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Review of impacts of the 2019–20 wildfires on biodiversity

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Chapters 3 to 19 provide a reckoning of the 2019–20 wildfire impacts on natural and cultural values. The chapters document that these fires affected, in varying ways, much of the environmental fabric of Australia including key biodiversity sites and protected areas, soils, aquatic and marine systems, ecological communities, plants, fungi and animals, including many threatened species. Here, we review the information across these chapters, drawing out common features of impacts and opportunities.

Impacts

The fires burnt over 103 400 km^2, affecting hundreds of protected areas, including substantial proportions of World Heritage areas inscribed for their cultural and natural values, and some of Australia's key biodiversity areas. The fire-caused loss of vegetation and changes to soil properties increased erosion rates up to threefold, leading to massive sediment pulses in waterways that killed aquatic organisms, filled pools and smothered streambed substrates. Sediment was transported dozens of kilometres downstream, even affecting littoral and marine areas. Some of the effects on the abiotic scaffolding of life, such as changes to soil chemistry, nutrient cycles and stream morphology, may take decades to unwind, and may not recover before future fires further degrade the system. The fires affected tangible and intangible cultural values; burnt dozens of ecological communities, including ecosystems that rarely (if ever) experience fire; and caused population losses in hundreds of vertebrate species, and tens of thousands of invertebrate, plant and fungi species (Fig. 20.1). Impacts ranged from severe to negligible, and even beneficial for some species. Some affected species and ecological communities will never be made good: some species are now extinct or nearly so (e.g. Yalmy galaxias (*Galaxias* sp. nov. 'Yalmy'; Chapter 6), *Banksia montana* mealybug (*Pseudococcus markharveyi*; Chapter 11), and some ecological communities are unlikely to return to their pre-fire state, given projections for future climate and fire regimes.

The 2019–20 wildfires were so extensive that heavily impacted species were diverse, in terms of their pre-fire conservation status (threatened/non-threatened); habitat (e.g. rainforest, wetlands, woodlands); whether terrestrial or aquatic; and whether range-restricted or wide-ranging. However, although many wide-ranging species across the forests of eastern Australia suffered major losses, the species whose distributions most extensively

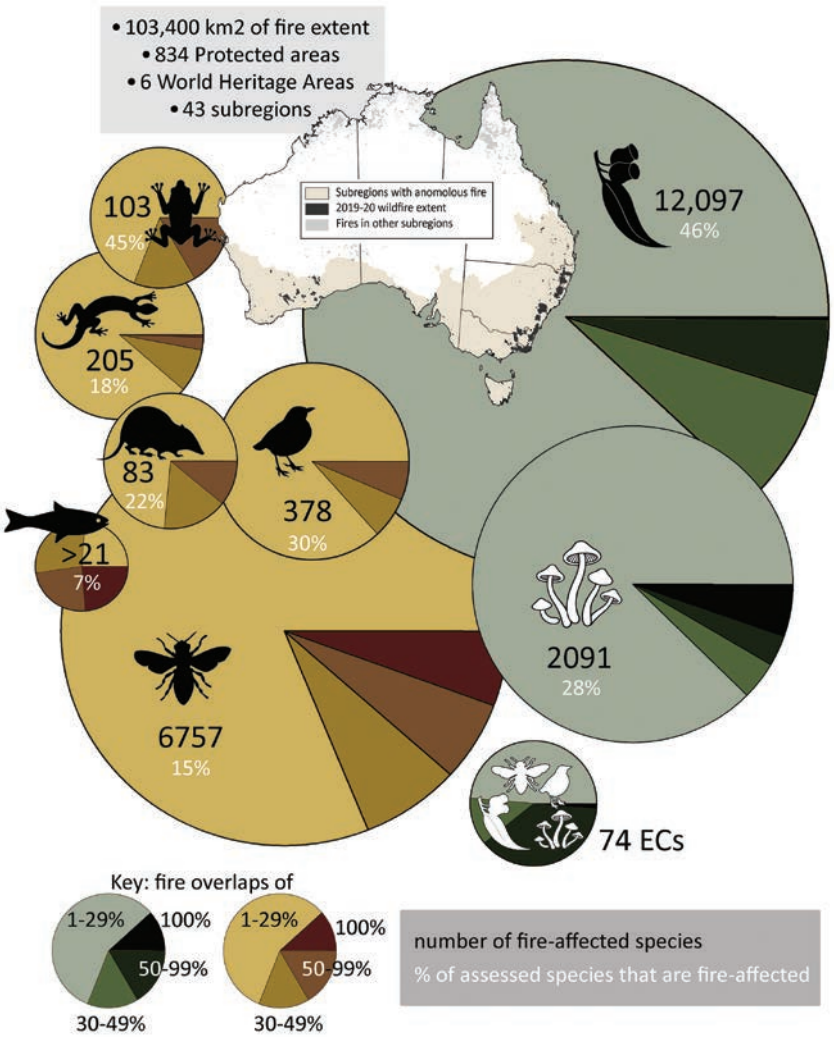

Fig. 20.1. Summary of exposure of species and ecological communities to the 2019–20 wildfires. The map shows the fire-affected subregions (beige), the fire extent within those subregions (dark grey), and areas that burnt elsewhere in Australia that season (light grey). The pies summarise fire exposure for different species groups. The number of fire-affected species with ranges that overlapped fires by 1% or more are shown in black text, and also depicted by the relative sizes of the pies (although these are not to scale). Of the fire-affected species, the relative proportions of species whose distributions overlapped with fire by 1–29%, 30–49%, 50–99% and 100% are shown by the pie segments. The number of species assessed within each species group (from top right, moving clockwise): plants (26 062), fungi (7445), ecological communities (92), invertebrates (45 428), fish (281), mammals (386), birds (1276 including ultrataxa), reptiles (1128), and frogs (227). Note that the numbers of species assessed, and therefore the numbers that are fire-affected, are substantial underestimates for invertebrates and fungi: of ~320 000 invertebrate species, only 45 428 are described and have distribution data available, suggesting the real number of fire-affected species could be at least seven times greater than the 6767 depicted here. Of the estimated 50 000 to 250 000 fungi species, 7445 are described and have distribution data, suggesting the real number of fire-affected fungi species could be considerably more than seven times the 2091 depicted here. The information to compile this figure comes from Chapters 3–19 and references therein.

overlapped with fire tended to be range-restricted. The preceding chapters indicate that 787 invertebrate, 66 vertebrate, 178 fungi and 593 plant species had at least 50% of their range burnt in these fires, an extraordinary outcome from a single event. Many of these species have now been listed as threatened, or uplisted due to these losses, with listing assessments pending for many others. Fire-affected ecological communities were similarly diverse, ranging from rainforests to peatlands, and including fire-prone communities such as heathlands as well as fire-sensitive communities.

Common features of biodiversity impacts across Chapters 3–19 include:

- For most species, estimating fire-caused population loss is challenging because of scant pre-existing monitoring and limited knowledge of species' fire response. Where evidence on fire responses is available, it is usually from studies of less extreme fires. Assessing fire impacts has been especially difficult for poorly known groups such as fungi and invertebrates.
- Fires can kill individual plants, fungi and animals directly, but (indirect) mortality after fire can exceed mortality during the fire because resource availability changes radically, and exposure to other threats may increase.
- As well as amplifying the short-term effect of fires, these interactions with other threats can suppress longer-term recovery of populations. For example:
    - Areas of lower habitat integrity, including areas that are fragmented, or used for forestry in recent decades, are more likely to burn at high severity.
    - For animals, fire may amplify predation risk by introduced predators, or disease susceptibility, or exacerbate competition from introduced herbivores.
    - For plants and ecological communities, the antecedent conditions critically modify the impacts of fire. For example, in areas of increased fire frequency, short fire intervals strongly disadvantage some species and powerfully reorganise species assemblages. Pre-fire drought also strongly moderates the fire response of ecological communities, and many plant and animal species.
- The response of populations and ecological communities to fire depends on their pre-fire conservation status; recovery is more challenging for populations that are already reduced or declining.
- Fire impacts may be most significant, and recovery most challenging, for species and environments with an evolutionary history of infrequent disturbance.
- Some species are unlikely to return to their pre-fire size over the next decade or more; their recovery may be thwarted by projected increases in fire incidence.
- Some of the 2019–20 wildfire impacts will be long-lasting and reverberating. For example, as well as changes to soil properties and the physical structure of streams and littoral areas, hollow-bearing trees and logs may be scarce in some areas for decades. Species that rely on these features will be correspondingly affected.
- Not all species were adversely affected by the fires; for example, some plant species that rely on disturbance for germination have experienced large recruitment events.

Opportunities

The review of Chapters 3 to 19 also highlights some conservation opportunities. For example, populations of introduced species were reduced by the 2019–20 wildfires, or made more vulnerable to control options. Some of these opportunities were seized by management agencies (e.g. increasing the extent or intensity of aerial baiting and shooting). Other options remain for future trials, such as capitalising on the range reductions of

invasive fish species by preventing their re-expansion using instream barriers. In addition, some of the emergency rescue operations for freshwater species and birds, and seed and cutting salvage for plants, demonstrated what could be achieved in the future, with more forethought, planning and resourcing.

It is important to reflect that all knowledge available before the 2019–20 wildfires (on species distribution, status and trends, sensitivity to threats and response to management) was crucial for informing the management response; similarly, all conservation management that had been undertaken to that point, to support species and ecological communities, contributed to resilience in the populations and ecological communities affected by the wildfires. Much survey, monitoring and management action are occurring in the aftermath of the 2019–20 wildfires, and this effort will sharpen current and future assessments of impacts and management effectiveness, support recovery, and help build resilience to future fires.