%
31%	3,663	65.80%	38	0.70%	1,741	31.30%	121	2.20%
100%	204	59.70%	26	7.70%	101	29.70%	10	2.90%
10%	191	47.20%	0	0.10%	142	35.20%	71	17.60%
41%	784	32.70%	-	0.00%	1,490	62.10%	123	5.10%
14%	33	27.40%	-	0.00%	81	67.50%	6	5.10%
21%	43	19.20%	-	0.00%	174	77.60%	7	3.20%
67%	25	10.30%	-	0.00%	212	88.10%	4	1.60%

The following table sets out the results for the floodplain region in decreasing order of % of intact natural vegetation areas:

Municipality - State	% in the floodplain	Natural Vegetation 2008		Water 2008		Anthropic use areas 2002		Conversion to Anthropic use 2002-2008	
		km^2	%	km^2	%	km^2	%	km^2	%
Barão de Melgaço - MT	100%	10.492	93.90%	129	1.20%	368	3.30%	186	1.70%
Corumbá - MS	97%	59.190	93.80%	874	1.40%	1.932	3.10%	1.097	1.70%
Poconé - MT	84%	13.358	91.70%	453	3.10%	654	4.50%	100	0.70%
Itiquira - MT	22%	1.712	87.30%	4	0.20%	206	10.50%	39	2.00%
Aquidauana - MS	79%	10.730	80.50%	50	0.40%	1.937	14.50%	619	4.60%
Nossa Senhora do Livramento - MT	34%	1.385	78.80%	4	0.20%	311	17.70%	58	3.30%
Miranda - MS	43%	1.829	77.30%	11	0.50%	462	19.50%	64	2.70%
Santo Antônio do Leverger - MT	62%	5.840	77.10%	39	0.50%	1.465	19.30%	229	3.00%
Cáceres - MT	85%	15.262	73.70%	962	4.60%	3.844	18.60%	639	3.10%
Rio Verde de Mato Grosso - MS	43%	2.450	69.50%	9	0.20%	861	24.40%	205	5.80%
Coxim - MS	20%	855	66.00%	6	0.50%	364	28.10%	71	5.50%
Porto Murtinho - MS	31%	3.663	65.80%	38	0.70%	1.741	31.30%	121	2.20%
Ladário - MS	100%	204	59.70%	26	7.70%	101	29.70%	10	2.90%
Sonora - MS	10%	191	47.20%	0	0.10%	142	35.20%	71	17.60%
Porto Esperidião - MT	41%	784	32.70%	-	0.00%	1.490	62.10%	123	5.10%
Glória D'Oeste - MT	14%	33	27.40%	-	0.00%	81	67.50%	6	5.10%
Mirassol d'Oeste - MT	21%	43	19.20%	-	0.00%	174	77.60%	7	3.20%

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Cartographic References

Biome: Biomes base of the IBGE, 2004 (1st approximation) scale 1:5,000,000;

Highlands and Floodplain: Generated using the IBGE biomes base for 2004 (1st approximation);

Map of the Area subject to Atlantic Forest Legislation: IBGE-2007 - scale 1:5,000,000;

Regions: Pantanal floodplain regions base made available by Embrapa Pantanal. Source: Silva and Abdon, 1998. The highland area is subdivided by states;

River Basins: Sub-basins of the Upper Paraguay Basin, level 3 of the National Water Regulatory Agency - ANA), revised by the National Water Resources Council;

Municipalities and states: digital map of Brazilian IBGE - 2007 - scale 1:2,500,000.

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Bacia
do Alto Paraguai
Conservação e Sustentabilidade

ISBN 9788586440281

Articulation of the Project

Presented by:

CONSERVAÇÃO INTERNACIONAL BRASIL · ecoa 20 anos · AVINA · SOS Pantanal · WWF Brasil

Support

Embrapa Pantanal · SOS Mata Atlântica

Execution

ArcPlan

Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin Brazilian Portion

Appendix I: Fieldwork

Bacia do Alto Paraguai

Conservação e Sustentabilidade

Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin
Brazilian Portion
Period of Analysis: 2002 to 2008

Presented by:

Support:

Execution:

Fieldwork

During the work of interpreting data, fieldwork was undertaken to clear up the main doubts and carry out field recognition of the types of vegetation and land use visualised in the satellite images.

It must be stressed that the fieldwork was not just intended to validate the mapping but also aimed at providing the technical staff responsible for interpreting the images with the necessary experience to enable them to associate the patterns observed in the images with practical knowledge in the field.

Field work –Northern central part of the highlands and the Pantanal

Field work in the northern region of the basin was carried out from 29 September to 4 October by Arcplan technical staff members, Flávio Sammarco and Natalia Crusco and a specialist in geo-processing from Conservação Internacional, Ana Ribeiro.

The trajectory of the field work was divided into three main stages: the first consisted of the region around the Fazenda Rio Negro ranch, the second was in the region of the Serra de Amolar (Amolar Mountains) and the third stage took place in the region between Caceres and the Chapada dos Guimarães (Guimarães Plateau) in the sub-basins of the Paraguay and Cuiabá Rivers.

The fieldwork was registered by taking photographs and recording GPS coordinates during all stages. The part that was done by car was also accompanied by Arcgis connecting the GPS to a Notebook to carry out a validation of the mapping.

The total distance travelled was around 2,000 km over a period of six days. 970 photos were taken and GPS coordinates were registered for 416 points.

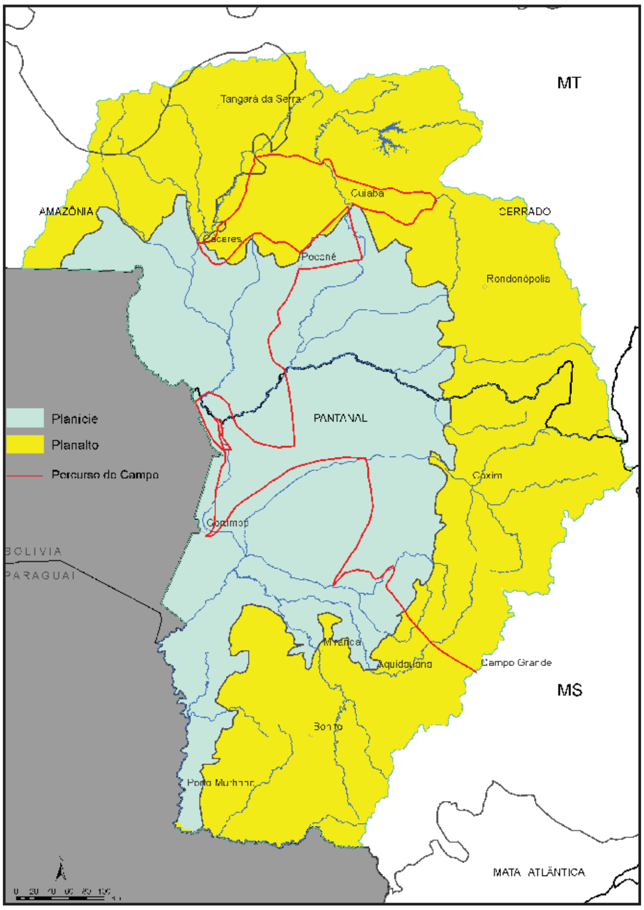


Figure 1. Itinerary of the field work in the northern part of the Basin.

There now follows a presentation of each stretch of the journey with an overall appraisal of the most relevant aspects that were identified in the field:

29 September, 2008 - Campo Grande/Rio Negro farm

Figure 2. Photographs taken en route from Campo Grande to Rio Negro farm. On the left a view of salinas and on the right Gramineous Savannah in the foreground and shrubby savannah beyond.

Flight from Campo Grande to fazenda (ranch) Rio Negro (approximately 1.5 hours) In the afternoon a short excursion by car to the Private Nature Reserve area of the Rio Negro Ranch (Aquidauana Pantanal).

30 September, 2008 – Rio Negro farm / Vila do Amolar

Two-hour flight from Rio Negro farm to Corumbá (refuelling) flight passing over the Nhecolândia, Paiaguás and Paraguay Pantanal.

40 minute flight from Corumbá to Vila do Amolar (Paraguay pantanal) then by boat of the Serra do Amolar area passing through Ecotropica's Private Nature Reserve 'Acorizal" and Barra de São Lourenço.

Figure 3. Photographs taken along the route from Rio Negro farm to Vila do Amolar. On the left an area converted into pastureland and on the right an area of natural vegetation.

01 October, 2008 – Vila do Amolar / Cuiabá

Two-hour flight from Vila do Amolar to Porto Jofre (refuelling) passing over the Paiaguás Pantanal.

Two-hour flight from Porto Jofre to Cuiabá. The last part of the flight was along the route of the Trans-pantaneira highway as far as Poconé and then headed off towards Cuiabá (inside the area of the Poconé Pantanal).

Figure 4. Photographs taken en route by plane from Vila do Amolar to Cuiabá. On the left, Shrubby Savannah and on the right an area of pasture contiguous with an area of Shrubby Savannah.

02 October, 2008 – Cuiabá/Cáceres

Field work carried out by car along the route: Cuiabá-Cangas-Poconé-Cáceres covering a distance of 252 km.

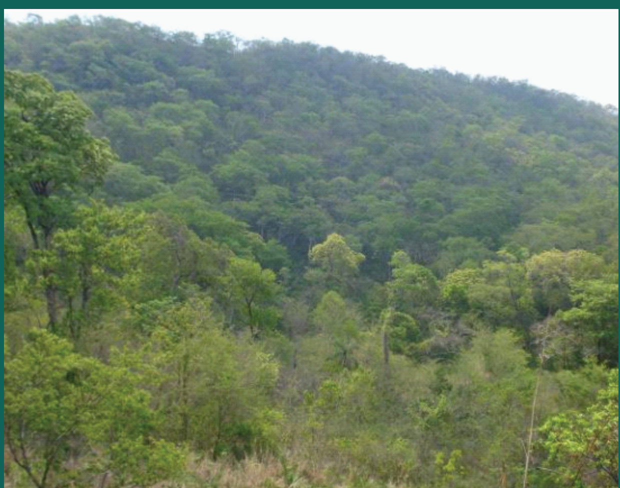


Figure 5. Photographs taken en route from Cuiabá to Cáceres On the left Forested Savannah and on the right an area of mining activities.

03 October, 2008 – Cáceres / Chapada dos Guimarães

Overland trip by car: Cáceres-Novo Oriente-Porto Estrela-Barra dos Bugres-Jangada-Acorizal-Guia-Cuiabá-Chapada dos Guimarães, a total of 354 km.

Figure 6. Photographs taken en route from Cáceres to Chapada dos Guimarães showing areas of Steppe-type Savannah.

03 October, 2008 – Chapada dos Guimarães / Cuiabá

The last stretch of the car trip: Chapada dos Guimarães-São Vicente-Várzea Grande, a total of roughly 140 km.

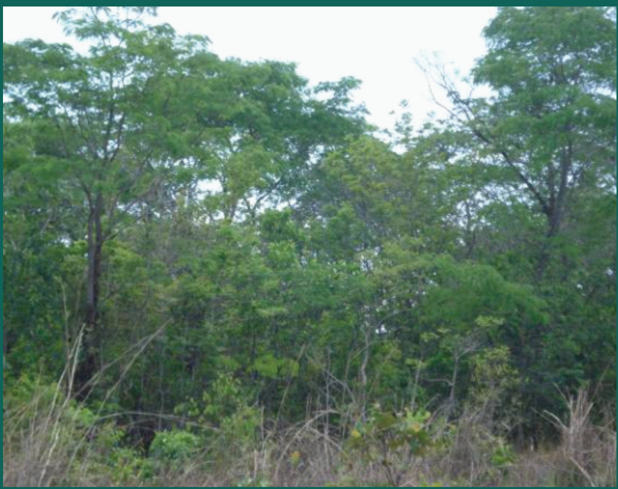


Figure 7. Photographs taken en route from Chapada dos Guimarães to Cuiabá. On the left, an area prepared for planting pasture and on the right an area of Parkland Savannah and Gallery Forest.

Field Work Report – Pantanal (Southern Region)

In the period from October 06, 2008 to October 10, 2008 a distance of 1708 Km was travelled by car and 578 geo-referenced photographs were taken that are now part of the ARCGIS database.

The fieldwork was undertaken by a member of Arcplan's technical staff, Eduardo Reis Rosa, and an analyst attached to the WWF's Pantanal Forever Programme, Eduardo Mongelli Figure 8 shows the trajectory of the week-long field trip as a red line.

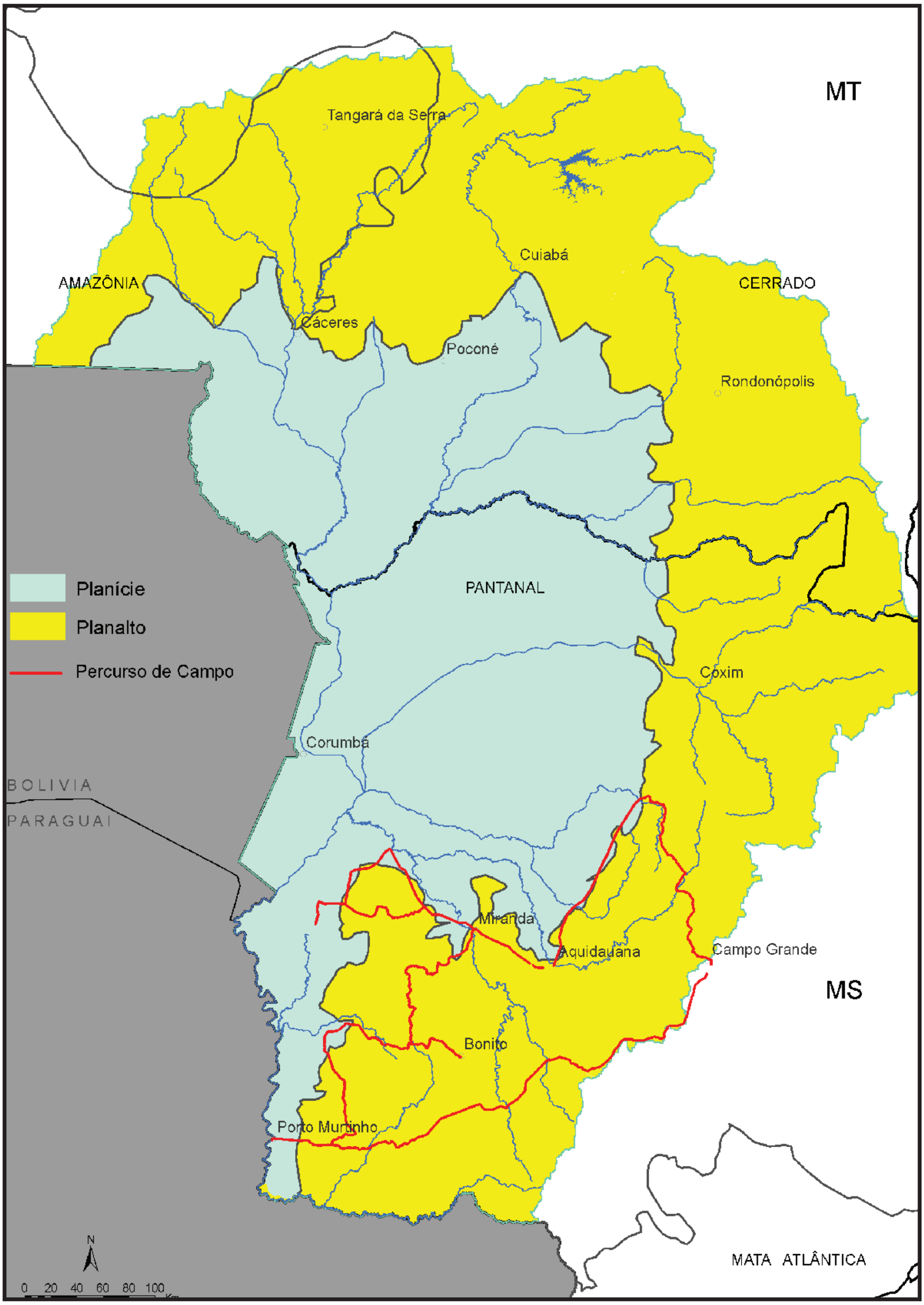


Figure 8. Figure showing the itinerary of the fieldwork in the southern region of the basin.

There now follows a presentation of each stretch of the journey with an overall appraisal of the most relevant aspects that were identified in the field.

07 October, 2008 - Campo Grande/ Anastácio

The route followed was 337 km long starting from Campo Grande and passing through Rochedo, Corguinho, Rio Negro to arrive at Anastácio.

The northern part of the route was marked by the presence of fragments of vegetation of the Forested Savannah type (upper part of figure 33), in the middle of areas of pastures that extend right up to their point of contact with Semi-deciduous seasonal alluvial forests near the bottom of the valleys.

Figure 9. In the upper part of the picture, a forest in an area of pasture with Alluvial Forest in the lowest part of the valley .

In the southern part of the route the main features were the open areas of woody savannahs and Parkland savannah resulting from the process of creating pastures.

Figure 10. Area of shrubby savannah cleared to make way for pasture.

Clearing the areas means removing the shrubby and arboreal vegetation, burning whatever wood is not needed for other purposes, harrowing the area and sowing grass seed to establish the pastures.

Figure 11. Area of Shrubby Savanna cleared to make way for pasture and in the background, Forested Savannah on the steep hillsides.

07 October, 2008 – Anastácio / Miranda

The second stretch began in Anastácio, passed through Miranda, Guaicurus and on as far as the ranch 'Fazenda Jatobá', near to the westernmost limit of the trajectory; then on to Morro do Azeite in the extreme north of the route and back to Miranda. The total distance of the trip was 434 Km .

One feature that should be mentioned of the western part of the route was the vegetation with stands of Paratudo trees and Carandá palms (Parkland Savannah and Steppe-type Parkland) where the presence of cattle, pasture management making use of burning, and clearing and burning the vegetation to make way for pasture are all altering the environment and introducing environmental unbalance.

Figure 12. Area used as pasture with stands of Paratudo trees.

Figures 13 and 14 below show areas of Carandá palm stands where the vegetation has been removed to implant pastures.

Figure 13. Area originally covered by stands of Carandá palms cleared to make way fro pasture.

Figure 14. Area originally covered with Carandá pals visible in the background. In the foreground implanted pasture.

08 October, 2008 – Miranda / Bonito

The third stretch began in Miranda, passing through Bodoquena, Morraria, Baia das Garças and arriving at Bonito, 212 Km journey. Outstanding on this particular stretch was the Serra da Bodoquena National Park with a total area of 77,232 hectares (Ibama).

The route used passed through the northern tip of the Park where the predominant vegetation is Seasonal Deciduous Sub-montana Forest. Figure 41 gives an overall view of the Bodaquena Mountains with the hills in the middle ground covered by forest.

Figure 15. Panoramic view of the Serra da Bodoquena National Park.

Figure 16 below shows the situation of the Sub-Montana Forests found in the northern part of the Park.

Figure 16. View of the northern part of the Serra da Bodoquena National Park.

Anthropic areas with pastures in the west and a mixture of pasture and agricultural areas in the east surround the forested areas of the Bodoquena Park.

The use of fire in the formation and management of pastureland is one of the problems in evidence in the areas surrounding the Park.

Figure 17. Area of recently felled and burned Forest in the Serra da Bodoquena.

The landscape on either side of the road that connects the northern and southern parts of the Serra da Bodoquena is marked by the presence of areas of anthropic use.

Figure 18. Areas of pasture between the northern and southern fragments of the Serra da Bodoquena National Park.

Figure 19. Agricultural area in the foreground and fragments of forest belonging to the southern fragment of the Serra da Bodoquena National Park.

09 October, 2008 – Bonito / Porto Murtinho

The fourth stretch started from Bonito and passed through Baia das Garças, fazenda Tomásia, fazenda Firme, and Rio Tereré before joining the main road leading to Porto Murtinho, a total distance of 295 km.

The outstanding features of that stretch were the hills covered with Forested Savannah and the areas of pastureland in the flats.

Figure 20. Pasture areas in the foreground and Forested Savannah on the hills in the background.

The steppe-type savannah areas with occasional trees are opened up for use as pasture and the vegetation cover other than trees is eliminated and substituted by grasses.

Figure 21. Parkland Savannah area prepared for the implantation of pasture.

Figure 22. Mechanized disc-harrowing to prepare for the implantation of pasture in an area of Forested Savannah.

Some of the areas still have scattered clumps of trees around the pastureland but there are large areas where the native vegetation has been completely eliminated.

Figure 23. Pastureland with scattered trees in the foreground and Forested Savannah beyond.

10 October, 2008 – Porto Murtinho / Campo Grande

The fifth stretch began in Porto Murtinho and passed through Jardim, Nioaque, Sidrolândia, arriving at Campo Grande, a total journey of 430 km. The most notable feature was the presence of forests especially on those hillsides where the slopes were very steep.

Figure 24. Area cleared for the implantation of pasture with Forested Savannah in the background.

The Parkland Savannah areas are the ones where the greatest alterations appear. All the shrubby vegetation is completely cleared and only scattered trees remain in the pasture areas.

Figure 25. Open area with the soil completely exposed ready for the implantation of pasture.

Figure 26. Established pasture with scattered trees in the background.

Bacia
do Alto Paraguai
Conservação e Sustentabilidade

Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin Brazilian Portion

Appendix II : Accuracy Analysis

Bacia do Alto Paraguai
Conservação e Sustentabilidade

Monitoring alterations in vegetation cover
and land use in the Upper Paraguay River Basin
Brazilian Portion
Period of Analysis: 2002 to 2008

Presented by:

Support:

Execution:

1. Analysis of the accuracy of the mapping

A methodology based on the comparison of the mapping done witrh high resolution images using statistical sampling techniques was developed to detect and quantify errors made in the interpretation of Landsat TM images and establish an Accuracy Index for the work.

25 CBERS satellite, HRC sensor images with a spatial resolution of 2.5 metres were used using random selection techniques but covering all areas of the Upper Paraguay River Basin.
CBERS images can be downloaded free-of-charge at the Inpe site: ***http://www.dgi.inpe.br/CDSR/***

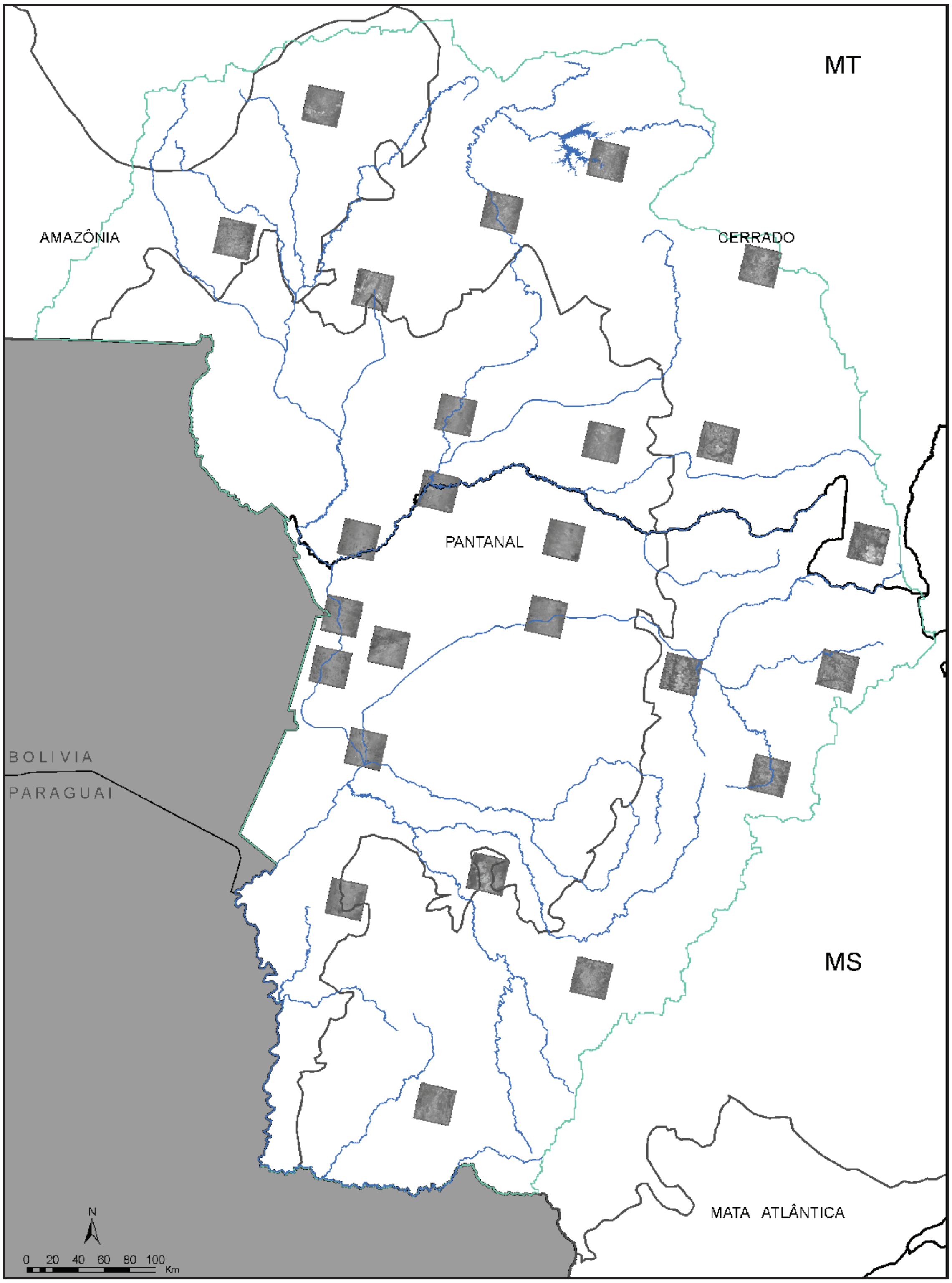


Figure 1. Areas of CBERS HRC images used to analyse accuracy of interpretations.

Within each image field 20 random sample points were selected totalling 500 points in all.

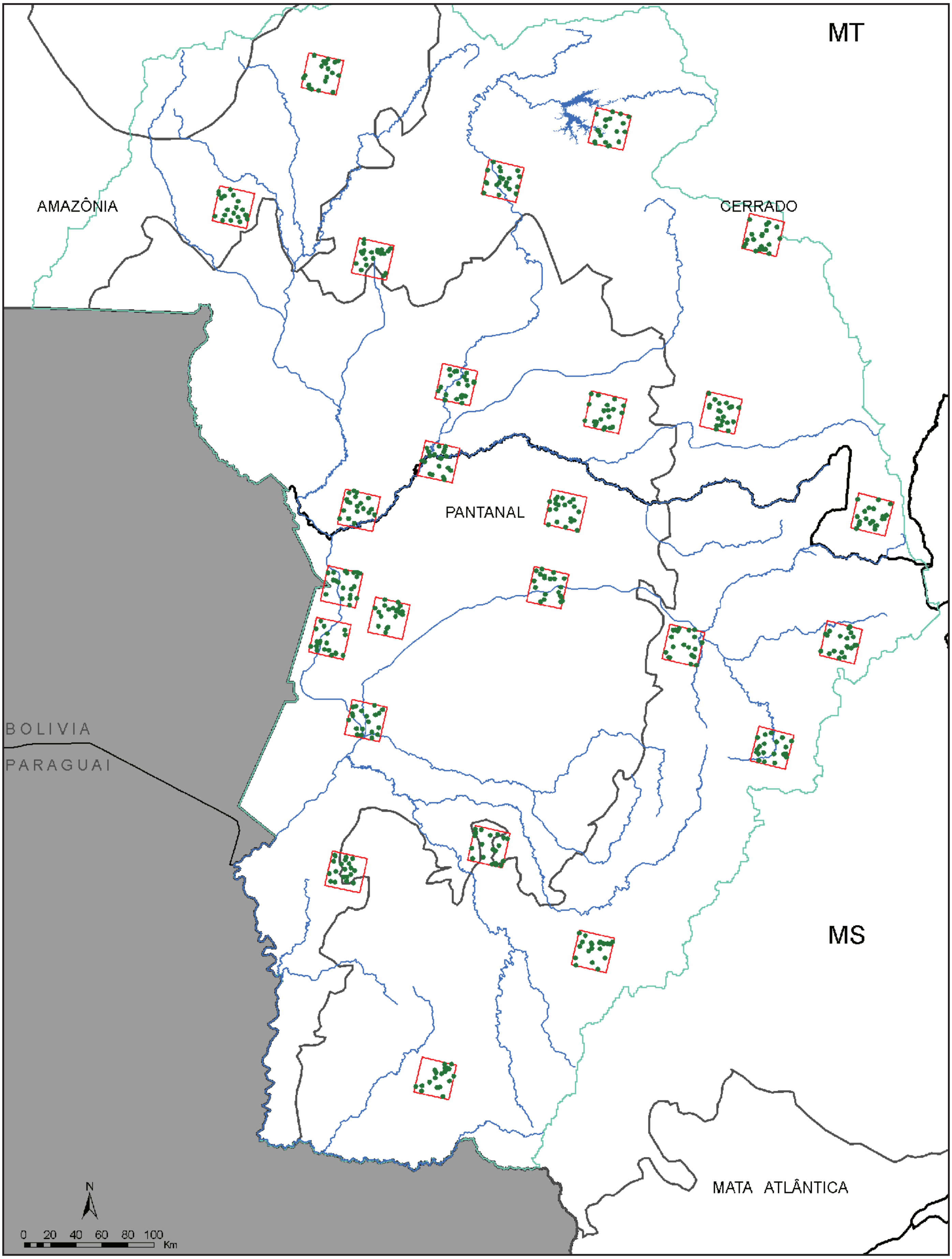


Figure 2. Distribution of the 25 image areas and the 20 random points in each one.

The sample points were generated using na extension to a programme developed for ArcGIS, known as "arcscripts", that is available for downloading free-of–charge at the ESRI through the following Link:

http://arcscripts.esri.com/details.asp?dbid=12098

For each point the vegetation cover and land use categories were interpreted using the CBERS HRC 2.5 metre resolution images on a scale of 1:10,000. By comparing the interpretations with the interpretations for the same areas made in the 2008 mapping it was possible to identify identification mistakes.

The vegetation and land use categories were also checked against the Landsat images for the year 2000 used in the project. That made it possible to detect any errors in the monitoring of changes for the period 2000 to 2008.

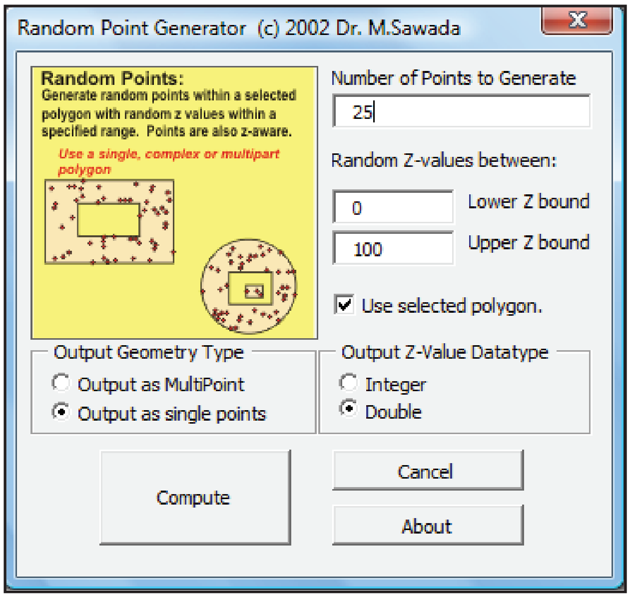


Figure 3. Screen of the programme extension used to generate random sample points.

The Accuracy index was generated by quantifying the number of points where the interpretations of vegetation classes or land use categories made using CBERS HRC images were not in agreement with those made using the Landsat TM images. That sampling methodology also made it possible to identify the types of discrepancy and errors found in the mapping.

The categories of land use interpreted using the CBERS HRC images were compared with those produced for the year 2008. Of the total 500 points investigated only 20 showed any discrepancies between their classifications. Figure 4 shows the points that were in agreement and those where discrepancies were found.

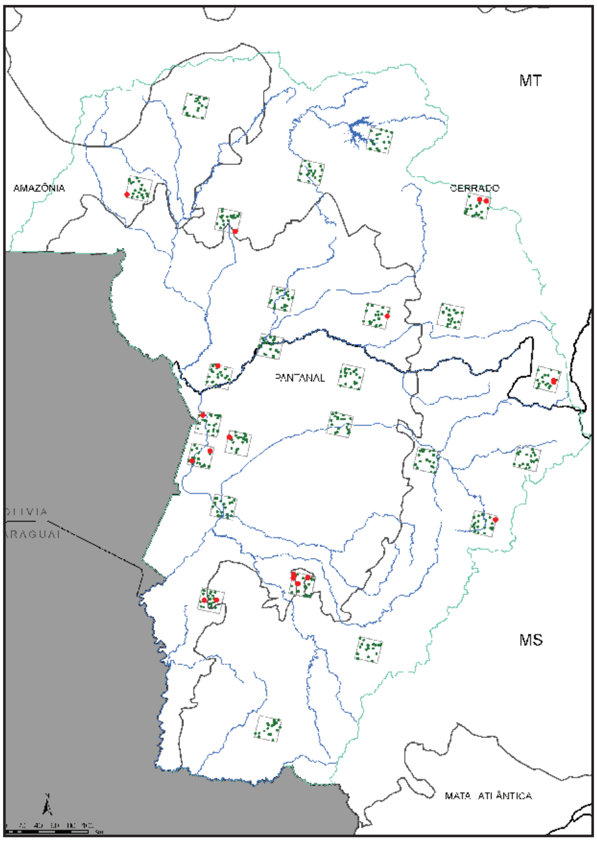


Figure 4. Sample points in red showing discrepancy between interpretations of natural vegetation and land use categories attributed using CBERS HRC images and those of the 2008 mapping process using Landsat TM images. The sample points in green represent agreement between classifications.

Using the same random sample points a comparison was made with the 2002 map classifications and that revealed no further errors.

Types of errors revealed by the mapping accuracy analysis

Of the total 500 points investigated, only 20 (4%) showed any discrepancies in the classification of natural vegetation and land use attributed using the CBERS images and those of the mapping process for 2008 and they were as follows:

Mistaking one natural vegetation class for another

Nine sample points were found with discrepancies between the classifications of natural vegetation classes corresponding to 1.8%.

In the tables below the column marked ID and the number identifies the respective polygon on the map the HRC CLASS column refers to the interpretation made using the HRC images and the column 2008 Class gives the interpretation made using the 2008 Landsat TM images.

ID	HRC CLASS	2008 CLASS
40	Forested Savannah	Shrubby Savannah
44	Gramineous Savannah	Forested Savannah
52	Forested Savannah	Shrubby Savannah
59	Forested Savannah	Shrubby Savannah
110	Forested Savannah	Shrubby Savannah
170	Vegetation under Fluvial Influence	Shrubby Savannah
223	Forested Savannah	Gramineous Savannah
414	Shrubby Savannah	Gramineous Savannah
417	Shrubby Savannah	Gramineous Savannah

These points represent mistaken identifications of natural vegetation classes and account for 1.8% of the inaccuracy in the mapping.

Mistaking pasture for natural vegetation and vice-versa

Points were identified where there was disagreement in classification of areas as natural vegetation or anthropic use (pasture). Such mistakes account for 1.2% of the inaccuracy in the mapping.

ID	HRC CLASS	2008 CLASS
42	Forested Savannah	Pasture
312	Gramineous Savannah	Pasture
382	Shrubby Savannah	Pasture
282	Pasture	Forested Savannah
395	Pasture	Gramineous Savannah
459	Pasture	Gramineous Savannah

A closer analysis of these discrepancies shows that there was no mistake in the interpretation but rather; small areas of natural vegetation were not distinguished as details in the midst of large areas of pasture. Figures 5 and 6 below give a better idea of how such discrepancies occurred:

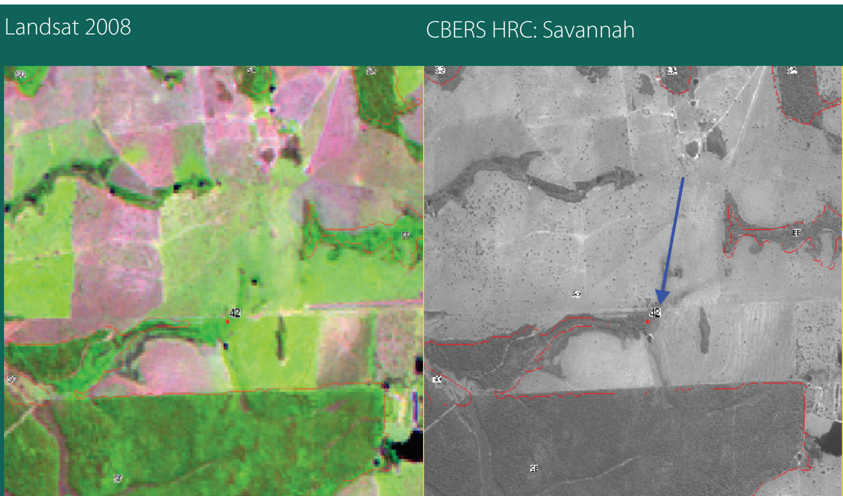


Figure 5. Image of point 42 (red dot) indicated by the blue arrow; failure to observe detail in an area of pasture.

Landsat 2008 CBERS HRC: Savannah

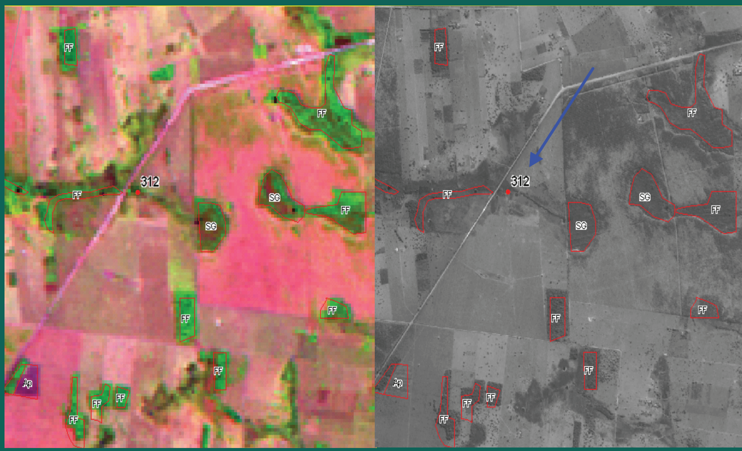


Figure 6. Image of point 312 (red dot) indicated by the blue arrow; failure to observe detail in an area of pasture

Landsat 2008 CBERS HRC

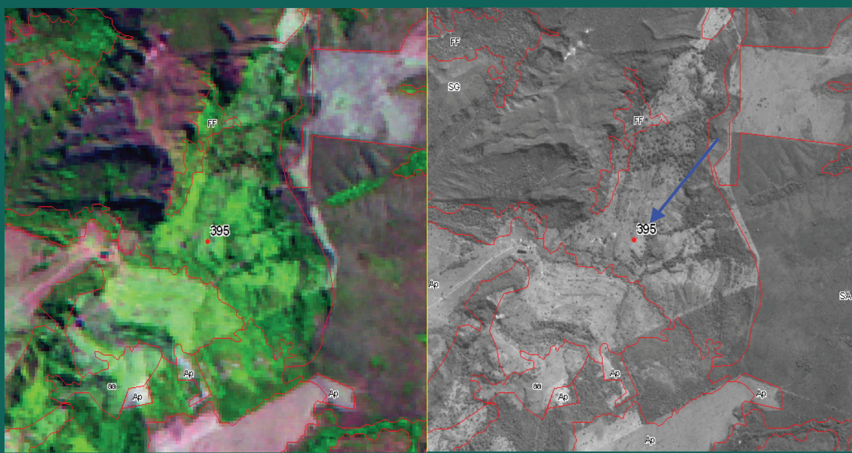


Figure 7. Image of point 395 (red dot) indicated by the blue arrow; mistaking Parkland Savannah Landsat 2008 image) for pasture.

The latter cases occurred in the Cerrado region where the Probio 2002 mapping used as a reference base shows large areas of pasture that include very small stands of natural vegetation or gallery Forest that were not shown in the detail enhancement.

Great efforts were made to identify the details of those natural vegetation areas that were not distinguished on the Probio 2002 mapping and as a result the number of polygons jumped from 46,000 in the Probio base to more than 82,000 in the project mapping. 17,000 of those polygons however, refer to alteration detected between 2002 and 2008.

However, that kind of error did not affect the monitoring data because those cases had not been mapped as areas of alteration in the period 2002 to 2008.

<u>Mistakes in the identification of vegetation under fluvial influence and áreas classified as water</u>

Three points of discrepancy were found in the separation of these two classes representing 0.6% of the inaccuracies.

ID	HRC CLASS	2008 CLASS
193	**Water**	**Vegetation under Fluvial Influence**
195	**Water**	**Vegetation under Fluvial Influence**
216	**Water**	**Vegetation under Fluvial Influence**

Those discrepancies occurred because details of some lakes with vegetation under fluvial influence were not distinguished as can be seen in Figure 8:

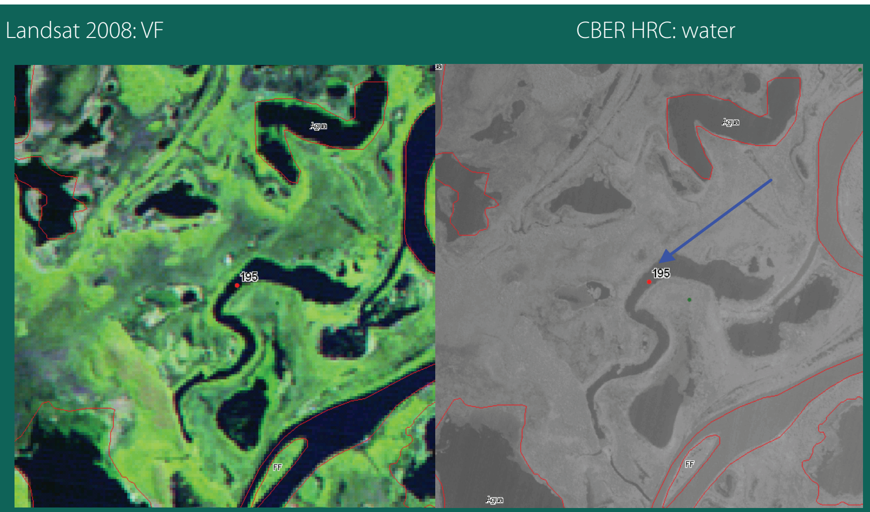


Figure 8.Image of validation point 196 (red dot) indicated by the blue arrow, lakes where details of vegetation under fluvial influence were not distinguished.

Confusing Anthropic Alteration classification with pasture

Two points exhibited this mistake corresponding to an inaccuracy of 0.4%.

ID	**HRC CLASS**	**2008 CLASS**
124	**Pasture**	**Anthropic Alteration**
127	**Pasture**	**Anthropic Alteration**

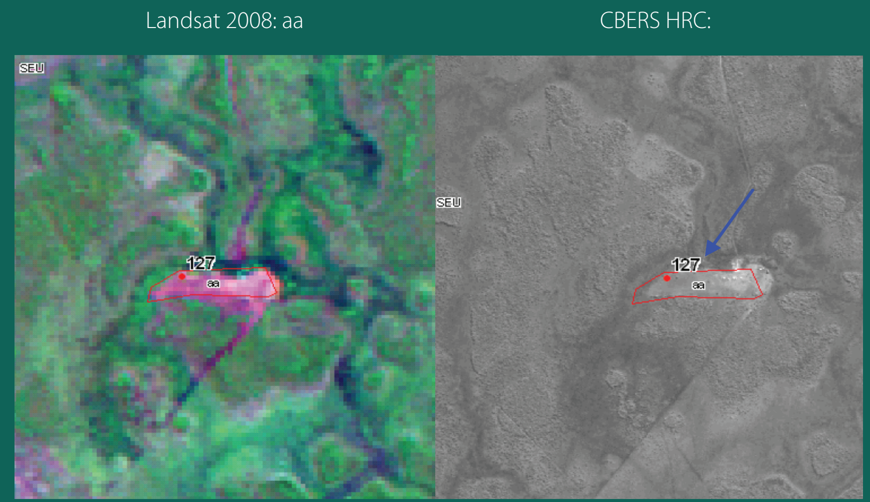


Figure 9. Image of validation point 127 (red dot) indicated by the blue arrow is na área of pasture classified as altered area

Final results of the accuracy analysis

The final result of the analysis points to a an accuracy index of 96% in the mapping done for 2008 taking into account all types of errors found.

According to the analysis a certain degree of confusion exists between some classes of natural vegetation and the classes of altered areas and pasture.

It can be expected that there is a certain amount of tiny areas of natural vegetation not displayed in detail scattered among the large areas of pastureland.

Monitoring errors for the period 2002 to 2008 were not detected thereby confirming the high level of reliability pf the mapping in regard to its main focus on the monitoring changes in natural vegetation and land use patterns.

Bacia
do Alto Paraguai
Conservação e Sustentabilidade

Monitoring alterations in vegetation cover and land use in the Upper Paraguay River Basin Brazilian Portion

Appendix III: Spatial Accuracy Analysis

Bacia do Alto Paraguai
Conservação e Sustentabilidade

Monitoring alterations in vegetation cover
and land use in the Upper Paraguay River Basin
Brazilian Portion
Period of Analysis: 2002 to 2008

Presented by:

Support:

Execution:

1. Spatial accuracy analysis

The process of monitoring alterations in natural vegetation in the Upper Paraguay River Basin – Bap initially made use of the Probio 2002 project data as its reference base.

Figure 1 is an example of how important it was to employ the vector data file produced by the Probio project as a reference:

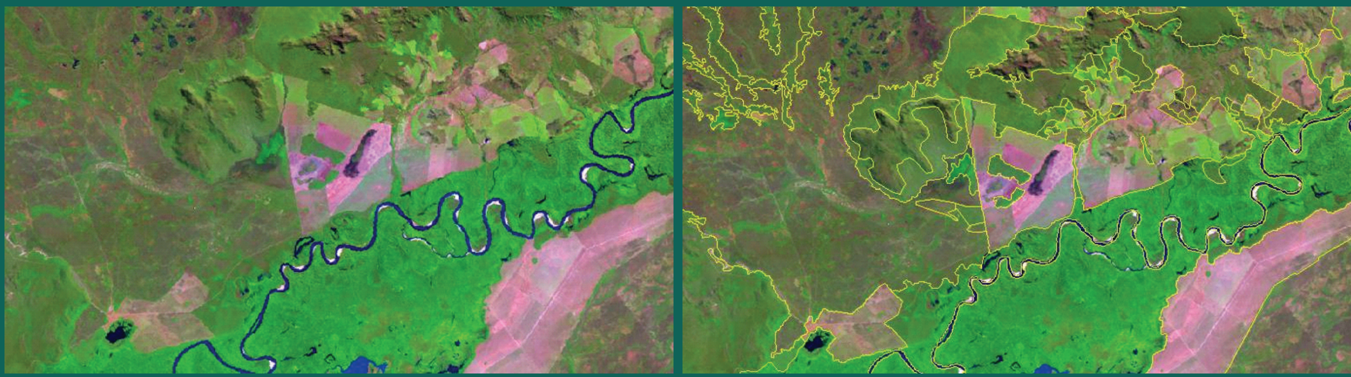


Figure 1. Appearance of the Probio project vector data file (yellow line in the lower image) imposed on a Landsat TM satellite image for 2002.

Using the Probio data as the reference meant that possible distortions and generalizations that it contains because of the scale used of 1:250,000 and the lack of detail were inevitably incorporated into the initial cartographic data base of the present project.

Altering the spatial reference would have meant abandoning the Probio vectors and starting the whole process from zero. That would have made the project unfeasible in terms of cost and the timetable foreseen for its execution. Accordingly the spatial references of Probio 2002 were adopted as the base for the monitoring. The 2008 images were geo referenced based on the Probio images for 2002.

The object of this analysis was to evaluate the kind of distortion or displacement caused by adopting that solution. Three reference bases will be used to analyse displacement:
- Mosaics of ortho-rectified Nasa images for 2000;
- GPS coordinate points in the field established by ArcPlan, with the support of the technical team formed by entities supporting the project ;
- GPS coordinate points in the field supplied by Embrapa Pantanal.

Validation of displacement based on Nasa images

The ortho-rectified Nasa Landsat ETM images have excellent spatial accuracy and many projects have made use of them as spatial references for geo-referencing satellite images.

Those images have a resolution of around 15 metres and are available in UTM/DATUM WGS84, MrSID format. For validation purposes the images were re-projected in UTM using DATUM SAD69.

A reference grid was generated consisting of 533 cells set within the limits established in the IBGE maps on a scale of 1:50,000 as shown in Figure 2:

A comparison to detect displacements was made between the Probio 2002 image and the NASA 2000 image for each individual cell in the grid.

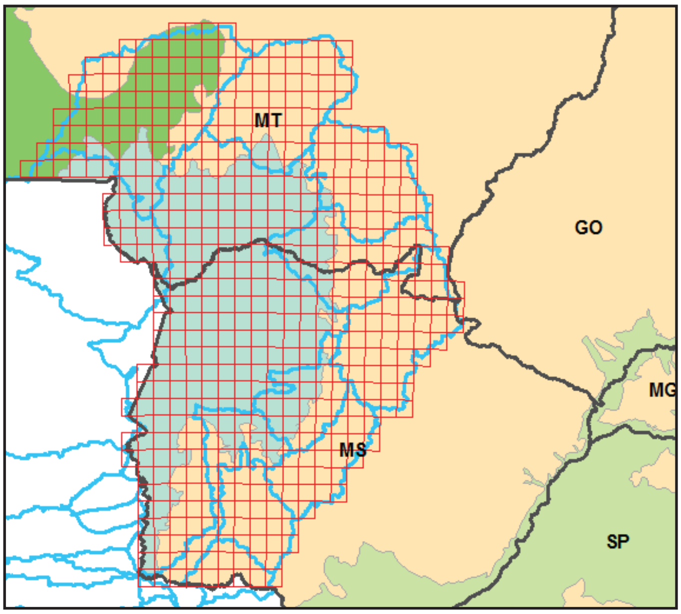


Figure 2. Reference grid set on the IBGE 1:50,000 maps for displacement analysis purposes

Displacement was measured directly by visualization on the computer monitor screen using a scale of approximately 1:30,000, and comparing the central regions of the cell of the two images.

In the case of some cells it was necessary to alter the focus from the centre to a part of the cell where there were recognizable elements present in both images that made it possible to compare their positions.

Measurement was done by selecting an element that was clearly visible in both images and preferably an element that had not suffered alterations (agricultural areas with clearly defined limits, crossroads etc.).

In other cases patches of vegetation had to be used. In such cases the surroundings of the cell were also analysed to ensure that the element selected had not suffered alteration.

Analysis of the results

Figure 3 shows the results of displacement analysis:

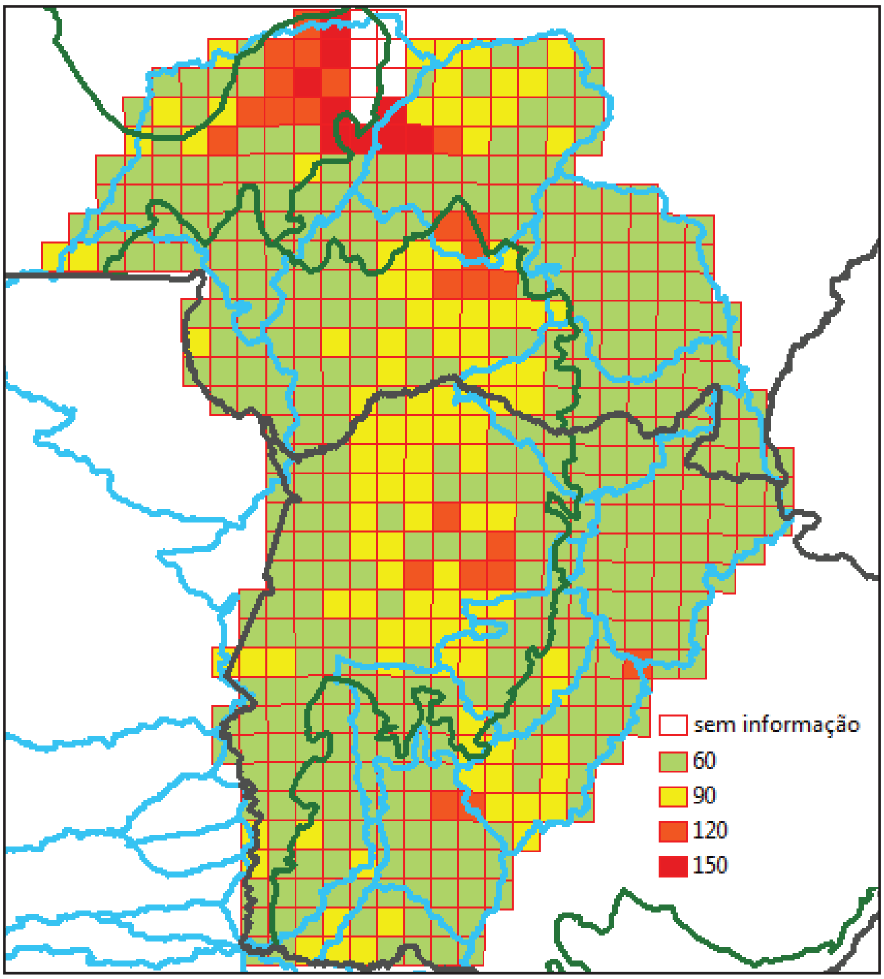


Figure 3. Map showing the results of displacement analysis.

The legend displays displacements of 60, 90, 120 and 150 metros, identified by the colours green, yellow, orange and red respectively. Areas for which there is no data appear in white.

The 60 metre displacements that correspond to two pixels in the Landsat TM images are considered to be within an acceptable margin of error taking into account the area covered by a pixel in the image and the area of the region as a whole.

Those of around 90 metres could possibly be considered how difficult it is to identify features to serve as control points in the region of the Pantanal. In such areas the images have to be geo-referenced using patches of vegetation or the courses of the rivers and those vary between the two dates.

Although considered large, displacements of around 120 metres were not corrected but those of around 150 metres were too big and had to be adjusted.

All the Cerrado areas with displacements of around 150 metres in the northern region of the basin were adjusted during the period of execution of the projects. In that region, the mosaic of Probio images does not coincide with the vector shapefile available for the same area. A Landsat TM image for 2002 was used and geo-referenced on the basis of Nasa images for the year 2000 to enhance geo-referencing for the area as a whole.

Those cells shown as 'no data available' are areas within the Amazon formation and no satellite images or Probio interpretations were available for them. Accordingly Landsat TM images for 2002 were used and geo-referenced on the basis of Nasa images for that same year.

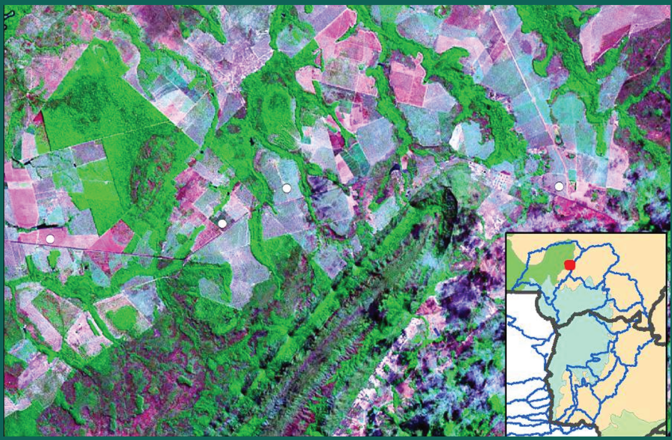
Verification of geo-referenced image displacements using field coordinates.

Fieldwork was carried out using a simple GPS navigation instrument. Its precision varied from 5 to 15 metres depending on the position and the number of satellites captured.

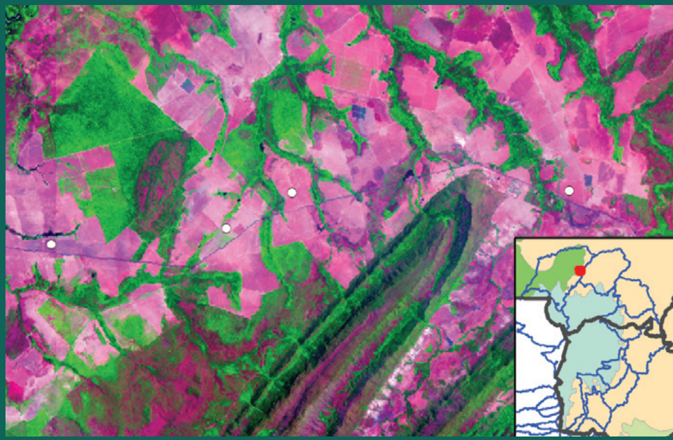
The figures below (groups of three representing the same area) display the field coordinates (symbolized by white circles with a black surrounding) set out on Landsat 7 ETM images for the year 2000 ortho-rectified by Nasa, Landsat 7 ETM images for the year 2002 geo-referenced by the Probio (2002) and Landsat 5 TM images for the year 2008 geo-referenced in the present project (2008).

The first set of three figures (Nasa, 2002 and 2008) shows a consistent displacement for all three images. Those displacements are in relation to the field points, which were registered in a moving vehicle. The four sets of images that follow are examples of different areas (figures in groups of three, Nasa, 2002 and 2008) and display field points with displacements of less than 60 metres.

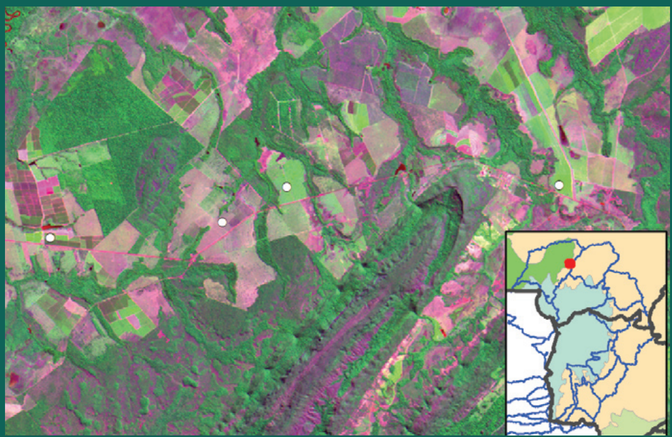
The figures are on a scale of 1:100,000:



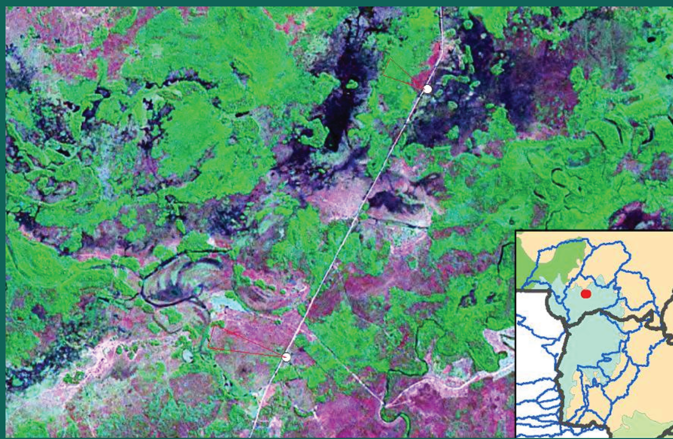
Nasa



2002

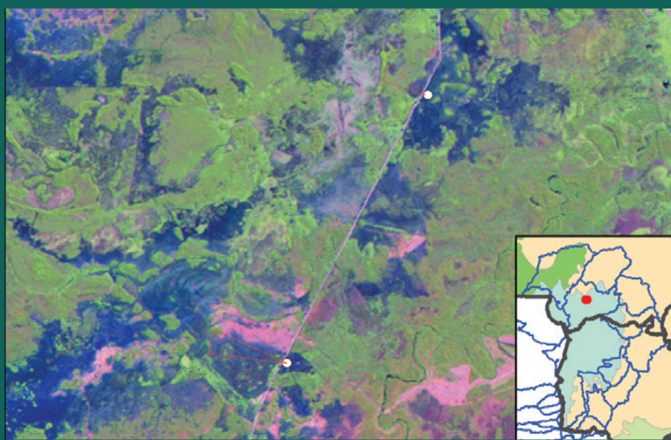


2008

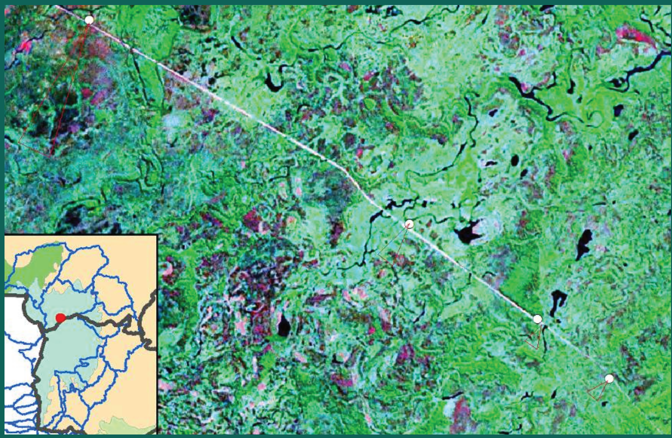


Nasa

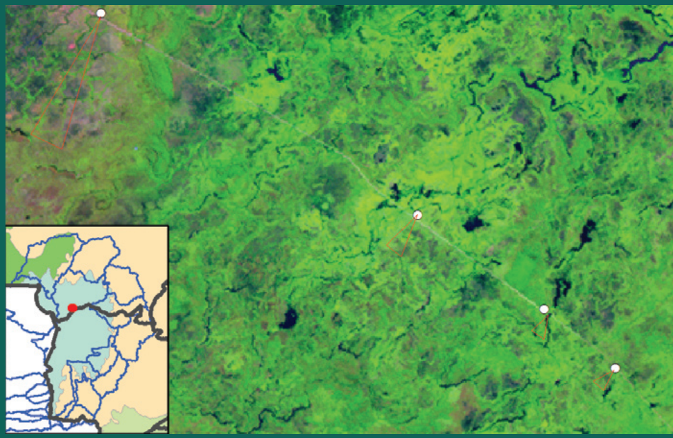
2002



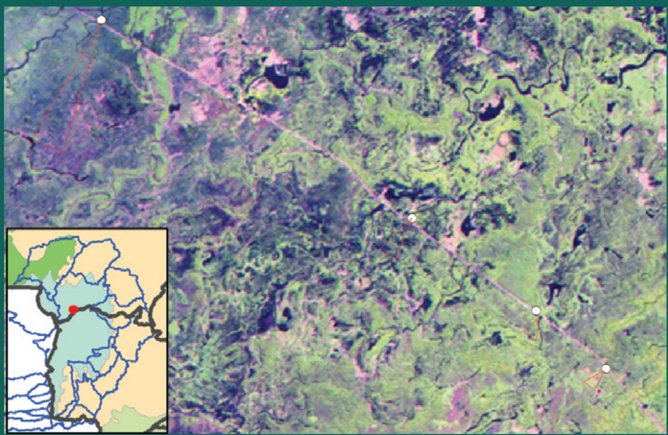
2008



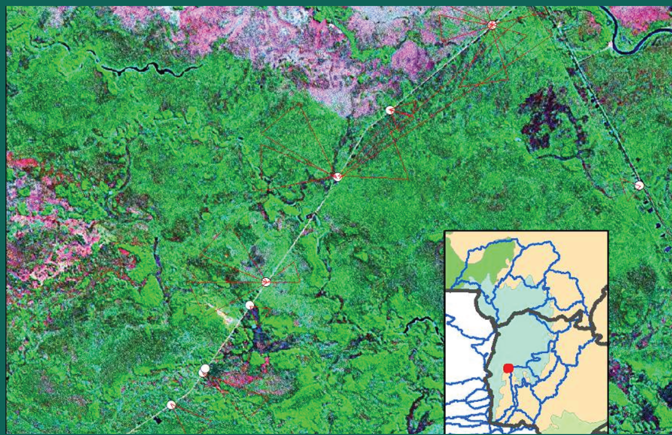
Nasa



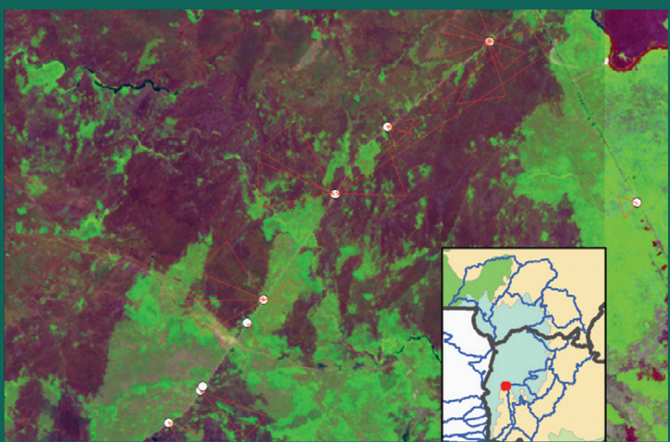
2002



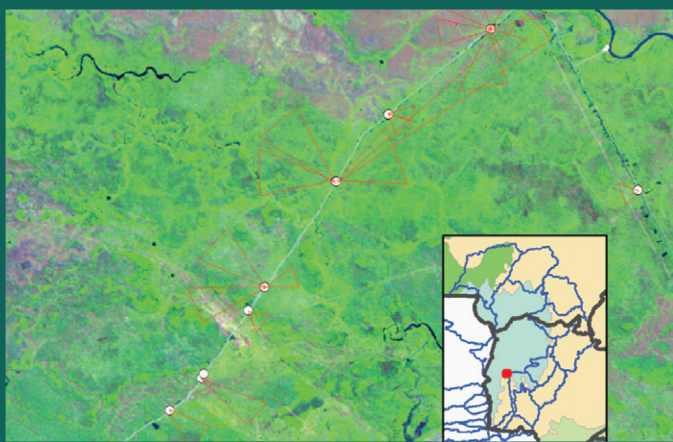
2008



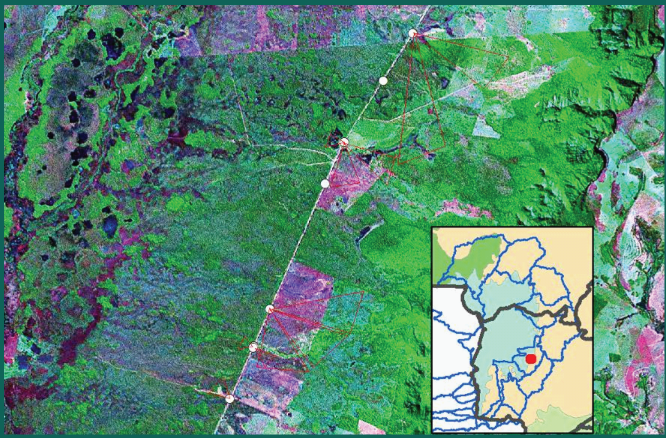
Nasa



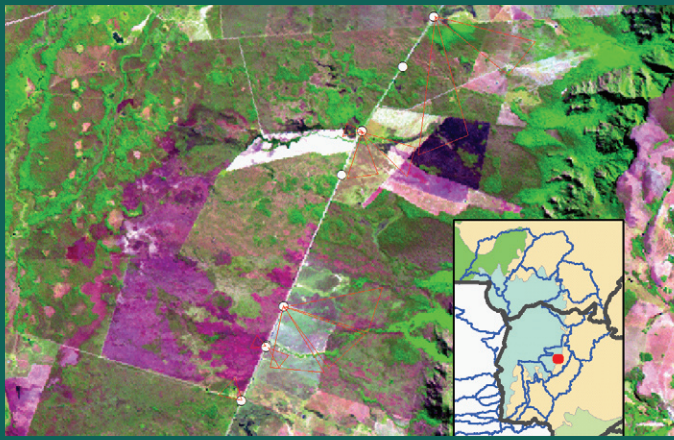
2002



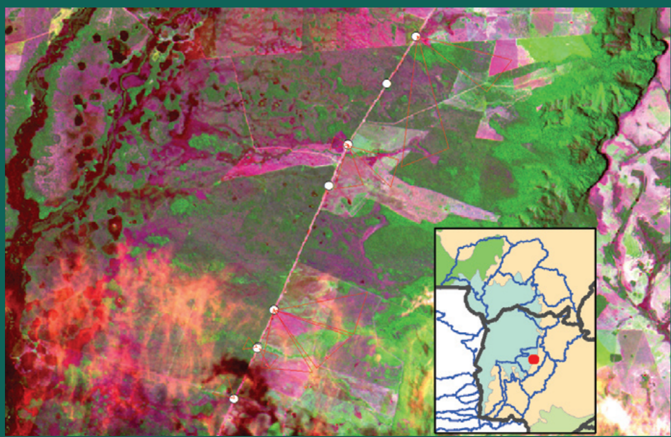
2008



Nasa



2002



2008

Verification of displacements in geo-referenced images using Embrapa Pantanal field coordinates

Another analysis of displacement was done using field coordinates supplied Embrapao Pantanal (PADOVANI, C. R.; PELLEGRIN, L. A. Landsat image mosaics of the Pantanal for the year 2000, 2003 - Embrapa Pantanal).

There are over 2,000 such points (represented by circles against a dark background) along the main roads in the upper Paraguay river basin region as can be seen in Figure 4:

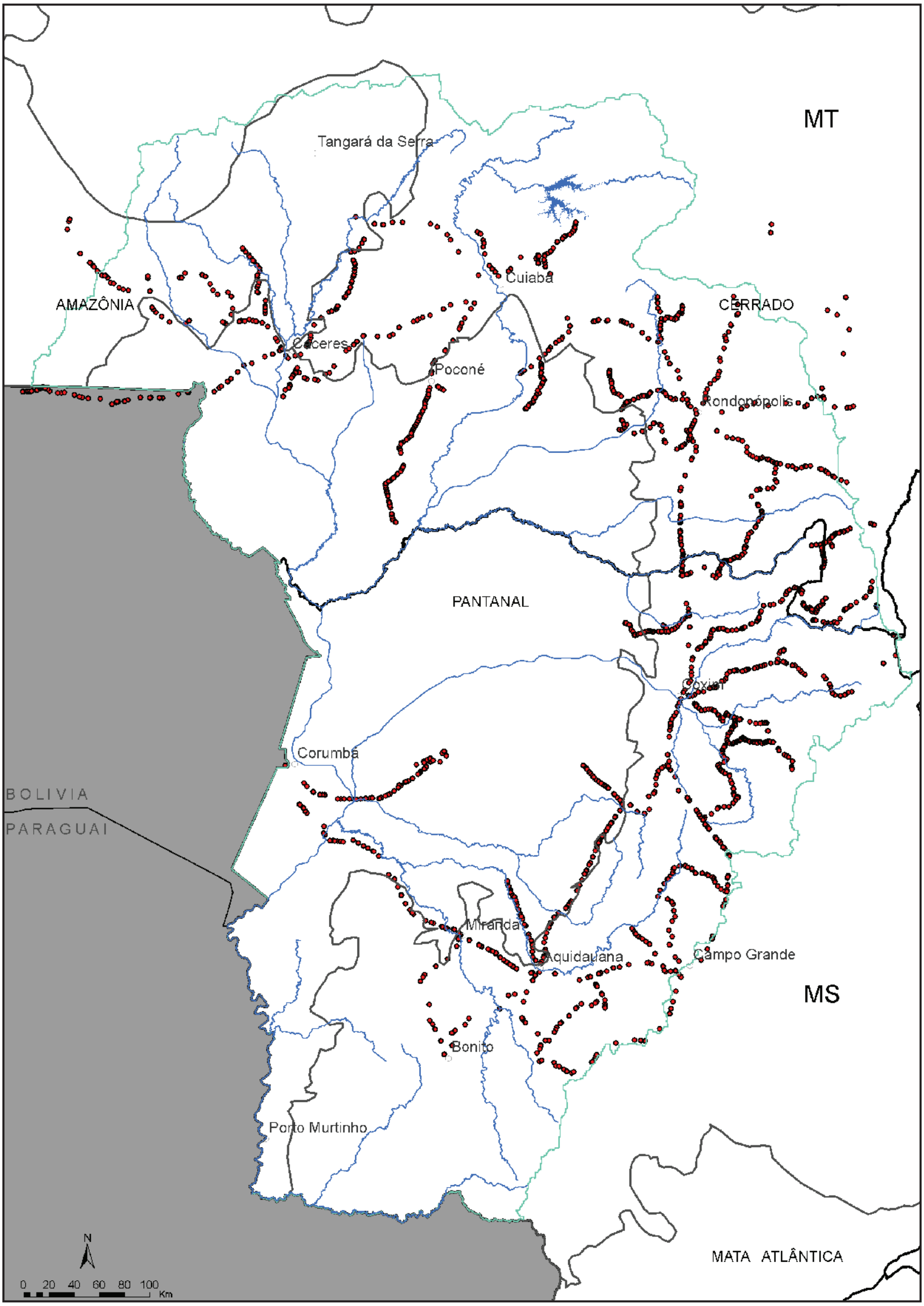


Figure 4. Field coordinates supplied by Embrapa Pantanal.

The four figures below on the scale of 1:250,000, represent different areas with images for the year 2008 showing how the field coordinates confirm a good level of consistency in the spatial references of the images used by the project:

The figure below shows a detail on the scale of 1:50,000 of the image above. On this scale it is possible to detect those points that have an average displacement of 30 to 60 metres which is the equivalent of 2 pixels in the Landsat TM satellite images:

Conclusions of the displacement analysis

The displacements detected in the images do not affect the monitoring of alterations in vegetation cover for the period 2002 to 2008 because the images for 2008 were geo-referenced on the basis of the 2002 images.

Around 75% of the base has a displacement of 60 metres or less which is an acceptable margin for Landsat TM images as it corresponds to a mere 2 pixels of displacement.

The adjustments in the northern area of the basin where the problem was more critical were made using the project base itself.

Approximately 20% of the base has errors varying from 60 to 90 metres. Those displacements can be further investigated in future monitoring projects. There would only be any real need to adjust them if there were cartographic bases on a scale of 1:50,000 available for use as spatial references.

There are some areas (around 5%) with displacements of 120 to 150 metros and those definitely need to be corrected in future versions of the database.

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