Impact of Wildfires on Ecosystems and Wildlife

Subjects: Environmental Sciences

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Wildfires are common occurrences worldwide that can destroy vast forest areas and kill numerous animals in a few hours. The researchers describe how the different species are expected to behave during a wildfire and the impacts on the ecosystem.

mortality burns conservation wildfire wildlife

1. Introduction

Wildfires are common occurrences worldwide, defined as destructive and unregulated fires in rural areas on vegetation spots (e.g., forests, savannas, grasslands) [1]. Climate change, rising global temperatures, less precipitation, the introduction of exotic species of plants that consume an excessive quantity of water (e.g., eucalyptus), heavy agriculture, and deforestation play an active role in increasing the number of fires and their intensity and destructive power [2]. In addition, environmental conditions influence the prevalence and severity of fires, which in some cases, lengthens the fire season and widens burn areas [1]. Wildfires can originate from numerous natural sources or are caused by humans [1]. Lightning, dryness, or volcanic eruptions are the leading causes of forest fires. Human-caused wildfires can be caused by accidents, such as campfires, cigarettes, burning debris, electrical shocks, equipment breakdowns, fireworks, etc. [1]. Moreover, power lines are a source of some devastating forest fires. Some of these fires can occur due to the interaction between wild animals and power lines, especially birds, such as diurnal raptors, *Corvidae*, and nocturnal raptors. In a study carried out in Spain between 2000 and 2012, of the 2788 wildfires caused by power lines, 30 were fauna-mediated. These fires destroyed 9.06 hectares of vegetation [3].

In some instances, forest fires may be caused by arson. An example occurred in Brazil and is known as “Fire Day”. On 10 August 2019, numerous rural producers in the country’s northern region started a joint movement to set fire to several areas of the Amazon rainforest to create pasture areas [4]. The presence of wind, organic matter, dry soil, and low humidity have accelerated the onset of a rapidly spreading wildfire that becomes difficult to control and extinguish [1].

The economic problems and losses experienced by domestic, wild, and human animals are significant consequences of fires [1]. However, in some regions, for millennia, forest fires have become a natural element of the ecosystem (e.g., Australia, North America), and wild species have a long relationship with them, at times, with benefits [1]. Savannahs, grasslands, pine forests, and Mediterranean scrubland are ecosystems that benefit from

small-scale wildfires throughout the year [5][6][7]. Fires can help regenerate plants, increase biomass, decrease the irregularity of the habitat, increase significant diversity of food fonts, increase the production of seeds, and increase the nutritional value of plants [8]. As predators and scavengers, certain animals also benefit from forest fires [9].

Wildfires not only affect animals and the ecosystem, but they also have long-term and short-term socioeconomic impacts. Property loss (e.g., infrastructures, cars, agriculture fields, fabrics) is one of the wildfires' immediate economic impacts [10]. The loss of property is accompanied by the displacement of people from their homes, the decimation of businesses, and the substantial effects on insurers [11]. Moreover, forest fires impact tourism, as they can erase outdoor spaces that attract tourists and drive them away for years. They also negatively affect hospitality, restaurants, and other industries [12][13]. Air quality is a major risk associated with forest fires. Around eight billion tons of CO_2 have been emitted per year in the least the past two decades. For example, in 2015, wildfire smoke in Palangkaraya, Indonesia, increased the air quality index to 2000. It has resulted in 500,000 severe respiratory infections and an estimated 100,000 premature deaths. Water quality may also be affected, an issue that can last months or years [14]. From 2000 to 2012, the cost of forest fires in the Mediterranean region was estimated at approximately 7.6–12.4 million euros due to repairs, loss of biodiversity, and CO_2 emissions [3].

Numerous studies focus on the impacts of wildfires on ecosystems, flora, domestic animals, and humans. Nevertheless, regarding wildlife, little is still known. Currently, there is no accurate assessment of the number of animals that die each year in fires. This is due to the absence of precise numbers of wild populations in the years previous to the fire and to the difficulty of quantifying post-fire mortality because bodies are often scorched (e.g., species like amphibians and insects are too small to be counted) [9]. Furthermore, post-fire counts are rarely conducted, and it is difficult to determine if the animals died or migrated in response to the fire. Even though wildfires are a common and recurrent problem worldwide, most of the time, they are a neglected issue, especially regarding wildlife. The information is scarce, dispersed by several bibliographical references, and not easily accessible. In addition, veterinaries, biologists, NGOs, firefighters, and volunteers often need to be trained to act correctly.

Most animals can detect forest fires and identify the hazards associated with them. However, according to size and species, they have different defense mechanisms (**Figure 1**). Some of them run, while others can seek refuge underground or in the water. Some species may even profit from confusion and hunt small prey as they try to escape the fire [15].

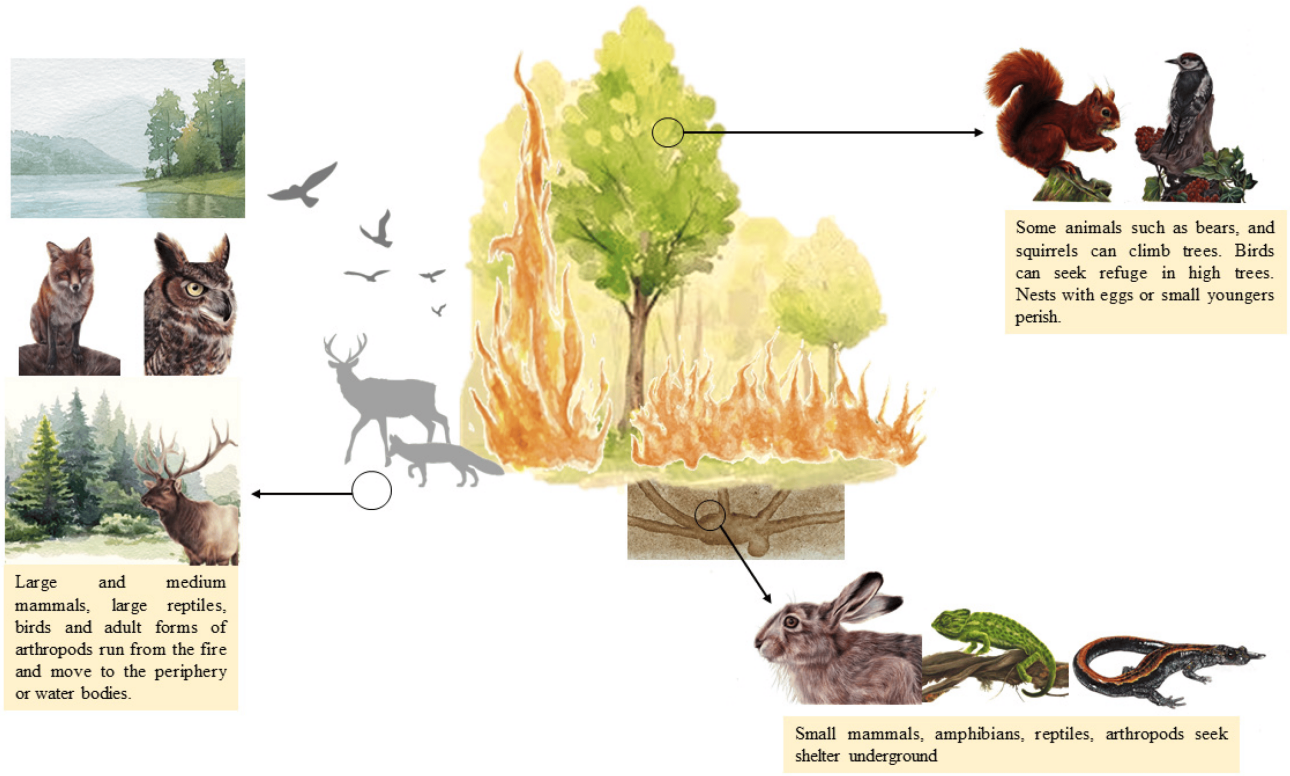

Figure 1. A conceptual model illustrating animal responses to wildfire (Illustrations: Andreia Gracês).

- *Mammals*

The ability of mammals to survive fire will depend on their mobility, size, velocity, and duration of the fire [16]. Larger animals, such as deer, wolves, or wild boars, are highly mobile. They run from the fire and move to the periphery [17][18], and some can even swim along rivers. Some animals, such as bears and squirrels, can climb trees [9]. Small mammal species also can run from the fire in groups to clearings, road cuts, depressions, and hiking trails [18][19]. However, most small mammals, such as mice and rabbits, tend to seek refuge underground or in sheltered places within the burn, such as underground tunnels, stumps, root holes, pathways under moist forest litter, and spaces under a rock, talus, and sizeable dead wood [18].

- *Birds*

Birds fly from fire zones to others, except for eggs and very young birds [8]. However, the species that fly at a lower altitude can be affected by smoke inhalation [20].

- *Amphibians and Reptiles*

Larger, more mobile reptiles usually run from the fire [9][21], while smaller reptiles and amphibians have limited capacity to escape. Small lizards, turtles, and frogs seek refuge underground in holes or burrows [22]. Amphibians that live near aquatic areas can also seek shelter in water bodies [9].

- *Aquatic animals*

Aquatic animals can be better protected from forest fires while living in large bodies of water. However, they have limited mobility, except for those living in running water like rivers. During a wildfire, due to the high temperatures, water can exceed the lethal limits of temperatures and vapor temperature, leading to severe heat damage [23]. This will lead to other phenomena, such as changes in pH, turbidity, accumulation of toxins [24], and excessive sedimentation affecting aquatic fauna [25][26][27]. Excessive sediments, such as ashes or organic debris, can squeeze or displace fish eggs in the bottom of the water bodies [28].

- *Invertebrates*

Eggs, nymphs, and adult stages of arthropods may be affected due to the heat of the flames, and species with immobile life stages that live in surface litter or aboveground plant tissue usually perish [29]. Some adults burrow or fly out of flames [9][29].

2. Impact on Ecosystems and Wildlife

The consequences of wildfires in the ecosystem are diverse. There is a tremendous loss of fauna and flora. Habitat becomes simple and poor due to reduced diversity [30]. Shrubs and grass replace forests. Loss of forest cover results in higher temperatures in the forest soil, which can affect plant growth and animal behavior. Increased temperatures impact cavity-nesting species, such as birds and small mammals. Dead trees produce extreme temperatures in nest cavities, affecting egg incubation and the survival of heat-sensitive young birds and mammals [31].

The adverse effects of forest fires are directly related to animal injury and the destruction of nesting and breeding areas, shelters, and food sources [1][15][32]. Although some animals can be used for the occurrence of wildfires, they suffer stress. However, there are not enough studies on stress's short- and long-term effects [9]. Typically, the most affected are the slower-moving species, like turtles, badgers, and elderly and very young animals who are unable to escape [15]. Moreover, as wildfires often occur in late spring or summer, stress also delays the recovery and reproduction of the population [9].

In 2020, 78% of the total area of the jaguar territory in Pantanal (Brazil) was burned. The high number of fires that year and prior years had a negative impact on jaguar populations. The main effects observed were temporary displacements, which made it difficult to find new suitable areas, increased territorial conflicts, and decreased survival and reproductive success. In addition, many animals have suffered from starvation, dehydration, and death, further contributing to the decline of the already threatened population of jaguars in Pantanal [33]. The animals that abandoned the area to escape the fire may return, depending on how much the fire altered the habitat structure and food supply [8]. Non-burrowing mammals, reptiles, and birds may return within hours or days [8]. After a fire, when animals return to the burned area, they inspect the environment to determine settlement options [9]. Although some animals can return to take advantage of the new habitat and adapt their diet and behavior, others

cannot survive and migrate to other areas. If the habitat does not provide the structure or food necessary for survival and reproduction, they move to fire-free areas, unburnt islands, or nearby unburnt vegetation [9][34]. For example, large mammals such as deer or moose depend on a significant amount of vegetation for their diet, bedding, shelter, and thermal protection [9]. As a result, many animals die after the fire from starvation. Other animals can wander into urban and suburban areas in search of new habitats where they come into contact with humans [15].

Animals are not equally affected by stress factors following a fire. The magnitude and duration of the fire, type of vegetation, climate, smoke, and water bodies are some factors that will determine the impact on animals. Another aspect to consider is associated with the animal, such as species, physical condition, age, physiological status, response to stress, availability of food or water, or injuries (e.g., burns or smoke inhalation). Therefore, it is necessary to account for various nuances in animals and fireplaces that determine the susceptibility to illness after a fire [32]. The migration of animals to new regions is associated with pathogens (e.g., viruses, parasites) spreading or with the acquisition of new pathogens in the newly explored areas [35]. Increased contact of wildlife with people and domestic animals also increases the risk of exposure to and transmission of diseases with zoonotic potential [15]. In addition, fires can also favor the occurrence of arboviral infections. For instance, in Brazil, studies have linked fires to outbreaks of diseases, such as dengue fever, Zika virus, chikungunya, and yellow fever [35].

Critical soil biological processes alternate after the fire due to increased light, temperature, and wind from unprotected soil. Examples are humidity reduction, loss of nitrogen and carbon to the atmosphere deposit of charcoal and ash, and other physicochemical alterations (bacterial and fungal activity and population changes) in soil [36]. This results in increased canopy fracture, higher tree fall rates, differentiation of plant diversity, and downward displacement of vertical stratification of foliage density. As a result, housing and food are reduced, resulting in a shift in wildlife distribution [37]. In addition, the lack of coverage makes small species, such as mice, amphibians, lizards, and insects, more visually exposed and easily targeted by predators [37][38].

The Watershed's morphology in the long term is also affected by fires [39]. Post-fire sediments can provide new resources for aquatic animals or become a source of pollution in their habitat [40]. Some species present accelerated growth rates after recolonizing post-fire rivers [41]. On the other hand, aquatic fauna can perish due to variations in water pH, turbidity, and toxins from the post-fire sediments. Shellfish mortality is also reported in sea costs where waters full of post-fire debris flow [9].

However, some ecosystems have adapted to and benefitted from small-scale forest fires. Ash is a natural fertilizer for the soil and contributes to the growth of new seeds in these areas. Fires eliminate dead and sick plants and do not let overgrown forests occur, allowing more sunlight to reach the ground and healthier plants to grow. It allows for greater plant diversity, helping to increase ecosystem resilience by creating an island with different microhabitats [1][32]. Some animal species benefit from fires regarding foraging and nesting behaviors. The deadwood on the ground can provide food, shelter, and a cavity nest to some species. Invertebrates, small mammals, birds, amphibians, and reptiles pursue protection and cover in this down wood [8]. Predators and scavengers are often attracted to burns because their food is more abundant or exposed than on unburned sites.

Necrophagous species, such as vultures, can benefit from the number of carcasses available after a fire. For example, woodpeckers are especially attracted to burning areas due to the high number of beetles and other invertebrates present in dead wood [8].

References

1. Haque, M.K.; Azad, M.A.K.; Hossain, M.Y.; Ahmed, T.; Uddin, M.; Hossain, M.M. Wildfire in Australia during 2019–2020, Its Impact on Health, Biodiversity and Environment with Some Proposals for Risk Management: A Review. J. Environ. Prot. 2021, 12, 391–414.
2. Walley, D. How Wildfires Affect Wildlife. Available online: https://spca.bc.ca/news/how-wildfires-affect-wildlife/ (accessed on 24 July 2022).
3. Guil, F.; Soria, M.Á.; Margalida, A.; Pérez-García, J.M. Wildfires as Collateral Effects of Wildlife Electrocution: An Economic Approach to the Situation in Spain in Recent Years. Sci. Total Environ. 2018, 625, 460–469.
4. Machado, L. O que se sabe sobre o “Dia do Fogo”, momento-chave das queimadas na Amazônia. BBC News Brasil, 27 August 2019.
5. Panzer, R. Compatibility of Prescribed Burning with the Conservation of Insects in Small, Isolated Prairie Reserves. Conserv. Biol. 2002, 16, 1296–1307.
6. Keeley, J.E.; Fotheringham, C.J.; Baer-Keeley, M. Factors Affecting Plant Diversity during Post-Fire Recovery and Succession of Mediterranean-Climate Shrublands in California, USA. Divers. Distrib. 2005, 11, 525–537.
7. Kaufman, G.A.; Kaufman, D.W.; Finck, E.J. Influence of Fire and Topography on Habitat Selection by Peromyscus Maniculatus and Reithrodontomys Megalotis in Ungrazed Tallgrass Prairie. J. Mammal. 1988, 69, 342–352.
8. Smith, J.K. Wildland Fire in Ecosystems: Effects of Fire on Fauna; U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: Fort Collins, CO, USA, 2000; p. RMRS-GTR-42-V1.
9. Gutiérrez, J.; de Miguel, J. Fires in Nature: A Review of the Challenges for Wild Animals. Eur. J. Ecol. 2021, 7, 14643.
10. NFPA Report—Fire Loss in the United States. Available online: https://www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Fire-loss-in-the-United-States (accessed on 5 January 2023).
11. Nielsen-Pincus, M.; Moseley, C.; Gebert, K. Job Growth and Loss across Sectors and Time in the Western US: The Impact of Large Wildfires. For. Policy Econ. 2014, 38, 199–206.

12. U.S. Bureau of Economic Analysis (BEA). Outdoor Recreation. Available online: https://www.bea.gov/data/special-topics/outdoor-recreation (accessed on 5 January 2023).
13. Martinho, V.J.P.D. Socioeconomic Impacts of Forest Fires upon Portugal: An Analysis for the Agricultural and Forestry Sectors. Sustainability 2019, 11, 374.
14. Miller, L. What Are the Environmental & Socioeconomic Impacts of Wildfire Emissions? Available online: https://metone.com/what-are-the-environmental-socio-economic-impacts-of-wildfire-emissions/ (accessed on 5 January 2023).
15. Albery, G.F.; Turilli, I.; Joseph, M.B.; Foley, J.; Frere, C.H.; Bansal, S. From Flames to Inflammation: How Wildfires Affect Patterns of Wildlife Disease. Fire Ecol. 2021, 17, 23.
16. Wrigth, H.; Bailey, A. Fire Ecology: United States and Southern Canada; Wiley: Hoboken, NJ, USA, 1982; ISBN 978-0-471-09033-5.
17. Cardillo, M. Biological Determinants of Extinction Risk: Why Are Smaller Species Less Vulnerable? Anim. Conserv. 2003, 6, 63–69.
18. Ford, W.M.; Menzel, M.A.; McGill, D.W.; Laerm, J.; McCay, T.S. Effects of a Community Restoration Fire on Small Mammals and Herpetofauna in the Southern Appalachians. For. Ecol. Manag. 1999, 114, 233–243.
19. Geluso, K.N.; Bragg, T.B. Fire-Avoidance Behavior of Meadow Voles (Microtus pennsylvanicus). Am. Midl. Nat. 1986, 116, 202–205.
20. Sanderfoot, O.V.; Bassing, S.B.; Brusa, J.L.; Emmet, R.L.; Gillman, S.J.; Swift, K.; Gardner, B. A Review of the Effects of Wildfire Smoke on the Health and Behavior of Wildlife. Environ. Res. Lett. 2021, 16, 123003.
21. Patterson, G.B. The Effect of Burning-off Tussock Grassland on the Population Density of Common Skinks. N. Z. J. Zool. 1984, 11, 189–194.
22. Fenner, A.L.; Bull, C.M. Short-Term Impact of Grassland Fire on the Endangered Pygmy Bluetongue Lizard. J. Zool. 2007, 272, 444–450.
23. Gill, A.M.; Allan, G. Large Fires, Fire Effects and the Fire-Regime Concept. Int. J. Wildland Fire 2008, 17, 688–695.
24. Gresswell, R.E. Fire and Aquatic Ecosystems in Forested Biomes of North America. Trans. Am. Fish. Soc. 1999, 128, 193–221.
25. Bozek, M.A.; Young, M.K. Fish mortality resulting from delayed effects of fire in the greater yellowstone ecosystem. Great Basin Nat. 1994, 54, 91–95.
26. Dunham, J.B.; Rosenberger, A.E.; Luce, C.H.; Rieman, B.E. Influences of Wildfire and Channel Reorganization on Spatial and Temporal Variation in Stream Temperature and the Distribution of

Fish and Amphibians. Ecosystems 2007, 10, 335–346.

27. Lyon, J.P.; O'connor, J.P. Smoke on the Water: Can Riverine Fish Populations Recover Following a Catastrophic Fire-Related Sediment Slug? Austral Ecol. 2008, 33, 794–806.
28. Bjornn, T.C.; Brusven, M.A.; Molnau, M.P.; Miligan, J.H.; Klamt, R.A.; Chacho, E.; Schaye, C. Transport of Granitic Sediment in Streams and Its Effects on Insects and Fish; Bulletin No. 17; University of Idaho: Moscow, ID, USA, 1977; Available online: https://www.lib.uidaho.edu/digital/iwdl/docs/iwdl-197701.html (accessed on 23 August 2022).
29. Lyon, L.J.; Crawford, H.S.; Czuhai, E.; Fredriksen, R.L.; Harlow, R.F.; Metz, L.J.; Pearson, H.A.; States, U. Effects of Fire on Fauna: A State-of-Knowledge Review; U.S. Dept. of Agriculture, Forest Service: Washington, DC, USA, 1978; pp. 1–52.
30. Sutherland, E.; Dickman, C. Mechanisms of Recovery after Fire by Rodents in the Australian Environment. Wildl. Res. 1999, 26, 405–419.
31. Wiebe, K. Microclimate of Tree Cavity Nests: Is It Important for Reproductive Success in Northern Flickers? Auk 2001, 118, 412–421.
32. Fonseca, F. How Wildfires Impact Wildlife and Their Habitats. Available online: https://www.pbs.org/newshour/science/explainer-how-wildfires-impact-wildlife-their-habitat (accessed on 24 July 2022).
33. De Barros, A.E.; Morato, R.G.; Fleming, C.H.; Pardini, R.; Oliveira-Santos, L.G.R.; Tomas, W.M.; Kantek, D.L.Z.; Tortato, F.R.; Fragoso, C.E.; Azevedo, F.C.C.; et al. Wildfires Disproportionately Affected Jaguars in the Pantanal. Commun. Biol. 2022, 5, 1028.
34. Bowman, D.M.J.S.; Murphy, B.P.; Burrows, G.; Crisp, M.D. Fire Regimes and the Evolution of the Australian Biota. In Flammable Australia; Bradstock, R.A., Gill, A.M., Williams, R.J., Eds.; CSIRO Publishing: Melbourne, Australia, 2012; pp. 43–67. ISBN 978-0-643-10482-2.
35. Ellwanger, J.H.; Fearnside, P.M.; Ziliotto, M.; Valverde-Villegas, J.M.; Veiga, A.B.G.D.; Vieira, G.F.; Bach, E.; Cardoso, J.C.; Müller, N.F.D.; Lopes, G.; et al. Synthesising the Connections between Environmental Disturbances and Zoonotic Spillover. An. Acad. Bras. Cienc. 2022, 94, e20211530.
36. Certini, G. Effects of Fire on Properties of Forest Soils: A Review. Oecologia 2005, 143, 1–10.
37. Sims, H.P.; Buckner, C.H. The Effect of Clear Cutting and Burning of Pinus Banksiana Forests on the Populations of Small Mammals in Southeastern Manitoba. Am. Midl. Nat. 1973, 90, 228–231.
38. Prada, M.; Marinho-Filho, J. Effects of Fire on the Abundance of Xenarthrans in Mato Grosso, Brazil. Austral Ecol. 2004, 29, 568–573.
39. Moody, J.A.; Martin, D.A. Initial Hydrologic and Geomorphic Response Following a Wildfire in the Colorado Front Range. Earth Surf. Process. Landf. 2001, 26, 1049–1070.

40. Brito, D.Q.; Passos, C.J.S.; Muniz, D.H.F.; Oliveira-Filho, E.C. Aquatic Ecotoxicity of Ashes from Brazilian Savanna Wildfires. Environ. Sci. Pollut. Res. 2017, 24, 19671–19682.
41. Goode, J.R.; Luce, C.H.; Buffington, J.M. Enhanced Sediment Delivery in a Changing Climate in Semi-Arid Mountain Basins: Implications for Water Resource Management and Aquatic Habitat in the Northern Rocky Mountains. Geomorphology 2012, 139–140, 1–15.