ANTHROPOGENIC DRIVERS ASSOCIATED WITH FIRE SPOTS OCCURRENCE IN SOUTHWEST OF TOCANTINS STATE, BRAZIL

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ABSTRACT

This study aimed to identify drivers associated with the occurrence of fire spots at the end of the dry season from 2015 to 2019. The study area covered three municipalities in Tocantins State, Brazil: Pium, Formoso do Araguaia and Lagoa da Confusão. We used a spatial generalized additive model with point samples of occurrence and nonoccurrence of fire spots. The drivers analyzed were: topography, land cover, fire risk and drivers related to human activities. Our results showed that the drivers associated with the occurrence of fire spots differ among studied years, and they are related to forest formations, savanna formations, grassland, cropland, pasture, distance from roads, distance from settlements, settlement projects, protect areas, burned area in the year prior to the fire spots and fire risk.

Keywords: Spatial generalized additive model; wildfire; human activities.

RESUMO

O presente trabalho teve como objetivo identificar fatores associados a ocorrência de focos de queima no final da estação seca de 2015 a 2019. A área de estudo abrangeu três municípios do Estado do Tocantins: Pium, Formoso do Araguaia e Lagoa da Confusão. Utilizamos um modelo aditivo generalizado espacial com amostras pontuais de ocorrência e não ocorrência de focos de queima. Os fatores analisados foram: topografia, cobertura da terra, risco de fogo e fatores relacionados às atividades humanas. Nossos resultados mostraram que os fatores associados à ocorrência de focos de incêndio diferem entre os anos estudados e estão relacionados com formações florestais, formações savânicas, formações campestres, agricultura, pastagem, distância de estradas, distância de

povoamentos, projetos de assentamento, unidades de conservação, área queimada no ano anterior ao foco de queima e risco de fogo.

Palavras-chave: Modelo aditivo generalizado espacial; queimadas e incêndios florestais; atividades humanas.

Introduction

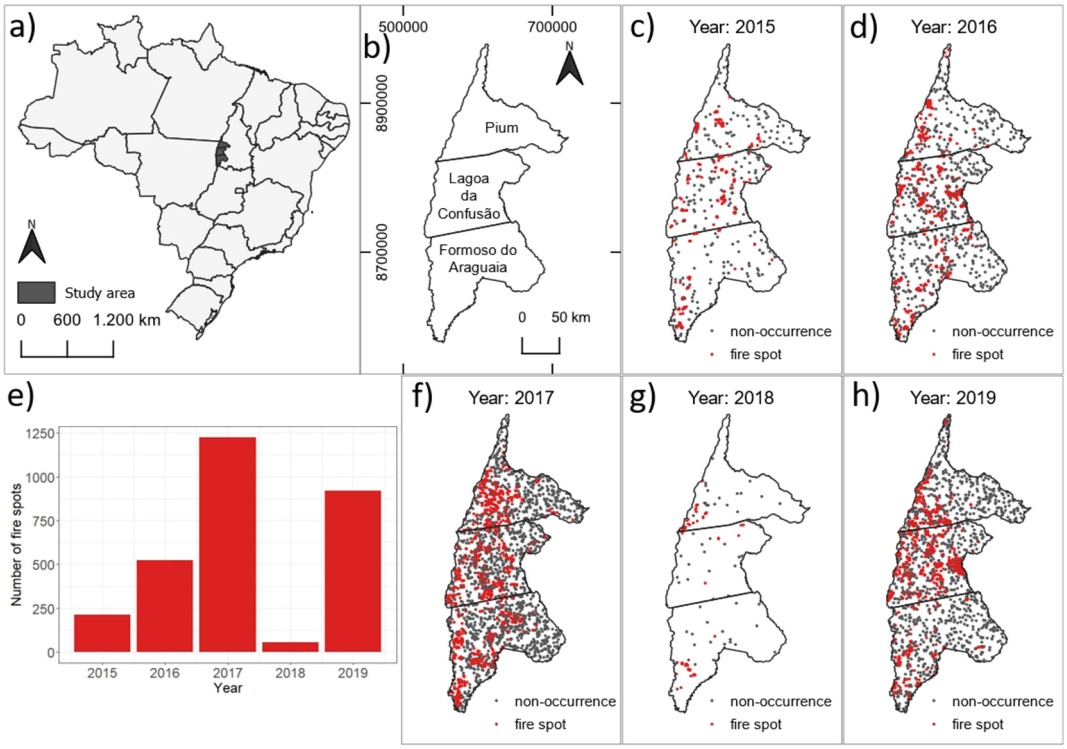
The fire regime has been altered by climate and the intensity of human activities, mainly those related to agricultural activities (BOWMAN *et al*., 2009). In the last 50 years in the Brazilian Cerrado biome, the wildfires have tended to be concentrated at the end of the dry season, and they have occurred every two to three years, causing serious damages to fire-sensitive vegetation (SCHMIDT; ELOY, 2020), with higher tree mortality (MIRANDA, 2010), soil degradation, biological invasions and general loss of biodiversity (PIVELLO, 2011).

In the context, we seek to answer the following question: what drivers are associated with these fire spots occurrence at the end of the dry season? To answer this question, this study aimed to evaluate the occurrence of fire spots in three municipalities in the southwest region of Tocantins State, Brazil, using a spatial generalized additive model, from 2015 to 2019.

Materials and methods

Three municipalities in the southwest of Tocantins State, Brazil, formed the study area: Formoso do Araguaia, Lagoa da Confusão e Pium (Figure 1).

Figure 1. a) Localization of study area in Brazil; b) Municipalities of study area; c), d), f), g) e h) Localization of fire spots and non-occurrence spots; e) Graph of number of fire spots per year.



Data used for this study included fire spots occurrence (INPE, 2020) and nonoccurrence spots, which were randomly generated, as response variable (Figure 1). The selected exploratory variables included environmental variables, fire risk - calculated with meteorological, vegetation, elevation and presence of fire data (INPE,2020) - and variables related to human activities (Table 1). For each year, a spatial generalized additive model was generated with training samples (70% of the data). To verify the predictive capacity of the model, the Area Under The Curve (AUC) was used with validation data (30% of the data) and to assess the association of each driver with the fire spots occurrence, we used the odds ratio.

Table 1. Exploratory variables included in this study.

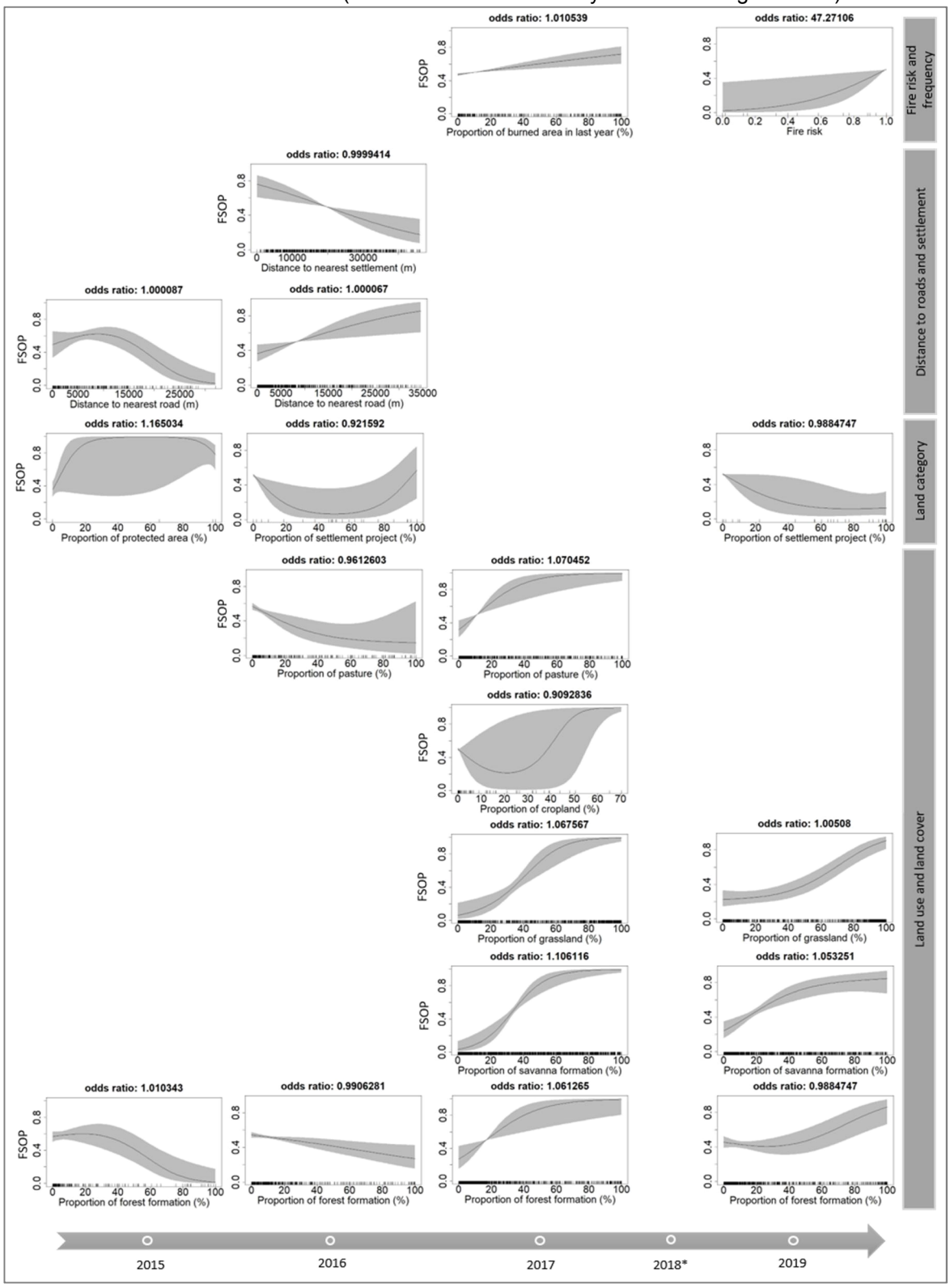
Variables	Description	Source
Fire risk	Scale from 0 (minimum risk) to 1 (critical risk).	Programa Queimadas – Inpe www.inpe.br/queimadas/bdqueimadas
Burned area	Coverage percentage within a 500m radius buffer of the spot	
Land use and land cover: forest formations, savanna formations, grassland, pasture, cropland and soy plantation		Projeto MapBiomas - Coleção 5.0 www.mapbiomas.org
Deforestation area		Prodes Cerrado www.cerrado.obt.inpe.br
Land category: private property, public lands, settlement projects of agrarian reform, conservation unit and indigenous lands		Atlas da agropecuária – Imaflora www.atlasagropecuario.imaflora.org Acervo fundiário - Incra www.acervofundiario.gov.br ICMBio www.icmbio.gov.br
Roads	Distance to nearest road (meters)	Secretária do Meio Ambiente e Recursos Naturais www.semades.to.gov.br
Settlements including cities, towns, villages, settlement project agrovillages, indigenous villages and isolated urban áreas	Distance to nearest settlement (meters)	IBGE www.ibge.gov.br/
Topography: bearing and slope	Slope: degrees Bearing: gray leves	Projeto Topodata www.dpi.inpe.br/topodata

Results and discussion

The models presented AUC/ROC of 89.01% for 2015, 85.07% for 2016, 83.24% for 2017 e 87.47% for 2019, which correspond to satisfactory prediction models. For 2018, the year with the lowest number of fire spots occurrence, none of the analyzed drivers showed an acceptable significance in the mode adjustment. In the Figure 2, the Fire Spots Occurrence Probability (FSOP) is showed relating to the drivers for each year.

The relative contribution of the drivers differs among years studied. The estimated odds ratio shows that, in 2019, the fire risk exerts the largest influence on fire spots occurrence. Savanna and grassland formations are dependent/influenced fire (BERLINK;LIMA,2020), thus, its association with fire was expected. However, the

Figure 2. Fire spots occurrence probability (FSOP) of the drivers in three municipalities in Southwest of Tocantins States (* none of the factors analyzed showed significance).



association with the fire occurrence in forest formations in 2017 and 2019 is unsettling, due to the ecosystem fire-sensitiveness.

In 2017, pastures and cropland showed a higher FSOP. Among the land categories, in 2015, protected areas showed higher FSOP in their boundaries. In settlement projects in 2016, the probability was higher inside and outside them, but lower on property boundaries. Yet, the probability was lower within settlement projects in 2019. The FSOP of distance from road had opposite behavior between 2015 and 2016, which may be related to get access to locations for both to fire ignition and to fire control. For the distance from settlement, its inverse relationship appeared in 2016, as the greater the distance, the lower the FSOP. In 2017, due to the larger number of fires, the FSOP was greater in burned areas in the prior year. The fire spots occurrence in the study area and period was not associated with deforested areas, topography, indigenous lands, public lands, private properties and soy plantations.

Final remarks

Drivers associated with fire spots occurrence differ among the studied years and showed a relationship to land use and land cover, distance from roads, distance from settlements, land categories, burned area in the year prior to the fire spots and fire risk. The identification of these drivers does not guarantee that the places where the factors occur will suffer from fires, but they can contribute to local planning or evaluation of fire control actions.

References

BERLINCK, C. N.; LIMA, L. H. A. Implementation of integrated fire management in brazilian federal protected areas: results and perspectives. **Biodiversidade BrasileiraBioBrasil**, n. 2, p. 128-138, 2021.

BOWMAN, D. M.; BALCH, J. K.; ARTAXO, P.; BOND, W. J.; CARLSON, J. M.; COCHRANE, M. A.; D'ANTONIO, C. M.; DEFRIES, R. S.; DOYLE,J. C.; HARRISON, S. P. et al. Fire in the earth system.Science, **American Association for the Advancement of Science**, v. 324, n. 5926, p. 481–484, 2009.

INPE, Instituto Nacional de Pesquisas Espaciais. **Banco de dados de queimadas**. Disponível em: http://www.inpe.br/queimadas/bdqueimadas. Acesso em: 22 nov. 2020

MIRANDA, H. S. **Efeitos do regime do fogo sobre a estrutura de comunidades de cerrado: Resultados do projeto Fogo**. Brasília: Ibama, 2010

PIVELLO, V. R. The use of fire in the cerrado and amazonian rainforests of brazil:past and present. **Fire ecology**, Springer, v. 7, n. 1, p. 24–39, 2011.

SCHMIDT, I. B.; ELOY, L. Fire regime in the brazilian savanna: Recent changes,policy and management. **Flora**, p. 151613, 2020.