Fires in the Cerrado Biome (Brazil), between 1999 and 2018

Maíra Iaê S. Rocha[a], Diego Tarley F. Nascimento[b]*

[a] State University of Goiás, Goiás, Brazil
[b] Federal University of Goiás, Goiania, Brazil
* diego_nascimento@ufg.br

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Introduction

Fires are closely related to deforestation and agricultural activities in Brazil, and the Cerrado biome, the Brazilian Savanna, is no exception. Commonly utilized by traditional peoples, fires are used for cleaning pastures, preparing crops and burning bagasse. However, this practice has also been used for the deforestation of natural vegetation to incorporate agricultural activities, especially for the production of commodities.

The Amazon and the Cerrado stand out with the highest amounts of fires among the Brazilian biomes, in the period from 1998 to 2019. Although the Amazon presents the highest incidence of fire outbreaks throughout the historical series, the Cerrado remains in second place. In some of these years, the amount of fires in the Cerrado approaches that recorded in the Amazon, as seen in 2010, while in other years there is a greater incidence of outbreaks in the Cerrado, as recorded in 2011 and 2012.

In view of this context, the objective here is to analyze the spatio-temporal distribution of the fire outbreaks registered from 1999 to 2018 in the Cerrado. The study area comprises the second largest Brazilian biome, which occupies an area of approximately 2,036 km² - representing about 24% of the Brazilian territory (Figure 1).

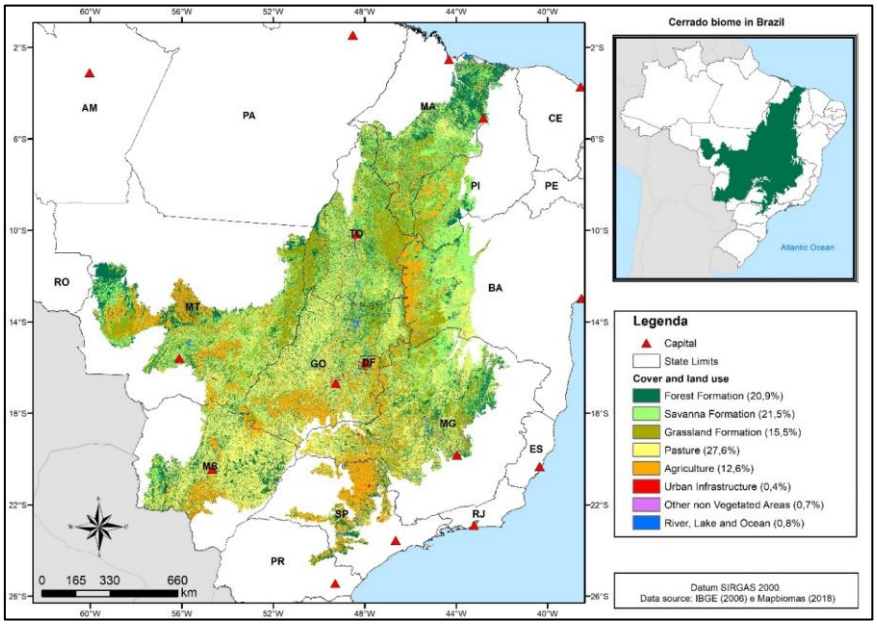

Figure 1: Location and soil cover of the Cerrado biome (2018).
Note: to view with higher quality and resolution, access the link: https://cutt.ly/0grNXJy

The Cerrado is considered one of the 34 hotspots for the conservation of global biodiversity (MITTERMEIER et al., 2004), with about 41.3% of its natural cover already being converted to human uses (Projeto Mapbiomas, 2018).

Method

Basically, the methodological procedures consisted of acquiring and analyzing secondary data. From the Burning Database of the National Institute for Space Research (http://queimadas.dgi.inpe.br/queimadas/bdqueimadas/), were obtained fire outbreaks, a point data with number of set location (x, y), representing a fire, or better, a fire outbreak, in vectorial format, recorded in the Cerrado between 1999 and 2018. The data were treated in a Microsoft Office Excel spreadsheet (version 2016) and later arranged in a Geographic Information System (GIS) environment, specifically in the ArcGIS software (version 10.3), for quantifying the fires outbreaks and estimating the spatial density by interpolation, using the kernel method.

Results

The cerrado vegetation is severely prone to the occurrence and spread of burning due to, among other factors, the presence of grasses that produce highly flammable and aerated fuel during the dry season (BOND; KEELEY, 2005). Barbosa (2015) points out that (natural) fire has been active in this biome for thousands of years, influencing the formation and evolution of the biome. For this reason, the Cerrado is considered a biome adapted and dependent on fire. However, the spatio-temporal dynamics of fires in the biome demonstrate the worrying anthropic influence in this process.

The average number of annual fire outbreaks in the Cerrado, based on the years analyzed, is 69,513. The standard deviation of the annual quantities is 29,058 fires outbreaks - which demonstrates a considerable annual variability in this biome. Among the twenty years analyzed, twelve have an annual quantity of fire outbreaks below the average value, which represents more than half of the years (60%), while eight years have a quantity above the average value. The year with the highest record of fire is 2007, with 137,918 outbreaks, closely followed by 2010, with 133,394 fire outbreaks. In contrast, the years 2000 and 2009 recorded the lowest occurrences of fires, with 34,393 and 35,899 outbreaks, respectively. The range between the years 2007 and 2000 is 103,525 fire outbreaks (Table 1).

Table 1 also shows a higher concentration of fires in the dry season. In the five months that characterize the period of drought in the region (May-September) account for about 71% of the fire outbreaks recorded throughout the year, while the seven months of the rainy season account for only 29%. In some years, as recorded in 2010, the dry period accounts for 82% of the annual amount of fire outbreaks. This shows that the fires in the Cerrado are mainly of anthropic origin, because the natural fires would be associated with the rainy season, in view of occurring due to electrical discharges that accompany precipitation events.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	188	469	82	382	856	1.757	3.465	11.933	14.455	8.354	1.434	475	**43.850**
2000	266	89	114	253	914	2.556	2.530	6.995	10.117	9.038	1.149	372	**34.393**
2001	182	109	69	304	713	3.606	3.242	9.541	16.623	7.702	1.834	609	**44.534**
2002	368	355	391	777	1.884	4.210	7.462	17.815	30.105	16.744	5.273	1.802	**78.719**
2003	654	587	472	1.052	2.475	7.079	10.477	10.140	29.227	15.008	4.763	2.179	**84.113**
2004	452	376	773	970	2.975	7.047	8.804	12.473	33.509	15.148	8.243	2.792	**93.562**
2005	587	869	536	1.071	1.968	3.383	7.454	14.627	24.521	23.550	5.251	1.930	**85.747**
2006	1.001	413	498	584	1.650	3.415	6.442	11.705	16.566	7.524	5.274	1.808	**56.880**
2007	755	402	1.118	964	2.924	7.051	10.548	35.678	49.980	22.008	4.939	1.551	**137.918**
2008	421	321	339	590	1.320	2.632	5.229	8.643	15.477	17.024	5.486	1.452	**58.934**
2009	676	403	461	448	836	1.641	4.224	6.492	9.851	5.526	4.195	1.146	**35.899**
2010	717	751	883	1.438	2.508	6.443	12.359	35.226	52.491	14.419	4.623	1.536	**133.394**
2011	456	321	308	703	1.376	3.378	5.366	11.387	26.468	7.656	2.889	1.374	**61.682**
2012	421	478	764	1.092	1.896	3.817	9.362	22.737	30.053	16.515	1.830	1.635	**90.600**
2013	475	604	613	706	1.418	2.684	4.761	8.496	12.615	7.696	2.370	1.579	**44.017**
2014	567	315	497	897	1.673	3.849	6.220	15.525	15.523	16.357	3.085	1.363	**65.871**
2015	1.096	383	528	634	1.174	3.313	4.662	12.684	23.795	19.531	4.731	2.563	**75.094**
2016	392	1.048	767	1.449	1.782	3.187	8.675	13.730	13.256	9.968	3.647	932	**58.833**
2017	491	376	687	696	1.428	2.858	6.258	10.815	26.975	12.393	2.345	1.440	**66.762**
2018	521	235	842	549	1.729	2.922	5.220	7.992	11.467	5.041	1.763	1.168	**39.449**
Minimum	182	89	69	253	713	1.641	2.530	6.492	9.851	5.041	1.149	372	34.393
Maximum	1.096	1.048	1.118	1.449	2.975	7.079	12.359	35.678	52.491	23.550	8.243	2.792	137.918
Average	**534**	**445**	**537**	**778**	**1.675**	**3.841**	**6.638**	**14.232**	**23.154**	**12.860**	**3.756**	**1.485**	**69.513**
%	1	1	1	1	2	6	10	20	33	19	5	2	100

Table 1 - Distribution of fire outbreaks in the Cerrado biome between 1999 and 2018.

In fact, it is precisely in the consecutive August-September-October quarter that the highest incidence of fires occurs in the Cerrado, with an average of 72% of the annual amount of outbreaks, reaching 82%, as seen in 2002. This period is consistent with the end of the drought and the return of the rains (in the second half of October), when there is a renewal of pastures, the preparation of planting areas and the burning of bagasse. In this quarter, the highlight should be given to the month of September, which reaches 33% of the annual amount of fire outbreaks.

A comparative analysis of the maps in Figure 2 shows, mainly, in the north, but also in the northeast and northwest of the Cerrado, the predominance of the two classes with the highest density of fire outbreaks over the successive years analyzed, represented by the dark tones and related to incidences greater than 301 fire outbreaks - reaching 5,368 – in 2007. The first two regions comprise the states of Maranhão (MA), Tocantins (TO), Piauí (PI) and Bahia (BA) –that form a region known in the literature as MATOPIBA, on of the most recent agricultural frontier in Brazil (Pereira & Pauli, 2016) where fire is used as a management tool in agropastoral practices (Vieira Filho, 2016). The third region is denominate as “Arc of Deforestation” (Nogueira et al., 2007, 2008), alluding to the intense devastation of the natural landscapes of this transition area (ecotone) between Cerrado, Amazon and Pantanal, which is home to a rich biodiversity of fauna and flora.

In the first three years of the analyzed time series (1999 to 2001), there is a predominance of the two classes with lower density of outbreaks (<300 fire outbreaks) in almost the entire Cerrado biome, with a successive increase in the class of lower density of fire outbreaks (<100). However, between 2002 and 2005 these classes tend to fall back, in terms of extension, giving space to classes with density greater than 301 fire outbreaks, with greater emphasis on the class with density greater than 501 fire outbreaks, which apparently reaches half of the area, as seen in 2004 and 2005.

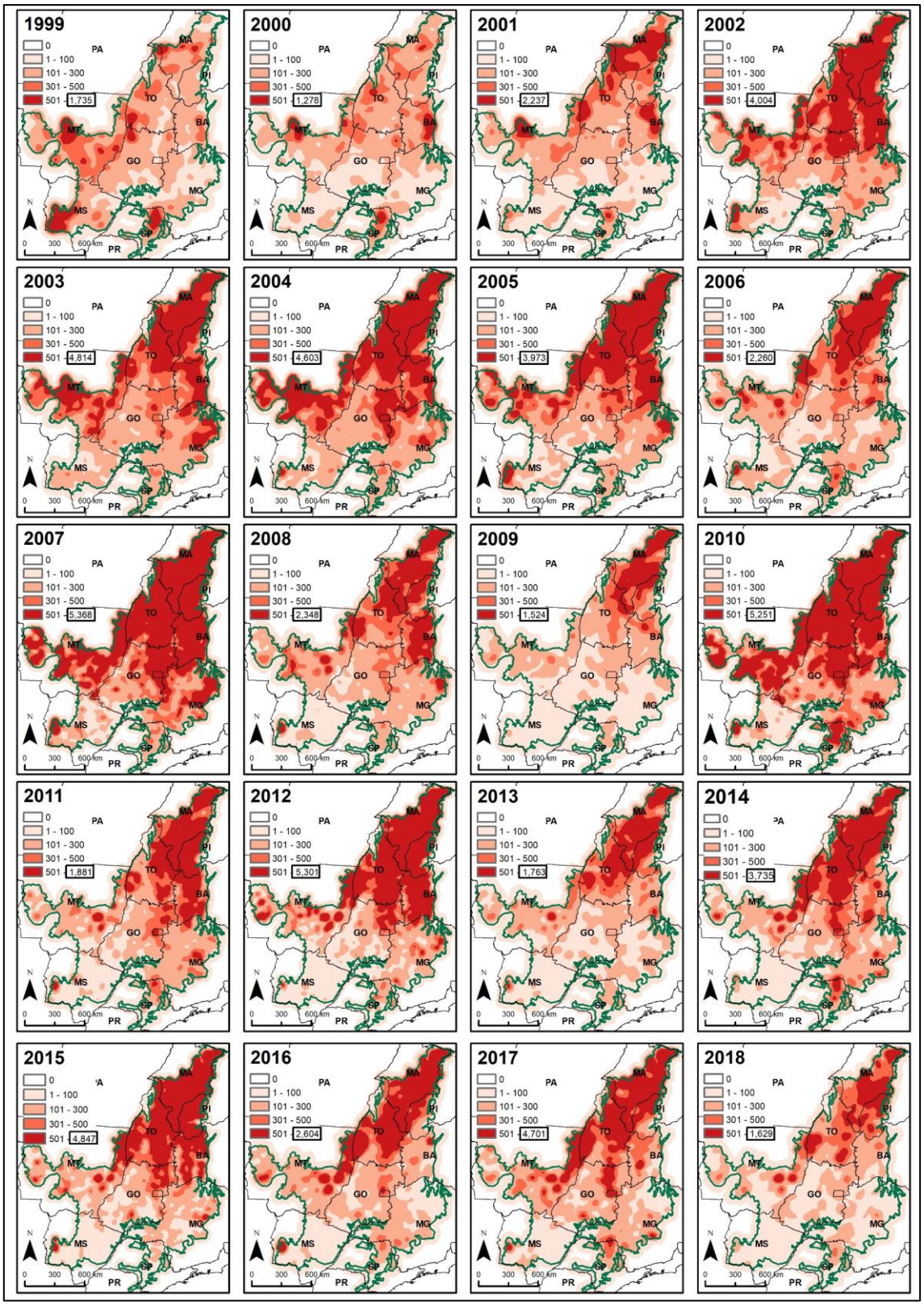

Figure 2 - Incidence of fire outbreaks (per kilometer square) in the Cerrado biome between 1999 and 2018.

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In 2006, there is a reduction in the density of fire outbreaks in the Cerrado, but an opposite scenario occurs in the following year (2007), when the class with the highest density of fires outbreaks starts to occupy more than half of this biome. In the two years

that follow, there is again a decrease in outbreaks, with the density class above 300 fire outbreaks being restricted to the north of the Cerrado. In 2010, the classes with the highest density of fire outbreaks once again predominate, in a pattern quite similar to that seen in 2007 - it is worth remembering that these two years refer to the largest number of fire outbreaks registered in the Cerrado.

Discussion and Conclusion

Between the period from 1999 to 2018, the average occurrence of 65,513 fire outbreaks was recorded in the Cerrado biome, which can reach surprising amounts, such as 137,918 outbreaks, as recorded in 2007. There is an expressive concentration of fires in the dry period, especially in the August- September-October quarter, which accounts for about 72% of annual occurrences. Over the years, the largest amount of fire outbreaks occurs mainly in agricultural frontier areas, especially in the MATOPIBA region and Arc of Deforestation.

Therefore, for being a research still in development, the analysis here is an exploratory evaluation of the fire outbreak data registered from 1999 to 2018 to determine some understanding of the spatio-temporal fire patterns in the Cerrado biome. The next step is to undertake a rigorous and objective analysis of the data to identify trends over space and time, performing an emerging hot spot analysis.

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