BURNED AREA TRENDS IN THE BRAZILIAN CERRADO: THE ROLES OF CLIMATE AND ANTHROPOGENIC DRIVERS

Patrícia S. Silva[1], Julia A. Rodrigues[2], Filippe L. M. Santos[2], Joana Nogueira[2,3], Allan A. Pereira[4], Leonardo F. Peres[2], Duarte Oom[5], Carlos C. DaCamara[1], José M. C. Pereira[6], and Renata Libonati[1,2,6]

BACKGROUND

- The Brazilian Savanna (Cerrado) is one of the **most important global biodiversity** hotspots.
- It is, on average, responsible for more than 50% of Brazil's annual burned area.
- Keep in mind that **Brazil is one of the regions with higher fire activity** worldwide.
- Cerrado is **increasingly endangered**: less than 20% of its natural vegetation cover remains undisturbed; and future projections of a warmer and drier climate put this **biome at high risk**.

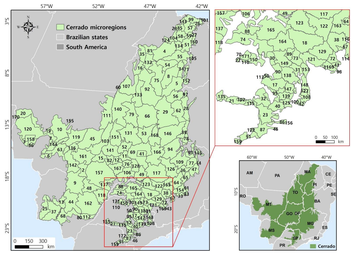


Figure 1. Spatial distribution of the 172 microregions (light green, each with identifier - ID) across the Cerrado biome (dark green) in central Brazil.

DATA AND METHODS

- Burned Area (BA): MODIS MCD64A1 C6 (Giglio et al., 2018).
- Land use (LU): MapBiomas collection v4 (MapBiomas Project, 2019).
- Population density (PD): Brazilian Institute of Geography and Statistics.
- Meteorological fields: daily fields at 18 UTC of surface air temperature, relative humidity, wind speed, and 24-hour precipitation from ERA5 (C3S, 2017).
- ➢ Fire danger index (FWI): the Canadian Forest Fire Weather Index (Wagner, 1974).
- ➢ Microregions: Brazilian Institute of Geography and Statistics (IBGE, 1990).

Methods:
The study period (2001-2018) was divided and averaged over three 6-year periods to analyze each variable over the study region. Then, drivers were evaluated using simple linear regression between interannual values of total BA and each of the variables: dry-season (JJASO) averaged FWI; annual LU; and annual PD. Lastly, to estimate trends, given the short length of the time series, we used non-parametric methods: the Theil-Sen regression (Theil, 1950; Sen, 1968) and the modified Mann-Kendall test (Hamed and Rao, 1998), which accounts for the effects of serial correlation.

CHARACTERIZATION

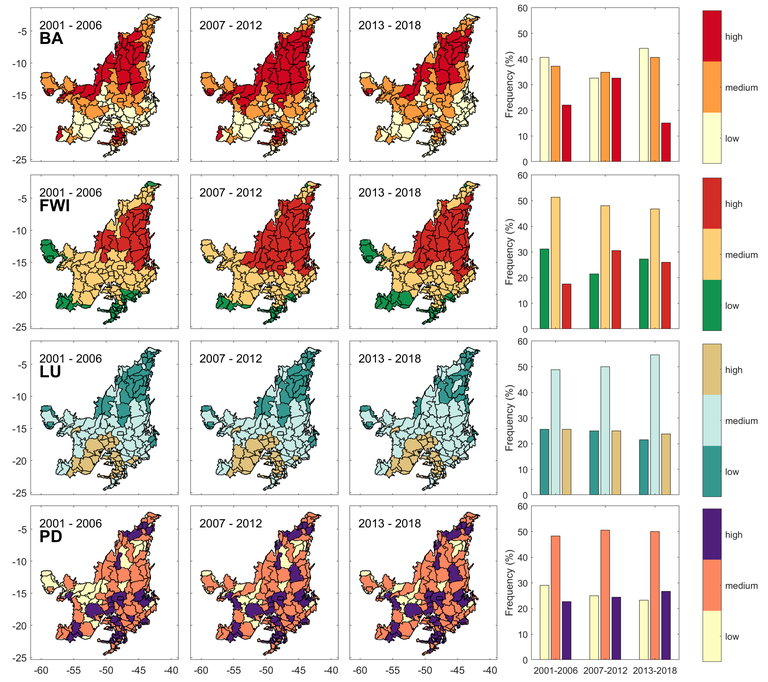
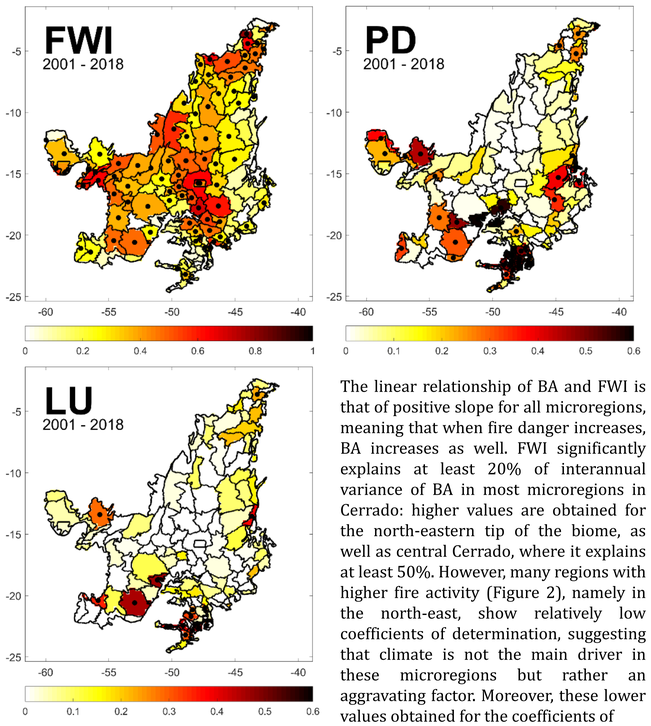


Figure 2. Averages over three 6-year periods (2001-2006; 2007-2012; 2013-2018) for: annual BA (first row); dry season-averaged FWI (second row); annual LU (third row); and annual PD (last row). Fourth column represents their corresponding frequencies of each category defined as lower/upper quartiles for "Low"/"High", and "Medium" the values between the 25th and 75th percentiles.

DRIVERS

Figure 3. Coefficient of determination between interannual BA and FWI/LU/PD for Cerrado from 2001 to 2018. The filled (empty) circles represent significance below the 5 (10)% level.



The linear relationship of BA and FWI is that of positive slope for all microregions, meaning that when fire danger increases, BA increases as well. FWI significantly explains at least 20% of interannual variance of BA in most microregions in Cerrado: higher values are obtained for the north-eastern tip of the biome, as well as central Cerrado, where it explains at least 50%. However, many regions with higher fire activity (Figure 2), namely in the north-east, show relatively low coefficients of determination, suggesting that climate is not the main driver in these microregions but rather an aggravating factor. Moreover, these lower values obtained for the coefficients of determination might suggest that these regions are shifting from a climate-controlled historical fire season to a disturbed regime.

On the other hand, BA and LU relationship is much more complex than that of BA and FWI: fire is used to clear native vegetation into arable land, in which case burned area increases; and the use of controlled and seasonal fire in the harvest season and to clear the agricultural fields, in which case burned area decreases. Accordingly, when performing simple linear regression using LU as a predictor of burned area, distinct signals were found, and the vast majority of which were not significant at the 5/10% level. Similarly, PD was also found to have very different signals, where those microregions with significant results obtained negative slopes.

TRENDS

Contrasting spatial patterns were found for BA, LU and FWI in the 2001-2018 period. Conversely, both PD and FWI over the historical period, show widespread positive values in Cerrado. When looking at the latter is clear that there has been a positive trend in Cerrado over the last decades. It's also worth noting that negative trends achieved for FWI in 2001-2018 are not significant.
North-eastern Cerrado shows positive BA and LU trends, consistent with this region being the biome's latest agricultural frontier (MATOPIBA).

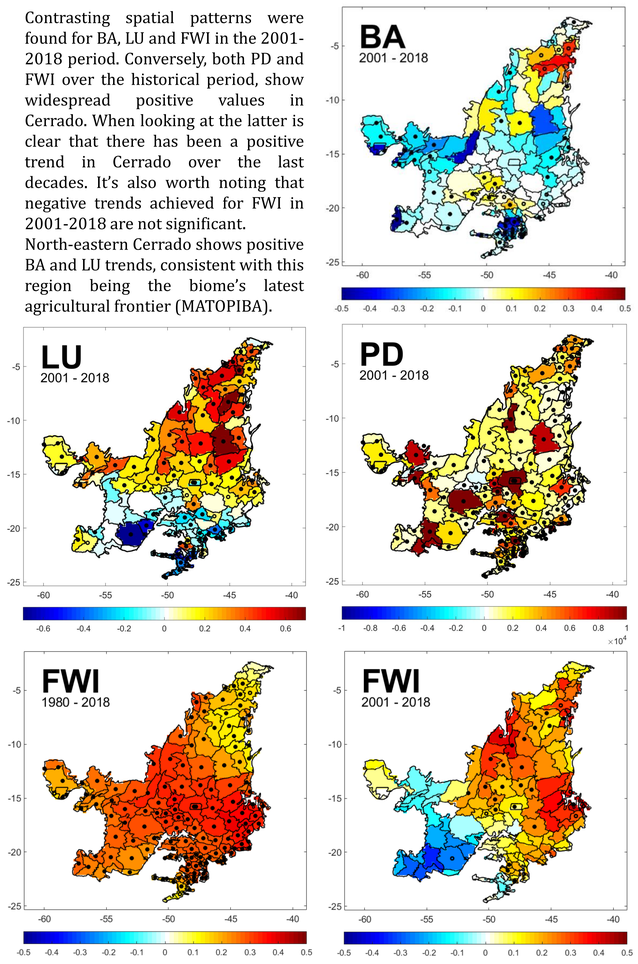


Figure 4. Trends of normalized BA, FWI, LU and PD over 2001–2018., and historical (1980-2018) FWI. Warmer (cooler) colors represent an upward (downward) trend and filled (empty) circles represent significance below the 5 (10)% level.

DISCUSSION

Here, we present the preliminary results of studying burned area drivers and their recent trends in the Brazilian Cerrado. We found that there is high variability within the biome and, amongst the drivers evaluated, only FWI showed significant results throughout Cerrado, explaining at least 20% of interannual variance of BA. It's worth emphasizing that climate provides conditions for burning, but fire events are always dependent on ignition, which in Brazil is known to be almost certainly human. The remaining drivers, LU and PD, did not prove to be relevant factors in the vast majority of the biome, with very low values of coefficient of determination and no spatial consistency. They were also found to have much more complex relationships with burned area, heavily dependent on the regional context and other variables not considered here (such as deforestation). Furthermore, north-eastern Cerrado was found to be fairly explained by FWI, where some microregions obtained coefficient of determination values beyond 50%. This region also showed positive BA and LU trends, consistent with it being Cerrado's latest agricultural frontier (also known as MATOPIBA), heavily marked by the clearing of natural vegetation (savanna).

Trend analysis showed a significant positive trend in FWI over the last 38 years, over the whole biome. PD also seems to be increasing in most microregions, as well as LU in northern Cerrado. BA obtained highly variable trends.

These results lead us to conclude that the human-driven component of burned area must be further evaluated. We hypothesize that urban area, fuel availability and topography might play a significant role in short term BA variability as well as fire management and environmental policies.

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[1]Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749–016, Lisboa, Portugal
[2]Departamento de Meteorologia, Universidade Federal do Rio de Janeiro, 21941-916, Rio de Janeiro, Brazil
[3]Programa de Monitoramento de Queimada por Satélites, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil
[4]Instituto Federal de Ciência e Tecnologia do Sul de Minas Gerais, 37890-000, Muzambinho, MG, Brazil
[5]European Commission, Joint Research Centre (JRC), Ispra, Italy
[6]Centro de Estudos Florestais (CEF), Instituto Superior de Agronomia, Universidade de Lisboa,1349-017, Lisboa, Portugal

Contact: pssilva@fc.ul.pt