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Impacts of the 2019–20 wildfires on native mammals

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Summary

Context and challenges

- The fate of some mammal species in the 2019–20 wildfires was a high-profile – emblematic – concern for the community, with such attention catalysing concerted responses by many organisations.
- The impacts of the wildfires were superimposed on a prevalent pattern of decline for many Australian mammals.
- Post-fire recovery of many mammal species will be challenging, given the individual and compounding impacts of other threats and a changing fire regime likely to be characterised by more frequent comparable fires.
- On-ground research following the 2019–20 wildfires has provided some evidence about population-level impacts at some sites.

Main findings

- The 2019–20 wildfires burnt at least 50% of the distributions of five mammal species and 30–50% of the distributions of a further 18 mammal species.
- Including subspecies, the most extreme fire overlap (95% of range burnt) was for the Kangaroo Island dunnart (*Sminthopsis griseoventer aitkeni*).
- Post-fire sampling has confirmed marked population losses in burnt areas for a range of mammals, especially where fires were of high severity.
- Population losses due to the 2019–20 wildfires are likely to have been of sufficient magnitude to render five mammal taxa newly eligible for listing as threatened.
- Many government agencies and other groups instituted management interventions in the immediate aftermath of the fires. These efforts are likely to have achieved some local benefits.
- Most of the fire-affected mammal species are unlikely to recover to their pre-fire population size over the next decade; and ongoing decline of many species is likely should comparable fires recur in the future.

Introduction

Mammals attracted much of the public and media concern about the impacts of the 2019–20 wildfires. Particularly prominent were rescue efforts for koalas (*Phascolarctos cinereus*) and kangaroos injured in the fires (Fig. 16.1; see also Chapter 26), and food supplementation for brush-tailed rock-wallabies (*Petrogale penicillatus*) in some burnt areas (see Chapter 24). Reflecting this profile and concern, among its other investments in conservation of fire-affected species, the Australian Government allocated $14 million to post-fire recovery of one mammal species, alone, the koala (Chapter 22). However, even the plight of mammals hitherto largely unknown to the public – most notably the Kangaroo Island dunnart – was heavily profiled. In this chapter, we describe the impacts on mammals occurring in the fire-affected regions. We also briefly describe some management actions that were implemented, and ongoing management required to support recovery and reduce the likelihood of such loss in any comparable future fire. Note that this chapter considers responses of native mammals only; information on some introduced mammals is given in Chapter 17, in the context of compounding threats.

The 2019–20 Australian wildfires were without modern precedent (Chapter 2), and their impacts on mammals are likely to have been comparably exceptional. However, when considering impact, it is informative to use a broader frame of reference than that year's fires alone. Many mammal species in the regions burnt by these fires were declining before 2019–20 (e.g. Woinarski *et al.* 2015; Wagner *et al.* 2020). Furthermore, the 2019–20 wildfires formed part of a changing regime, of wildfires occurring more frequently, in some cases causing transitions in vegetation beyond the previously prevailing successional cycle (Lindenmayer and Taylor 2020b). The return of mammal fauna to their state before the

Fig. 16.1. Eastern grey kangaroo (*Macropus giganteus*) in a landscape extensively burnt by the 2019–20 wildfires, Kangaroo Island. (Photo: Nicolas Rakotopare/Threatened Species Recovery Hub)

2019–20 wildfires may therefore no longer be possible as some habitats and resources are unlikely to recover before the next fires occur (Camac *et al*. 2017).

Many of the short-term impacts on mammals of the 2019–20 wildfires have not yet been evaluated directly, and longer-term impacts may take many years to be realised. Hence, in this chapter we try to contextualise the impacts of the 2019–20 wildfires with the knowledge base accruing from many previous studies in southern and eastern Australia of responses of mammals to fire (e.g. Bradstock 2008). Such previous studies have been conducted in most of the habitats that were burnt in 2019–20, including montane ash forests (Lindenmayer *et al*. 2021), alpine and subalpine environments (Green and Sanecki 2006), heathlands (Fox 1982), and coastal and foothill forests (Lunney 1987). Nonetheless, some of the information derived from these previous studies may provide only limited inference on the impacts of, and recovery potential following, the 2019–20 wildfires given the exceptional scale of the 2019–20 wildfires, and the extent to which they burnt habitats (notably rainforests) that have rarely been burnt previously (Collins *et al*. 2021).

Findings

Impacts of the 2019–20 wildfires

Three main approaches have been used to evaluate the impacts of the 2019–20 wildfires on mammals. The first approach, described in Chapter 12, used spatial modelling of mammal densities to estimate the number of mammals (albeit excluding bats) that occurred pre-fire in areas burnt in the 2019–20 wildfires. This tally was 143 million native mammals, mostly comprising rodents (50 million), possums (39 million) and small dasyurids (37 million). Undoubtedly, many of these individual mammals were killed by fire, but that proportion is unresolved.

The second approach involved spatial analysis to superimpose mapping of the areas burnt in the 2019–20 wildfires on the known distributions of mammal species (Legge *et al*. 2022). This analysis found that five mammal species – long-footed potoroo (*Potorous longipes*), Hastings River mouse (*Pseudomys oralis*), parma wallaby (*Notomacropus parma*), brush-tailed rock-wallaby and brown antechinus (*Antechinus stuartii*) – had at least 50% of their distributions burnt in the 2019–20 wildfires and a further 18 species had 30–50% burnt (Table 16.1). Seventeen mammal species or subspecies that were recognised as threatened before the fire had at least 10% of their distributions burnt, with six of these having at least 50% burnt. The maximum fire overlap was for the threatened Kangaroo Island dunnart, with 95% of its distribution burnt, including 90% at high severity. Notably, the 2019–20 fires affected a very broad suite of mammals, including species narrowly endemic to rainforests (e.g. black-tailed antechinus (*Antechinus arktos*)), the aquatic platypus (*Ornithorhynchus anatinus*) (Bino *et al*. 2021), and highly dispersive species such as grey-headed flying-fox (*Pteropus poliocephalus*) (Baranowski *et al*. 2021).

The proportion of a species' population killed in fires will generally be less than the proportion of the distribution burnt, because some individuals in burnt areas survive fire. Legge *et al*. (in press) used expert elicitation to estimate proportional population losses for each species at sites exposed to mild fires and to severe fires. Experts estimated this proportion immediately after fire, at 1-year post-fire and at 10 years (or three generations, whichever longer) post-fire. This assessment concluded that the 2019–20 wildfires caused an immediate population reduction of 65% for Kangaroo Island dunnart, 39% for long-footed potoroo, 34% for Hastings River mouse, and 20–30% for six other taxa: Kangaroo

Table 16.1. Summary of distributional overlap with fire (for high severity fires and total fire), and estimated percentage population loss for the mammal taxa most affected by the 2019–20 fires (modified from Legge *et al.* (in press)).

All taxa with at least 50% overlap with fire are included, along with threatened (and Near Threatened) taxa with at least 10% overlap with fire. Conservation status is as before the 2019–20 wildfires: CR Critically Endangered, EN Endangered, VU Vulnerable, NT Near Threatened, LC Least Concern. Note that % population decline is expressed relative to a standardised population size of 100 immediately pre-fire (i.e. -64.8 indicates the total population declined by an estimated 64.8%); decline was not estimated for two taxa (nd). Non-threatened species with 30–49.9% overlap with fire (hence not included in the body of this Table) comprise sugar glider (*Petaurus breviceps*) (47.8% overlap), eastern broad-nosed bat (*Scotorepens orion*) (46.8%), eastern forest bat (*Vespadelus pumilus*) (43.5%), long-nosed bandicoot (*Perameles nasuta*) (43.3%), red-necked pademelon (*Thylogale thetis*) (42.7%), greater broad-nosed bat (*Scoteanax rueppellii*) (41.6%), short-eared possum (*Trichosurus caninus*) (40.2%), mainland dusky antechinus (39.4%), white-footed dunnart (*Sminthopsis leucopus*) (37.5%), swamp rat (36.0%), agile antechinus (*Antechinus agilis*) (35.0%), eastern pygmy possum (*Cercartetus nanus*) (34.2%), eastern false pipistrelle (*Falsistrellus tasmaniensis*) (33.8%), feathertail glider (*Acrobates pygmaeus*) (33.8%) and bush rat (*Rattus fuscipes*) (30.8%).

		% overlap with fire		Estimated % population decline			Pre-fire conservation status	
Common name	**Scientific name**	**severe**	**total**	**1-week**	**1-yr**	**10-yr**	**EPBC**	**IUCN**
Kangaroo Island dunnart	*Sminthopsis fuligonosus aitkeni*	90.2	95.2	–64.8	–64.9	–46.4	EN	CR
Long-footed potoroo	*Potorous longipes*	38.1	81.4	–38.9	–46.3	–36.7	EN	VU
Hastings River mouse	*Pseudomys oralis*	22.1	73.7	–34.0	–36.0	–30.2	EN	VU
Kangaroo Island echidna	*Tachyglossus aculeatus multiaculeatus*	53.2	63.2	–27.7	–29.4	–23.8	EN	LC (as species)
Parma wallaby	*Notomacropus parma*	17.5	59.4	–20.4	–24.2	–15.9		NT
Long-nosed potoroo (NSW, Vic)	*Potorous tridactylus trisulcatus*	28.8	56.6	–26.0	–35.8	–33.4	VU (as *P. t. tridactylus*)	NT (as species)
Brush-tailed rock-wallaby	*Petrogale penicillata*	20.0	50.6	–10.4	–16.2	–22.7	VU	VU
Brown antechinus	*Antechinus stuartii*	20.8	50.3	–23.0	–26.3	–12.2		LC
New Holland mouse	*Pseudomys novaehollandiae*	15.5	45.6	–13.8	–23.9	–26.1	VU	VU
Southern brown bandicoot (SE Aust)	*Isoodon obesulus obesulus*	21.7	42.7	nd	nd	nd	EN	LC (as species)
Yellow-bellied glider (SE Aust)	*Petaurus australis*	16.9	41.4	–17.4	–21.0	–25.0		NT (as species)
Long-nosed potoroo (Qld, NSW)	*Potorous tridactylus tridactylus*	11.3	41.3	–14.4	–24.0	–24.7	VU (as *P. t. tridactylus*)	NT (as species)

Common name	Scientific name	% overlap with fire		Estimated % population decline			Pre-fire conservation status	
		severe	total	1-week	1-yr	10-yr	EPBC	IUCN
Spotted-tail quoll (SE mainland)	*Dasyurus maculatus maculatus* (SE mainland)	16.9	40.4	−12.7	−18.0	−17.9	EN	NT (as species)
Greater glider	*Petauroides volans*	14.6	35.6	−17.7	−21.7	−31.5	VU	VU
Platypus	*Ornithorhynchus anatinus*	11.4	27.4	−2.9	−8.4	−13.7		NT
Broad-toothed rat (mainland)	*Mastacomys fuscus mordicus*	14.3	27.2	−14.8	−17.9	−22.2	VU	NT (as species)
Smoky mouse	*Pseudomys fumeus*	12.5	27.1	−9.3	−17.0	−17.8	EN	VU
Large-eared pied bat	*Chalinolobus dwyeri*	9.9	26.6	nd	nd	nd	VU	NT
Koala	*Phascolarctos cinereus*	6.9	16.9	−7.1	−9.9	−25.8	VU (popn in Qld, NSW, ACT)	VU
Mountain pygmy-possum	*Burramys parvus*	13.3	15.7	−5.2	−9.2	−13.5	EN	CR
Grey-headed flying-fox	*Pteropus poliocephalus*	6.1	15.2	−3.3	−10.2	−15.2	VU	VU

Island echidna (*Tachyglossus aculeatus multiaculeatus*), parma wallaby, the south-eastern mainland subspecies of long-nosed potoroo (*Potorous tridactylus trisulcatus*), brown antechinus, mainland dusky antechinus (*Antechinus mimetes*) and swamp rat (*Rattus lutreolus*) (Table 16.1). The elicitation further predicted that most of the fire-affected species will show little recovery over the decade after fire, even under the unlikely presumption of no comparable wildfires in this period. In part, this predicted lack of recovery is because fire impacts were superimposed on a prevailing pattern of decline associated with other threats.

Based on these estimates of population losses, Legge *et al.* (in press) considered that five mammal taxa (mainland dusky antechinus, parma wallaby, platypus, long-nosed bandicoot and the south-eastern Australian subspecies of yellow-bellied glider (*Petaurus australis*)) are likely to be newly eligible for listing as threatened under the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and a further eight already listed taxa (mainland subspecies of broad-toothed rat (*Mastacomys fuscus mordicus*), greater glider (*Petauroides volans*), koala, long-footed potoroo, the two mainland subspecies of long-nosed potoroo (*Potorous tridactylus tridactylus* and *P. t. trisulcatus*), New Holland mouse (*Pseudomys novaehollandiae*) and Kangaroo Island dunnart) are likely to be eligible for up-listing (Box 16.1). To our knowledge, over recent centuries, no other single event has caused such an acute and sudden deterioration in the conservation status of so many mammal species. For the most fire-affected mammals, the process for listing as threatened or up-listing under the EPBC Act is underway, providing formal recognition of their extent of loss and some additional protection.

Box 16.1. Greater glider and yellow-bellied glider

Australia's two largest gliders, the greater glider (Fig. 16.2) and yellow-bellied glider, occur extensively across the forests of eastern Australia. Both had much of their range burnt in the 2019–20 wildfires (36% for greater glider and 41% for yellow-bellied glider). Both are dependent on large tree hollows for denning, with trees typically forming such hollows only when > 100 years old (Lindenmayer *et al.* 2013). These two glider species are undergoing broad-scale decline, mostly as a result of vegetation clearance, timber-harvesting, climate change and fire (McLean *et al.* 2018; Wagner *et al.* 2020; Lefoe *et al.* 2022). Both have low reproductive rates, so will recover very slowly from major disturbance. Greater gliders also have limited dispersal capability (Tyndale-Biscoe and Smith 1969), so may take many years to recolonise areas from which a population has been lost (Smith and Smith 2020). Greater gliders are obligate folivores, so may face major food shortages in burnt landscapes: early observers reported them 'crawling weakly over charred ground' weeks after the Victorian 1939 wildfire, and those that survived the fire 'died subsequently of starvation' (Fleay 1947). In contrast, yellow-bellied gliders have broader diets and occupy larger home ranges (Goldingay and Kavanagh 1991) so may persist somewhat better in largely burnt landscapes.

To investigate the impact of the 2019–20 wildfires, spotlight surveys were undertaken in high elevation forests in East Gippsland, Victoria, 1 year after the fires at 30 sites with pre-fire (mostly since 2010) records of greater gliders. At each site, a 500 m transect was surveyed using double-observer spotlighting methods (Cripps *et al.* 2021). An owl call playback survey was also undertaken 100 m away from each transect to target forest owls. Yellow-bellied gliders are known to respond to owl calls and the playback of owl calls probably increased detectability for this species. Greater

Fig. 16.2. The 2019–20 wildfires had a severe impact on the greater glider population. (Photo: Andrew Geschke)

gliders and yellow-bellied gliders were detected at 57% and 53% of sites respectively, and were detected more frequently in unburnt forest or forest burnt at low or medium severity than in forest burnt at high severity (Table 16.2).

Other post-fire surveys in burnt lower-elevation forests in East Gippsland found very low detections of greater gliders at previously occupied sites. Rutter and Blake (2020) detected greater gliders at only 29% of 24 previously occupied sites, and Burns and Atkins (2021) detected greater gliders at only one of 12 (8%) previously occupied sites. Yellow-bellied gliders appear to be more able to persist within the fire footprint, and were detected at 42% (10 of 24) (Rutter and Blake 2020) and 47% (14 of 30) of sites surveyed (Burns and Atkins 2021).

Comparable declines and losses due to the 2019–20 wildfires have also been reported for greater gliders in the Blue Mountains of New South Wales. At 16 sites known to be occupied by greater gliders before the fires, no gliders were recorded in sampling at 10 and 17 months post-fire at the two severely burnt sites, and they were considered extirpated from areas burnt with high severity; there was a mean decline of 43% in six moderately burnt sites; but also a mean decline of 34% at eight unburnt sites, attributed to extreme heat and drought (Smith and Smith 2021).

Table 16.2. Detections of the greater glider and the yellow-bellied glider during surveys in Victoria, summarised by fire severity.

All sampled sites had pre-fire greater glider records.

Species	Unburnt sites surveyed	Unburnt sites detected	Low–medium severity sites surveyed	Low–medium severity sites detected	High severity sites surveyed	High severity sites detected
Greater glider	5	4 (80%)	18	11 (61%)	7	2 (29%)
Yellow-bellied glider	5	3 (60%)	18	11 (61%)	7	2 (29%)

These spatial overlap assessments may be conservative, as fire-related impacts on mammals may also have extended beyond the burnt area. In an intriguing but disconcerting study, Peters *et al*. (2021) noted that nine smoky mice (*Pseudomys fumeus*) in a captive colony held outdoors 20 km from the nearest fire died 3 to 30 days after the approach of a 2019–20 wildfire, with pathological and clinical evidence demonstrating that these individuals died due to smoke inhalation. Currently, there is no information on the extent to which the susceptibility to smoke of the unfortunately named smoky mouse is representative of other mammal species, or of the extent to which the impact of smoke attenuates over distance or duration. However, the death of these mice does indicate that at least some mammal populations occurring in unburnt patches within or on the periphery of the fire scar may not persist, potentially subverting the previously assumed refugial value of such patches.

The third approach to estimating impacts of the 2019–20 wildfires has involved on-ground surveys to directly compare the abundance of some mammal species in matched burnt and unburnt areas, or at sites sampled before and after the 2019–20 wildfires, or a combination of these (a Before-After-Control-Impact (BACI) design). A constraint on the Before-After sampling approach is the limited amount of monitoring established for most Australian mammals. This direct approach has the advantage of collection of robust data rather than inference or expert opinion but, because of its resource demands, has been undertaken for only some species, in some parts of their range. Many of the results have not yet been analysed or published, and for obvious reasons this approach has provided data to date only on the short-term responses to the 2019–20 wildfires. Examples of this approach are presented in Boxes 16.1 to 16.3; all demonstrate that populations declined in burnt areas, with decline most marked in areas where fire was of high severity.

Box 16.2. Golden-tipped bat

The impacts of wildfire on insectivorous bats are varied (Law *et al*. 2018). One species, the golden-tipped bat (*Phoniscus papuensis*) (Fig. 16.3) has particular ecological specialisations that render it especially susceptible to fire. This bat roosts in suspended nests made by yellow-throated scrubwren (*Sericornis citreogularis*) or brown gerygone (*Gerygone mouki*), typically located in the forest understorey: these are highly likely to be destroyed with any fire. It also forages mostly on spiders taken from webs strung among shrubs, and this resource is also likely to be severely depleted by fire. The habitats mostly favoured by golden-tipped bats – rainforest and wet eucalypt forest gullies – rarely burn, but this was not the case in the 2019–20 wildfires, at least in part because drought preceding the fires probably increased the flammability of such patches. Extensive trapping surveys were conducted across 35 burnt and 26 unburnt rainforest sites 1 year after the 2019–20 fires (Law *et al*. in press). Site occupancy was found to be > 90% at sites surrounded by extensive rainforest and gully systems or unburnt forest, but just 20% in comparable sites where 100% of the surrounding area was burnt (regardless of severity). Radio-tracking also revealed bats did not roost where rainforest was burnt by high severity fire. Maternal bats did not avoid roosting in rainforest burnt by low severity fire in northern New South Wales, though roost selection avoided rainforest burnt by such fires in southern New South Wales,

Fig. 16.3. Golden-tipped bat. (Photo: Brad Law)

suggesting some variability in responses to fire. These results illustrate the vulnerability of rainforest-dependent species to extreme fire events, even though such areas are normally protected from fire.

Box 16.3. Koala

There have been several studies aiming to assess the impacts of the 2019–20 wildfires on koala populations. In north-eastern New South Wales, 123 sites sampled (using pellet counts) for koalas before the 2019–20 fires were re-sampled 2–7 months after fire. Post-fire site occupancy of koalas declined markedly (median reduction of 71%) relative to pre-fire occupancy. Fire severity affected the extent of koala loss, with survival fivefold higher at sites burnt in fires of low to medium severity than at sites exposed to severe fire (Phillips *et al.* 2020). In contrast, a different sampling approach (using acoustic monitoring) of koalas in hinterland forests of north-eastern New South Wales reported that fire had no effect on site occupancy rate, but a dramatic (at least short-term) effect on density, with 100% reduction in density where fire was severe within a 1 km radius of the sample site, 50% reduction where fire severity was moderate and no change where it was low severity (Law *et al.* 2022). Some recovery was evident one year after fire in areas where high severity fire dominated. In southern

New South Wales, Cristescu *et al.* (in press) used drones with thermal imagery ~30 days post-fire to compare koala density at two sets of paired burnt and unburnt sites, reporting 24% and 26% lower densities in the two burnt sets of sites relative to their unburnt controls. That study also sampled two sets of paired burnt and unburnt sites ~100 days post-fire in south-eastern Queensland, based on searches for scats by detection dogs. That research found that koala density was 71% lower in burnt areas relative to unburnt control areas in one set, but 317% higher in burnt sites relative to unburnt controls at the other set, noting that this result may be due in part to poorly-matched controls. This study noted that koalas rapidly used fire-affected trees, feeding (within 3 months of fire) on epicormic growth, and could maintain home ranges within fire-affected areas.

The 2019–20 wildfires reduced populations of many mammal species. There may be important ramifications of such losses, as many of these affected species (such as flying-foxes, bandicoots and potoroos) perform important ecological roles. Reduced populations of these species may compromise the recovery of ecosystem health and functionality in burnt landscapes.

Broad context for impact and recovery

With caveats due to the exceptional size of the 2019–20 wildfires, the evidence base built from many decades of research on the responses of mammals to previous wildfires (e.g. Arthur *et al.* 2012) can be used to infer the longer-term consequences of the 2019–20 fires. Unsurprisingly, this research body has demonstrated that there are marked differences among mammal species in their susceptibility to population loss in fires, and in the time taken to recover (Whelan *et al.* 2002). This variation is associated in part with differences among species in ecological and life history traits. Species that are less capable of fleeing fire, and that have no protective shelter (e.g. burrows), are more likely to suffer higher rates of mortality during fire. Species with more pronounced dietary or habitat specialisation, or that have more dependence on resources that are prone to depletion by fire, will tend to have lower rates of survival in the aftermath of fire. Species with low reproductive rates and more limited dispersal ability are likely to take longer to recover. Impacts vary also with characteristics of the fire and with the spatial and temporal patterning of fires (the fire regime). Impacts also vary according to the evolutionary history of the environment, with typically more tolerance to fire, and more likelihood of recovery, in many eucalypt forests than in rainforests (Box 16.2). Fire impacts are also likely to be more pronounced and long-lasting for some mammals in montane ash forests, where the dominant eucalypt trees are killed by fire and tree regrowth is from seed, than in other eucalypt forests and woodlands, where trees are more likely to survive fire, producing post-fire epicormic foliage.

Many mammals are likely to be killed in the fire itself. Nonetheless, survival rates may be high for some species even in severely burnt areas (Banks *et al.* 2011b) and, for some mammal species, recovery post-fire is largely a result of recruitment from the residue of those animals that survived in burnt areas (Banks *et al.* 2011a). In landscapes that are mostly burnt, unburnt patches may provide refuges and source areas for recolonisation into burnt areas (Berry *et al.* 2015); however, the edges of burnt and unburnt vegetation may be targeted by feral cats (Hradsky 2020). Native mammals that survive in their burnt home ranges may also be more exposed to higher predation rates after fire (Arthur *et al.* 2012) because the fire has removed vegetation cover and because higher-risk foraging may be necessary in an environment with fewer food resources. Fire may also reduce the abundance of den sites such as tree hollows, a critical resource for many mammal species and one that may take more than a century to restore (Lindenmayer *et al.* 2013). Very extensive fires, such as the 2019–20 wildfires, also tend to homogenise the landscape, reducing its ecological variability and hence its capability to support diverse assemblages of mammals, and the variety of resources it can offer to individual species. This latter factor may be especially important for species such as Leadbeater's possum (*Gymnobelideus leadbeateri*) which requires a mix of resources that may be most readily attained in habitat mosaics of variable time since fire (Nitschke *et al.* 2020).

Furthermore, although many mammal species may suffer major losses in individual fires, it is the patterning of successive fires that may most critically affect viability of mammal populations. Population modelling has demonstrated that an increasing frequency and extent of fires – especially where accompanied by other threats – is likely to drive precipitous population declines for many mammal species, including koala (Lunney *et al.* 2007) and Leadbeater's possum (Todd *et al.* 2016). Because of changing disturbance regimes (fire and timber-harvesting), older-aged forests are a diminishing component of the landscape (Chapter 19). These habitats may be critical conservation strongholds for hollow-dependent mammals, and hence should be recognised as assets for protection in fire planning and operations (Lindenmayer and Taylor 2020a).

Management responses

Some management actions taken before and after the 2019–20 wildfires may have reduced the impacts of these fires on mammals and helped support their post-fire recovery. In some regions, sustained control programs for introduced predators led (pre-fire) to population increases for some threatened mammals such as long-footed potoroo (e.g. Robley *et al.* 2014). These programs probably contributed to an increased likelihood that sufficient individuals survived fire to maintain population viability. Furthermore, the establishment of such predator control programs also allowed for their rapid reimplementation following the 2019–20 fires, to help reduce compounding impacts. Survey and monitoring programs established for some threatened mammals before the 2019–20 fires provided a baseline from which to assess the extent of loss in the fires and to provide a target for post-fire recovery. In some cases, research undertaken before the 2019–20 fires resulted in the development of effective survey protocols for species with low detectability (e.g. Hohnen *et al.* 2019), thereby allowing for post-fire surveys to most efficiently locate and protect populations that survived the fires. Although there proved to be no need in the 2019–20 fires, there are now well-established and successful captive-breeding programs for some threatened mammals, such as mountain pygmy-possum (*Burramys parvus*). Such insurance populations provide a potential source for re-establishment of populations that may be lost in any future comparable fire (e.g. Chapter 27).

Management actions were taken soon after the 2019–20 wildfire to aid surviving mammal individuals, to reduce other threats and to support recovery. Rapid responses were made by many groups to find, treat and provide shelter for mammals injured in the fires (see Chapter 26). Previous post-fire research had provided evidence of reasonable survivorship for treated koalas released back to the wild (Lunney *et al.* 2004), so such animal welfare and rehabilitation efforts can provide at least a local benefit to recovery. Targeted and broad-scale control programs, mostly poison baiting, for introduced predators were implemented at many sites following the 2019–20 wildfires (see Chapter 17). A population of the Kangaroo Island dunnart that was discovered in a partly burnt landscape was protected post-fire by the rapid construction of predator-proof fencing (see Chapters 24, 25). At some sites with surviving dunnart populations, at which fire had removed vegetation cover, artificial shelters were also provided to reduce post-fire predation risks (Fig. 16.4).

There were also some high-profile programs undertaken to supply food for some mammal populations persisting in largely burnt landscapes, including aerial food drops for rock-wallabies (Chapter 24) and provision of nutrient-rich biscuits for mountain pygmy-possums (Chapter 27). In many largely burnt landscapes, in which the abundance of hollow-bearing trees had been markedly reduced by fire, conservation organisations and community groups provided nest boxes or artificial hollows for hollow-dependent mammals and birds. Conversely, some management actions taken after fire are likely to have had inimical impacts on mammal survival and recovery; most notably, salvage logging will have compounded the losses of hollows caused through fire (see Chapter 19).

Even with the large body of research that has been undertaken on the impacts of fire on Australian mammals, there remain some important knowledge gaps that should be addressed. These include (1) the relative cost-effectiveness of management actions taken after fire to help recover mammals; (2) whether critical sites for the conservation of mammals can be identified, circumscribed and included as assets for protection during fire control operations; (3) the extent to which smoke causes mortality in mammals beyond the fire perimeter; (4) what mechanisms can reduce the likelihood of future catastrophic fire, and the extent to which these mechanisms themselves cause detriment to mammals;

Fig. 16.4. Artificial shelters were constructed in some burnt landscapes to reduce risks of predation for native mammals after fire, in this case for Kangaroo Island dunnart. (Photo: Nicolas Rakotopare/Threatened Species Recovery Hub)

and (5) the capability for post-fire recovery of mammals, especially those restricted to habitats that are ill-adapted to fire (notably rainforests).

Conclusions

The 2019–20 wildfires caused severe population losses of many mammal species. These losses have acutely compounded the impacts of other threats that were already driving decline in much of the distinctive Australian mammal fauna. Comparable catastrophic fires are likely to recur more frequently in the future, due to global climate change. Many of the mammal species most affected by the 2019–20 wildfires are unlikely to recover to their pre-fire population size, especially if recovery is interrupted by comparable fires within 10–20 years. Conservation efforts taken in the period since the fires have provided some local and regional benefits, but the extent of such benefit is not yet well resolved.

Recommendations

- Increase the likelihood of recovery (and build resilience) for fire-affected mammal species through the more pervasive and effective implementation of programs for the control of threats that are more tractable to manage (especially habitat loss, timber-harvesting, and introduced predators).
- Expand monitoring programs to more effectively chart recovery and evaluate the effectiveness of recovery actions taken after the 2019–20 wildfires.
- Undertake research on the impact of fire (and fire regimes) on mammal species for which fire responses are poorly known, to help inform assessments of fire impacts in the future.
- Undertake research on the impacts of smoke on mammal species, to allow for a more robust estimate of mortality beyond the fire perimeter.
- Within largely burnt regions, instigate active management programs that aim to protect unburnt (especially long-unburnt) patches from further fire.
- Identify other key sites, such as natural fire refugia, for the conservation of threatened mammals and seek to recognise these in fire management plans as assets for protection during fire operations.
- Implement legislation, policy and practice that more effectively and rapidly reduces greenhouse gas emissions – else, there will be an escalating rate of destructive fires that will be beyond the capacity of many mammal species to survive or recover from.

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