Science for Saving Species

Research findings factsheet

Project 8.3.4

Threatened Species Recovery Hub

National Environmental Science Programme

Animal behaviour and mortality during fire

In brief

Recent megafires across the globe have drawn attention to the plight of animals exposed to wildfire. Our current knowledge of the extent and characteristics of animal mortality during fire remains rudimentary, hindering our ability to predict how animal populations may be impacted in the future.

Fire is a lethal threat, and there is likely to be strong selection for animals to recognise the sight, smell and sounds of fire, and deploy fire-avoidance behaviours that maximise survival. We explored how animals respond behaviourally to fire cues. We concluded that animals are not passive victims of approaching fire, but instead have finely tuned behavioural responses that probably evolved over time to enhance survival. However, fire is expanding into new ecosystem types under a changing climate, and animals that have not evolved in the presence of fire may lack fire-avoidance behaviours. This may place such species at considerable risk of mortality.

We also conducted a global systematic literature review to estimate how many animals die during fire. Our review suggests that while relatively few animals are killed during fire, a higher proportion of animals are killed by severe fires than mild fires. However, only one study investigated the mortality of animals during a megafire, and most studies investigated low-intensity fires and a small number of animals.

Our review highlights how little we currently know about the direct effects of fire on animal mortality, and shows the critical need for further research to improve our capacity to predict the impact of fires on mortality of native Australian wildlife.

Eastern Pygmy-possum. Image: Catching The Eye, CC BY 2.0, Flickr

Background

Earth's warming and drying climate, combined with changes in land use and biota, is altering the nature of global fire activity. Recent megafires in Australia, California, Siberia and the Amazon have drawn the world's attention to the plight of wildlife exposed to unprecedented fires. A megafire is defined as one that burns more than 100,000 hectares of land.

Although fires burn 300–500 million hectares of land annually, we know surprisingly little about how animals behave in the face of fire, and how many die due to wildfires. Experts estimated that billions of mammals, reptiles, birds and frogs were killed in the 2019–20 megafires in Australia, but these were just "back of the envelope" calculations. A lack of data has reduced our ability to predict the impacts of fires of various intensities on populations of native wildlife species.

Some animals can survive a fire, and whether they do so depends on the behavioural, physiological and morphological traits of the animal; characteristics of the environment (e.g., fuel loads); and the behaviour of the fire (e.g., intensity, rate of spread). Fire can exert strong selective pressure on animal populations, yet we understand very little about how fire acts as an evolutionary force on animals.

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Background (continued)

Fires produce cues: odours, sights and sounds that signal its presence in the landscape; and the ability of animals to recognise and respond to these cues is a matter of life and death.

Species that inhabit ecosystems that rarely experience fire may be naïve to its impacts and unable to recognise fire cues as a sign of impending danger until it's too late. These species could be at an enhanced risk of extinction as the distribution of fire extends into new ecosystem types.

Yellow-footed Antechinus (Antechinus flavipes)
Image: Patrick Kavanagh, CC BY 2.0, Flickr

Main aims of research

We reviewed the global data on fire-induced wildlife mortality in an attempt to develop a greater understanding of the number of terrestrial vertebrates killed during fires. We also aimed to understand animal behavioural responses to fire.

What we did

When an animal is faced with a potentially lethal threat, its behaviour will often govern its survival. We first reviewed the literature regarding how animals respond behaviourally to fire, drawing on recent studies showing that many species of wildlife are finely attuned to the sights, smells and sounds of an approaching fire. Animal behavioural responses to fire are similar to those of prey responding to predators. Given this, we collaborated with research experts on predator–prey interactions to draw on insights into the drivers of animal responses to fire cues.

We also wanted to understand the direct impacts of fire on animal mortality. To address this, we conducted a global systematic literature review. The most useful and reliable empirical data on how many animals die during fire came from studies that tracked individuals before and after a fire event, allowing a calculation of the proportion of the study animals that lived and died. Yet these data are scattered throughout an increasingly voluminous scientific literature, and before this project there had been no synthesis of studies documenting fire-induced mortality.

We focused our review on terrestrial vertebrates (amphibians, birds, mammals and reptiles) directly killed during wildfires. We then produced statistical models to compare animal survival during fire as a function of the traits of the animals (e.g., body mass, ecological attributes, taxonomic grouping) and the nature of the fire (e.g., fire severity).

Key findings

Animal behaviour and fire

In our literature search we found many examples of animals responding to fire cues, including frogs fleeing for cover on hearing the crackling sounds of fire and examples of lizards "smelling" fire. For example, eastern pygmy possums (*Cercartetus nanus*) and Gould's long-eared bats (*Nyctophilus gouldi*) will arise from torpor when exposed to smoke. (Torpor is similar to hibernation but for a shorter period of time, and involves an animal slowing its metabolism and lowering its body temperature to use less energy.) Some animals can sense the risk of fire despite being bred in captivity, suggesting that their responses are innate. We also identified a range of animal responses to fire, which we term fire-avoidance behaviours, that are aimed at reducing the risk of death by fire (Figure 1).

These fire-avoidance behaviours included:

- immediate evacuation from a fire front;
- rapid refuge-seeking followed by delayed evacuation (leaving in the days following a fire, once the risk had passed);
- sheltering in place, whereby animals tough it out within the fire boundary until vegetation begins to recover; and
- doubling back into a fire front to gain access to the safety of burned areas.

Key findings (continued)

The central bearded dragon (*Pogona vitticeps*) uses delayed evacuation, seeking refuge until a fire has passed and then seeking unburnt habitat (Figure 2). On the other hand, antechinus (*Antechinus* spp.) have evolved the ability to shelter in place for prolonged periods by entering torpor to avoid dehydration, starvation or predation risk in simplified post-fire landscapes.

Drawing analogies between fire and predation, we identified a potential phenomenon known as "fire naivety", akin to "predator naivety". The latter is a condition in which animals fail to detect or respond to the risk of a predator with which they have no evolutionary history. Fire naivety describes situations in which species that have not evolved alongside fire fail to detect or appropriately respond to the risk of approaching fire, placing them at enhanced risk of mortality.

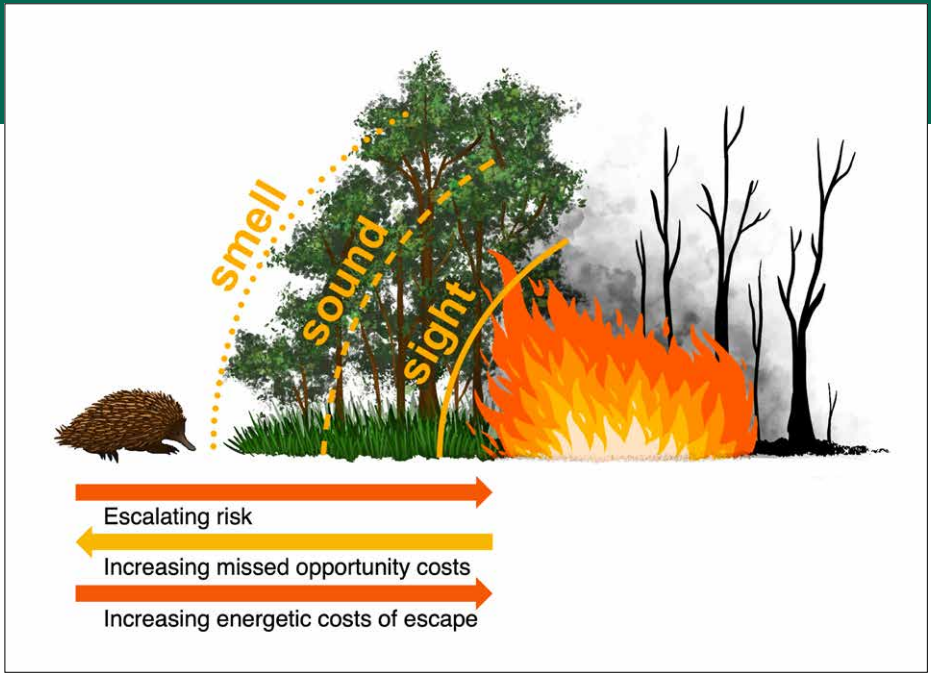

Figure 1: *Fires produce smells, sounds and visual cues which might be used by animals to reduce their risk of mortality in a fire. Image: Nimmo et al 2021.*

Animal mortality from fire

We found only 31 articles that tracked the fate of animals during fire events. These articles provided 43 examples of the direct effects of fire on 31 species. The studies spanned Africa, North America and Oceania from 1984 to 2020. Most studies were conducted in either the United States or Australia (52% and 42%, respectively) and focused on mammals and reptiles (53% and 30%, respectively). The sample size of animals monitored through the passage of fire tended to be small, with around half the studies monitoring fewer than 10 individual animals.

The literature showed a bias towards studying animal mortality during low-severity fires: only 30% of studies examined responses to severe fire, and only one study documented the mortality of animals during a megafire.

We found a high level of animal survival across all studies, with an average of 3% (1–9%) of monitored animals dying during the fires. The proportion of animals that died during a mild fire was slightly less than average (2% [1–7%]), while the proportion of animals that died during severe fire was significantly higher (7% [2–21%]). Overall, most studies (65%) recorded no direct mortality caused by fire, with all tracked animals surviving. Nonetheless, a number of instances demonstrated how profoundly some severe fires can impact animal populations. For example, in a study of a herd of 165 threatened African bush elephants, 29 (18%) died as a direct result of an uncontrolled wildfire in South Africa.

We have almost no data on animal survival during large, fast-moving megafires. Extreme fire behaviour during such an event may well lead to exceptionally high animal mortality. Therefore, we cannot confidently extrapolate from the figures in the global literature to extreme fire events such as the 2019-20 Australian megafires.

Figure 2: *Central bearded dragons (left) typically seek refuge until a fire has passed then seek unburnt habitat, whereas antechinus species (right) shelter in place during a fire for prolonged periods by entering torpor. Image: Nimmo et al 2021.*

Implications and recommendations

Animals have finely tuned behavioural responses to fire that have probably evolved over time to enhance survival. However, animals that have not evolved in the presence of fire may lack these behavioural strategies, placing them at considerable risk of mortality when fires burn areas that usually escape fire, as we saw during the Australian 2019-20 megafires.

A lot remains to be learned about fire-induced mortality, but many animals appear to survive the initial passage of fire. However, the post-fire environment presents novel challenges that may have significant effects on the persistence of local populations. By consuming grass, shrubs and hollow logs, fires simplify habitats and remove cover for prey animals. They also consume food and dry up water resources for all surviving species. This can affect the survival of individuals and the persistence of populations in the weeks, months and years following major fires. Hence, further mortality is likely to follow the fire event that may well exceed the mortality experienced during the fire.

Conservation efforts that address the challenges faced by animals in the post-fire landscape could be valuable in reducing the long-term indirect impacts felt by animal populations following a fire.

Efforts that reduce predation pressure, such as the addition of artificial refuges to the landscape and targeted control of invasive predators, and those that replace resources consumed by fire, such as supplemental food and water stations and nest boxes, could be leveraged to reduce the vulnerability of populations of threatened species following severe wildfires.

Central bearded dragon. Image: Chris Jolly

Cited material

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Cite this publication as NESP Threatened Species Recovery Hub. 2021. Animal behaviour and mortality during fire, Project 8.3.4 Research findings factsheet.

This project is supported through funding from the Australian Government's National Environmental Science Program.