News & views

Figure 1 | An Australian bushfire in early 2020.

Conservation biology

Complex biodiversity outcomes after megafires

Gavin M. Jones

An ambitious analysis of data has revealed the effects of the 2019–20 Australian megafires on biodiversity. It turns out that the outcome is more nuanced than just the anticipated picture of a massive loss of species. See p.898

For a few years, it seemed as if everything was burning down. In 2020 and 2021, in California, Oregon and Washington, US fire records were shattered, with devastating effects for wildlife habitat[1,2]. In 2020, 4 million hectares of drought-stricken wetland and savannah burnt in the Brazilian Pantanal region, killing 17 million animals[3]. In late 2019 and early 2020, bushfires raged during the height of summer in Australia, burning an astonishing 10.3 million hectares of shrubland and forest, corresponding to just under half the area of the United Kingdom. On page 898, Driscoll *et al.*[4] present a detailed look at the consequences of the Australian megafires for biodiversity.

The Australian fires (Fig. 1) spurred a veritable cornucopia of research about wildlife in the context of fires. Studies published shortly afterwards suggested that the fires overlapped the habitats of numerous threatened species and might cause other species to become threatened[5]. One study estimated that up to three billion vertebrates were affected[6]. Follow-up studies by dozens of research teams have examined the effects of the bushfires on birds[7], invertebrates[8], plants[9] and other organisms. But differing environmental contexts and methodologies across the various studies limited scientists' ability to gain a clear picture of how the fires affected Australian biodiversity as a whole.

Driscoll and colleagues use the power of analysing multiple data sets, and their meta-analysis has uncovered the true effects of these unprecedented fires. Collating 62 data sets containing 810,000 records of the occurrence or abundance of more than 2,200 biological groupings (taxa), the authors generated what is possibly the largest assessment of the relationship between fire and wildlife ever conducted. Driscoll *et al.* compared biodiversity in burnt and unburnt areas.

The main finding across more than 1,600 standardized 'effects' (findings presented on the same numerical scale) for the occurrence or abundance of species unquestionably showed a decline, even if the effect was small (a standardized effect size of −0.08). The implication is that Australian biodiversity appears slightly worse off now than it was before the 2019–20 fire season.

But the overall effect misses the story entirely. Almost half (44%) of all effects for species were positive, and the magnitude of positive effects (+0.29) was similar to that of the negative effects (−0.34). That fire could have positive effects for biodiversity is not surprising. For example, fire-killed trees are a boon to insects that can, in turn, provide an all-you-can-eat buffet for some birds[10]; floral diversity in burnt landscapes can provide abundant nectar for bees and birds[11]; and fire can generate a wide range of habitats that facilitate the co-occurrence of many species[12]. The overall weak negative effect size of −0.08 reflects the balancing of the strongly positive and negative effects on species across the large and varied study area.

What does this result mean? The conclusion is that, depending on where you look and what you look at, the local effects of the bushfires might yield strong increases or decreases in the occurrence or abundance of species. Overall, the effects were far from uniform.

Often, the presence of such a great variety of positive and negative effects in meta-analyses can be explained by other variables. For example, one might expect that the amount of vegetation consumed by fires (burn severity) would explain the discrepancy in fire effects. But rather than clarifying the picture, Driscoll and colleagues found that burn severity amplified both the positive and negative effects of the fires. That is, areas that experienced higher burn severities saw larger effects, both positive and negative, on species occurrence or abundance. The same pattern was true for areas that experienced pre-fire drought, and for areas that experienced short intervals between fires before the 2019–20 season. So, we are left with a great deal of uncertainty about the causes of the vast range of biodiversity responses to the Australian fires.

It seems that, yet again, context dependence reigns supreme. Ecologists should not be surprised at the apparent lack of unifying principles explaining system behaviour, or at least in their inability to put their finger on what those principles are. Ecology is famously messy, and observed phenomena are context- and scale-dependent. Driscoll and colleagues' work represents a truly impressive effort and an exemplary application of meta-analysis in ecology. But it also underscores that meta-analysis in ecology sometimes fails to amount to more than the sum of its parts.

The work nevertheless yields the verifiable, robust result that the 2019–20 Australian fires resulted, on average, in decreased occurrence and abundance of flora and fauna. What can be done to support biodiversity, moving forwards? Despite variation, the overall effects do suggest that fire-driven decreases in biodiversity were smaller in protected areas than in unprotected ones, in places that had experienced relatively few previous fires over relatively longer intervals, and when large unburnt areas were present in a studied landscape. Driscoll and colleagues therefore recommend rapid wildfire suppression – putting out fires before they get out of hand – and an expansion of protected areas as strategies for safeguarding biodiversity and habitats.

However, in my view, if history is any guide, wildfire suppression is a deeply misguided and unsustainable conservation strategy. The western United States – another of Earth's most fire-prone regions – is witnessing the devastating ecological and social consequences of more than a century of aggressive fire suppression[13]. When fire-prone systems are fire-starved, they become more vulnerable to fire-driven transformation and loss[14,15]. Protected areas, when used to resist natural disturbances, can lead to greater habitat losses compared with unprotected landscape[1] and can reinforce the exclusion of Indigenous people[16]. Moreover, given that nearly half of the fire effects detected by Driscoll *et al.* were positive, then suppressing fires might be a counterproductive intervention for many species, even in the short term.

"Ecology is famously messy, and observed phenomena are context- and scale-dependent."

Good conservation approaches will recognize and embrace fire's role in ecosystems, and in generating ecological variation that supports biodiversity[12]. In some systems where fire has been long suppressed, reducing fuels through planned burning or cutting younger understorey trees that can spread ground fire into the tree canopies might be needed[17,18]. In naturally fire-resistant systems with long intervals between fires, active management can direct these systems towards future fire resilience[19]. Recognizing the human role in fire-prone ecosystems and empowering Indigenous stewardship will also lead to better biodiversity outcomes[20]. Driscoll and colleagues' comprehensive analysis reinforces the growing threat of megafires while also pointing to the remarkable and surprising non-uniformity of their ecological effects.

Gavin M. Jones is in the USDA Forest Service, Rocky Mountain Research Station, Albuquerque, New Mexico 87102, USA.
e-mail: gavin.jones@usda.gov

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