



## Human land occupation regulates the effect of the climate on the burned area of the Cerrado biome

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The Brazilian Cerrado is a heterogeneous biome formed by a mosaic of savannas, grasslands, and smaller patches of denser woody forms. In this biome, fire is a natural disturbance agent that contributes to maintaining its open ecosystems and rich biodiversity. However, modern human activities and climate change are altering its fire regimes. In tropical savannas, land-use expansion is usually associated to a decrease in burned area primarily through land fragmentation, but also through active fire suppression. Meanwhile, climate change is fostering fire weather conditions, exacerbating fire activity. Hence, the two main drivers of fire could be pushing burned area in opposite directions, both with important ecological consequences for the Cerrado. However, it remains unclear how these two drivers interact, which is essential to devise effective fire management policies and conservation plans.

In this study, we use a causal inference framework to quantify the interaction between anthropic area percentage – as a proxy of human presence and fragmentation – and various climatic variables on their effects on Cerrado's burned area. As well, we explore the spatial structure of temporal trends in burned area, anthropic expansion and climate change, and quantify the causal effect of the last two on the former.

We use geospatial data from different sources on a 0.2° grid over the Cerrado for the period 1985 to 2020. We use burned area and land use data from the MapBiomas project, and climate re-analysis data from ERA5 Land, CHIRPS and TerraClimate. We design our models using Directed Acyclic Graphs, a graphic representation of the causal relations between the predictors and burned area that informs variable selection for causal inference. Hence, based on these DAGs, we build multilevel Bayesian regression models to quantify the effects of the predictors and their interactions.

We find that a larger presence of land-use activities keeps burned area low and, importantly, hinders the effects of the climate. That is, while in landscapes composed mostly of native vegetation hotter and drier conditions increase burned area as expected; in anthropic landscapes,

humans completely limit burned area responsiveness to climate. We also find spatially heterogeneous increasing and decreasing trends in burned area over the period, but concentrated in those areas of the Cerrado that were mostly natural in 1985. In these areas, a large anthropic expansion brought about a decrease in burned area, while we observe an increase in burned area in relation to climate change only in the areas that remained intact throughout the study period.

In conclusion, burned area in the Cerrado is shaped primarily by the extent of human presence in the landscape, even limiting the effects of the climate, while climatic effects become relevant in areas with larger tracts of native vegetation, suggesting that these areas may be more vulnerable to climate change.