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Brazilian Cerrado agricultural border dynamics: policy and environmental implications

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Abstract. We aim to review how the process of occupation and consolidation of the agricultural frontier in the Brazilian Cerrado occurred, as well as to verify the environmental impact of the productive systems in this region and to indicate the contribution of the public policies to the agrarian advance of this Biome. The expansion of the agricultural frontier in the Cerrado Biome began in the 1960s as an alternative to the growth of the Brazilian economy. The search for economic improvement, provided economic growth, however, generated social exclusion and environmental degradation. The changes in landscapes and the threat status of many Cerrado species led to the emergence of conservation initiatives by the government. What is expected of this biome is that strategies and initiatives that contribute to rural progress must broaden development objectives to encompass not only economic growth but also environmental aspects.
Keywords: Brazilian savannah; landscape change; agriculture.

Context and analysis

The Cerrado is the most diverse savannah in the world, being the second largest biome in Brazil, only smaller than the Amazon (Klink & Machado, 2005, de Souza Ferreira, 2017), however, is one of the most threatened biomes, being considered a hotspots. For the conservation of world biodiversity (Myers et al., 2000), its distribution occurs in environments with great physiognomic variation, including forest, savanna and grassland formations that are associated with different soil classes and geological formations (Torres et al., 2017). The location of the Cerrado in a central position to several species-rich biomes (e.g. Amazon Rainforest, Atlantic Forest, and Caatinga) and the possible adaptive barrier represented by fire, were possibly the major contributors to the remarkable species richness of this biome (Silva & Bates, 2002).

The Cerrado flora is influenced by several factors, such as climate, soil, water and nutrient availability, and geomorphology and topography. Moreover, it is conditioned by latitude, frequency of groundwater depth burns, fragmentation, among others, besides, the plant species are distributed in several phytophysiognomic types that make up the vegetal mosaic of this biome (Ribeiro & Walter, 2008).

The Cerrado biome in the lato sensu sense stands out for understanding several distinct biomes that are not just different phytophysiognomies of the same biome (Eiten ,1994 ;Batalha, 2011), which makes it an important area for conservation. The Cerrado connects with the Amazon in a transition zone that displays a mosaic of savannas and forests (Ratter et al., 1973; Ivanauskas et al., 2004; Marimon et al., 2006). In general, the expansion of the Cerrado agricultural frontier has led to a conversion process in native vegetation, from native forests to agriculture causing environmental changes on a larger scale, increasing greenhouse gas emissions which, consequently, causes the extension of dry season (Maciel et al., 2016; Marimon et al., 2006).

Several studies estimate that in the future scenario, by 2050 there will be deforestation of 13.5% of the remaining Cerrado biome (Dutra & De Souza, 2017). Thus, systematic studies are important for the planning of actions to prevent and combat deforestation, especially in ecosystems threatened by anthropic action, as well as to set goals that aim to control and efficiently manage production for years to come (Da Silva Miranda, 2015). Thus, investments and research are needed to find alternative sources of resources, scrutiny with respect to the exploitation of nature and pollution, as

well as the creation of larger areas of environmental protection.

Given this scenario and the imminent concern about global climate change caused by the advancement of agricultural frontiers in Brazil and the world, and considering the Cerrado as an effective example of the agricultural frontier in Brazil, in this work, we aim to: i) review the process of occupation and consolidation of the agricultural frontier in the Brazilian Cerrado, ii) verify the influence of production systems in the expansion process, iii) list the contribution of public policies to the agrarian advance of this biome. In addition to this introduction and the methodological procedures, this paper is organized around three focuses: in the first, we address relevant conceptual issues, such as the concept of agricultural frontier, in order to provide a basis for subsequent discussions. In the second, we summarize the contributions of agricultural systems to the advancement of agricultural frontiers in the Cerrado region. In the third, we discuss the public policies that contributed to the expansion of the Cerrado agricultural frontier, so that each topic represents a part of the story that involves the advance of the frontier in the central region of the country.

Methodological procedures

Study area

The Brazilian Cerrado comprises a range of approximately 2 million km2 (Figure 1), representing 23% of the national territory (IBGE 2012), is formed by a vegetation mosaic, occupying the entire Federal District, more than half of the states of. Goiás (97%), Maranhão (65%), Mato Grosso do Sul (61%), Minas Gerais (57%) and Tocantins (91%), as well as portions of six other states (IBGE, 2012) and surrounds the boundaries southeast, south and southwest of the Amazon Basin. The climate of the Cerrado biome is tropical savanna (Aw) according to the Köppen classification, with a predominance of higher seasonality and lower rainfall. (Peel et al., 2007). The rainy season usually begins in September/October and lasts until April, with rainfall ranging from 1,800 mm to 2,000 throughout the year. Annual temperatures range from 15°C to 37°C, with an average of 23-26°C. The soil classified as a typical dystrophic Red-Yellow Latosol according to the Brazilian Soil classificationSystem (Embrapa, 1999).

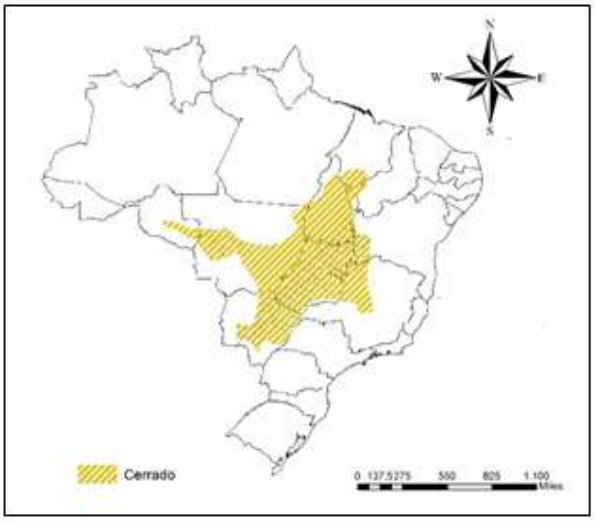

Figure 1. Location of the Brazilian Cerrado. Source: Authors.

Database

Searches were performed on the following databases: i) *Web of Science*, ii) *google scholar*, iii) *Scopus, iv*) *Scielo.* We selected the articles published from 1978 to 2018, search date was due to the period of occupation and expansion of the Cerrado. For these searches we use free terms related to the problem in question. We analyzed the original articles indexed in the period established above and used those that generally addressed the themes: i) agricultural occupation and consolidation, ii) production systems, iii) public policies and agricultural frontier expansion, all related to the Cerrado Biome. We divided these works into two categories, using the following parameters: environmental conservation (A) and agriculture (B), so that we could analyze from the obtained works the view of the Brazilian Cerrado agricultural frontier.

Agricultural border: historical background and definitions

The term “agricultural frontier” originated with the publication of the article “The significance of the frontier in American history” (1910) by Frederick Jackson Turner. For this author, agricultural frontier is perceived, not as a geographical boundary between countries or political territories, but as free land in the process of occupation or colonization. Although there is a broad conceptualization of the term agricultural frontier expansion, on the one hand, for example, it defines frontier as “a place of discovery and mismatch between the different, such as the Indians and the civilized, and the great landowners and the peasants ”(Martins, 1996), for this author border is always characterized by conflicts. On the other hand, the agricultural frontier can be defined as a movement of economic and demographic occupation of a given territory (Becker, 1988). For this author, the frontier represents, therefore, the interests of industrial and financial capital. There are also those who understand the agricultural frontier as a territory in the process of economic incorporation into the national space,

which have natural resources and agriculture, as the pillar of the economy. Here, in this paper, we call the agricultural frontier as the boundaries established by agricultural production areas.

Processes involved in the occupation and consolidation of the cerrado biome

Occupation Process

The process of agricultural occupation corresponds to the beginning of a spatial organization (Albaladejo et al., 1996). It is a stage characterized as expansion front (Martins, 1996). The expansion front is commonly used as a synonym for the frontier of civilization, usually by anthropologists. In this process, it is configured as the moment of migration and settlement of farmers' families, the implementation of economic enterprises, such as: commercial, banking and colonizing companies, as well as the implementation of infrastructure and basic health services (Becker, nineteen ninety). In this process, environmental impacts are already relevant (Bentes, 2005).

The process of agricultural occupation in the Cerrados began in the 1930s, with the construction of the railroad that connected São Paulo to the city of Anápolis (Goiás). However, the expansion intensified after the construction of the country's capital (Brasilia) and the implementation of the road system. State intervention in the Cerrados takes place in the 1940s, during the Vargas Government, through the Cerrados Colonization Project, with the consignment of agricultural colonies in Dourados in Mato Grosso do Sul and Ceres in Goiás (Shiki, 1997). In general, Brazilian agriculture began to expand since the 1960s, in which the context of modernization and development of the country, proposed by Juscelino Kubitschek through the established Goals Plan, is inserted. In the specific case of the Brazilian Cerrado, this process began in the mid-1970s with the expansion of agricultural production in modern agriculture standards, based on the technological package of the "Green Revolution" (Delgado, 1985), and through characteristic factors such as rural credit oriented measures, selective technical assistance, risk insurance, tax incentives, among other factors (Salim, 1986). Another factor that certainly contributed decisively to the occupation of the Cerrado was the low price of land (Moura,1989), several studies indicate that at the time when occupation in the Cerrado intensified, the price of "virgin" land in the region was equivalent to one third of the share of prices recorded in the South and Southeast agricultural regions (Cunha, 1994).

Consolidation Process

The consolidation process is about the different forms of occupation and use of space, such as family farming, gold mining, timber, livestock, and other crops (Tourrand; Valarié; Oliveira, 2007). Agricultural consolidation, broadly speaking, is the introduction of capital and technology intensive agriculture (Frederico, 2010). In the Cerrado, the consolidation process was directly influenced by the agriculture model, known as modern agriculture and by government actions that invested heavily in research aimed at technologies, in particular the physicochemical innovations that considerably improved the soils and, in a way, adapted them to the demands of capital, represented by commodities[1] (Bernardes, 2015).

The consolidation of agricultural activity in the Cerrado region had an effective participation of the state and private capital of large and medium owners (Delgado, 1985, Rocha, 2012). This consolidation occurred through some specific factors that were crucial, in addition to the deliberate policy of the Brazilian State, such as the rapid modernization caused, among other factors, by the environmental characteristics of the region itself (Topography conducive to large-scale mechanization, climatic suitability, defined seasons, one drought and one rainy season, water availability and adequate light) (Da Silva Miranda, 2015), Allied to these issues, there was the view that it was necessary to meet the new demands of the consumer market, especially in the Southeast, due to the industrial revolution that occurred in the country during this period (Rezende, 2002). In a mix of fast-paced economic development and progressive advancement of agricultural frontiers, the Brazilian Cerrado has become a grand alternative of economic possibilities and has established itself with definitive integration.

Productive systems and their impacts in the cerrado region

The idea is growing that modern agriculture has become less and less harmful to the environment, with techniques adopted to mitigate impacts (Rodrigues; Melo, 2017). In contrast, the real evidence of climate change that has been reflected in the productivity of arable land and/or global agricultural systems coupled with the compromise of grain supply. This fact has promoted a promising debate about the conciliation between productive systems and the maintenance of biodiversity. (Foley, 2017).

Although the agricultural market has demonstrated its capacity to produce through adversity, in Brazil there are regions that suffer most from droughts and heavy rains, such as the semiarid and the South, and there are areas of less vulnerability to natural phenomena, such as the Brazilian Midwest (Silva et al., 2006). Thus, the magnitude of the impact of climate change on a productive system depends on its vulnerability to climate phenomena associated with this change. Thus, different systems or forms of agricultural production may present varying degrees of vulnerability to the effects of climate change, which may eventually be mitigated through the design of appropriate adaptation strategies (Martins et al., 2010), This fact undoubtedly was decisive for the

Cerrado to become an area of agricultural expansion.

Each and every productive system generates environmental damages, what differentiates the magnitude of these impacts, and it is in this sense that the debates have been happening. If, on the one hand, the contamination of the springs with the gradual increase of the use of phytosanitary products, the disordered deforestation, priceless losses of flora and fauna, formation of gullies, on the other hand, there is the front of an agriculture allied to the environment (deforestation) and with mitigation strategies (Rodrigues; Melo, 2017). For a long time, investment in modernization has provided economic growth, leading to social suppression and environmental devastation. Just as the growth of the economy of Brazilian agriculture is significant for the capitalization of the country, so are the numbers of social exclusion of the unfortunate in detriment of the devastation of the native species of the various Brazilian biomes (Virgilio, 2017).

In an attempt to solidify the junction between production systems and environmental conservation, agroecology seen as a scientific-technological focus brings a reconnection of agriculture in the dynamics of ecosystems and has been cited by several authors as being able to respond to current aspirations and future demands of the population. for sufficient food in quality and diversity (Pinheiro & Durigan, 2009).

Environmental challenges and the role of public policies in the expansion of the cerrado border

The agrarian environment of the Brazilian Cerrado areas, has undergone several transformations in the last forty years, bringing significant effects from the social, economic and environmental point of view (Matos & Pessoa, 2012). And advances with great potential for agricultural frontier expansion in this region began around the 1970s, with the implementation of territorial public policies in the region. From then on, instruments for revitalizing and modernizing Brazilian agriculture were formulated, such as the PNDs (National Development Plans) that aimed to boost the agricultural sector and expand the production of food and raw materials; increase the number of exports, and redistribute, in geographical terms, the rural populations through the colonization (Oliveira, 1997).

The first National Development Plan (PND) had a colonization perspective; on the other hand, the second PND was focused on an occupation based on a new model of global economic policy, with emphasis on production for increased exports. The first PND had a colonization perspective; on the other hand, the second PND was concentrated on an occupation based on a new model of global economic policy, with emphasis on production for increased exports (Costa, 1988). Thus, the Cerrado became strategic in the implementation and consolidation of new areas for cultivation, due to the geographical position and the physical and environmental characteristics of the region, which allowed the expansion of agricultural production in modern agriculture standards, based on the package. Green Revolution (Silva, 2000). The implementation of large-scale agriculture was seen as necessary to meet production demands and boost the economy. This fact reflects the number of studies addressing during this decade the importance of agriculture in the central region of the country for the economic development of Brazil (Figure 2).

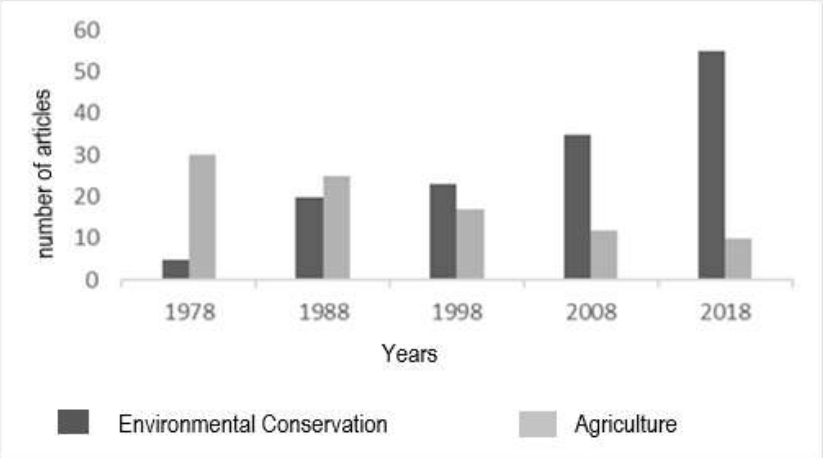

Figure 2: Relationship between works addressing environmental concerns and those that emphasize the importance of agriculture in the Cerrado region.

Due to economic factors and the demand for new productive locations, agricultural frontiers undergo constant displacement in search of increased agricultural productivity (Cardoso, 2017). Programs aimed at the development of the Cerrado sought to occupy the Midwest of the country, promoting its economic development through

agricultural expansion in the region (De Oliveira et al., 2017). It is noted that this agricultural expansion of the cerrado is the most important phenomenon of Brazilian agriculture in the last three decades and has been criticized for the alteration of the natural landscape due to the predominance of large-scale, highly mechanized production, with small space for family agriculture (Rezende & Rezende, 2003). Landscape changes in the Cerrado and the threat status of many of its species have led to the emergence of conservation initiatives by government, non-governmental organizations (NGOs), researchers and the private sector (Klink & Machado, 2005).

From this perspective, it is indicated that rural development initiatives and strategies should broaden development objectives to encompass not only economic growth but also environmental aspects (Melo, 2017). in the past, public policies have neglected the implications of development for the conservation of the Cerrado, but today there is a great opportunity for actions that involve various sectors of society in the pursuit of conservation and sustainable use of this biome (Klink & Machado 2005). This current scenario illustrates possible alternatives in which a policy mix is the creation of instruments to reconcile agricultural expansion, conservation of Cerrado remnants and restoration of critical habitats for endangered species (Strassburg, et al., 2017). One of the main challenges in the conservation of the Cerrado is to demonstrate the importance that biodiversity plays in the functioning of ecosystems. To this end, several policies are launched, such as the creation of compensation mechanisms that would attract the interest of the private sector, while at the same time would benefit the conservation of the Cerrado; the expansion and consolidation of conservation units; the creation of protected areas and alternative economic activities (ecotourism, sustainable use of fauna and flora products, medicinal plants) (Klink & Machado, 2005).

Each of these policies is already in place in some way, what remains now is a concentrated Effort by all stakeholders (governments, supply chain actors, financial agents, NGOs, and individuals in society at large) to prevent the environmental collapse of the Cerrado (Strassburg, et al., 2017).

Final considerations

This review sought to provide an understanding of the process of occupation and consolidation of the central region of the country, which was caused by several factors (eg, the role of the state, the technological package, the price of land, the geographical position and the peculiar environmental characteristics of the area), and the expansion of the Cerrado agricultural frontier is a product of the sum of these factors. In addition, the review shows us that native Cerrado vegetation has been increasingly replaced by a variety of grains, with an increasingly optimistic future outlook for crop growth. It turns out that grains do not perform the ecological function of the Cerrado trees and shrubs, which with their deep roots recharge the aquifers that supply much of Brazil, these and other factors require attention both in the sense of agricultural production and in the sense of conservation of nature, since water becomes the essence of both forces.

We have found evidence that the various public policies have influenced and continue to influence the expansion of borders in this region, and what is expected in the future is that strategies and initiatives that contribute to agrarian progress should broaden development goals to encompass not only economic growth, but also environmental aspects. Overall, the results of this review show that there is still a trend of agricultural expansion coupled with the Brazilian Cerrado, but there is also a clear concern related to environmental problems. Analyzes such as these are permeated by the search for information that supports strategies that promote the integration between productive systems and the conservation of biodiversity.

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