ARTICLE

URBAN FIRE OUTBREAKS AND BIODIVERSITY: THE ROLE OF HABITAT SUITABILITY IN FIRE INCIDENCE ACROSS A TROPICAL METROPOLIS

TULACI BHAKTI

Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil
tulaci.faria.duarte@gmail.com

JOÃO CARLOS PENA

Araucaria Sustainability and Innovation Lab (LASI), Environmental Studies Center (CEA), São Paulo State University (UNESP), Rio Claro, São Paulo, Brazil

MARCOS RODRIGUES

Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil

Abstract: This study investigates the relationship between urban fire outbreaks and biodiversity in a tropical urban environment, using an index that assesses urban suitability for biodiversity. Analyzing 9,877 fire records from 2011 to 2020, we found that the highest frequency of fire outbreaks occurred in areas with intermediate suitability levels, typically peri-urban vegetated zones with limited law enforcement. In contrast, areas with the lowest biodiversity suitability exhibited the fewest incidents, likely due to stricter regulations and alternative land uses. Notably, regions with high biodiversity suitability showed double the frequency of fire occurrences compared to areas with lower suitability, suggesting significant human disturbances within preserved vegetation patches. Our findings indicate that urbanization correlates with increased fire risks, emphasizing the need for effective fire management strategies. Furthermore, this research highlights the critical need for public policies aimed at raising awareness of the ecological and health impacts of urban fire outbreaks. By linking fire outbreaks to urban biodiversity, this study underscores the importance of integrating environmental considerations into urban planning and management to mitigate adverse effects on both ecosystems and human populations.

Key-words: Urban ecology; Fire management; Habitat suitability; Environmental policy; Urban Biodiversity Suitability index.

INCÊNDIOS URBANOS E BIODIVERSIDADE: O PAPEL DA ADEQUAÇÃO DO HABITAT NA INCIDÊNCIA DE INCÊNDIOS EM UMA METRÓPOLE TROPICAL

Resumo: Este estudo investiga a relação entre incêndios urbanos e biodiversidade em um ambiente urbano tropical, utilizando um índice que avalia a adequabilidade urbana para a biodiversidade. Analisando 9.877 registros de incêndios entre 2011 e 2020, identificamos que a maior frequência de ocorrências foi registrada em áreas com níveis intermediários de adequabilidade, tipicamente zonas periurbanas vegetadas com fiscalização limitada. Em contraste, áreas com menor adequabilidade à biodiversidade apresentaram o menor número de incidentes, provavelmente devido a regulamentações mais rigorosas e usos alternativos do solo. Notavelmente, regiões com altos valores de adequabilidade à biodiversidade exibiram o dobro de ocorrências de incêndios em comparação às áreas de menor valor, sugerindo distúrbios humanos significativos em fragmentos vegetados preservados. Nossos resultados indicam que a urbanização está associada a maiores riscos de incêndios, destacando a necessidade de estratégias eficazes de manejo do fogo. Além disso, este estudo enfatiza a importância de políticas públicas voltadas para a conscientização sobre os impactos ecológicos e de saúde decorrentes de incêndios urbanos. Ao relacionar as ocorrências de incêndios à biodiversidade urbana, o trabalho reforça a relevância de integrar considerações ambientais no planejamento e na gestão urbana para mitigar os efeitos adversos nos ecossistemas e nas populações humanas.

Key words: Ecologia urbana; Manejo do fogo; Adequabilidade de habitats; Política ambiental; Índice de Adequabilidade para a Biodiversidade Urbana

Introduction

Fire outbreaks and their impact on biodiversity are normally associated with wild areas (Silveira et al., 2016; Durán-Medraño et al., 2017). These events, best known as wildfires, occur almost annually, and their frequencies are prospectively increasing worldwide due to climate change (Pausas & Keeley, 2021). In addition, there is a direct impact on biodiversity, with a significant reduction of vegetation (Pivello et al., 2021; Tyukavina et al., 2022), leading to habitat loss for fauna, as well as severe damage to human populations, especially those living near or in rural areas (Chas-Amil et al., 2013; Salvati & Ferrara, 2014).

Nevertheless, fire outbreaks can also affect both people and biodiversity in urban environments, either directly (when occurring within or near urban landscapes) or indirectly (when occurring in surrounding landscapes) (Kotze et al., 2022; Cobbinah et al., 2023). Many studies have explored the consequences of fire outbreaks in urban environments, focusing on phenomena like smog, with an emphasis on human health and the destruction of infrastructure (MacLeod et al., 2019; Calkin et al., 2023). However, the effects of urban fire outbreaks on urban biodiversity remain underexplored. It has already been demonstrated that fires impact habitat quality for birds and the natural regeneration processes mediated by them (Lindenmayer et al., 2008; Stojanovic et al., 2016). Additionally, the impacts of fire-related air pollution on urban wildlife behavior have been addressed, as they can affect both animal movement and vocalization (Sanderfoot et al., 2021).

To efficiently address the occurrence of fire outbreaks in cities, it is important to investigate whether these fires are influenced by the environmental and spatial characteristics of urban landscapes. Within cities, fire outbreaks may be linked to human conflicts, particularly in regions of interest for real estate development (Chas-Amil et al., 2013; Salvati & Ranalli, 2015). There is also a direct association between urban growth and the occurrence of fires, as cities expand into vegetated areas, affecting both the structure of the vegetation (Hubert et al., 2023; Schug et al., 2023) and urban biodiversity (Chang & Lee, 2016; Stojanovic et al., 2016).

Investigations focused on urban environments have gained significant importance, whether due to continuous urban growth and the associated increase in population in these areas (United Nations, 2018), or because of the high biodiversity found in urban environments (Bhakti et al., 2024). Moreover, monitoring fire outbreaks at this scale is more challenging compared to wildfires in large forested areas, which can be tracked using various satellite systems (MapBiomas, 2024). Assessing urban fires is also a way to highlight the impact they can have on both biodiversity as a whole and human populations, emphasizing the need for public policies with this focus.

Assumed the potential for urban fire outbreaks to strongly impact biodiversity, and the fact that fire occurrences are influenced by urban landscape characteristics, this study aims to assess how spatial characteristics related to bird habitat suitability in a large metropolis may influence the occurrence of urban fire outbreaks. To do this, we used the Urban Biodiversity Suitability (UBS) index developed by Bhakti et al. (2024), which is based on a knowledge-driven approach incorporating four landscape attributes: human accessibility, soundscape, built artifacts and volume, and land cover. The UBS index is particularly useful for identifying urban areas that, despite human presence, offer environmental conditions favorable for sustaining biodiversity. In a previous assessment, regions with high UBS index values were characterized by a high amount of vegetation — especially woody cover — reduced noise exposure, and lower levels of accessibility and built artifacts (Bhakti et al., 2024). Thus, the goal of this study was to evaluate whether the UBS index can also describe urban vegetated areas that are at higher risk for fire outbreaks, based on the geospatial characteristics of Belo Horizonte (Minas Gerais, Brazil). As fire outbreaks in cities are often linked to peri-urban areas undergoing expansion (Schug et al., 2023), we hypothesize that fires are more likely to occur in regions with intermediate to high biodiversity suitability levels according to the UBS index.

Methods

Study area

We conducted our study within the municipality of Belo Horizonte, State of Minas Gerais, Brazil (-19.899152, -43.955470), characterized by a predominantly urbanized landscape and lower population density in peri-urban regions (Belo Horizonte, 2019). The climate is divided between a dry and cool season from April to September, and a rainy and humid season from October to March (Alvares et al., 2013). The municipality is situated within the ecotone of two biodiversity hotspots, the Atlantic Forest and Cerrado (Myers et al., 2000), and contains around 100 protected areas, as well as other green spaces in peri-urban zones (Xavier, 2018; Bhakti et al., 2024).

We selected Belo Horizonte as our case study because it is the same city for which the

UBS Index was developed. Additionally, a recent study indicated that the majority of air pollution in this region is attributable to fire outbreaks (Sobrinho et al., 2024), highlighting the need for further investigation into the spatial distribution of these occurrences. Furthermore, the municipality has experienced a high incidence of fires during recent dry seasons, with smoke completely covering the territory (Haddad, 2024). This point was crucial in our search for local data, particularly from public agencies that deal directly with fire prevention and response in urban areas. In this way, we obtained more accurate data for the urban scale, which we believe can have a greater impact and be applicable as a return of the research to public policies.

Urban Biodiversity Suitability index - UBS

The UBS index was developed with the aim of identifying urban areas with greater suitability for biodiversity (Bhakti et al., 2024). To achieve this, it combined four geospatial layers: human accessibility, soundscape, built artifacts and volume, and land cover. All these layers represent different ways to characterize urban structure, indicating locations with lower accessibility, less noise and built volume, as well as higher vegetation cover. To validate the UBS index, it was used bird data collected in 120 survey sites distributed throughout Belo Horizonte landscape. As a result, it was found that locations with higher UBS values also exhibited greater bird taxonomic and functional diversities, indicating a positive relationship between the environmental and landscape quality indicated by the UBS index and biodiversity (Bhakti et al., 2024). Although the UBS index can be extrapolated to various urban biodiversity groups, it is important to highlight that its validation was based on birds. Therefore, it is recommended that the use of its results take this limitation into account, and that other fauna groups be used to broaden the understanding of the relationship between biodiversity and urban data.

Fire outbreak data and analyses

To assess the relationships between the suitability levels of the UBS Index and the occurrence of urban fire outbreaks, we used data from 9,877 records collected between 2011 and 2020. These records were obtained as a point feature map from the Minas Gerais State Fire Department within the municipality of Belo Horizonte (https://www.bombeiros.mg.gov.br/) (Fig. 1A). These records represent occurrences of fire outbreaks in urban vegetation, including vacant lots, public and private green spaces, brownfields, and protected areas. The full dataset is available in Supplementary Material (see Bhakti, 2025).

We built a histogram to assess the distribution of the frequencies of fire outbreak records according with the five classes representing the levels of the UBS Index, 1 being the lowest and 5 the highest suitability levels (Fig. 1B). Additionally, we conducted a chi-square test to determine if there was a significant association between the occurrence

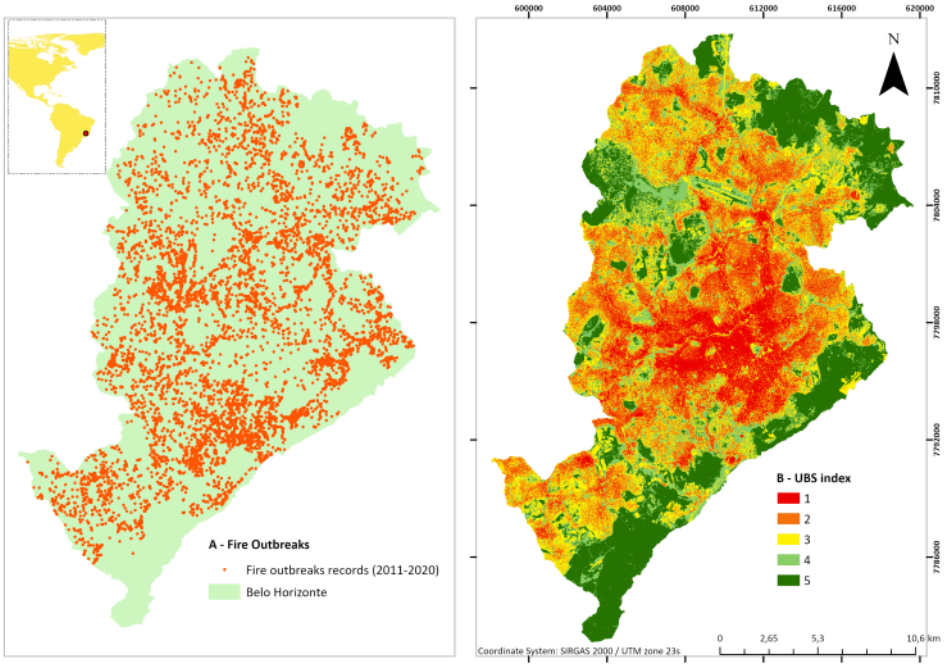

Fig 1. (A) Records of fire outbreaks in urban vegetation in the Belo Horizonte municipality (Minas Gerais, Brazil) during the period from 2011 to 2020. (B) Urban Biodiversity Suitability index (UBS): 1 being the lowest and 5 the highest suitability levels.

of fires and the UBS classes. This test allowed us to evaluate whether the observed frequencies of fires in the different classes were significantly different from the expected frequencies, providing a deeper understanding of the potential interactions between urbanization and biodiversity in the Belo Horizonte region.

Results

According with our expectations, most of the fire outbreak records occurred at intermediate levels (UBS: 2, 3 and 4 - 7,489 records), followed by high levels of suitability (UBS: 5 -1580 records) and the areas with the lowest suitability values were those with the lowest frequency of records (UBS: 1 - 806). Therefore, the regions with the lowest UBS Index values, i.e. with a higher degree of urbanization, presented the lowest frequency of fire outbreak records. (Fig. 2).

We found a significant association between the occurrence of fire outbreak records and the classes of the Urban Biodiversity Suitability Index (UBS) ($\chi^2 = 1251.6$, df = 4, $p < 2.2e\text{-}16$). The expected frequencies for each class were approximately 1975.4. UBS 1 and 5 showed an occurrence of fires below what was expected, while classes 2, 3, and 4 exhibited a higher incidence, indicating that areas with intermediate levels of suitability for biodiversity are associated with a higher number of fire outbreak in urban vegetation (Fig. 2).

Discussion

The UBS Index can describe patterns of fire outbreaks across an urban landscape: the highest frequency of records occurred at intermediate suitability levels. They mainly represent peri-urban vegetated areas, where law enforcement is probably limited, typically located near large vegetated zones yet distant from densely populated areas. In contrast, vegetated areas with the lowest biodiversity suitability levels exhibited the lowest frequency of fire outbreaks, likely due to small vacant lots and brownfields situated in the most urbanized areas, where law enforcement is presumably stricter, and alternative land uses (such as cattle ranching and agriculture) are limited. Conversely, areas with the highest biodiversity suitability showed double the frequency of outbreaks, indicating human disturbances within native and preserved vegetation patches. This pattern was only highlighted due to the utilization of long-term data collected over

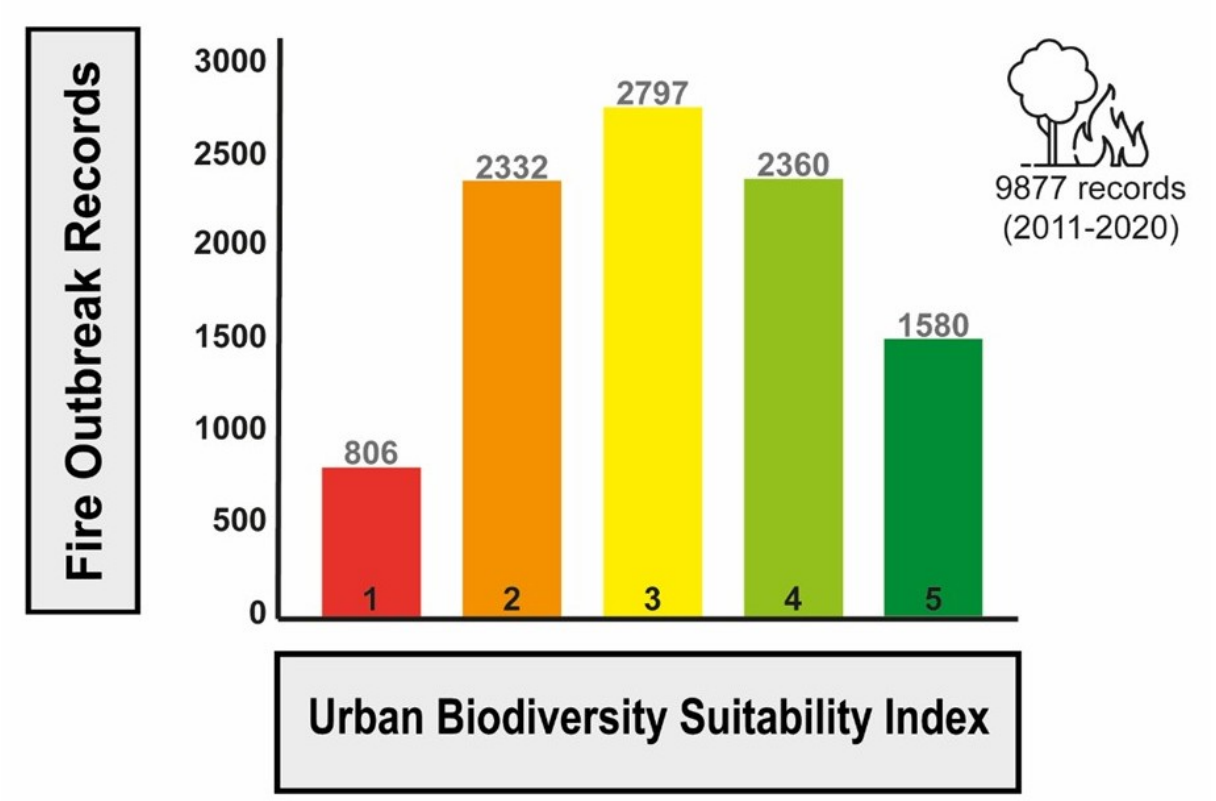

Fig. 2. Histogram frequency of fire outbreaks according to the suitability levels described by the Urban Biodiversity Suitability Index (UBS: 1 to 5) developed for Belo Horizonte (Minas Gerais, Brazil).

nearly 10 years. Such data allow for a better assessment of impacts and the establishment of patterns for the sampled area, as well as for spatial and temporal variables (Bispo et al., 2023). Although the UBS Index effectively describes these spatial patterns, it is important to acknowledge that areas with the same UBS classification value (1 to 5) may still present relevant ecological differences, such as variation in vegetation structure, land use types, and conservation status. This is expected, considering that each index value reflects a combination of multiple urban and environmental layers. Therefore, while similar UBS values indicate comparable levels of overall suitability for biodiversity, they do not imply ecological uniformity at finer scales. Rather, they reflect composite patterns of human accessibility, noise levels, built structure density, and vegetation cover, which together influence habitat suitability across heterogeneous urban landscapes.

Despite the important role of fire outbreaks in modulating habitat quality and availability for biodiversity (Haugaasen et al., 2003), they can facilitate the spread of exotic species across natural areas (Rossi et al., 2014), as well as lead to changes in the vegetation structure (Silveira et al., 2016; Pivello et al., 2021), which can directly affect biodiversity, including habitat for some bird species (Stojanovic et al., 2016). Thus, our findings highlight a worrisome pattern that urban areas that harbor intermediate to high levels of suitability for urban biodiversity also concentrates most of the fire outbreak records across this urban landscape.

Relating the occurrence of these fire outbreaks to urbanization is a starting point for assessing their impacts on biodiversity (Hubert et al., 2023). With the expansion of built surfaces in cities, there is also greater access to more isolated green areas (such as peri-urban areas), which implies an increase in the probability of occurrence of fires. These areas are not only spatial transition zones but also harbor distinct ecological features. In particular, they often differ from other urban sectors in terms of vegetation structure and bird species composition, with birds responding to subtle gradients of habitat quality and landscape configuration (MacGregor-Fors, 2010). Our findings reinforce this ecological distinction, as the high incidence of fire outbreaks in these areas reveals a convergence of biodiversity relevance and human pressure. This relationship can be associated with the use of fire as a management practice to prepare new areas for urban expansion, especially grassland and open habitat vegetation patches (Barger et al., 2003). Those areas are more easily occupied due to the lower above ground biomass than forest patches (Bhakti et al., 2020). Additionally, fire is used not only to facilitate urban expansion but also as a form to prepare the soil for agriculture, although considered as an environmental crime in Brazil (Brasil, 1998). Such practice can cause the spread of flames to various green spaces, including protected areas (Rezende, 2023), causing health problems due to smoke, affecting biodiversity, and increasing public spending on firefighting (CBMMG, 2023). Therefore, regions with intermediate levels of the UBS Index and with high frequency of fire outbreaks may receive special attention for surveillance and environmental education programs, increasing the awareness of the human population about impacts of the use of fires not only on biodiversity, but also on human health and well-being (e.g., air pollution, respiratory issues, property damage). The continuous changes caused by fire outbreaks and the lack of campaigns or management actions by stakeholders can result in ecological impacts and a reduction in the ecosystem services that urban vegetation provides for the human population (Cobbinah et al., 2023).

Given the complex issue of fires, it must be viewed through the lens of political decisions (Pivello et al., 2021), requiring actions related to the development of laws and effective enforcement by executive authorities. To illustrate, in 2024, Brazil experienced a record number of fires, with smoke and its effects felt across the country (Castro, 2024; MapBiomas, 2024; Sinimbú, 2024). This was also true for the municipality of Belo Horizonte, where this study was conducted (Fig. 3), with urban areas in Minas Gerais alone recording more than 25,000 fire occurrences (Ferreira, 2024). Although the UBS index is biased towards bird occurrence, and other taxonomic groups are important to fully understand the relationship with fire outbreaks, this highlights the urgent need for preventative measures. Therefore, it is essential to use long-term data in comparison with urban biodiversity assessment indices in these new times.

Finally, we would like to conclude this study with the following recommendations:

- We reinforce the need for further studies that relates urban fire outbreaks and the occurrence of biodiversity in cities, since urban landscapes are important refuges for native flora and fauna (Rega-Brodsky et al., 2022).
- Second, the approach we adopted in this study can be considered as a form of integrated management of urban green spaces. By relating the occurrence of fire outbreaks with vegetated areas with specific spatial characteristics, it is possible to investigate people motivations for the use of fire, as well as assist in the formulation of public policies

Fig. 3. Examples of scenarios involving urban fires in the municipality of Belo Horizonte (Minas Gerais, Brazil) during the dry season of 2024.

aiming at reducing the occurrence of fire outbreaks and their impacts on urban biodiversity and human health.

Acknowledgement

TB received scholarships from the Coordination of Superior Level Staff Improvement (CAPES process: 88887.364396/2019-00) and thanks to Fundo Brasileiro para a Biodiversidade (FUNBIO / Humanize) and Idea Wild for their support. JCP was supported by FAPESP (Processes #2018/00107-3; 2021/10195-0). The authors thanks Minas Gerais State Fire Department for providing the fire outbreaks data of Belo Horizonte (CBMMG).

References

Alvares, C. A., J. L. Stape, P. C. Sentelhas, J. L. de M. Gonsalves & G. Sparovek. 2013. Köppen's climate classification map for Brazil. Meteorol. Zeitschrift 22: 711–728. DOI: https://doi.org/10.1127/0941-2948/2013/0507

Barger, N. N., C. M. D'Antonio, T. Ghneim & E. Cuevas. 2003. Constraints to colonization and growth of the African grass, Melinis minutiflora, in a Venezuelan savanna. Plant Ecol. 167: 31–43. DOI: https://doi.org/10.1023/A:1023903901286

Belo Horizonte. 2019. Plano Diretor do Município de Belo Horizonte - Lei no 11.181. Lei no 11.181.

Bhakti, T. 2025. Supplementary Material I - Data for: "Urban fire outbreaks and biodiversity: The role of habitat suitability in fire incidence across a tropical metropolis [Data set]. In Rev. Biol. Neotrop. / J. Neotrop. Biol. 22(2): 60–68. Zenodo. DOI: https://doi.org/10.5281/zenodo.17426192

Bhakti, T., J. C. Pena, A. C. M. Moura, D. Pujoni, L. Saliba & M. Rodrigues. 2024. Urban biodiversity suitability index: decoding the relationships between cities and birds. Urban Ecosyst. 27: 305–319. DOI: https://doi.org/10.1007/s11252-023-01446-5

Bhakti, T., J. C. Pena & M. Rodrigues. 2020. Unplanned urban growth and its potential impacts on bird species in a South American city. Floram 27: e20190111. DOI: https://doi.org/10.1590/2179-8087.011119

Bispo, R., F. J. Marques, A. Penha, P. Espadinha-Cruz & A. Grilo. 2023. A decade of urban fires: Portuguese events between 2013 and 2022. Sci. Data 10: 569. DOI: https://doi.org/10.1038/s41597-023-02476-6

Brasil. 1998. Lei no 9.605, de 12 de fevereiro de 1998 - Dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente, e dá outras providências.

Calkin, D. E., K. Barrett, J. D. Cohen, M. A. Finney, S. J. Pyne & S. L. Quarles. 2023. Wildland-urban fire disasters aren't actually a wildfire problem. Proceedings of the Natl. Acad. Sci. U. S. A. 120: e2315797120. DOI: https://doi.org/10.1073/PNAS.2315797120/ASSET/4C179F59-62CB-4050-B08E-F7F6A46EC9CA/ASSETS/IMAGES/LARGE/PNAS.2315797120FIG01.JPG

Castro, G. 2024. Nasa flagra imagens de fumaça de incêndios sobre o Brasil. CNN Brasil - Estadão Conteúdo.

CBMMG. 2023. Período chuvoso nem acabou, mas incêndios em lotes vagos já começaram. Corpo de Bombeiros Militar de Minas Gerais.

Chang, H. Y. & Y. F. Lee. 2016. Effects of area size, heterogeneity, isolation, and disturbances on urban park avifauna in a highly populated tropical city. Urban Ecosyst. 19: 257–274. DOI: https://-doi.org/10.1007/s11252-015-0481-5

Chas-Amil, M. L., J. Touza & E. García-Martínez. 2013. Forest fires in the wildland-urban interface: A spatial analysis of forest fragmentation and human impacts. Appl. Geogr. 43: 127–137. DOI: https://doi.org/10.1016/j.apge-og.2013.06.010

Cobbinah, P. B., M. O. Asibey & A. Dela Azumah. 2023. Urban forest and the question of planning-sustainability inadequacy. Cities 140: 104453. DOI: https://doi.org/10.1016/j.citi-es.2023.104453

Durán-Medraño, R., E. Varela, D. Garza-Gil, A. Prada, M. X. Vázquez & M. Soliño. 2017. Valuation of terrestrial and marine biodiversity losses caused by forest wildfires. J. Behav. Exp. Econ. 71: 88–95. DOI: https://doi.org/10.1016/j.so-cec.2017.10.001

Ferreira, A. C. 2024. Queimadas em áreas urbanas ultrapassam 25 mil ocorrências em Minas Gerais em 2024. G1.

Haddad, B. 2024. BH está com céu encoberto por fumaça devido à névoa seca causada por incêndios e baixa umidade do ar. Hoje em Dia.

Haugaasen, T., J. Barlow & C. A. Peres. 2003. Effects of surface fires on understorey insectivorous birds and terrestrial arthropods in central Brazilian Amazonia. Anim. Conserv. 6: 299–306. DOI: https://doi.org/10.1017/S1367943003003366

Hubert, M. M., J. A. Schweitzer, X. Giam & M. Papeş. 2023. Contrasting effects of urbanization and fire on understory plant communities in the natural and wildland–urban interface. Ecosphere 14: 1–17. DOI: https://doi.org/10.1002/ecs2.4520

Kotze, D. Johan, E. C. Lowe, J. S. MacIvor, A. Ossola, B. A. Norton, D. F. Hochuli, L. Mata, M. Moretti, S. A. Gagné, I. T. Handa, T. M. Jones, C. G. Threlfall & A. K. Hahs. 2022. Urban forest invertebrates: how they shape and respond to the urban environment. Urban Ecosyst. 25: 1589–1609. DOI: https://doi.org/10.1007/s11252-022-01240-9

Lindenmayer, D. B., J. T. Wood, R. B. Cunningham, C. Macgregor, M. Crane, D. Michael, R. Montague-Drake, D. Brown, R. Muntz & A. M. Gill. 2008. Testing hypotheses associated with bird responses to wildfire. Ecol. Appl. 18: 1967–1983. DOI: https://doi.org/10.1890/07-1943.1Macleod, T. A., A. K. Hahs & T. D. Penman. 2019. Balancing fire risk and human thermal comfort in fire-prone urban landscapes. PLoS ONE 14: e0225981. DOI: https://doi.org/10.1371/-journal.pone.0225981

MacGregor-Fors, I. 2010. How to measure the urban-wildland ecotone: Redefining 'peri-urban' areas. Ecological Research 25: 883–887. DOI: https://doi.org/10.1007/s11284-010-0717-z

Mapbiomas. 2024. Agosto responde por quase metade da área queimada no Brasil em 2024.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. Da Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858. DOI: https://doi.org/10.1590/2179-8087.011119

Pausas, J. G. & J. E. Keeley. 2021. Wildfires and global change. Front. Ecol. Environ. 19: 387–395. DOI: https://doi.org/10.1002/fee.2359

Pivello, V. R., I. Vieira, A. V. Christianini, D. B. Ribeiro, L. da S. Menezes, C. N. Berlinck, F. P. L. Melo, J. A. Marengo, C. G. Tornquist, W. M. Tomas & G. E. Overbeck. Understanding Brazil's catastrophic fires: Causes, consequences and policy needed to prevent future tragedies. Perspect. Ecol. Conserv. 19: 233–255. DOI: https://doi.org/10.1016/J.PECON.2021.06.005

Rega-Brodsky C. C., M. F. J. Aronson, M. R. Piana, E. S. Carpenter, A. K. Hahs, A. Herrera-Montes, S. Knapp, D. J. Kotze, C. A. Lepczyk, M. Moretti, A. B. Salisbury, N. S. G. Williams, K. Jung, M. Katti, I. MacGregor-Fors, J. S. MacIvor, F. A. La Sorte, V. Sheel, C. G. Threlfall & C. H. Nilon. 2022. Urban biodiversity: State of the science and future directions. Urban Ecosyst. 25: 1083–1096. DOI: https://doi.org/10.1007/s11252-022-01207-wRezende, G. 2023. Vídeo: incêndios atingem Serra do Curral e lote vago no Belvedere, em BH. O Tempo - Cidades.

Rossi, R. D., C. R. Martins, P. L. Viana, E. L. Rodrigues & J. E. C. Figueira. 2014. Impact of invasion by molasses grass (Melinis minutiflora P. Beauv.) on native species and on fires in areas of campo-cerrado in Brazil. Acta Bot. Brasilica 28: 631–637. DOI: https://doi.org/10.1590/0102-33062014ABB3390

Salvati, L. & A. Ferrara. 2014. Do land cover changes shape sensitivity to forest fires in peri-urban areas? Urban For. Urban Green. 13: 571–575. DOI: https://doi.org/10.1016/j.ufug.2014.03.004

Salvati, L. & F. Ranalli. 2015. "Land of Fires": Urban growth, economic crisis, and forest fires in Attica, Greece. Geogr. Res. 53: 68–80. DOI: https://doi.org/10.1111/1745-5871.12093

Sanderfoot, O. V., S. B. Bassing, J. L. Brusa, R. L. Emmet, S. J. Gillman, K. Swift & B. Gardner. 2021. A review of the effects of wildfire smoke on the health and behavior of wildlife. Environ. Int. 151: 106418. DOI: https://doi.org/10.1016/j.envint.2021.106418

Schug, F., A. Bar-Massada, A. R. Carlson, H. Cox, T. J. Hawbaker, D. Helmers, P. Hostert, D. Kaim, N. K. Kasraee, S. Martinuzzi, M. H. Mockrin, K. A. Pfoch & V. C. Radeloff. 2023. The global wildland–urban interface. Nature. DOI: https://doi.org/10.1038/s41586-023-06320-0

Silveira, J. M., J. Louzada, J. Barlow, R. Andrade, L. Mestre, R. Solar, S. Lacau & M. A. Cochrane. 2016. A Multi-Taxa Assessment of Biodiversity Change After Single and Recurrent Wildfires in a Brazilian Amazon Forest. Biotropica 48: 170–180. DOI: https://doi.org/10.1111/btp.12267

Sinimbú, F. 2024. Fumaça de queimadas atinge cidades de dez estados. Agência Brasil.

Sobrinho, O. M., L. D. Martins, R. Pedruzzi, W. Vizuete & T. T. de A. Albuquerque. 2024. From mining to fire outbreaks: The relative impact of pollutants sources on air quality in the metropolitan area of Belo Horizonte. Atmos. Pollut. Res. 15: 102118. DOI: https://doi.org/10.1016/j.apr.2024.102118

Stojanovic, D., J. Webb Nee Voogdt, M. Webb, H. Cook & R. Heinsohn. 2016. Loss of habitat for a secondary cavity nesting bird after wildfire. For. Ecol. Manage. 360: 235–241. DOI: https://-doi.org/10.1016/J.FORECO.2015.10.040

Tyukavina, A., P. Potapov, M. C. Hansen, A. H. Pickens, S. V. Stehman, S. Turubanova, D. Parker, V. Zalles, A. Lima, I. Kommareddy, X. P. Song, L. Wang & N. Harris. 2022. Global trends of forest loss due to fire from 2001 to 2019. Front. Remote Sens. 3: 825190. DOI: https://doi.org/10.3389/fr-sen.2022.825190

United Nations. 2018. World Urbanization Prospects: The 2018 Revision. Department of Economic and Social Affairs, Population Division.

Xavier, E. R. S. 2018. Áreas Protegidas urbanas e conservação de um ecótone Cerrado-Mata Atlântica. Belo Horizonte: Universidade Federal de Minas Gerais. DOI: https://doi.org/10.13140/RG.2.2.11607.32169

Editor Científico/ Scientific Editor: Pablo Cuevas-Reyes, Universidad Michoacana de San Nicolás de Hidalgo, Morélia, Mexico
Recebido / Recibido / Received: 23.12.2024
Revisado / Revised: 12.02.2025
Aceito / Aceptado /Accepted: 20.05.2025
Publicado / Published: 24.10.2025
DOI:10.5216/rbn.v22i2.81332
Dados disponíveis / Datos disponibles / Available data: Repository not informed