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Editorial

Novel Approaches and Techniques for Understanding Vegetation Fires in South America

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Vegetation fires represent a major disturbance in the tropics, with South America notable for having both fire-sensitive (e.g., Amazonia and Atlantic Forest) and fire-prone (e.g., Cerrado and Pantanal) biomes. In addition, fire activity in this region is associated with anthropogenic and biophysical processes, including deforestation and crop management, lightning, and favorable meteorological conditions. The complexity of vegetation fires in South America is observed from two recent fire crises: the 2019 Amazonia fire crisis, which was mainly associated with deforestation [1], and the 2020 Pantanal fire crisis [2], which was triggered by unprecedented drought and heat wave events [3–5].

It has been recognized that wildfires directly or indirectly affect several of the United Nations Sustainable Development Goals, although they are not explicitly mentioned by them [6,7]. Despite this, wildfires in South America have been progressively increasing in terms of their frequency and impact. Concurrently, the quantification of their drivers, their extension, the post-disturbance recovery, the associated economic losses, their emission of trace gases and aerosols, and how to prevent them remains challenging. The number of articles published on this topic is increasing; using the Web of Science Core Collection database, we conducted an advanced search with the terms "Fires" and "South America" to identify articles published from 1990 to 2022. This search returned a total of 986 peer-reviewed articles, with 58% of them published within the last 10 years (Figure 1). This demonstrates the consolidation of this research field over time. We also note that only four South American countries were represented among the countries of the top 10 corresponding author (Figure 2).

The Special Issue "Vegetation Fires in South America" contributed to both understanding the occurrence of fires in South America and incentivizing South American scientists to publish in an international journal. Of the nine articles published, the first authors of eight of them were affiliated with a South American institution. Carrión-Paladines et al. [8] evaluated the effects of wildfire severity on physicochemical soil properties in the humid montane scrublands of southern Ecuador based on the Normalized Burn Ratio (NBR) index and soil samples from burned and unburned areas. In areas burned due to recent high-severity wildfires, SOM, N, P, Cu, and Zn content decreased drastically, while soil compaction increased. In older wildfires, total SOM, N, P, and K content and soil pH increased when compared with areas that had

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never been affected by fires. These results represent an important basis for the environmental restoration of the study area.

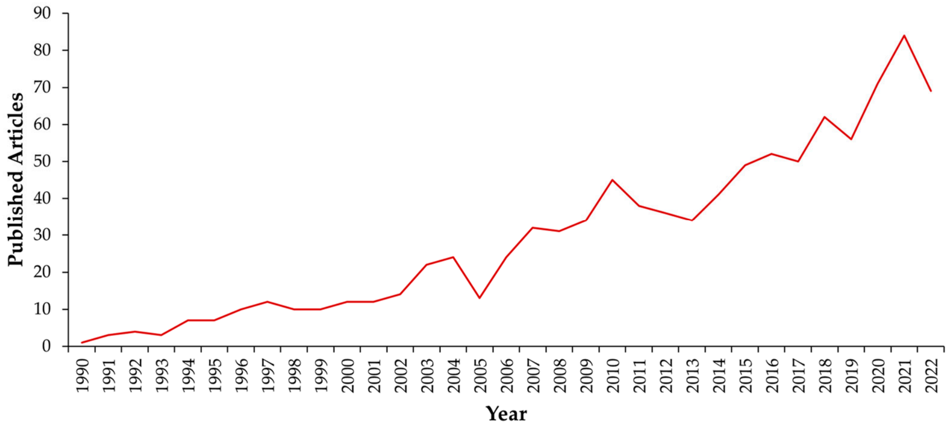

Figure 1. Yearly published articles identified between 1990 and 2022 after performing an advanced search with the terms "Fires" and "South America" in the Web of Science Core Collection database.

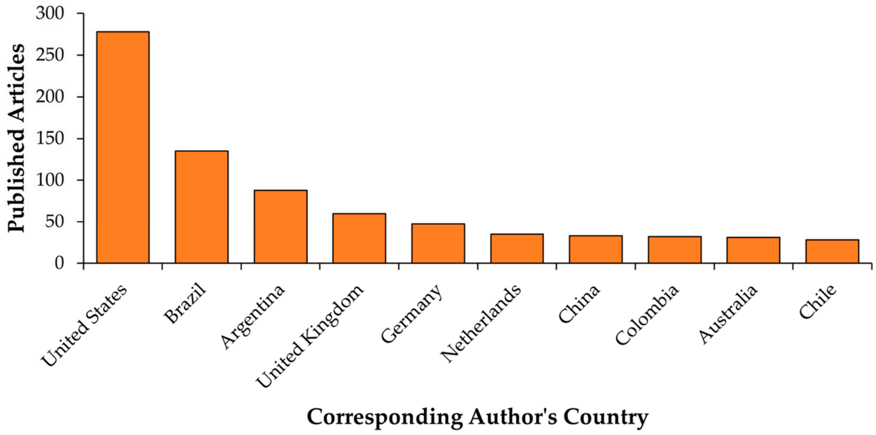

Figure 2. Countries of the top 10 corresponding authors of articles published between 1990 and 2022 after performing an advanced search with the terms "Fires" and "South America" in the Web of Science Core Collection database.

In a similar study also conducted in southern Ecuador, Maxwald et al. [9] identified the most reliable vegetation indices for post-fire vegetation monitoring, and analyzed vegetation recovery across different classes of fire severity. The authors concluded that the most reliable vegetation indices for monitoring post-fire vegetation recovery were the Leaf Chlorophyll Content Index (LCCI) and Normalized Difference Red-Edge and SWIR2 (NDRESWIR). They also observed that vegetation recovered to a great extent within the first year of the fire event's occurrence, because of the seasonal grass-species found in the study area. After one year, vegetation in the low- and moderate–high fire severity classes recovered to the pre-fire level. Fire severity was also assessed by Alarcon-Aguirre et al. [10] in Madre de Dios, southeast Peruvian Amazon, this time based on synthetic aperture radar (SAR) images. The authors developed algorithms to map fire severity based on change detection, concluding that Sentinel-1 cross-polarized (VH) data are suitable for detecting and quantifying fire severity.

A vegetation Index, in this case, the Normalized Difference Vegetation Index (NDVI), was employed by Maillard [11] to identify trends in the recovery of natural vegetation after wildfires in Bolivia over 20 years. The author found that more than half of the burned areas in Bolivia between 2001 and 2021 were in a continuous process of regeneration. However, a degradation process related to recurrent fires was identified in a few areas. A long time series (2000 to 2020) was also used by Bolaño-Díaz et al. [12] to spatially and temporally characterize the occurrence of fires in Colombia using Moderate Resolution Imaging Spectroradiometer (MODIS) active fire data. Inter-annual fire peaks were observed in 2004 and 2007, while the occurrence of fires was concentrated in the Orinoquia, Andean, and Caribbean regions. Seasonally, 87% of the active fires were identified in the dry season (December–March). This showed that fire activity varied strongly according to region and year over the period analyzed, with temperature representing an important driver of fires in Colombia. Another interesting study conducted by Bolaño-Díaz et al. [13] in Colombia analyzed the effect of forest fire events that occurred in Isla Salamanca Natural Park on air quality in the Northern part of the country. Particulate matter with concentrations less than 2.5 ($PM_{2.5}$) higher than the standard values established by the Colombian regulations were identified in the district of Barranquilla after two major fire events occurred in Isla Salamanca Natural Park.

Two important articles published in the abovementioned Special Issue were conducted in the Brazilian Amazonia. In recent years, fires, especially those related to deforestation [14], have been consolidated as a major threat to the standing forests in this region. Dutra et al. [15] assessed the spatial patterns of the burned areas in an emerging deforestation frontier located in the state of Amazonas (Southwestern Amazonia). The authors found a correlation between burned area and climate, land cover, private properties, and protected areas, and identified an increased deforestation trend on public land that led to an increase in fires from 66% to 84% in 2019. Moreover, decreasing rainfall and increasing temperature anomaly trends, especially during the dry season, increased the extent of annual natural vegetation affected by fires. Silva-Junior et al. [16] assessed forest fragmentation and forest fire dynamics in the state of Maranhão (Eastern Amazonia) by integrating active fires, burned area, land use and land cover, rainfall, and surface temperature datasets. Forest cover decreased by 31,302 km^2 between 1985 and 2017, with 63% of the loss concentrated in core forest areas. At the same time, the extent of forest edges was reduced by 38%, and isolated forest patch size increased by 239%. Between 2003 and 2017, forest fires impacted 60% of the total forest.

A novel analysis related to fires in Brazil was published by Inacio et al. [17], who employed a detrended cross-correlation analysis and a rolling window approach to understand the coupling between fires and economic growth-related variables (agricultural planted areas, ethanol production, rainfall in the Midwest region, and gross domestic product). The authors found a positive cross-correlation between the level of fires and agricultural planted area and ethanol production. Among other conclusions, they highlighted that fires have the potential to damage Brazilian economic growth in the short and long term.

This overview summarized the major findings of the nine articles published in the Special Issue "Vegetation Fires in South America". As these studies show, fires have been severely impacting South America, yet environmental changes related to the occurrence of fires in this region, which may impact global climate dynamics and change, carbon and water cycles, and biodiversity, are still undermined and poorly understood. Moreover, with most of the studies related to South America focusing on the biophysical characteristics of the fires themselves, or their environmental impacts, there are scientific gaps regarding the interaction of wildfires with food security; human displacement and health; gender; mental health; the loss of historical and culturally or religiously important places; the loss of and impacts on fauna, etc. These interactions represent reality for many of our ecosystems. In addition, the complexities of modern disasters compound their negative impacts, as demonstrated by the increase in fire-related air pollution during the COVID-19 crisis [18–20]. Many of these impacts and their chains are still invisible to scientists. This means that policies either do not consider them, or if they do, they may not be informed by local reality due to a lack of data. Therefore, the Special Issue "Vegetation Fires in South America" contributed to the development of a better understanding of the causes, consequences, and impacts of fires on the continent; however, more novel and high-quality research on this topic is still required.

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