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DYNAMICS OF VEGETAL COVER AND CHANGES IN LAND USE IN THE STATE OF PARÁ OVER THREE DECADES

ABSTRACT: Understanding the patterns resulting from the dynamic process of changes in vegetation cover and land use in the Amazon is of strategic relevance as a tool to support forest conservation. In addition, we can ally such information to the establishment of notions of sustainable economic development for the region. The aim of this study was to analyze, from the zone of expansion of the agricultural frontier in the State of Pará, the intensity of the transformation of the use of natural forest areas; through occupation by human activities such as implementing pasture, agriculture, and mining to the detriment of the reduction of forested areas, over a historical series of thirty-four years (1985 to 2018). The data used are high spatial and temporal resolution remote sensing data, produced from Collection 4 of the MapBiomas Project for the State of Pará. The most significant land occupation practice and the one on the rise over the 34 years analyzed was the implementation of pastures for livestock production. Which at the end of 2018, had an occupied area equivalent to 200,000 Km^2, an increase of 400% compared to the initial year observed (1985). A behavior inversely proportional to what happened with the forest cover areas, which over the 34 years analyzed, lost the equivalent of 160,000 km^2.

KEYWORDS: Amazon, Forest cover, Livestock.

DINÂMICA DA COBERTURA VEGETAL E MUDANÇAS NO USO DA TERRA NO ESTADO DO PARÁ AO LONGO DE TRÊS DÉCADAS

RESUMO: A compreensão dos padrões resultantes do dinâmico processo de mudanças da cobertura vegetal e de uso da terra na Amazônia são de relevância estratégica como ferramenta de subsídio à conservação da floresta. Além disso, tais informações podem ser

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aliadas ao estabelecimento de noções de desenvolvimento econômico sustentável para a região. O objetivo deste estudo foi analisar, a partir da zona de expansão da fronteira agropecuária no estado no Pará, a intensidade da transformação do uso das áreas de florestas naturais; através da ocupação por atividades antrópicas como a implantação de pastagem, agricultura e mineração em detrimento da diminuição das áreas florestadas, ao longo de uma série histórica de trinta e quatro anos (1985 até 2018). Os dados utilizados são de sensoriamento remoto de alta resolução espacial e temporal, produzidos a partir da Collection 4 do Projeto MapBiomas para o estado do Pará. A prática de ocupação territorial mais significativa e em maior ascensão no decorrer dos 34 anos analisados foi a de implantação de pastagens para a produção pecuária. A qual ao término do ano de 2018 tinha área ocupada equivalente a 200.000 Km^2, um aumento de 400% em relação ao ano inicial observado (1985). Um comportamento inversamente proporcional ao ocorrido com as áreas de cobertura florestal, que ao longo dos 34 anos analisados perderam o equivalente a 160.000 Km^2.

DINÁMICA DE COBERTURA VEGETAL Y CAMBIOS EN EL USO DE LA TIERRA EN EL ESTADO DE PARÁ A LO LARGO DE TRES DÉCADAS

RESUMEN: Comprender los patrones resultantes del proceso dinámico de cambios en la cobertura vegetal y el uso del suelo en la Amazonía es de relevancia estratégica como herramienta de apoyo a la conservación de los bosques. Además, dicha información puede ser aliada al establecimiento de nociones de desarrollo económico sostenible para la región. El objetivo de este estudio fue analizar, a partir de la zona de expansión de la frontera agrícola en el estado de Pará, la intensidad de la transformación del uso de las áreas de bosques naturales; a través de la ocupación por actividades humanas como la implementación de pastos, agricultura y minería en detrimento de la reducción de áreas boscosas, a lo largo de una serie histórica de treinta y cuatro años (1985 a 2018). Los datos utilizados son datos de teledetección de alta resolución espacial y temporal, producidos a partir de la Colección 4 del Proyecto MapBiomas para el estado de Pará. La práctica de ocupación territorial más significativa y creciente durante los 34 años analizados fue la implementación de pastos para la producción ganadera. El cual al cierre de 2018 contaba con una superficie ocupada equivalente a 200.000 Km^2, un incremento del 400% respecto al año inicial observado (1985). Un comportamiento inversamente proporcional a lo ocurrido con las áreas de cobertura forestal, que en los 34 años analizados perdieron el equivalente a 160.000 Km^2.

PALABRAS CLAVES: Amazonia, Cobertura forestal, Ganadería.

INTRODUCTION

Since the process of occupation of the Amazon relied on government incentives, starting in the 1970s, the removal of natural vegetation cover has shown a growing and consistent trend (FEARNSIDE, 2005). Deforestation records point to a variation of 11,030 km ^{2} /year in 1991, reaching a peak of 27,772 km ^{2} /year in 1994 (INPE, 2013). This characteristic of expansion of territorial occupation is quite recurrent in Brazil since the colonization process by Europeans and is also related to the economic cycles which are predominant in each period (ALMEIDA et al., 2014). Such a strategy is mainly based on the aim of advancing the agricultural frontier through all regions of the country (IUCN et al., 2011), especially for areas with a low level of territorial integration (SOARES-FILHO et al., 2006).

The occupation model integrated by people from different locations in the national territory made the demography of the Amazon region diversified, with particularities linked to ecological needs and socioeconomic standards. In such a way that, although it holds less than 15% of the population with housing in rural areas in Brazil, it is towards this part of the country that almost 55% of the lots distributed by the National Institute of Colonization and Agrarian Reform are directed (TOURNEAU; BURSZTYN, 2010).

Recent technological advances in geotechnologies and cloud data processing have made it possible to monitor the dynamics of land use and land cover with high spatial resolution data, almost in real time (HANSEN et al., 2013). Initiatives to facilitate access to these types of data, such as Global Forest Watch (2021), also contribute to the monitoring of natural ecosystems on a large scale. Such information is suitable for developing studies that analyze, over time, changes in the scope, for example, of Brazilian biomes, such as the Amazon, where the State of Pará is located (YANAI et al., 2020).

The MapBiomas project was launched in July 2015 to contribute to the understanding of the land cover

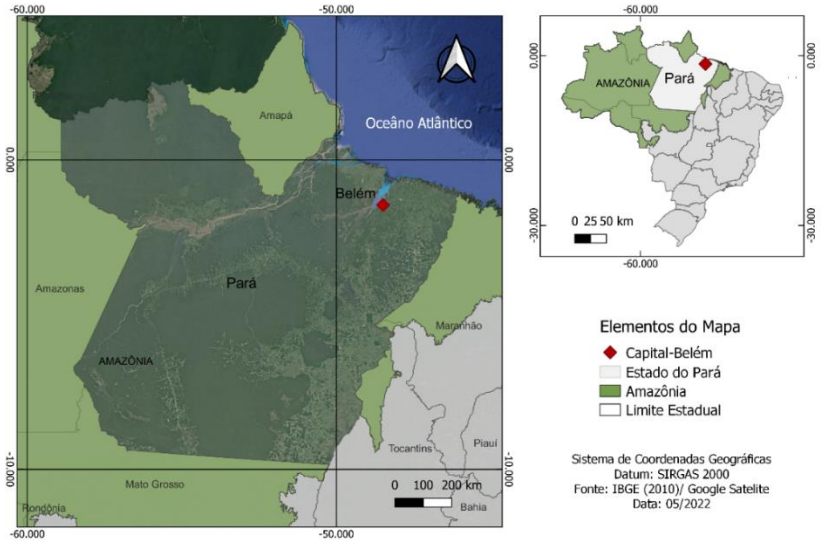
and land use (LCLU) dynamics in Brazil (SOUZA et al., 2020). The maps produced were based on the Landsat Data Archive (LDA), available on Google Earth, covering the year 1985 to the present day. Throughout this article will be analyzed through graphs and maps developed with the help of tools: ArcMap software (version 10.5), Microsoft Excel® 2016 and RStudio software, the extension gained by the agriculture, mining, and livestock variables in the territory of the State of Pará, from 1985 to 2018. Besides the influence that these activities possibly had on the reduction of forest cover, the State of Pará presented one of the highest rates of removal of natural vegetation cover, as highlighted by data presented by the National Institute for Space Research. Therefore, developing studies about the land cover and land use of this federative unit is essential to understand the consequent dimensions of the form of uncontrolled development that is reality in it. Besides allowing to point out rational solutions to minimize or definitively resolve, at a lower cost and time, the negative environmental consequences (PEREIRA et al., 2011). An example of the possible analyzes is the observation of how the variables agriculture, mining and livestock can be related to the decrease in the coverage of natural forests.

In this study, based on the expansion zone of the agricultural frontier in the state of Pará, the intensity of the decrease in natural forests because of occupation by human activities such as pasture, agriculture, and mining over a historical series of thirty and four years (1985 to 2018).

MATERIAL AND METHODS

The Brazilian federative unit of Pará occupies a territorial extension of 1,245,759.305 Km ^{2} (IBGE, 2018), being the second largest state in the country, smaller only than Amazonas. It is in the northern region of Brazil, in the eastern part of the Amazon, as shown in Figure 1.

Figure 1. Territorial map of the State of Pará.



Source: IBGE (2017). Elaboration: The authors (2020).

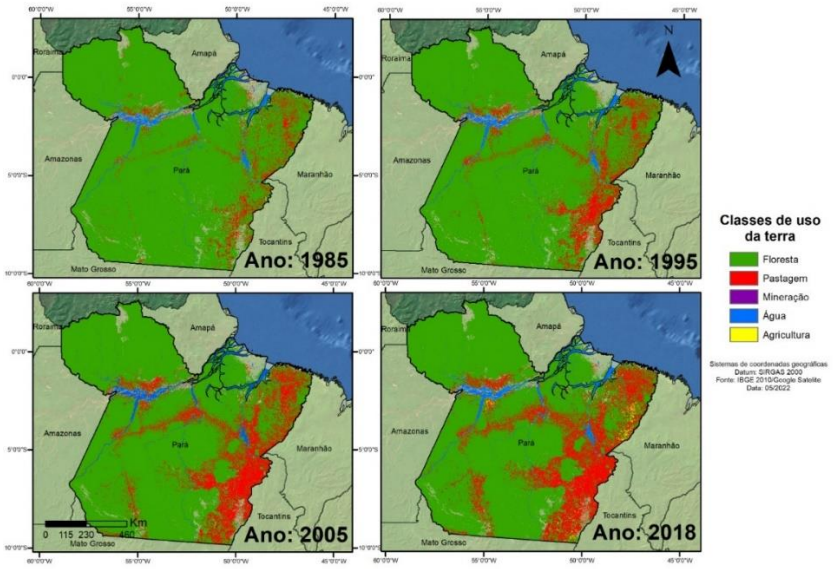
For the development of the study, the entire extension of the state of Pará was analyzed, which was made possible through Collection 4 of the MapBiomas Project, which provides time series of land cover and use in Brazil from 1985 to 2018 (http:// mapbiomas.org). The dataset used to assess the loss of forest cover (deforestation) is derived from remote sensing from Landsat satellites (5 & 8), with a spatial resolution of 30 m from the pixel-by-pixel classification (MAPBIOMAS, 2019).

Collection 4 of the MapBiomas Project features items such as maps of the Amazon biome, Atlantic Forest, Caatinga, Cerrado, Pampa and Pantanal. The project was also divided into cross-cutting themes: agriculture, pasture, forestry plantation, mining, and urban infrastructure. Even though the coastal zone is not officially considered a biome, this region that covers dunes, beaches and mangroves was assumed.

To gain the information corresponding to the amount of forest cover loss (deforestation) due to land use activities, the attribute tables (accessed through the ArcMap software (version 10.5) referring to each practice (pasture, agriculture, and mining), for the respective year, were exported to

Microsoft Excel® 2016 software, in which the conversion of the pixel value from 900 m^2 to km^2 was performed (Figure 2). The graphs developed with the purpose of illustrating the data got in the processing were made in R language with the 'ggplot2' package.

Figure 2. Scope of forest cover in the State of Pará in the period between 1985 and 2018.



Source: IBGE (2018). Elaboration: The authors (2022).

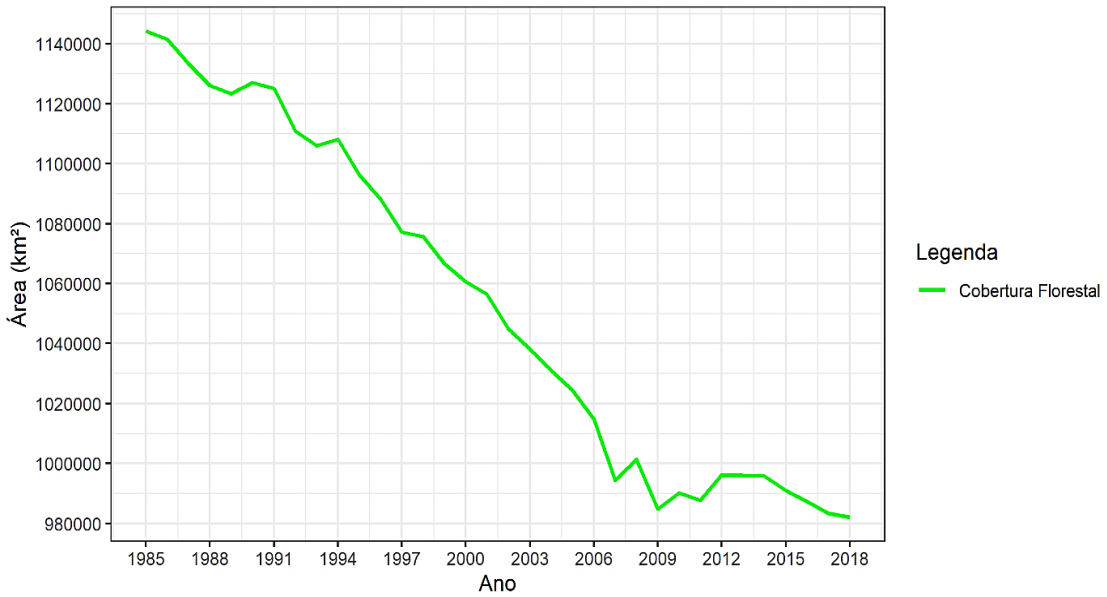
RESULTS AND DISCUSSION

The data in the MapBiomas platform dates to the mid-1980s. During this period, government incentives to settle the Amazon were already taking place and the consequences could already be observed (BECKER, 2007). However, as shown in Figure 3, the area corresponding to forest cover in the State of Pará was still dominant, comprising approximately 1,140,000 Km^2.

Over the years, deforestation has gradually made forest cover less comprehensive. At the turn of the 21st century (year 2000) the total number of cut forests corresponded to around 80,000 Km^2. This reality has become increasingly stressed throughout the first decade of the 21st century. Between 2006 and 2007, forest cover

was already a little less than 1,000,000 km ^{2}, going through an increase shortly before 2009, promoted by the abandonment of areas followed by natural regeneration, to decrease again that year. From 2012, until shortly before 2015, the area of forests was kept constant, but at the end of that period the decrease resumed. In 2018, the last year of analysis of the study, the forest cover was 980,000 Km^2. A loss equivalent to 160,000 Km^2, considering the 34 years analyzed.

Figure 3. Scope of forest cover in the State of Pará in the period between 1985 and 2018.



Source: MapBiomas (2019). Elaboration: The authors (2019).

In parallel, between 1985 and 2018, the dynamics of land use of activities such as agriculture, mining, and grazing (for livestock development) can also be analyzed. Such practices have their growth closely related to the consolidation of society in each region, with the purpose of promoting economic development (BECKER, 2005; DIAS-FILHO, 2011).

As shown in Figure 3, the activity that was consolidated over the 34 years analyzed with greater expressiveness in the State of Pará was the

implementation of pastures for the practice of extensive livestock. Which in 1985 (first year analyzed) occupied a territorial extension of 50,000 Km^2, this number, which between 1994 and 1997 doubled in size. The growth continued gradually, with more sinuous oscillations between the period corresponding to 2006-2012, in which the territorial occupation of the activity was between 175,000 Km^2 and a little over 200,000 Km^2. In 2018 (last year analyzed) the area occupied by pastures corresponded to 200,000 Km^2, an increase of 400% in relation to the initial year shown in the graph.

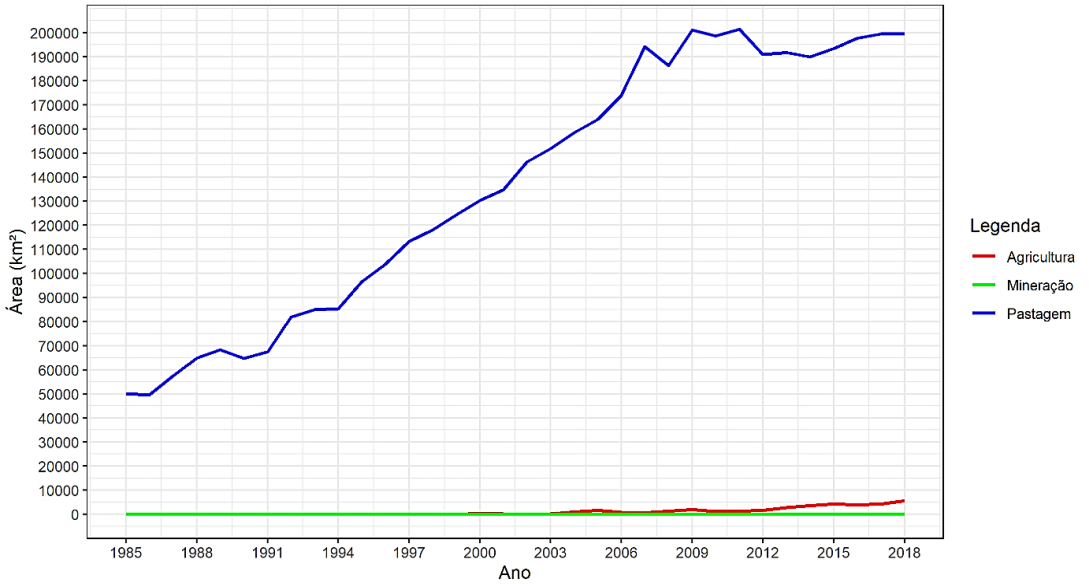
The contribution of livestock to the primary GDP (supplier of raw materials for the manufacturing industry) of the State of Pará is 26% (FAPESPA, 2017), placed in 5th position in the national ranking, with a number of animals, in 2016, of 20,476,783 and in constant growth, above the general average for Brazil (IBGE/SIDRA/PPM, 2020). Among the various factors that are related to the progress of cattle ranching in Pará, there are: the quality, quantity, and lower price of land in relation to other places in the country, besides the favorable climate for the growth of grass and forage that make up the pastures (DIAS-FILHO, 2011; FAPESPA, 2017).

Another study carried out in Pará, observing the dynamics of territorial occupation by pasture, shows that the area corresponding to this, in 2004, was 13.058 mi/ha, expanded to 14.635 mi/ha in 2008, equivalent to 12%. In 2010, there was a new increase of 14.065 mi/ha or 2.97%. Although in this same survey, in 2012, a decline of 9.13% (13,690 mi/ha) was observed in the pasture area. We attributed such an appointment to the difficulty of verifying the areas by the satellite, which had the limiting factor of cloud cover. So, in 2014, pasture corresponded to 16.062 million hectares (13% of the total territory of the state), after a growth of 17.32% (TERRACLASS, 2014). The cities with the largest cattle herds in the state are, in descending order: São Félix do Xingu, Marabá and Novo Repartimento (IBGE/SIDRA/PPM, 2013).

Activities that can also have their growth analyzed in Figure 3 are agriculture and mining. Which, despite the significant importance for the economic composition of the state of Pará (participation of the primary sector in the GDP of Pará: 56% agriculture), does not occupy a territorial extension as significant as pasture. Of the total territory of the federative unit in question, only 0.26% (3,191 thousand km^2) are dedicated to agricultural practices. The major crops are cassava, palm oil, soybeans, açai, sugarcane, corn, bananas, pineapples, oranges, and rice (IBGE/PAM, 2013).

Also, according to Figure 4, a little beyond 2003, the data were not significant enough to show any area occupied by the practices. This behavior continued to happen in agriculture until 2018. However, mining increased from 2003, which was situated until the end of the analyzed period, below 10,000 Km^2.

Figure 4. Territorial scope of pasture, agriculture, and mining activities in the State of Pará.

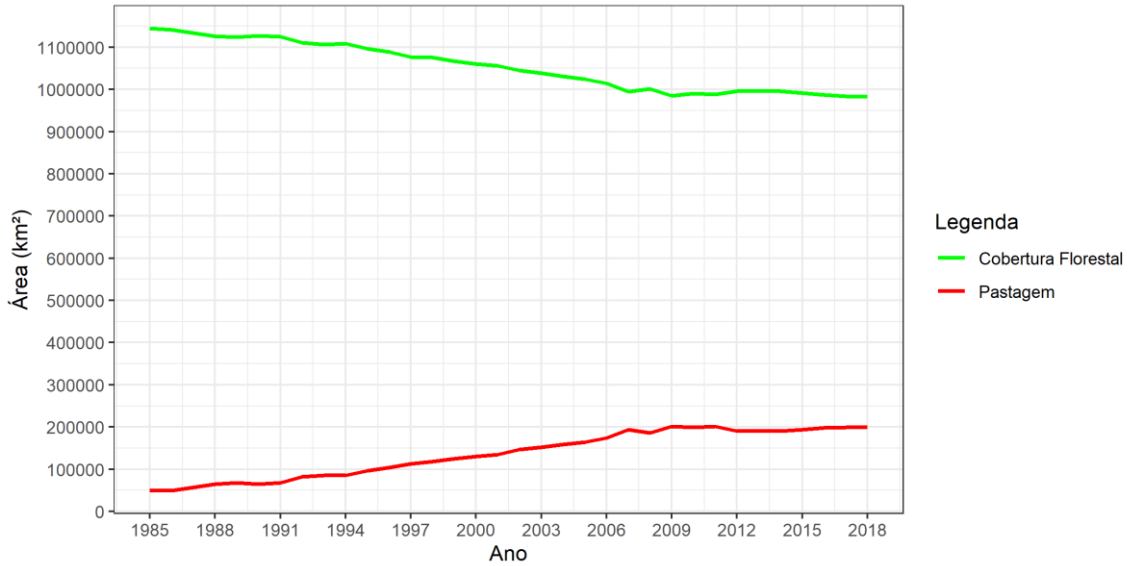


Source: MapBiomas (2019). Elaboration: The authors (2019).

Even with a small territorial occupation extension compared to pastures, mining has a significant contribution to the economy of the state of Pará. Between 2017-2018, there was a significant growth in the value from the sale of mineral goods, from R$34.8 billion to R$47.7 billion, an increase of 37%. The state was the largest collector of the Annual Fee per Hectare (TAH) in 2018, around BRL 12.9 million, equivalent to 15.8% of the national collection (AGÊNCIA..., 2018). The mining activity occupies specific areas of mineral occurrence even though it does not reach the occupation of many areas, it acts intensely in the localities where it is located.

The activity that showed its growth in greater territorial extension, over the 34 years analyzed (1985-2018), with the decrease in forest cover in the State of Pará, was the implementation of pastures (MACEDO et al., 2012). This finding can be seen in Figure 5, which clearly describes the inversely proportional behavior of the two variables.

Figure 5. Description of the inversely proportional behavior of the territorial occupation of forest and pasture areas in the State of Pará.



Source: MapBiomas (2019). Elaboration: The authors (2019).

CONCLUSION

The total loss of forest cover was 160,000 Km^2, considering the 34 years analyzed (1985-2018). Implementing pastures ended in 2018 with an occupied area of 200,000 Km^2, an increase of 400% compared to the initial year. Such activity grew inversely proportional to the decrease in areas occupied by forest cover in the state of Pará. The area occupied by mining activity in the state of Pará was not significant enough, over the 34 years analyzed, to show variation in the graph.

The findings got serve as a subsidy to understand which anthropic activity had its greatest growth related, over the years, with the loss of natural forest areas. Such information can contribute to establish new studies and strategies that reduce and even stop the advance of deforestation in the state, enabling sustainable development in the region.

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