R. Ra'e Ga
Curitiba, v. 46, n. 3, p. 155- 175, Set/2019

DOI: 10.5380/raega
eISSN:2177-2738

# DYNAMICS AND ENVIRONMENTAL STATE OF VEGETABLE COVERAGE AND LAND USE IN LANDSCAPE REGIONS OF THE SOUTHWESTERN PORTION OF THE BRAZILIAN STATE OF MATO GROSSO

# DINÂMICA E ESTADO AMBIENTAL DA COBERTURA VEGETAL E DOS USOS DA TERRA NAS REGIÕES DE PAISAGEM DA PORÇÃO SUDOESTE MATO-GROSSENSE BRASILEIRA

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**ABSTRACT**
The objective of this article is to investigate the space-time dynamics of vegetation cover and land use and the Environmental State of the landscape regions of the southwestern portion of the Brazilian state of Mato Grosso.The vegetation cover and land use maps were generated from the Landsat 5 satellite images from 1984, and Landsat 8 from 2013 in the SPRING software. Map quantifications and layouts were elaborated withArcGis. The regionalization and analysis of the environmental state of the landscape were made through a regional geoecological matrix. From the results obtained, it was verified that the anthropic uses in the period of study were expanded by 134.08% while the vegetal coverings were reduced by 21.66% and the water bodies by 39%. Pasture is the predominant land use in the region, 24.09% (31,335.86 km²), mainly occupying the flat and smooth wavy terrain. Forest cover totaled 66.36% (84,967.12 km²), being found mainly in forest fragments, in which the larger territorial dimensions are either protected by environmental legislation or located in indigenous lands. Eight landscape regions were delimited in the southwest portion of Mato Grosso, including the Paraguay River Depression, which presents the landscape with the highest percentage of anthropic uses, predominantly the Degraded Environmental State. It was concluded that there is a need to adopt land use practices that minimize the environmental degradation of landscape regions, considering that during the period under investigation, the expansion of anthropic uses, mainly Livestock, directly influenced the suppression of vegetation cover.

**Keywords:** Geotechnologies; Remote Sensing; Pantanal; Brazilian Cerrado; Upper Paraguay River Basin.

**RESUMO**
O objetivo desta pesquisa é investigar a dinâmica espaço-temporal da cobertura vegetal e do uso da terra e o Estado Ambiental das regiões de paisagem da porção sudoeste do estado brasileiro de Mato Grosso.Os mapas de cobertura vegetal e uso da terra foram gerados a partir das imagens dos satélites Landsat 5, de 1984, e 8, de 2013, no software SPRING. As quantificações e os layouts dos mapas foram elaborados no ArcGis. A regionalização e a análise do estado ambiental da paisagem foram efetuadas viamatriz geoecológica regional. A partir dos resultados obtidos, verificou-se que os usos antrópicos no período de estudo expandiu-seem 134,08%, enquanto as coberturas vegetais reduziram em 21,66% e os corpos hídricos em 39%. A pastagem é o uso da terra predominante na região 24,09 % (31.335,86 Km²), ocupando principalmente os terrenos planos e suave ondulado. A cobertura florestal totalizou 66,36% (84.967,12 Km²), sendo encontrada principalmente em fragmentos florestais, em que os de maiores dimensões territoriais estão protegidos por legislação ambiental ou situados em terras indígenas. Foram delimitadas 8 regiões de paisagem na porção sudoeste mato-grossense, dentre elas, a Depressão do Rio Paraguai é a que apresenta a paisagem com maior percentual de usos antrópicos, predominando o Estado Ambiental Degradado. Concluiu-se que há necessidade de adoção de práticas de manejo do uso da terra que minimizem a degradação ambiental das regiões de paisagem, considerando que no período investigado a expansão dos usos antrópicos, principalmente a Pecuária, influenciou diretamente na supressão da cobertura vegetal.

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DOI: 10.5380/raega
eISSN:2177-2738

**Palavras chave:** Geotecnologias; Sensoriamento remoto; Pantanal; Cerrado; Bacia do Alto Paraguai.

Recebidoem: 28/05/2019
Aceitoem: 22/07/2019

## 1. INTRODUCTION

The conservation of the landscape components of the southwest region of Mato Grosso state is essential for the continuity of its economic development, but it should be based on conservation principles. It should be considered that this territorial space covers twenty-two municipalities (largest municipal agglomeration among the planning regions of the state of Mato Grosso), whose livestock, agriculture, and tourism are the main sources of income generation.

The agriculture, developed in the parts of the plateau, has compromised the balance of the environmental elements of the Pantanal plain inserted in this territorial extension. According to Mato Grosso (2012, p. 28), in the southwest portion of the Mato Grosso planning there are several problems and bottlenecks, of which stand outamong others: strong degradation of the environment, little investment in technology development on biodiversity and natural resources, fragile basic sanitation infrastructure, and environmental degradation due to garbage accumulation.

In recent years, the development and expansion of agriculture, especially soybean cultivation, have been encouraged in the municipalities that contain Pantanal areas, such as Porto Esperidião, Cáceres, Curvelândia, among others. This fact implies two situations: areas covered by pasture are converted for use in agriculture or areas covered by vegetation are deforested for agricultural development.

In this regard, the vegetation cover is suppressed, characterizing the landscape region contained in the southwest portion of Mato Grosso's planning. According to Bertrand (1968, p. 251), the vegetation "always behaves as a true synthesis of the environment", evidencing possible imbalances in the other components of the landscape. Chollen (1951, p. 51) adds that the term landscape region "applies (...) to physical, structural or climatic clusters as domains characterized by their vegetation". It is essential to have the individualization of landscape macro-units, seen as large complexes of relief, a specific lithological constitution and an expressive morphostructural characteristic, as well as pedological and climatic, which give them a unique evidence (MARTINELLI and PEDROTTI, 2001).

Given the situation presented, geotechnologies such as Geographic Database (BDG), Remote Sensing (SR), Global Positioning System (GPS), Geographic Information System (GIS), among others, are tools that allowmonitoring and analysis of the environmental conservation status of the landscapes, as well as land use planning in consonance with environmental conservation.

Environmental monitoring can be understood as the knowledge and systematic monitoring of the situation of the environmental components of the physical and biotic means that compose the landscape. The objective is the recovery, improvement or maintenance of environmental quality, and it is related to the control of environmental variables, which change due to anthropic actions and/or natural transformations (BRASIL, 2018). On the other hand, according to Amorim and Oliveira (2008, p. 182), the Environmental State is considered as "the geoecological situation of the given landscape, determined by the type and degree of impact and the reactivity and their absorption capacity". Finally, it should be noted that the most favorable areas for recovery are those that have undergone changes in their stability (environmental state), that is, those in disturbed areas.

In view of the above, the scope of this research is to investigate the spatial-temporal dynamics of vegetation cover and land use and the Environmental State of the landscape regions of the southwestern portion of the Brazilian state of Mato Grosso.

## 2. MATERIAL AND METHODS

### 2.1- Study area

The southwest region of Mato Grosso planning - for the purpose of this study, totals 130,101.28 Km² (MATO GROSSO, 2017), covering the territorial extension of the twenty two municipalities and part of the territorial portions of Barra do Bugres and Juína (**Figure 1**).

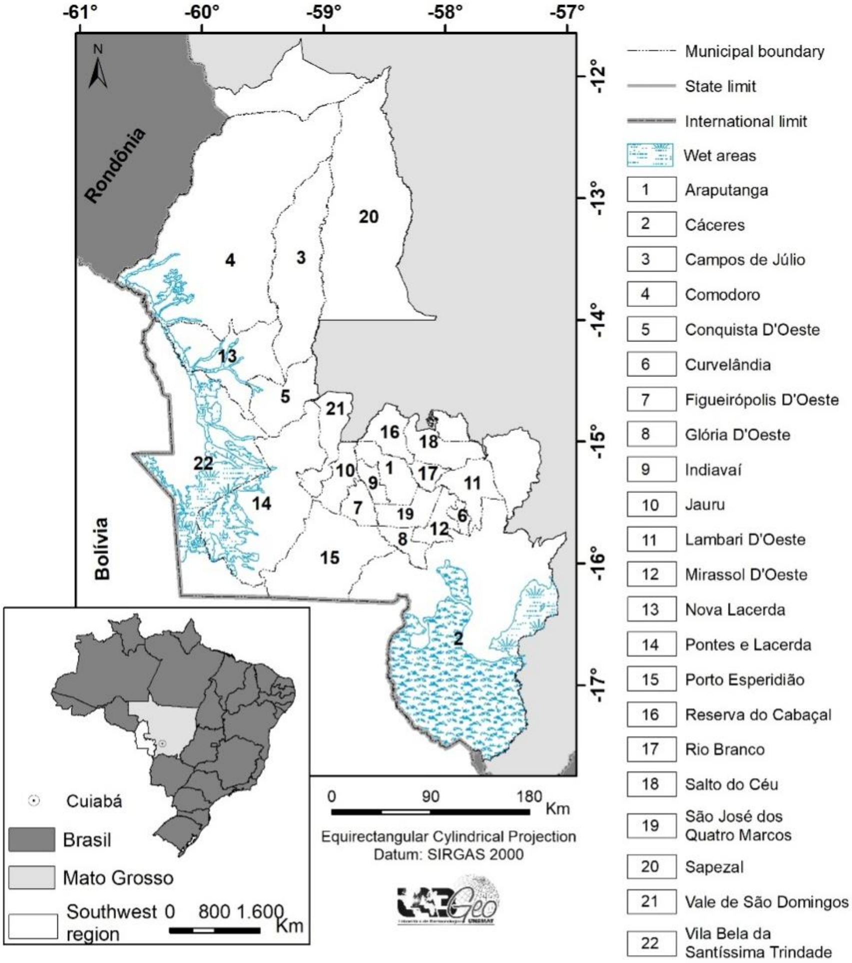


**Figure 1 -** Study area in the contexts: national, state, municipal and the southwest region of Mato Grosso state planning. Elaboration: the authors, 2019.

According to Mato Grosso (2012, p. 26), the State was regionalized into 12 planning regions that "comprise a set of socioeconomic-ecological units aggregated according to the integration of socioeconomic and ecological aspects with the structuring elements of the regions of influence of the urban poles", serving as an instrument to support society and public managers for the elaboration of public policies and as a basis for establishing the main government programs, including the Pluriannual Plan (PAP) and the Long-Term Plan (LTP).

### 2.2- Methodological procedures

Images of the Landsat-5 satellite, Thematic Mapper (TM) satellite, and the Landsat-8 satellite, Operational Land Imager (OLI) satellite were used for the months of May and June of 1984 for orbits/points: 230/69, 229/68, 229/69, 229/70, 229/71, 228/68, 228/69, 228/70, 228/71, 228/72, 227/70, 227/71 e 227/72.

Images of the Landsat-5 satellite were obtained from the National Institute for Space Research (INPE, acronym in Portuguese) and Landsat-8 on the site of the American Geological Survey, both free of charge. The spatial resolution of the images is 30 meters and was processed in spring, version 5.2.6 (CÂMARA *et al.*, 1996). A Geographic Database (GDB) was created using the metric coordinate system (UTM), the SIRGAS 2000 Geodetic System and the World Plate Carrée.

In the DBG, the vector file of the study area (.shp) was inserted to be used as a mask in the image clipping. The cropped images were segmented, using the growth method of the regions. The similarity and area parameters in Landsat 5 were both 15, and for Landsat 8, the similarity was 2400 and area 800. The difference in the similarity and area thresholds used for the segmentation of the images is the radiometric resolution of satellite images.

In Spring, the supervised classification was executed in two stages, during which the editions of the polygons created during the segmentation process were not performed. In the first stage of training, the following elements were considered: texture, pattern, shape, size, hue and color, shade, and location of areas for the definition of samples of vegetation cover and land use classes (FLORENZANO, 2002).

To define the samples nomenclature of the selected classes in the training stage, the Technical Manual of Brazilian Vegetation was used (IBGE, 2012). In the second stage of classification, the Bhattacharya classifier was adopted, with an acceptance threshold of 99.9%, concluding the stage with the execution of the mapping for the thematic classes and the matrix-vector conversion.

The vector file of plant cover and land use generated in Spring was exported and the post-classification procedures (correction after field work) were performed in ArcGIS (ESRI, 2018) as well as the quantification of thematic classes and the elaboration of map layouts in the scale of 1: 250,000.

In the process of regionalization of the landscape, the main natural aspects forming the landscape and their combinations were considered. Stable and structural variables such as relief and geology are exposed in the columns of the matrix; in the lines, the variables of climate, aridity, and predominant geomorphological processes are exposed (SEABRA *et al.*, 2012). From the combination of these study area variables in ArcGis, the different landscape regions were mapped on the scale of 1: 250,000.

The indicators Anthropogenic Transformation, Plant cover, Plant cover dynamics, Productivity and Soil degradation were used to define the environmental state. For each variable that composes the indicators, the weighted mean was calculated, multiplying the result by the area in km² that the variable occupies in the landscape of the investigated region. The final values of the Environmental State of each landscape region were systematized. Through the natural break method, which seeks to maximize the differences between classes (ESRI, 2018), they were stratified and the qualitative correspondence was made in classes: Stable, Unstable, Optimized, Conserved, Technically Supported, and Degraded for Mapping Representation.

The validation of the 2013 map was carried out through four fieldworks in the study region, with duration of 7 to 10 days each. Photographic records were made bya digital photographic camera with registration of the vegetation cover or georeferenced land use via GPS (Global Positioning System).

## 3. VEGETATION COVER AND LAND USE IN THE LANDSCAPE REGIONS OF SOUTHWEST OF MATO GROSSO

The southwest region of Mato Grosso presents 6 Areas of Ecological Tension, 9 types of Decidual Forest, 1 area of Fluvial Influence and 23 associated Savanna. Regarding land use, there was the presence of Agriculture, Areas degraded by mining, Urban influence, Livestock contacts with different types of vegetation, Livestock with Presence of Secondary Vegetation, Silviculture, Secondary Vegetation and Water (Table 1). Such a variety of flora can be attributed to the occurrence of the Amazônia, Cerrado and Pantanal biomes (BRASIL, 2018).

**Table 1.** Vegetation cover and land use and its dynamics in the different landscape regions of the research area.

| Landscape region | *Class* | 1984 | | 2013 | | Dynamics (%) |
|---|---|---|---|---|---|---|
| | | Km² | (%) | Km² | (%) | |
| I- Depressão do Guaporé | Agriculture | 0.00 | 0.00 | 421.31 | 2.02 | 100 |
| | Water | 304.13 | 1.45 | 197.38 | 0.94 | -54.09 |
| | Pasture | 3,098.83 | 14.82 | 8,753.93 | 41.87 | 64.60 |
| | Seasonal Decidual Forest Submontana | 39.85 | 0.19 | 50.52 | 0.24 | 21.13 |
| | Seasonal Semi-deciduous Alluvial Forest | 789.43 | 3.78 | 1,980.91 | 9.47 | 60.15 |
| | Seasonal Semi-deciduous Lowland Forest | 6,298.12 | 30.12 | 2,377.42 | 11.37 | -164.91 |
| | SubmontanaSeasonal Forest | 855.03 | 4.09 | 862.39 | 4.12 | 0.85 |
| | Areasdegradedby mining | 0.05 | 0.00 | 7.80 | 0.04 | 99.39 |
| | Urbaninfluence | 3.54 | 0.02 | 18.47 | 0.09 | 80.84 |
| | Ecological Tension Area with contact between Ombrophylous Forest and Seasonal Forest | 8.22 | 0.04 | 10.58 | 0.05 | 22.32 |
| | River and/or Lake Influence | 21.95 | 0.11 | 18.51 | 0.09 | -18.59 |
| | Savanna Arborizada | 588.02 | 2.81 | 715.32 | 3.42 | 17.80 |
| | Silviculture | 51.42 | 0.25 | 34.89 | 0.17 | -47,40 |
| | Savanna Florestada | 446.95 | 2.14 | 220.20 | 1.05 | -102.98 |
| | SavannaGramineous-Woody | 30.43 | 0.15 | 26.54 | 0.13 | -14.66 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 5,229.43 | 25.01 | 2,845.71 | 13.61 | -83.77 |
| | Savanna Park | 645.14 | 3.09 | 726.98 | 3.48 | 11.26 |
| | Ecological Tension Area with contact between Savanna and Savanna Estépica | 676.9 | 3.23 | 664.42 | 3.18 | -1.79 |
| | Ecological Tension Area with contact between Seasonal Savanna and Seasonal Forest | 1,820.27 | 8.71 | 973.82 | 4.66 | -86.92 |
| | **Total** | **20,907.09** | **100** | **20,907.09** | **100** | **-** |
| II- Depressão do Rio Paraguai | Agriculture | 346.69 | 1.18 | 597.63 | 2.04 | 41.99 |
| | Water | 383.42 | 1.31 | 234.11 | 0.80 | -63.78 |
| | Pasture | 13,111.32 | 44.73 | 18,128.59 | 61.84 | 27.68 |
| | Seasonal Decidual Forest Submontana | 24.31 | 0.08 | 1.08 | 0.07 | -27.37 |
| | Semi-deciduous Alluvial Seasonal Forest | 2,545.47 | 8.68 | 3,957.85 | 13.50 | 35.69 |
| | Seasonal Forest Semi-deciduous Lowlands | 1,725.86 | 5.89 | 997.04 | 3.40 | -73.10 |
| | SubmontanaSeasonal Forest | 218.06 | 0.74 | 71.95 | 0.25 | -203.10 |
| | Urbaninfluence | 30.95 | 0.11 | 85.01 | 0.29 | 63.60 |
| | Ecological Tension Area contact between Semi-deciduous Seasonal Forest and Pioneer Formations with Fluvial and/or Lake Influence | 0.77 | 0.00 | 4.75 | 0.02 | 8.89 |
| | Savanna Arborizada | 1,201.96 | 4.10 | 868.49 | 2.96 | -38.40 |
| | Silviculture | 16.08 | 0.05 | 438.30 | 1.50 | 96.33 |
| | Savanna Florestada | 7,887.92 | 26.91 | 3,080.76 | 10.51 | -156.04 |
| | SavannaGramineous-Woody | 49.27 | 0.17 | 15.01 | 0.05 | -228.18 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 1,459.99 | 4.98 | 504.68 | 1.72 | -189.29 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Savanna Park | 120.85 | 0.41 | 117.21 | 0.40 | -3.11 |
| | Ecological Tension Area with contact between Savanna and Savanna Estépica | 192.17 | 0.66 | 192.39 | 0.66 | 0.12 |
| | SecondaryVegetation | 0.00 | 0.00 | 2.24 | 0.01 | 100 |
| | **Total** | **29,315.09** | **100** | **29,315.09** | **100** | **-** |
| III- Planalto dos Parecis | Agriculture | 735.27 | 1.48 | 8,574.57 | 17.28 | 91.42 |
| | Water | 338.44 | 0.68 | 167.64 | 0.34 | -101.88 |
| | Pasture | 3,805.75 | 7.67 | 6,372.84 | 12.84 | 40.28 |
| | Seasonal Decidual Forest Submontana | 170.54 | 0.34 | 77.64 | 0.6 | -119.64 |
| | Semi-deciduous Alluvial Seasonal Forest | 1,669.63 | 3.36 | 2,637.02 | 5.31 | 36.68 |
| | Seasonal Forest Semi-deciduous Lowlands | 210.04 | 0.42 | 88.02 | 0.18 | -138.63 |
| | SubmontanaSeasonal Forest | 3,726.27 | 7.51 | 3,733.73 | 7.52 | 0.20 |
| | Areasdegradedby mining | 1.26 | 0.00 | 4.56 | 0.01 | 72.29 |
| | Urbaninfluence | 4.06 | 0.01 | 31.27 | 0.06 | 87.01 |
| | Ecological Tension Area with contact between Ombrophylous Forest and Seasonal Forest | 660.12 | 1.33 | 441.96 | 0.89 | -49.36 |
| | Savanna Arborizada | 16,283.74 | 32.81 | 16,642.18 | 33.54 | 2.15 |
| | Silviculture | 0.00 | 0.00 | 60.07 | 0.12 | 100 |
| | Savanna Florestada | 4,513.97 | 9.10 | 3,842.90 | 7.74 | -17.46 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 2,949.86 | 5.94 | 2,317.52 | 4.67 | -27.29 |
| | Savanna Park | 14,554.78 | 29.33 | 4,604.37 | 9.28 | -216.11 |
| | SecondaryVegetation | 0.00 | 0.00 | 27.44 | 0.06 | 100 |
| | **Total** | **49,623.75** | **100** | **49,623.75** | **100** | **-** |
| IV- Planaltos Residuais do Alto Guaporé | Water | 2.16 | 0.05 | 4.20 | 0.09 | 48.46 |
| | Pasture | 103.00 | 2.31 | 619.30 | 13.89 | 83.37 |
| | Seasonal Decidual Forest Submontana | 13.27 | 0.30 | 13.92 | 0.31 | 4.64 |
| | Semi-deciduous Alluvial Seasonal Forest | 7.72 | 0.17 | 90.66 | 2.03 | 91.49 |
| | Seasonal Forest Semi-deciduous Lowlands | 229.89 | 5.16 | 63.79 | 1.43 | -260.38 |
| | SubmontanaSeasonal Forest | 0.96 | 0.02 | 84.41 | 1.89 | 98.87 |
| | Areasdegradedby mining | 0.82 | 0.02 | 14.85 | 0.33 | 94.51 |
| | Urbaninfluence | 0.00 | 0.00 | 0.44 | 0.01 | 100 |
| | Savanna Arborizada | 299.78 | 6.72 | 308.38 | 6.92 | 2.79 |
| | Savanna Florestada | 149.54 | 3.35 | 148.60 | 3.33 | -0.64 |
| | SavannaGramineous-Woody | 235.03 | 5.27 | 200.21 | 4.49 | -17.39 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 2,490.33 | 55.86 | 1,358.02 | 30.46 | -83.38 |
| | Savanna Park | 923.92 | 20.72 | 1,551.77 | 34.80 | 40.46 |
| | Ecological Tension Area with contact between Seasonal Savanna and Seasonal Forest | 2.12 | 0.05 | 0.00 | 0.00 | 0.00 |
| | **Total** | **4,458.55** | **100** | **4,458.55** | **100** | **-** |
| V- Planícies e Pantanais do Médio e Alto Guaporé | Agriculture | 0.00 | 0.00 | 136.13 | 1.85 | 100 |
| | Water | 574.88 | 7.81 | 229.86 | 3.12 | -150.10 |
| | Pasture | 220.39 | 3.00 | 1,157.14 | 15.73 | 80.95 |
| | Seasonal Decidual Forest Submontana | 1.19 | 0.02 | 1.42 | 0.02 | 16.06 |
| | Semi-deciduous Alluvial Seasonal Forest | 1,031.85 | 14.02 | 1,091.41 | 14.83 | 5. 46 |
| | Seasonal Forest Semi-deciduous Lowlands | 1,007.63 | 13.69 | 361,01 | 4.91 | -179.11 |
| | SubmontanaSeasonal Forest | 75.63 | 1.03 | 34.26 | 0,47 | -120.77 |
| | Urbaninfluence | 1.04 | 0.01 | 3.14 | 0.04 | 66.80 |
| | River and/or Lake Influence | 18.77 | 0.26 | 22.79 | 0.31 | 17.65 |
| | Savanna Arborizada | 69.90 | 0.95 | 84.40 | 1.15 | 17.18 |
| | Savanna Florestada | 8.54 | 0,12 | 39.63 | 0.54 | 78,45 |
| | SavannaGramineous-Woody | 0.00 | 0.00 | 35.10 | 0.48 | 100 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 859.87 | 11.69 | 551.52 | 7.50 | -55.91 |
| | Savanna Park | 1,240.02 | 16.85 | 1,153.89 | 15.68 | -7.47 |
| | Ecological Tension Area with contact between Savanna and Savanna Estépica | 2,123.69 | 28.86 | 2,237.88 | 30.41 | 5.10 |
| | Ecological Tension Area with contact between Seasonal Savanna and Seasonal Forest | 124.69 | 1.69 | 218.51 | 2.97 | 42.94 |
| | **Total** | **7,358.09** | **100** | **7,358.09** | **100** | **-** |
| VI- Planícies e Pantanais Matogrossenses - Cáceres | Agriculture | 1,475.03 | 12.30 | 1,031.35 | 8.60 | -43.02 |
| | Water | 25.83 | 0.22 | 773.09 | 6.45 | 96.66 |
| | Semi-deciduous Alluvial Seasonal Forest | 235.35 | 1.96 | 197.44 | 1.65 | -19.20 |
| | Area of Ecological Tension contact between Semi-deciduous Seasonal Forest and Pioneer Formations with Fluvial and/or Lake Influence | 1,247.52 | 10.40 | 1,197.09 | 9.98 | -4.21 |
| | River and/or Lake Influence | 4.07 | 0.03 | 7.96 | 0.07 | 48.88 |
| | Savanna Arborizada | 2,357.42 | 19.66 | 2,021.01 | 16.85 | -16.65 |
| | Silviculture | 0.00 | 0.00 | 2.97 | 0.02 | 100 |
| | Savanna Florestada | 1,399.98 | 11.67 | 1,567.41 | 13.07 | 10.68 |
| | SavannaGramineous-Woody | 1,066.74 | 8.90 | 1,412.61 | 11.78 | 24.48 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 262.35 | 2.19 | 142.67 | 1.19 | -83.88 |
| | Ecological Tension Area with contact between Savanna and Savanna Estépica | 3,918.28 | 32.67 | 3,638.96 | 30.34 | -7.68 |
| | **Total** | **11,992.57** | **100** | **11,992.57** | **100** | **-** |
| VII- Planícies e Pantanais Matogrossense -Poconé | Agriculture | 110.90 | 5.65 | 83.07 | 4.23 | -33.50 |
| | Water | 167.49 | 8.53 | 457.28 | 23.30 | 63.37 |
| | Semi-deciduous Alluvial Seasonal Forest | 2.87 | 0.15 | 9.64 | 0.49 | 70.18 |
| | Area of Ecological Tension, contact between Semi-deciduous Seasonal Forest and Pioneer Formations with Fluvial and/or Lake Influence | 0.15 | 0.01 | 0,56 | 0.03 | 7.07 |
| | Savanna Arborizada | 728.85 | 37.13 | 300.62 | 15.32 | -142.44 |
| | Savanna Florestada | 83.59 | 4.26 | 141.04 | 7.19 | 40.73 |
| | SavannaGramineous-Woody | 488.12 | 24.87 | 393.11 | 20.03 | -24.17 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 159.20 | 8.11 | 274.75 | 14.00 | 42.05 |
| | Ecological Tension Area with contact between Savanna and Savanna Estepica | 221.67 | 11.29 | 302.78 | 15.43 | 26.79 |
| | **Total** | **1,962.85** | **100** | **1,962.85** | **100** | **-** |
| VIII- Província Serrana | Agriculture | 8.08 | 0.18 | 17.22 | 0.38 | 53.10 |
| | Water | 314.32 | 7.01 | 459.35 | 10.25 | 31.57 |
| | Seasonal Decidual Forest Submontana | 0.00 | 0.00 | 1.12 | 0.02 | 100 |
| | Semi-deciduous Alluvial Seasonal Forest | 3.06 | 0.07 | 8.49 | 0.19 | 63.92 |
| | Savanna Arborizada | 353.45 | 7.88 | 272.27 | 6.07 | -29.82 |
| | Silviculture | 0.34 | 0.01 | 2.79 | 0.06 | 87.93 |
| | Savanna Florestada | 3,720.50 | 82.99 | 3,630.10 | 80.97 | -2.49 |
| | Ecological Tension Area with contact between Savanna and Seasonal Forest | 18.09 | 0.40 | 18.37 | 0.41 | 1.55 |
| | Savanna Park | 65.45 | 1.46 | 73.56 | 1.64 | 11.02 |
| | **Total** | **4,483.29** | **100** | **4,483.29** | **100** | **-** |

In the landscape region of the DepressãoGuaporé (I) there was a decrease ofareas covered by vegetation formations; the highest reduction occurred in the Lowland Semi-deciduous Seasonal Forest (3,920.70 $km^2$) with increase of land use classes, with the introduction of Agriculture and the expansion of Livestock, which grew 5,655.10 $km^2$ (Table 1 and Figure 2).

De Fries et al. (2013) verified that the changes in landscapes in Mato Grosso from the 1970s to 2013 occurred due to the insertion of pastures and agricultural plantations to meet local, regional and international demands. These uses have been favored since the 1970s by the development of new crop varieties, improvements in soil management, government policies, and infrastructure investments that allowed for agricultural expansion (Agriculture and Livestock) to the extensions covered by Savanna and Amazon Forest in Mato Grosso (BINSWANGER, 1991 and FEARNSIDE, 2003).

The Depressão do Rio Paraguai (II) was the region where there was the greatest alteration of the landscape. In the Forms of Dissection, these landscapes were the sites that presented the lowest percentage of vegetation cover and were greatly altered due to the presence of 12 cities, 18 urban districts and several types of anthropic uses (Table 1 and Figure 2).

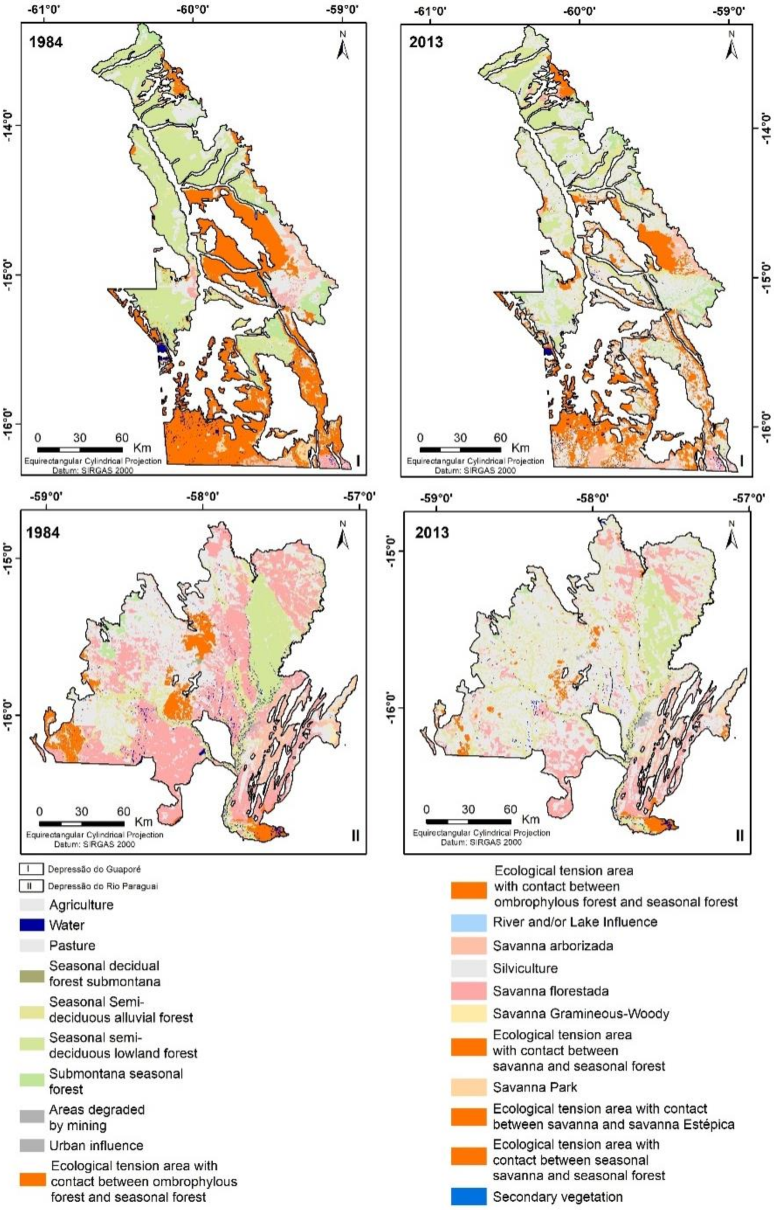


**Figure 2 -** Vegetation cover and land use in landscape units Depressão do Guaporé (I) and Depressão do Rio Paraguai (II). Elaboration: the authors, 2019.

Among the vegetation cover classes, the ones with the highest losses were Savanna Florestada (4,807.14 $km^2$) and the Ecological Tension Area with contact between the Savanna and the Seasonal Forest (955.31 $Km^2$). In the same period, the category of Livestock increased by 5,017.27 $Km^2$ and Agriculture expanded its area by 250.95 $Km^2$ with Sugarcane (*Saccharum officinarum*) as the main crop, followed by soybean.

A fewsituations that favored the expansion of the sugarcane crop in the region of studycan be mentioned such as the location of the Rio Branco Sugar Cane Growers Cooperative (COOPERB), located in the municipality of MirassolD'Oeste, the adaptability of sugarcane, as well as pasture to the edaphoclimatic conditions of Mato Grosso, particularly in the southwest portion, and the flat topography (FIETZ *et al*., 2008; NEVES *et al.*, 2013; RIBEIRO *et al*., 2015).

Population growth was observed in urban areas (IBGE, 2018 a, b, c, d) during the investigated period. In addition, there was an expansion of the areas used for urban purposes, as corroborated by the results obtained by Cochev et al. (2010), Santos and Zamparoni (2012) and Souza et al. (2018) when carrying out the multitemporal analysis in the city of Cáceres during the period investigated by this study, verified a relation between the increase of the urban area and the population growth. The landscape region of Planalto dos Parecis (III), with the greatest extension among the regions of the study area, has as its main feature the flat relief, which facilitates the development of agricultural activities. In this region, there was an increase of 7,839.29 km$^2$ of the Agriculture class and 2,567.09 Km$^2$ for Livestock, while the Savanna Park class had its area reduced by 9,950.41 Km$^2$(Table 1 and Figure 3). In 2013, reforestation plantations were mapped. It should be noted that Brazilian soybean production increased from 15 to 69 million tons between the 1980s and 2010due to the growing international demand for soybeans as animal food, with the production in Mato Grosso corresponding to 27% of the national production (MACEDO *et al.*, 2012).

In the landscape region of PlanaltosResiduais do Alto Guaporé (IV), there was expansion of the Livestock class (516,30 Km$^2$) and areas degraded by mining. The Ecological Tension Area with contact between Savanna and Seasonal Forest suffered a reduction of 1,132.31 km$^2$ because of the expansion of the classes of uses (Table 1 and Figure 3). According to Pires and Pierangeli (2011), "unlike agriculture, cattle ranching and other activities that cause impacts in large areas, mineral exploration causes a punctual impact in small areas, but in most cases of high intensity". The Water Masses of the region had an expansion of 2.03 Km$^2$ and the increase could be related to the period of image acquisition.

The landscape region Planícies e Pantanais do Médio e Alto Guaporé (V), which is characterized by the presence of flooded areas during most of the year, presented a reduction of 345.02 km$^2$ in its Water Masses. This reduction can be due to the date of the image used in the mapping or climatic anomalies that reached Mato Grosso, implying longer and extreme drought periods that influence the flood cycle of the Pantanal watersheds. The presented situation was verified in the municipality of Caceres where Nunes *et al.* (2016) found that in the dry season (from April to October), drought was classified as extreme (I> -0.6) during most of the study period (1971 to 2011).

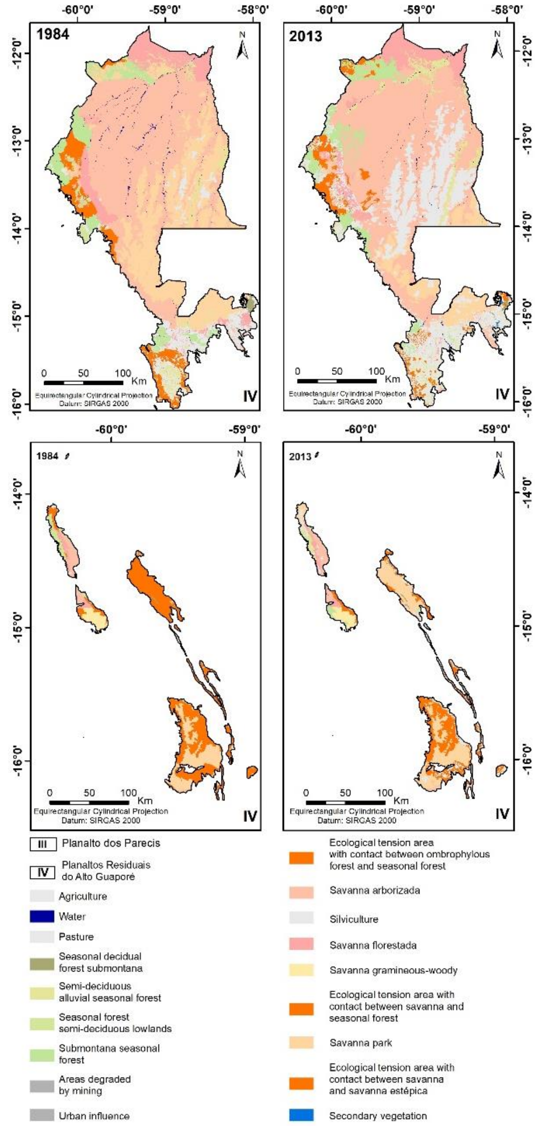


**Figure 3 -** Plant cover and land use in the landscape Planalto dos Parecis (III) and Planaltos Residuais do Alto Guaporé (IV). Elaboration: the authors, 2019.

In this region, Agriculture was mapped in 2013 and Livestock, which expanded 936.75 Km$^2$ (Table 1 and Figure 4), led to territorial decreases in vegetation classes of the Semi-deciduous Lowland Forest (645.99 Km$^2$) and the Area of Ecological Tension with contact between the Savanna and the Seasonal Forest (308.35 Km$^2$).

The landscape region Planícies e Pantanais Mato-grossenses – Cáceres (VI) has similar characteristic to the V region, that is, the constant presence of superficial water, which means that in this region the main economic activity is Extensive livestock directed to the breeding and fattening of cattle, using natural pasture (flooded area) and planted pasture (non-flooded area).

The Livestock class (planted pasture) increased 747.27 Km$^2$, consequently, other vegetation classes had their areas reduced, and the wooded portion of Savanna was reduced to 336.41 km$^2$ (Table 1 and Figure 4). The growth of livestock can be attributed to the implantation of a slaughterhouse in the city of Cáceres in 2004. This entailedin the increase of the herd and the deforestation to intensify the cultivation of pastures, reflecting in the period from 2006 to

2012 so that the municipality of Cáceres obtained good positions in the ranking of the largest cattle producers in the State and in the municipalities of Pantanal (AQUINO *et al.*, 2017).

When Rosseto (2009) investigated the Pantanal de Cáceres, it was verified that due to differences in soil types, there are areas with a better quality of natural pastures butthe areas that are located far from aquifer springs form lower quality pastures, which are rejected by the herd. The latter are replaced by exotic grasses that constitute the main characteristic of the modernization of livestock in search of productive optimization of the landscape of the studied area, although the climatic seasonality hampers the management of the exotic pastures. Another characteristic for productive optimization is the control of the calving season so they are not born during the flood season, which facilitates cattle management, increases productivity and increases the use of bulls.

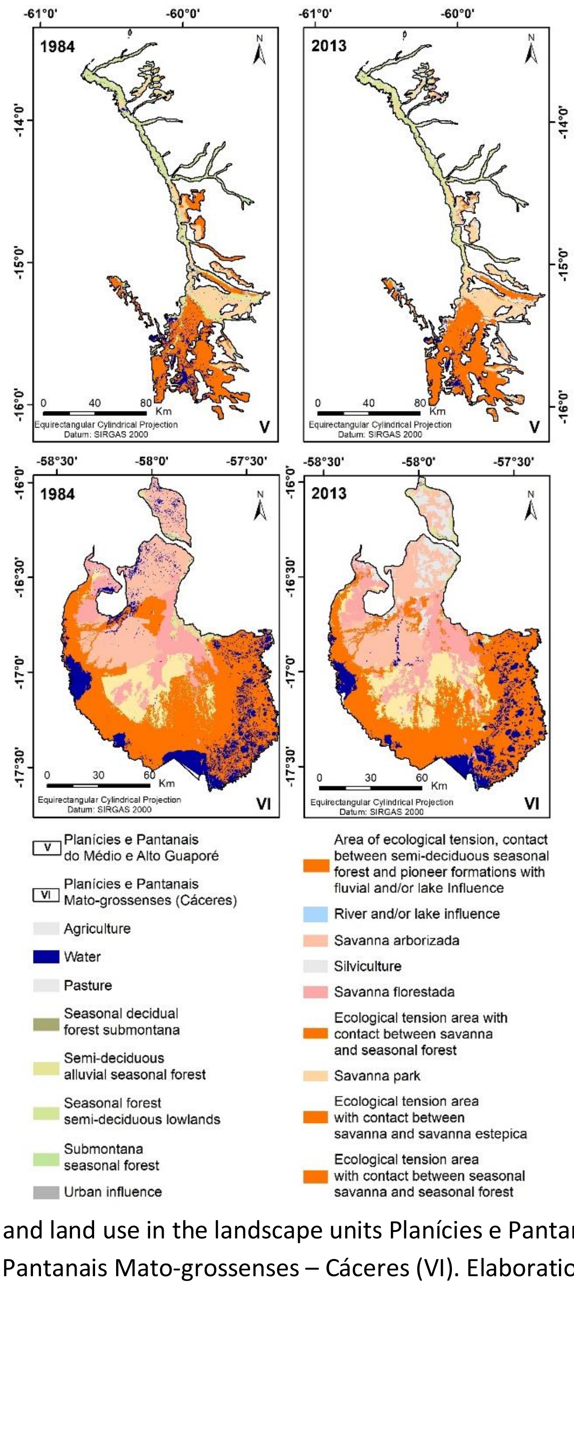


**Figure 4 -** Vegetation cover and land use in the landscape units Planícies e Pantanais do Médio e Alto Guaporé (V) and Planícies e Pantanais Mato-grossenses – Cáceres (VI). Elaboration: the authors, 2019.

Concerning the landscape region Planícies e Pantanais Mato-grossenses – Poconé (VII) the Livestock class grew 289.79 $Km^2$. In contrast, leafy Savannah was reduced in extension 428.23 $Km^2$ and its reduction can be linked to the growth of bovine livestock activity (Table 1 and Figure 4). As in the Pantanal de Poconé, in the portion of the Pantanal de Cáceres, located in the hydrographic basin of the Jauru river, the study by Miranda *et al.* (2017) found that the woody savanna was the phytophysiognomy that suffered the greatest suppression due to the conversion of its area to cattle development over a period of ten years, corroborating with the result presented in this research.

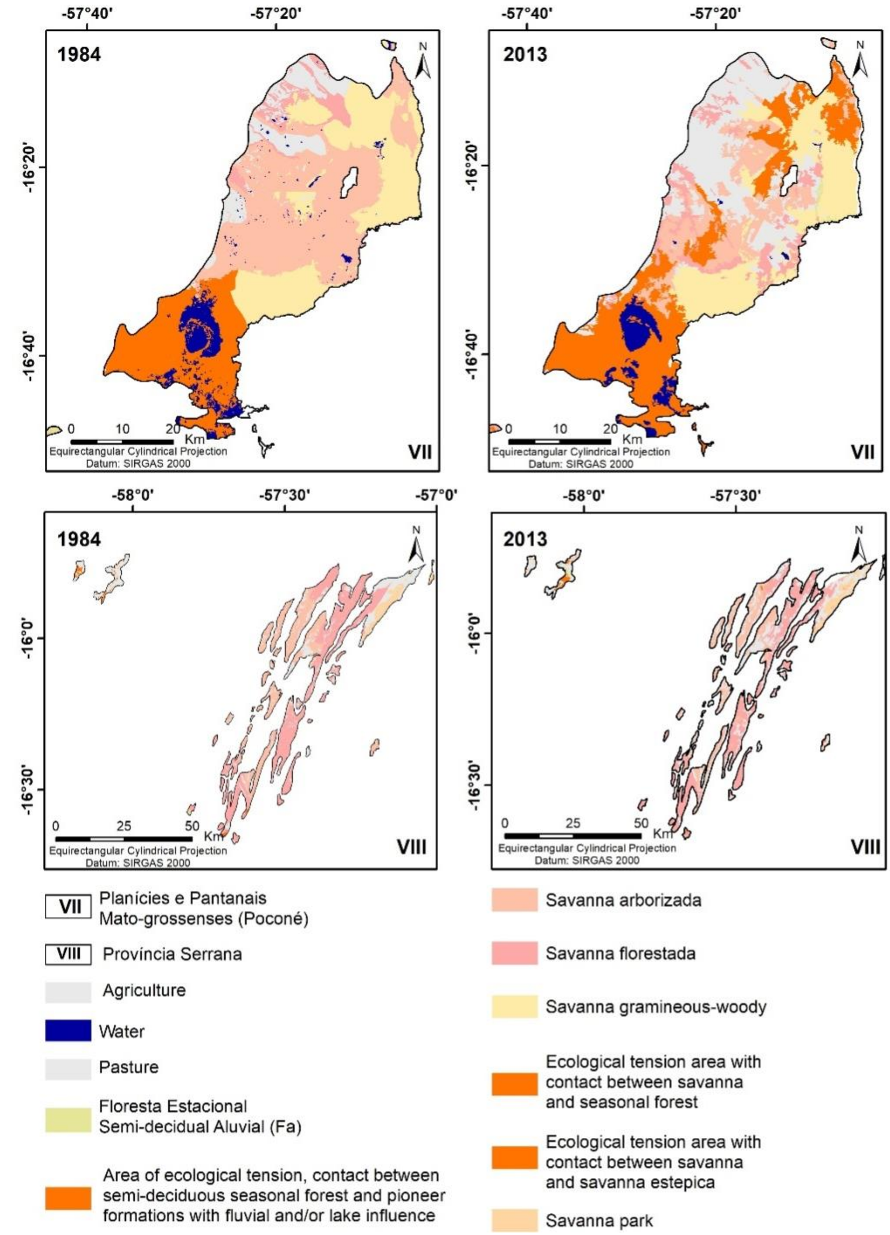


**Figure 5 -** Plant cover and land use in the landscape units Plains and Pantanal de Mato Grosso -Poconé (VII) and Província Serrana (VIII). Elaboration: the authors, 2019.

Finally, in the landscape region of the ProvínciaSerrana (VIII), there was an increase in the Agriculture class in the valleys, linked to soybean production, cattle raising and silviculture - Teak) (Table 1 and Figure 4). According to Kreitlow et al. (2014, p. 61), the valleys of the ProvínciaSerrana were classified in the geoenvironmental evaluation of the lands of the Brazilian municipality of Cáceresas being suitable for the cultivation of the Teak, which explains the growth of the class. The authors add that the valley spaces are economically used by the resident communities, linked to ten rural settlements that shelter 3,259 families, for the development of livestock and to a lesser extent for other uses, such as subsistence crops. Soy, which is the crop that occupies the largest land area in the region of the mountainous province, is linked to an agricultural enterprise.

## ENVIRONMENTAL STATE OF THE RESEARCH AREA LANDSCAPE REGIONS

Regarding the Environmental State of the landscape regions, it was verified that 65.75% of the territorial extension of the southwest portion of Mato Grosso in 1984 was Preserved; 11.74% Degraded; 4.19% Stable; 2.42% Unstable; 12.32% Optimized, and 3.57% Technically Supported. The situation was not favorable to the conservation of the vegetal cover because 29 years after the Environmental State, in 2013, 7.74% of the area of the southwestern portion of Mato Grosso was Conserved; 20.42% Degraded; 31.52% Stable; 15,95% Unstable; 12.67% Optimized, and 11.70% Technically Supported (Table 2 and Figure 6).

**Table 2**. Environmental states of the landscape regions of the study area.

| LandscapeRegion (Code) | Environmental State | Area (km² ) | | Dynamics |
|---|---|---|---|---|
| | | 1984 | 2013 | (%) |
| Depressão do Guaporé (I) | Preserved | 17,415.23 | 52.13 | -33,307.31 |
| | Stable | 338.03 | 105.00 | -221,93 |
| | Unstable | 3,153.84 | 20,749.97 | 84.80 |
| **Total** | | **20,907.10** | **20,907.10** | |
| Depressão do Rio Paraguai (II) | Degraded | 15,269.32 | 26,566.18 | 42.52 |
| | Optimized | 14,045.77 | 2,748.91 | -410.96 |
| **Total** | | **29.315,09** | **29.315,09** | |
| Planalto dos Parecis (III) | Preserved | 44,636.42 | 1,013.07 | -4,306.05 |
| | Stable | 338.44 | 33,385.64 | 98.99 |
| | Technically Supported | 4,648.89 | 15,225.04 | 69.47 |
| **Total** | | **49,623.75** | **49,623.75** | |
| Planaltos Residuais do Alto Guaporé (IV) | Stable | 4,458.55 | 4,458.55 | 0 |
| **Total** | | **4,458.55** | **4,458.55** | |
| Planícies e Pantanais do Médio e Alto Guaporé (V) | Conserved | 7,358.09 | 7,358.09 | 0 |
| **Total** | | **7,358.09** | **7,358.09** | |
| Planícies e Pantanais Matogrossenses (Cáceres) (VI) | Conserved | 11,966.74 | 223.86 | -5,245.64 |
| | Optimized | 25.83 | 11,768.71 | 99.78 |
| **Total** | | **11,992.57** | **11,992.57** | |
| Planícies e Pantanais Matogrossenses (Poconé) (VII) | Optimized | 1,962.85 | 1,962.85 | 0 |
| **Total** | | **1,962.85** | **1,962.85** | |
| Província Serrana (VIII) | Conserved | 4,160.56 | 1,427.93 | -191.37 |
| | Stable | 322.73 | 3,055.36 | 89.44 |
| **Total** | | **4.483,29** | **4.483,29** | |
| **Total area in km² of landscape regions** | | **130,101.28** | **130,101.28** | - |

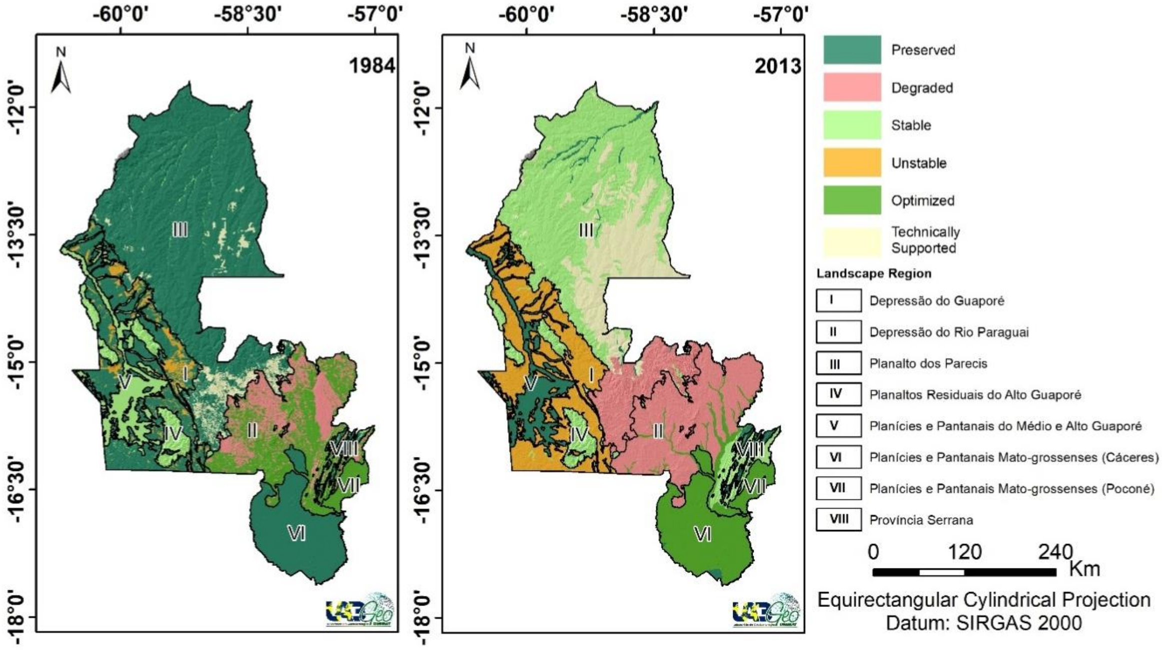


**Figure 6 -** Environmental State of the landscape regions of the research area. Elaboration: the authors, 2019.

In the Depressão do Guaporé (I), in 1983, the Environmental State was conserved and became unstable in 2013, that is, the landscape that was little transformed was fragmented due to the intensification of deforestation, which entailed the loss of connectivity between the fragmentsconcentrated in indigenous lands and riverbanks.

Livestock was expanded through the incorporation of areas covered with natural vegetation and the increase in mining activity. However, the presence of intense erosive processes (gullying) was not evidenced. Trombeta and Leal (2016) stated that "the greater the environmental degradation caused by incompatibility in land use and occupation, the stronger the degree of fragility, and the occurrence of environmental problems, the environmental state becomes more critical", indicating the instability in the State of Conservation.

Both the landscape region Planalto dos Parecis (III) and the ProvínciaSerrana unit (VIII) presented a change from the Conserved Environmental State in 1984 to Stable. In the first region in 1984, the landscape was little altered, but in 2013, it was muchtransformed, mainly by the intensive agriculture cultivated in the flat areas, in which the deforestation was intense. The natural productivity of the land is low and in order to overcome this limitation, the farmers make use of technological inputs, indicating that the agricultural activity is technologically supported.

There is a need for the development of actions aimed at the recovery of eroded areas, with measures of stabilization of slopes and protection of soils. With regard to the recommendation, Dibieso (2013, p. 223) stated that in order to contribute to the environmental planning and management of the river basin, specific guidelines, targets, and norms for uses in the different portions of the landscape units should be established. The aim is to ensure greater efficiency in the recovery, conservation, and protection of watercourses without which any human activity will have its development unviable.

In the ProvinciaSerrana (VIII), the landscape that was little transformed had its vegetation maintained in the mountains, where the environmental legislation restricts the use (Forest Code - BRASIL, 2012); thus, in 2013 there was a predominance of natural vegetation, although there was an intensification of livestock and agriculture activities developed in the valleys.

There is a preponderance of family farming that was guided by public policies, entailingin 2013 the existence of eight rural housing settlements that sheltered 813 families in that landscape region. However, the presence of severe erosive processes (ravines or gullies)was not verified. According to Lima et al. (2001), the maintenance of the vegetation in the sierras (Savanna Florestada) is important for agricultural activities because they provide a higher concentration of biomass, favorably influencing soil fertility.

The regionsthatmaintainedtheir Environmental Stateduringthestudyperiodwere Depressão do Rio Paraguai (II), Planaltos Residuais do Alto Guaporé (IV), Planícies e Pantanais do Médio e Alto Guaporé (V) and Planícies e Pantanais Matogrossenses (Poconé) (VII).

The Environmental State in 1984 of the Planícies e Pantanais do Médio e Alto Guaporé (V) was Preserved and remained as Conserved in 2013. In this region, the landscape was little transformed by the anthropic action by virtue of the fluvial dynamics (flood) that provides the renovation and the maintenance of native vegetation. In this regard, the adoption of Multifunctional Production Systems would favor the maintenance of the Environmental State through the flexible use of the constituent elements of the landscape according to its multiple functions (productive, ecological, socio-cultural and food security). This would enable the planning and management of the productive system in a holistic way and would encourage the efficient use of land (SANTOS, 2019).

In relation to the landscape region PlanaltosResiduais do Alto Guaporé (IV), in 1984, the State was Stable and it continued so until 2013 even though there was mining growth. The natural vegetation predominates in its extension ,severe erosive processes have not been verified and cattle raising is a widely developed activity.

It was verified that, in the Conservation Units, the vegetation is preserved and there is a recovery in the mining areas, which contributedpositively for the maintenance of the environmental stability. This is because, according to Araujo et al. (2005, p. 984), although mining is a temporary land use activity, it alters natural environmental conditions and is a strong modifier of the landscape, as it degrades large areas, often difficult to recover due to the degradation of vegetation, soils and waters.

Fernandes *et al.* (2014) add that the negative impacts that the activity generates are deforestation, erosion, contamination of water bodies, increase in the dispersion of heavy metals, soil changes, and fauna and flora impairment. Thus, the expansion of activity, as occurred in the period investigated, may entail the stability of the geosystems of the region, considering that practically all-mining activity implies the suppression of vegetation or impediment of its regeneration (MECHI and SANCHES, 2010, p. 209).

In 1984, the Environmental State of the Planícies e PantanaisMatogrossenses (Poconé) (VII) was optimized and thus maintained until 2013. The natural vegetation was little transformed by its use as a natural pasture for the main municipal economic activity, which is the extensive livestock in the traditional molds, due to the flood pulse that favors the regeneration of the Pantanal vegetation. The flood period (full and dry) determines the seasonal supply of areas for pasture and even the permanence of cattle.

From this perspective, Pantanal farmers have opted for the specialization of production, where the environmental character of the property is exploited, optimizing the productive space according to the needs of each stage of life of the herd, that is, in the stages of breeding, rebreeding, and fattening (SANTOS, 2019). This shows the optimization of the environmental components of the landscape region (relief, vegetation and water) in favor of production, which is at first carried out according to the limits of the environmental components, with to the aim of maintaining biodiversity and resilience of geosystems.

In 1983, in the region of the Depressão do Rio Paraguai (II), the Environmental State was degraded and it remained the same way in 2013. It is a unit intensely transformed by consolidated livestock activity with the presence of 12 cities, 18 urban districts, numerous communities, rural settlements and the use of their lands for various types of anthropic uses, predominantly Livestock and Agriculture (Sugarcane).

Vegetation cover is concentrated in fragments without connectivity. Deforestation in some portions has reached the riverbanks. In some places, soil erosion (ravines) has compromised the productivity of livestock activity, indicating that recovery and/or restoration will occur through the adoption of drastic intervention measures. In this case, environmental conservation is sought with the use of the minimum of external inputs, aiming to obtain productive eco-efficiency (SANTOS *et al.*, 2008).

In 1984, the Environmental State of the Planícies e PantanaisMatogrossenses (Cáceres) (VI) was conserved, becoming optimized in 2013. The landscape was sparsely transformed with a predominance of Savanna's natural vegetation. One of its grassy-woody phytophysiognomies is used as a pasture in extensive cattle ranching activity, which has been developed in the Pantanal for more than 200 years, showing that this activity is consolidated in this geographic space.

However, according to Rossetto (2009), the traditional Pantanal farmers have experienced conflicts due to the modernizing ideas introduced either by their descendantsor by technical assistance. This is because these farmers consider that, after contact with the globalized world and other modernized rural environments, their descendants and technicians seek to implement innovative techniques in order to measure productivity and accumulation of capital, in contrast withthe traditional knowledge that hasdetermined the management of livestock for at least two centuries.

For the traditional Pantanal farmers, the waters that spread in the plain during the floods represent a cyclical event responsible for the clearing of the fields and the renewal of the native pasture, dispensing the use of chemical inputs and the human workforce, thus putting into effect the control of invasive species (ROSSETTO; BRASIL JR., 2003).

According to the research by Crispim and Branco (2002), brachiaria (*Brachiariadecumbens*) and humidicula (*B. humidicola*) adapt to the natural conditions of the Pantanal. However, they warn that the use of cultivated pastures should be an alternative for some animal categories, such as weaned calves, first-calf heifers and bulls after the mating season and never as substitutes for native pastures.

## 4. CONCLUSIONS

It was concluded that there is a need to adopt land use management practices that minimize environmental degradation considering that during the period under investigation there was an increase in anthropic uses - mainly in Livestock and Agriculture - which directly corroborated the suppression of vegetation cover in landscape regions. This entailedthe alteration of the predominant Environmental State of the landscape regions of the Mato Grosso southwest portion, which was Conserved in 1984 and became Stable in the year of 2013, indicating that there were damages to the conservation of the environmental components of the landscape regions due to the regional economic development.

## 5. ACKNOWLEDGMENTS

We used data derived from the project "Modeling of environmental indicators for the definition of priority and strategic areas for the recovery of degraded areas in the southwest region of Mato Grosso/Brazil". This project is connected to the sub-network of social, environmental and technology studies for the productive system in the region southwest mato-grossense (REDA ASA), founded in the frame of edict MCT/CNPq/FNDCT/FAPs/MEC/CAPES/PRO-CENTRO-OESTE Nº 031/2010.

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