Spatial and Temporal Trends of Burnt Area in Angola

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Introduction

Fire is a key driver of natural ecosystems in Africa. However, human activity and climate change have altered fire frequency and severity in recent years, with negative effects on biodiversity conservation[1]. Angola, with very dry seasons and consecutive years of drought, ranks among the countries with the highest fire activity in sub-Saharan Africa[2].

Aims

The main aim of this study is to analyze spatial and temporal trends of the area annually burnt in Angola, in order to understand how these trends affected the conservation goals of the country. Specifically, we aimed to: (i) map fire incidence in Angola between 2001 and 2019; (ii) identify positive and negative trends in the annual burnt area; and (iii) analyze the association between the detected trends and the Angolan ecoregions, protected areas, and land cover classes.

Methods

We analyzed the presence of significant trends in burnt area in Angola using MODIS burnt area product MCD64A1 v.006[3], applying the contextual Mann–Kendall test and the Theil–Sen slope estimator. The contextual Mann–Kendall test allows the detection of homogeneous regions with similar trends, while the Theil–Sen slope estimator was applied to determine the rate of change of the annual burnt area in each cell with significant trends[3,5].

Finally, we compared the maps of burnt area trends with the WWF ecoregions, the Angolan system of protected areas, and land cover time-series maps.

Results

Our results showed that ca. 30% of the country's area burned every year. The northeast and southeast regions of Angola presented the highest percentage of annual burnt area per cell (Figure 1a). Since 2001, 64% of the cells burnt 15 years or more (Figure 1b).

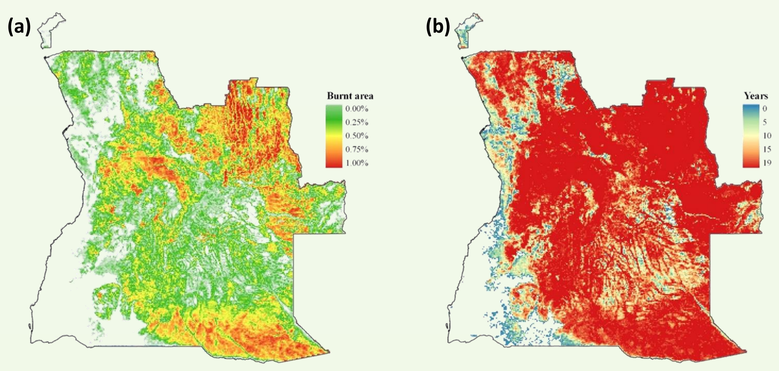

Figure 1. Burnt area in Angola, from 2001 to 2019: **(a)** map of the mean annual fraction of burnt area in each cell; **(b)** map of the number of years when each cell burnt since 2001.

The northeast and southeast Angola showed large clusters of decreasing trends of burnt area while the clusters of increasing trends were found mainly in central Angola, associated with savannas and grasslands of Angolan Miombo woodlands (Figure 2). The protected areas of Cameia, Luengue-Luiana, and Mavinga exhibited large areas of decreasing trends, while 23% of the Bicuar National Park was included in clusters of increasing trends.

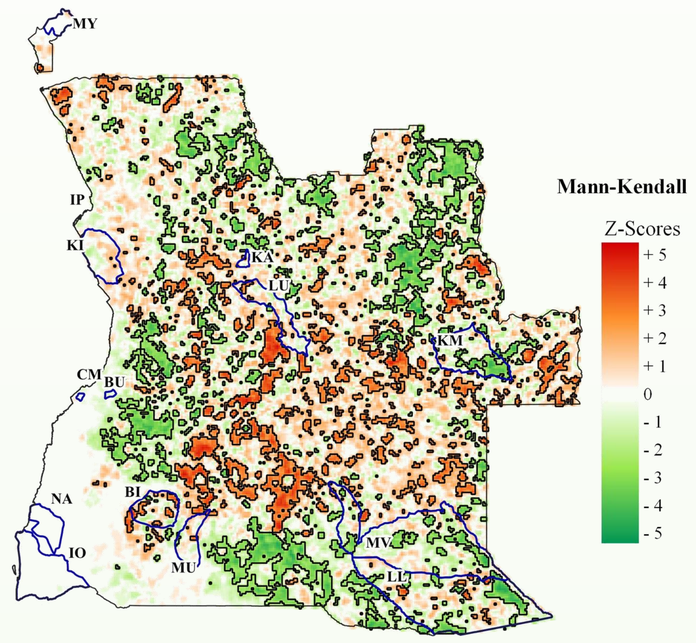

Figure 2. Trends of the annual burnt area in Angola for the 2001–2019 period. The positive z-scores correspond to areas of increasing trends, while the negative z-scores correspond to decreasing trends. The significant areas (with a confidence level of 95%) were outlined with black lines. Protected areas are indicated with blue outlines: BI, Bicuar; BU, Búfalo; KA, Cangandala; CM, Chimalavera; IO, Iona; IP, Ilheu dos Pássaros; KM, Cameia; KI, Quiçama; LL, Luengue-Luiana; LU, Luando; MV, Mavinga; MU, Mupa; MY, Maiombe; NA, Namibe.

Distinct patterns of land cover were found in areas of significant trends, where the clusters of increasing trends showed a higher fraction of forest cover (80%) than the clusters of decreasing trends (55%) (Figure 3).

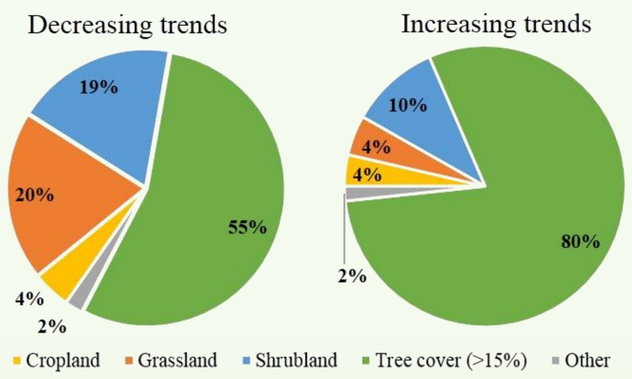

Figure 3. Proportions of the main land cover classes in areas of increasing and decreasing trends for the year 2018.

Management Implications

The detection of spatial and temporal patterns of burnt areas is a crucial step for the definition of conservation priorities and management strategies. This will allow for efficient distribution of fire management resources and public investment, resulting in improved management of Angolan vegetation.

References:
[1] Ferreira, L.N.; Vega-Oliveros, D.A.; Zhao, L.; Cardoso, M.F.; Macau, E.E. Global fire season severity analysis and forecasting. Comput. Geosci. 2020, 134, 104339.
[2] Mendelsohn, J.M. Landscape changes in Angola. In Biodiversity of Angola. Science & Conservation: A Modern Synthesis; Huntley, B.J., Russo, V., Lages, F., Ferrand, N., Eds.; Springer: Cham, Switzerland, 2019; pp. 123–137.
[3] MCD64A1 MODIS/Terra+Aqua Burnt Area Monthly L3 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. Available online: https://lpdaac.usgs.gov/products/mcd64a1v006/.
[4] Neeti, N.; Eastman, J.R. A contextual Mann-Kendall approach for the assessment of trend significance in image time series. Trans. GIS 2011, 15, 599–611.
[5] Chandler, R.E.; Scott, E.M. Statistical Methods for Trend Detection and Analysis in the Environmental Sciences; Wiley: Chichester, UK, 2011.

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