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Use of Remote Sensing in the Evaluation of the Behavior of Biophysical Variables in the Cerrado Biome.

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Abstract

The Cerrado is the second largest biome in South America, occupying an area of 2,036,448 km2, about 22% of the national territory. In the cerrado, changes in the behavior of biophysical variables such as vegetation index, surface temperature, precipitation and evapotranspiration and through remote sensing techniques have been used in temporal studies of changes in soil cover changes. Currently there are several remote sensors with different spatial, temporal and spectral resolutions, such as the products: MOD11 - Surface temperature; MOD16 - Evapotranspiration; MOD13 - Index of vegetation; TRMM - Precipitation. This study aims to evaluate the impact of land use change on the patterns of change of biophysical variables in regions of the Cerrado Biome. The work was developed in the region of the Cerrado biome, contemplating an extensive area of wide heterogeneity and natural cover. The choice of specific areas of study was based on data overlap of areas occupied by cerrado, pasture, sugarcane, eucalyptus and annual crops. Selection of MODIS data was performed according to the temporal availability of each product (8, 16 days or monthly). And it can be concluded that the vegetation index had an annual average reduction only in the transition from the cerrado to the annual harvest, the surface temperature had an increase in its average, only when the cerrado is changed to annual crop, annual average evapotranspiration increased in all transitions, and the average annual rainfall increased when the annual transition to sugarcane and the cerrado for annual cultivation.

Key words: Remote Sensing, Soil Use, MODIS, TRMM, vegetation index.

INTRODUCTION

In Brazil there are six large natural biomes; Amazonas, Caatinga, Pantanal, Atlantic Forest, Pampas and Cerrado. The Cerrado is the second largest biome in South America, occupying an area of 2,036,448 km2, about 22% of the national territory (Aquino & Oliveira, 2006). In the Cerrado, the sources of the three largest hydrographic basins of South America (Amazônica / Tocantins, São Francisco and Prata) are located, which results in a high aquifer potential and favors its biodiversity (WANTZEN et al., 2006). O Cerrado é um dos biomas mais ameaçados de extinção só ficando atrás da Mata Atlântica na região do Neotrópicos (Klink e Machado, 2005).

It has suffered from the lack of environmental legislation and, therefore, estimates the annual loss of native vegetation cover of 1.5%, or approximately 3 million hectares per year, due to the high rates of deforestation (Machado et al., 2004). Studies have shown that the conversion of natural vegetation to agricultural or pasture areas affect energy, water and carbon exchanges between the atmosphere and the continental surface (Claussen et al., 2001, Twine, 2004).

It may cause impacts due to changes in soil cover, since these changes in biophysical characteristics can significantly affect surface temperature, vegetation index, evapotranspiration and precipitation. The monitoring of the Earth's surface and temporal studies provides tools to observe the emission of greenhouse gases, using remote sensing provides effective methods to verify changes in land cover (Gómez et al, 2011; Pellikka et al., 2018).

Currently there are several remote sensors with different spatial, temporal and spectral resolutions for the quantification of changes in spatial and temporal vegetation (Lizaga et al., 2019), these changes can be understood with product results: MOD11 - Surface temperature; MOD16 - Evapotranspiration; MOD13 - Index of vegetation; TRMM - Precipitation. The objective of this work was to evaluate the impact of the change of the soil use through the products generated by the images of satellites verifying the changes in the patterns of the biophysical variables in regions of the Cerrado Biome.

MATERIAL AND METHODS

The study was carried out in the Cerrado Biome, located between latitudes: 21S and 6S and longitudes: 57W and 45W (Fig. 1 - look at the map that Pedro did and put the geographic coordinates). The climate of the region is classified according to Koppen-Geiger of the Aw (tropical) tipio, with drought in the winter and rainy season in the summer, with average annual rainfall of 1,540 mm (Alvares et al., 2013). The Cerrado biome was chosen due to its extensive area of wide heterogeneity and areas occupied by natural vegetation (cerrado).

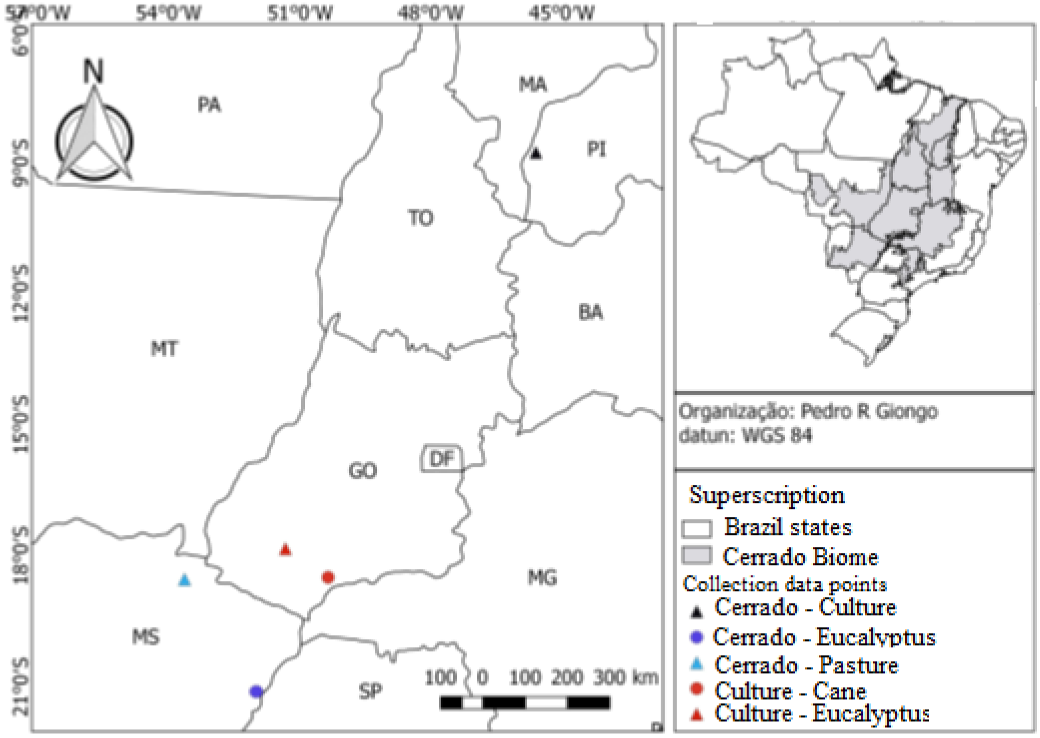

Fig.1Geographic coordinates of the areas sampled with the use and occupation of the soil in the Cerrado Biome from 2002 to 2014.

In the period from 2002 to 2014, areas that had undergone changes in the use and occupation of Cerrado soil for pasture, annual crop for sugarcane, Cerrado for eucalyptus, Cerrado for annual crop and annual crop for eucalyptus from database of the Image Processing and Geoprocessing Laboratory (LAPIG, 2015), the database of the DGI-INPE (INPE, 2014), e da U.S.G.S. (U.S. Geological Survey –United States Geological Survey) (USGS, 2014) and through data overlap: areas of deforestation (SIAD:2002-2014) and of new areas of sugarcane in Brazil (CANASAT, 2014); areas with eucalyptus plantations, soybean, corn and sugarcane; and pastures, with the purpose of contemplating the areas of expansion of the agricultural frontier within the closed biome. The areas of deforestation were obtained through the SIAD -Integrated Deforestation Alert System (Rocha et al., 2011) of the Laboratory of Image Processing and Geoprocessing (LAPIG) of the Federal University of Goiás (UFG), which uses images Vegetation Index of the sensor MODIS to detect new deforestation every year. In this study, the areas occupied by annual crops were established as areas of soybean and corn cultivation. The Cerrado designation was chosen for areas occupied by natural vegetation. The geographic coordinates referring to the land uses on the platform LAPIG, where the filtering takes place of the images referring to the past of the satellite, providing the information of the biophysical variables referring to the selected pixel. The geographic coordinates corresponding to the selected pixels in the interactive map of the LAPIG are shown in Fig. 1. Five pixels were selected for each soil use and the mean of these pixels was calculated.
We selected for this study the sensor products MODIS (*Moderate Resolution Imaging Spectroradiometer*): MOD11A2 – Surface temperature (Ts); MOD16A2 – Real Evapotranspiration (ETR), MOD13Q1 – Improved vegetation index (EVI2) and radar precipitation data TRMM (*Tropical Rainfall Measuring Mission*). The specifications of the sensors to obtain the biophysical variables are found in Table 1. O EVI2 is generated with two bands, the near infrared band and the red band of the product MOD 13 Q1.

Table 1. Sensor specifications for obtaining biophysical variables data

Sensors	Space Resolution	Temporal Resolution
MOD13Q1- vegetation index	250 m	16 days
MOD16A2- evapotranspirat	1 km	16 days
MOD11A2- surface temperature	1 km	8 days
TRMM 3B43- precipitation	30 km	daily

In order to detect land use change, the vegetation index was used through the analysis of temporal data, because through the generated graph, it is possible to observe through the spectral behavior of the target, changes in land use and cover. The identification of the areas was also based on the soil cover cycle (eucalyptus, sugarcane, soybean, corn, cerrado).

Then, on these selected areas (before and after the conversion of the soil use), the standards of each biophysical variable were evaluated (Ts, EVI2, ETR and precipitation), while natural vegetation and with new coverage. The data of the pixels of each polygon were arranged in spreadsheets for generation of graphs, which made possible the comparison and evaluation of the patterns of values obtained over time.

RESULTS AND DISCUSSION

In the cerrado vegetation is one of the parameters that changes during the seasons, since in the period considered rainy it is possible to observe a large scale of green areas indicating high values of vegetation index, already in the dry season the values for the index of vegetation will be low. This event is possible because the cerrado has both seasons well defined..

The behavior of the vegetative indexes through the time series of EVI2 shows that when one has the one area with the Cerrado or annual crops and years later is introduced eucalyptus plantations and pasture occurs the increase of vegetation indices (42,78 e 4,34 %) Fig. 1A and C and annual crops (soybean, corn and others) and places perennial and semi-perennial crops (Eucalyptus and Sugarcane). (70,28 e 26,29%) respectively Fig. 2B and E.

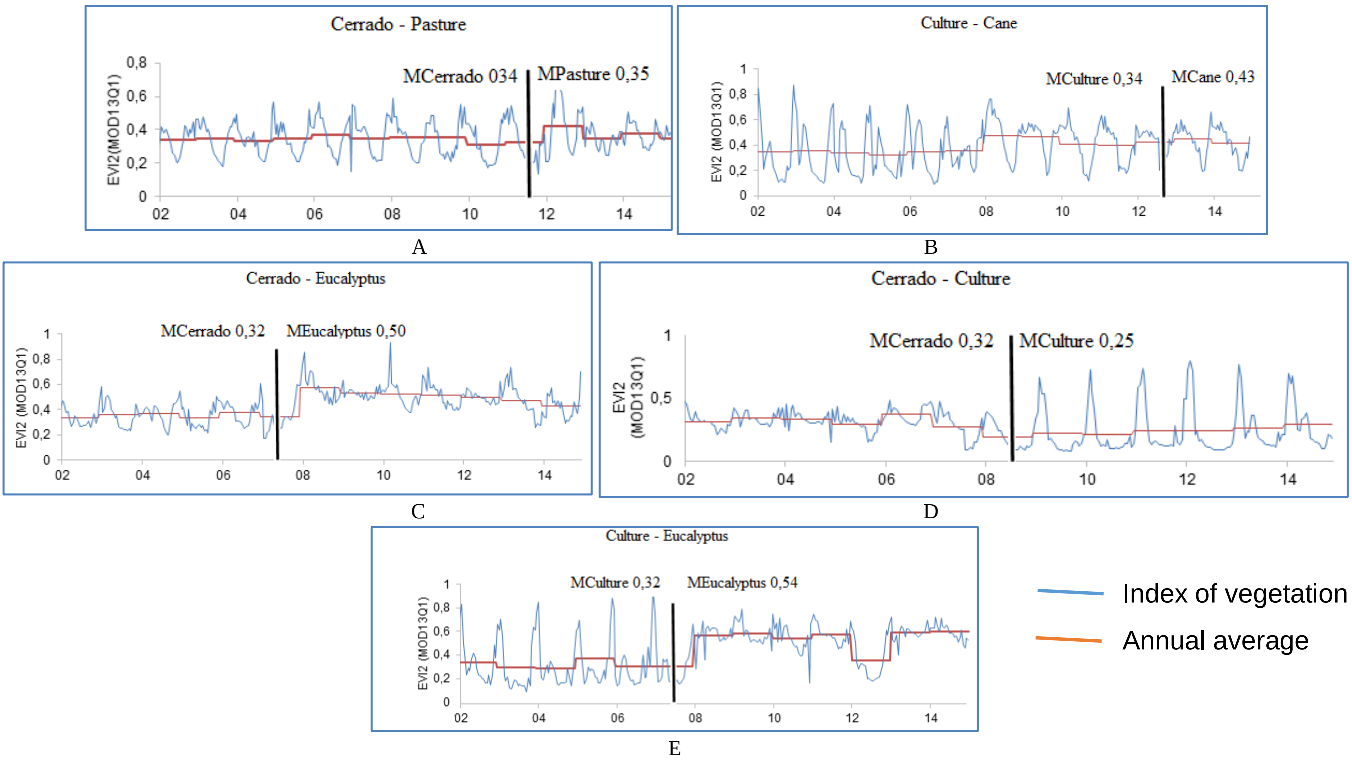

Fig. 2: Mean vegetation indexes from 2002 to 2014 for pixel samples in anthropic areas of A (cerrado-pasture, in Mato Grosso do Sul), B (cane-crop in Goiás), C (cerrado- eucalyptus, in Mato Grosso do Sul), D (cerrado-cultura in Bahia) and E (eucalyptus-culture in Goiás).

Soil utilization by pasture presents an average of 035 Fig. 2A, a similar behavior was observed in vegetation indexes with closed areas (0,34, 032 e 0,35) Fig. A, C e D and cultures (032 e 0,34) Fig. 2B e D. With the characteristic seasonality, influenced by the dry and rainy period, (Freitas et al., 2011).

When soil cover changes, the change in amplitude of vegetation index values is evident, losing the constant characteristic of maximum and minimum values of the cover when native. In this way, when the native vegetation is closed down by the annual crops, where it has the lowest vegetation index-24, 16% (Fig. 2D), finding more exposed soils due to not having vegetation or not at all. This positive influence of exposed soils was reported by (Van Hall et al. 2017).

The seasonal behavior of sugarcane and eucalyptus provided averages above 0.40. This seasonal behavior was also described by Gomes et al. (2009), which highlight the influence of rain and dry seasons on the decrease and increase of vegetation values.

An average annual increase in surface temperature was observed in the cerrado-culture transition, which corresponded to 5,24% (Fig. 3D), the replacement of the cerrado by the implantation of crops is one of the main factors for the deforestation of the cerrado, reaching 366.1000 ha in between 2002 and 2009 (Rocha et al 2012).

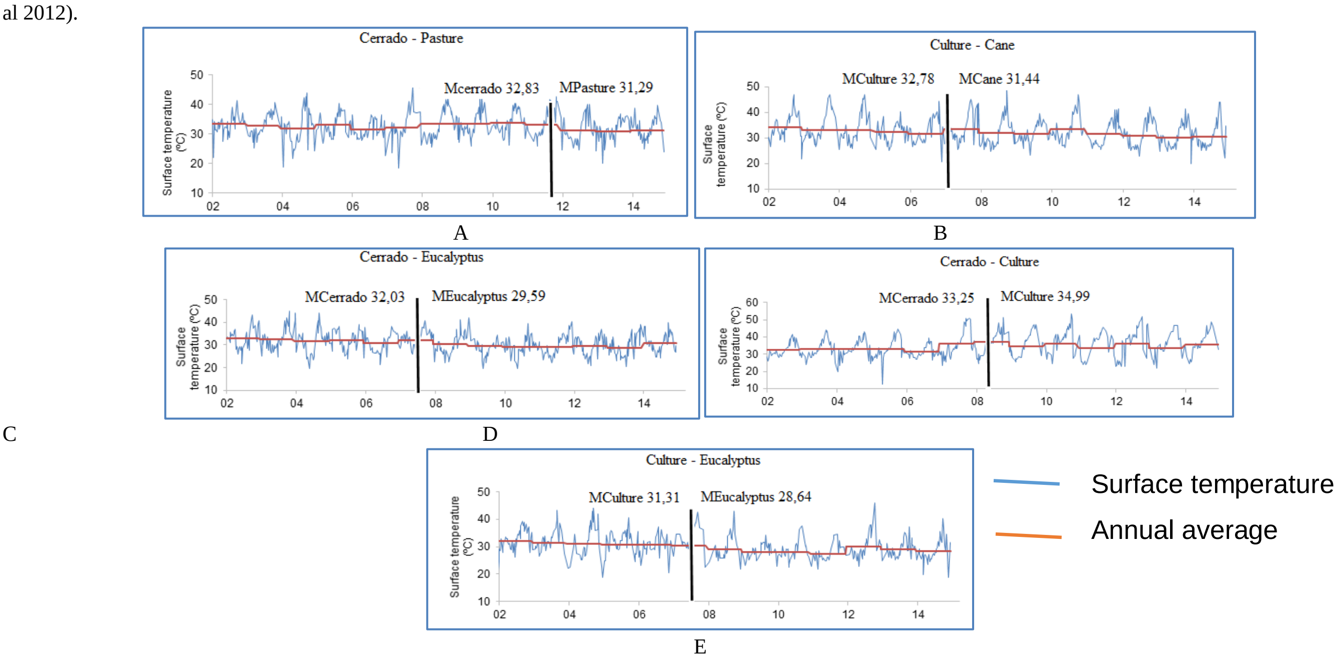

Fig. 3: Mean annual values of the Surface temperature values for the years 2002 to 2014, for pixel samples in anthropic areas of A (cerrado-pasture, Mato Grosso do Sul), B (cana- cana, Goiás), C (cerrado- eucalyptus, in Mato Grosso do Sul), D (cerrado-culture in Bahia) and E (eucalyptus-culture in Goiás).

When recording a low in temperature when introducing pastures, eucalyptus and sugarcane in areas of cerrado and replacing annual crops (Fig. 3), shows that when introducing perennial and semi-perennial crops they improve the soil cover and avoid leaving the soil exposed. Because the exposed soils register high temperatures seen in an area of deforestation in the State of Pernambuco (Lopes et al., 2010).

The change in land use can cause a rise or fall in temperature will depend a lot on whether to leave the soil exposed or the type of cover that will be in these soils. This leads to a number of problems, not only in those regions which have experienced an increase in temperature with changing land use, but at the global level. With the occurrence of temperature increase, the air's capacity to retain water vapor increases, causing slow development in plant species (Assad et al., 2004).

Anthropization and land use change in the cerrado biome has caused changes in the average annual behavior of evapotranspiration, as observed na Fig. 4, with an average increase of 21,88% in the closed-pasture transition in Mato Grosso do Sul (Fig. 3A), in 32,40% in the culture-cane transition (Fig. 4B), in 105,24% in the transition cede cerrado-eucalipto (Fig. 4C), in 18,41% in the closed-culture transition (Fig. 4D) e 176,47% in the cerra-eucalipto transition (Fig. 4E). There was no average reduction in evapotranspiration with land use change.

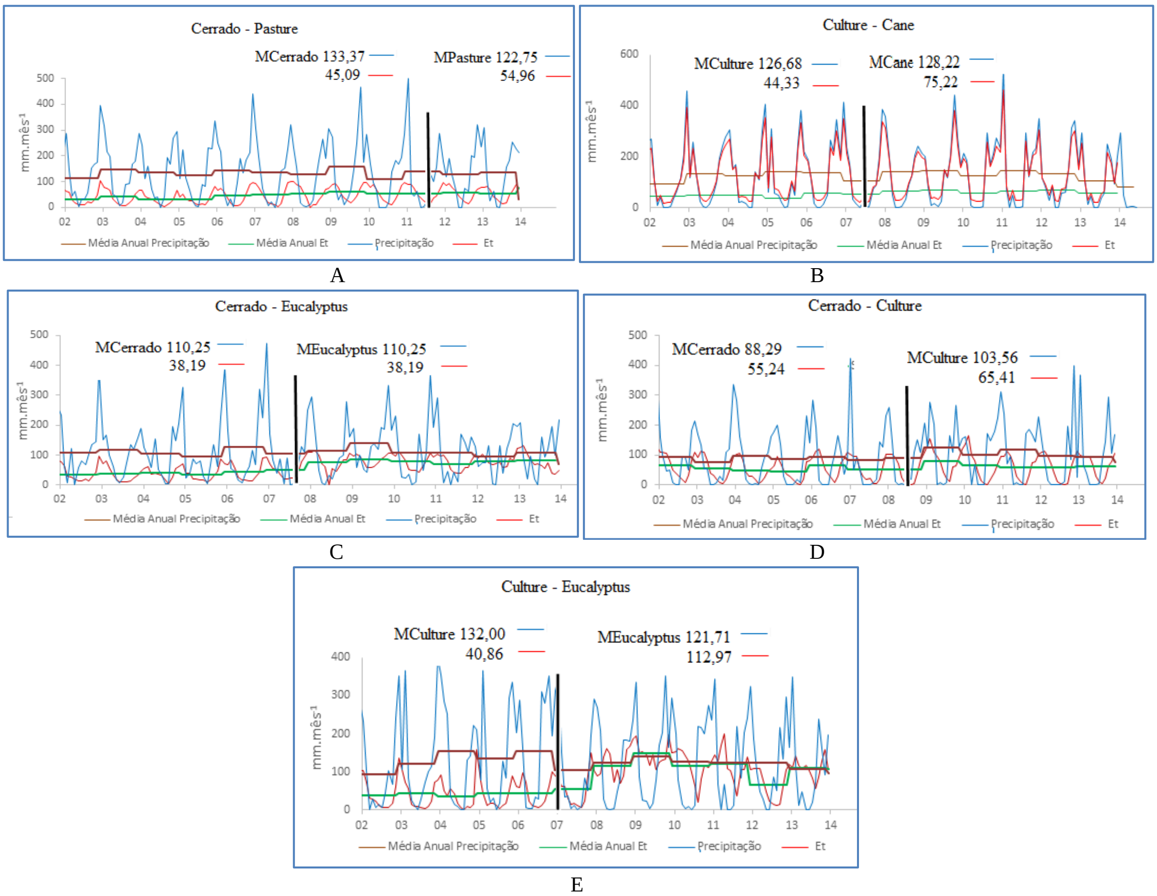

Fig. 4: Annual mean values of Evapotranspiration and Precipitation in the years 2002 to 2014, for pixel samples in anthropic areas of A (cerrado-pasture, in Mato Grosso do Sul), B (cana- cana, Goiás), C eucalyptus, in Mato Grosso do Sul), D (cerrado-culture in Bahia) and E (eucalyptus-culture in Goiás).

The highest increases were observed in the transition of cerrado-eucalyptus (Fig. 4C) and eucalyptus-culture (Fig. 4E), respectively, of 105 and 176%, observing that eucalyptus has a high rate of evapotranspiration when compared to soil with Cerrado and culture.

The change in land use usually causes a significant change in the evapotranspiration amplitude, considering the period of one year. In Fig. 4A, it is possible to identify that the evapotranspiration reaches peaks around 200 mm.m.-1 in the growing period, and in the off-season period, already presents values close to 0 (zero), values coincident to that found by (Giongo e Ferreira 2015).

Comparing evapotranspiration and mean precipitation (Fig. 4), it is noted that the volume of evapotranspirated water is less than the volume of precipitation. The precipitated volume may be smaller than the volume of water due to occur in the eucalyptus forests in most of the Brazilian regions where they are planted, that is, there are regions where the volume of evapotranspirated water (Vital, 2007).

An average annual increase in precipitation was observed in the sugar cane transition and in the Goiás 1,21% (Fig. 4B) and the closed-culture transition of 17,29% (Fig. 4D), reflecting changes that have had a positive impact. There is a decrease in the annual precipitation rate for the other transitions. For the closed-pasture transition in the Mato Grosso do Sul, there was a drop in 7,96% (Fig. 4A), in the transition from cerrado-eucalipto to Mato Grosso do Sul, 1,65% (Fig. 4C) e cultura eucalipto em Goiás (Fig. 4E), verifica- se também que houve uma queda na precipitação de 7,79%.

CONCLUSIONS

The change in land cover change and land use in the Cerrado by grazing, sugarcane, annual crops and eucalyptus plantations led to changes in the behavior of biophysical variables such as vegetation index, surface temperature, precipitation and evapotranspiration.

It is proven that the closed-culture transition causes biophysical variables to assume values that will negatively impact this biome, in comparison with the other transitions.

The vegetation index presented an annual average reduction only in the transition from cerrado to annual crop, and a great increase when changing from cerrado to eucalyptus and to eucalyptus.

The temperature of the surface had an increase in its mean also, only when the cerrado is altered for annual culture.

The mean annual evapotranspiration increased for all transitions, but in the transition from cerrado to annual crop, there was an insignificant increase compared to other changes in soil use.

Finally, mean annual precipitation increased when the annual transition to sugarcane and cerrado for annual cultivation, and reduction when from the cerrado to pasture, closed to eucalyptus and eucalyptus crop.

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