Science for Saving Species

Research findings factsheet

Project 8.4.3

Threatened Species Recovery Hub

National Environmental Science Programme

Managing herbivore impacts after mega-fires

In brief

Invasive herbivores, like rabbits, goats and feral horses, can pose a significant threat to threatened species and ecological communities, as can native herbivores, like kangaroos, in places where they are overabundant. Herbivore impacts can also be amplified when combined with fire and hinder the regeneration of key ecosystem species.

We conducted a literature review to determine how the threat from herbivores to native species and ecological communities interacts with wildfire and land management. We narrowed our investigation to herbivores greater than 1 kg, so rabbits and larger animals were examined, but rodents and insects were not.

We found only 29 studies that quantitatively evaluated the interaction between herbivores and fire in woody ecosystems; most were from manipulated experiments, and not wildfires. The studies generally reported an increase in herbivore activity by both native and non-native species after a fire, but reported little evidence on how herbivore populations were affected over the long term by fire.

The literature confirmed that herbivores target recently burnt areas in woody ecosystems. This response aligns with the "magnet effect" coined for grassy and savanna ecosystems, where grazers preferentially use recently burnt areas to exploit high-quality new plant growth.

The findings highlight the urgent need to quantify herbivore responses to extreme fire events in woody ecosystems and the post-fire impacts on biodiversity so that we can better inform future conservation efforts.

Feral goats in Australia.
Image: Robyn Jay, Flickr, CC BY-SA 2.0

Background

Invasive herbivores are a global threat to threatened species and ecological communities. They can have strong direct effects through grazing and browsing, or indirect impacts such as trampling, compaction and competition for resources. Introduced herbivores are typically considered to pose the greatest threat, but native herbivores that become locally overabundant can also pose a significant threat. In some highly degraded woody ecosystems, herbivores pose a critical threat even at moderate or low densities by preventing the regeneration of key ecosystem species.

The impacts of vertebrate herbivores could also be amplified when combined with drought or fire and hinder ecosystem recovery. For example, herbivores can take refuge in unburnt areas, and then exploit sensitive recovering growth.

Inappropriate fire regimes and landscape-scale wildfires may alter the risk, opportunity and cost-effectiveness of standard management practices related to mitigating herbivore threats to biodiversity. If fire can change a chronic threat from herbivores into an acute threat, timely intervention may be required to mitigate risk or exploit opportunities.

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Background (continued)

In the wake of the 2019–20 megafires, conservation managers in south-eastern Australia are concerned about the implications that interacting fire and herbivore threats may have for recovery of threatened species and ecological communities. There appears to be little in the scientific or technical literature to guide conservation managers on this issue for the purposes of emergency biodiversity response planning.

Feral rabbits in Australia.
Image: John Schilling, Flickr, CC BY-ND 2.0

Research aims

We conducted a literature review to determine what is known about how the threat from vertebrate herbivores to native species and ecological communities interacts with wildfire and land management.

We wanted to know if the global literature could inform us how to manage the interacting threats of herbivory and fire. We also aimed to understand what kind of studies and experiments were conducted to generate this knowledge.

What we did

We performed a systematic literature search of the Web of Science database using the search terms ((*fire AND herbivor* AND (biodiversity OR conservation) AND manage*)). The search returned 353 scientific publications.

We excluded studies conducted in savanna or grassland or that were review articles. The remaining publications (110 papers) were screened for relevance to our topic: whether the herbivores were mammals with a minimum adult mass of 1 kg (including rabbits but excluding rodents and insects), whether the inclusion of fire and herbivores allowed consideration of their interaction, and whether the inferences were supported by data analysis or simulation models.

The systematic review identified few studies that reported the responses of mammalian herbivores to large wildfires. We grouped and summarised each study based on the continent where the study was conducted, vegetation type, study design, whether the study incorporated wildfire or focused solely on managed fire, and the framing or conceptual model of he type and direction of the herbivore and fire interaction identified in each study.

For each study, we identified the focal herbivore species, and recorded their family; IUCN threat status; whether they were wild or domesticated; and native, non-native or described as an over-abundant native.

Herbivore response to fire was assigned to one of four modes: 1) change in landscape occurrence, 2) site selection, 3) impact and 4) time to rebalance (duration of herbivore site selection or impact).

We also identified all target species and recorded their taxonomic group, IUCN threat status, vulnerable life stage if described, whether herbivores had a direct or indirect impact, and the response to fire and herbivores.

A post fire landscape on Kangaroo Island.
Image: Nicolas Rakotopare

Key findings

We found only 29 studies that quantitatively evaluated the interaction between herbivores and fire in woody ecosystems. Most studies were conducted in Australia (55%), followed by North America (20%) and Eurasia (17%). Nine studies focused solely on wildfire, four incorporated both wildfire and managed fire, and 15 solely addressed managed fire. Forests and woodlands were the most frequently studied vegetation types. The review database can be accessed here.

Most of the studies (~78%) were based on data from manipulated experiments, with exclusion fencing the only herbivore management action investigated. Non-native herbivores were assessed in one-third of studies, and only six studies concerned both non-native herbivores and wildfire. Almost half of the 29 studies that evaluated fire herbivore interaction focused on the impact on a target species or group, including a few threatened species.

Studies generally reported an increase in herbivore activity or impact by both native and non-native species after a fire, but reported little other evidence of how herbivores populations were affected by fire. The studies confirmed the commonly held belief that herbivores target recently burnt areas in woody ecosystems. This response aligns with the "magnet effect" coined for grassy and savanna ecosystems, where grazers preferentially use recently burnt areas to exploit higher-quality new foliage.

The main reported impact, by both native and non-native herbivore species, was post-fire herbivory leading to a reduction in vegetation regeneration, recruitment, survival and cover. Studies that measured plant community composition also reported preferential targeting of more palatable species, such as herbs and grasses. Surprisingly, little mention was made of the impact on vegetation from herbivore trampling, rubbing or digging. Indirect impacts from resource competition or physical disturbance resulting in reduced habitat quality were reported for a variety of co-occurring animal species.

Not all studies found detrimental impacts of post-fire herbivory. For example, herbivory by some native species increased plant diversity, had beneficial effects for arthropod richness and abundance, and limited woody plant expansion. The majority of studies were not conducted for long enough to provide evidence that increased herbivory post-fire would have a significant or lasting negative effect on vegetation structure or competition. The one exception was a long-term monitoring study that found ongoing selective herbivory facilitated a change of vegetation type through removing grassy fuels; this limited fire propagation and led to encroachment by taller shrubs. Unexpectedly, we found no studies that reported change in the landscape occurrence of herbivores, that is, immigration to new areas, as a result of fire.

Only a few studies tested how fire characteristics influence post-fire herbivore responses and impacts. One study investigated the effect of fire intensity after a mixed-severity fire in North America, finding increased post-fire herbivory in areas burnt at high intensity verses moderate intensity. Only two studies discussed the effect of fire size, with one of these focusing on woodlands in southern Australia. Here they found herbivory pressure was greater in small managed burns relative to a large wildfire.

New growth on native trees after a fire on Kangaroo Island. Image: Nicolas Rakotopare

Six studies focused on threatened herbivores in recently burnt vegetation. The quokka (*Setonix brachyurus*) was found to browse on threatened flora and inhibited post-fire recruitment in the Endangered montane heath and thicket ecological community. The "magnet effect" of herbivores drawn to palatable new plant growth led to increased competition for food by the threatened brush-tailed rock wallaby (*Petrogale penicillate*).

Work cited

Kate Giljohann, David Duncan, Dave Forsyth and Peter Vesk (In prep.) Managing herbivore impacts after megafires.

Key knowledge gaps

We found a lack of information on the expected duration of the "magnet-effect" of herbivores to new growth in woody ecosystems, or whether observed impacts would result in long-term detrimental outcomes. This is crucial information for the robust allocation of conservation and remediation actions across the landscape in the aftermath of extensive wildfires. Field surveys are critical to understanding the immediate impacts of fire and post-fire herbivore activity; however, only long-term studies can reveal whether short-term effects will have ongoing impacts that are detrimental to populations or communities.

Mega-fires leave fewer refuges for animals, and can reduce herbivore abundance; however, none of the studies we reviewed provided evidence of how fire induces long-term change in landscape-scale occupancy by herbivores. Information on the role of fire characteristics was lacking, with information from small burns not readily transferable to mega-fires.

Interactions between disturbances and threats can trigger ecological changes. Yet the role of additional threats (e.g., harvesting, disease, predation) or altered ecological processes (e.g., rainfall or temperature anomalies) on fire–herbivore interactions is poorly researched, and we lack insight for predicting the outcome of such interactions. Severe wildfires often follow years of below-average rainfall, and as novel conditions resulting from Anthropogenic climate change continue, there is a clear need for more studies that evaluate the interaction between herbivores and fire under a range |of conditions.

Implications and recommendations

Our findings highlight the urgent need to quantify herbivore responses to extreme fire events in woody ecosystems and the post-fire impacts on biodiversity so that we can better inform future conservation efforts. In particular, long-term monitoring studies are needed.

Learning about the effect of large vertebrate herbivores after mega-fires is likely to be challenging. For example, the desired information about herbivore effects is usually obtained with experimental designs involving exclosure fencing, and fires of that intensity are likely to destroy such infrastructure. Assessment of the integrity of research infrastructure that might support opportunistic landscape-scale analyses should be a priority in the wake of large wildfires.

Greater visibility of the designs of research in progress could allow researchers to build contingent research designs, ready for deployment as soon after extreme wildfires as can be safely achieved. This information could be made available as a searchable database populated using templates to capture the necessary prospective metadata, such as promoted through research pre-registration, or even as may already be available to agencies through research permit applications.

Simulation approaches to explore the potential impact on threatened species and ecological communities of interactions of extreme wildfire and large herbivore impacts should be an essential part of the process of learning from the devastating 2019–20 megafires, and preparing as best as we can for those to come.

As herbivores, both native and non-native, target vegetation recovering after fire, the protection and monitoring of threatened species and threatened ecological communities in the post-fire environment is crucial. Post-fire monitoring of threatened fauna is also essential to understanding how best to aid recovery, and will provide important information for rapid response after the next major fire event.

Further Information

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