25

Responses of natural resource management groups to biodiversity loss and recovery in the 2019–20 wildfires

Rachel Morgain, Karleah K. Berris, Leigh Blackmore, Paul Donatiu, Paul Jennings, Cherie White and Jacob White

Summary

- Natural resource management (NRM) organisations are regional bodies that span Australia, and plan, coordinate and deliver programs that support healthy and productive country, communities and regional industries.
- A significant focus of NRM involves addressing landscape-level challenges in an integrated way through fostering engagement and participation, working with and empowering communities, First Nations groups and landholders, and building regional networks and linkages to deliver ground-up responses to regionally identified needs and priorities.
- Emergency funding for the 2019–20 wildfire response has been vital to supporting NRM organisations to respond to landscape-level recovery needs across tenures and across riparian, freshwater, terrestrial and coastal systems.
- NRM organisations frequently played a pivotal role in rapid response, including helping coordinate local and regional networks, serving as a focal point for community action, supporting First Nations priorities, providing a ready conduit for resources to support rapid on-ground action, and acting as a resource for community and landholders seeking information.
- A pre-existing knowledge base supported rapid response and effective prioritisation, but was uneven across landscapes, species and ecosystems.
- Greater investment in coordination, collaboration and planning between agencies would act to strengthen on-ground responses in future. That includes coordination of leadership roles and funding, and development of pre-approved emergency response and assessment plans for species and ecosystems.
- Greater flexibility in funding would help ensure it could be better targeted in future, for example ensuring that funding for First Nations and local

partnerships meets the most important priorities of those groups, that activities are undertaken at the most appropriate times, or that priorities that currently fall through the gaps of major programs, such as protecting refuges, managing waterways, supporting non-threatened or locally threatened species and restoring ecosystem function, are met.

- Significant knowledge of ecosystems, recovery actions and effective response capabilities has been increased through the recovery phase, but needs to be consolidated and built upon to strengthen our understanding and preparedness for future events.
- There is a need for long-term investment so that the sector can manage ongoing recovery priorities and build the resilience of these populations and ecosystems for future events.
- Wildfires of this severity place significant pressures on systems in place for responding to impacts and recovering biodiversity, including on communities and NRM managers themselves, suggesting a need to embed resilience and create more surge capacity in our human and organisational systems, as well as our species and ecosystems.

Introduction

Natural resource management (NRM) organisations are regional bodies established to deliver programs to support healthy and productive country and communities. There are currently 54 regional NRM organisations across Australia, spanning the continent, ranging from statutory bodies to non-government organisations. NRM organisations receive funding from state, territory and federal governments to build local and regional approaches to manage land, water, soil and biodiversity. A significant focus of NRM organisations is on fostering resilience across landscapes, ecosystems and communities through engaging and empowering local communities, landholders and First Nations organisations to build ground-up approaches and support on-ground activities that address local landscape-level priorities.

Natural resource managers have responded to a huge diversity of needs following the 2019–20 wildfires: to care for ecosystems, soils, waterways, species, heritage, and culturally significant sites, as well as supporting landholders and community recovery across public, private and mixed-tenure landscapes. In the wake of the fires, the severe impacts on communities and organisations from the disaster placed significant pressures on systems in place for biodiversity and landscape management. A wide range of questions are still emerging from landholders, First Nations and community members seeking to understand how to respond to the severe and complex impacts of the fires, and the interactions with other threats such as drought and flooding. Despite the immense challenges, communities have sought to take action to reconnect and help heal the landscapes around them.

NRM organisations were well placed to support and develop locally appropriate responses to these diverse and complex needs. The rapid mobilisation and coordinated responses of NRM organisations was made possible by their being situated in communities and by their knowledge of local ecosystems, networks and resources. By being flexible and responsive to local needs, they have provided a critical element in the fire response. In the wake of the fires, NRM organisations were called upon to help coordinate networks

and activities, assess impacts, guide and prioritise actions, mobilise communities and provide vital information, as well as to undertake assessments and recovery actions themselves for biodiversity, heritage and culturally and ecologically significant places. Taking an integrated approach to landscape management, NRM organisations have been able to address gaps between the responsibilities of other agencies, working across tenures and across terrestrial, riparian, freshwater, marine and coastal ecosystems. At the same time, being embedded in regions has allowed for an enduring focus, after the crisis response has passed, on longer-term recovery, and on preparedness for future events.

Aided by emergency funding from the Australian Government and state and territory governments, NRM organisations have helped undertake priority actions, coordinated with other response agencies and provided a focal point for wider community engagement. Forty-two regional NRM organisations were in regions affected by the fires, with 16 regions, plus Ocean Watch, receiving priority funding for urgent fire recovery actions from the Australian Government in their initial response to the fires. Thirteen of these regions were supported for longer-term recovery efforts through the Australian Government's Regional Fund (see Fig. 25.1; Chapter 22). The recovery actions coordinated by regional NRM organisations have spanned diverse activities from managing landscape-scale impacts such as weeds and overabundant and feral species, soil erosion and restoring fencing (including for grazing exclusion), to direct restoration, species-specific responses, and recovery actions for ecosystems, wetlands and river systems. Many NRM organisations have also partnered with First Nations communities to support caring for culturally significant sites and Country, and renewal of cultural fire and land management.

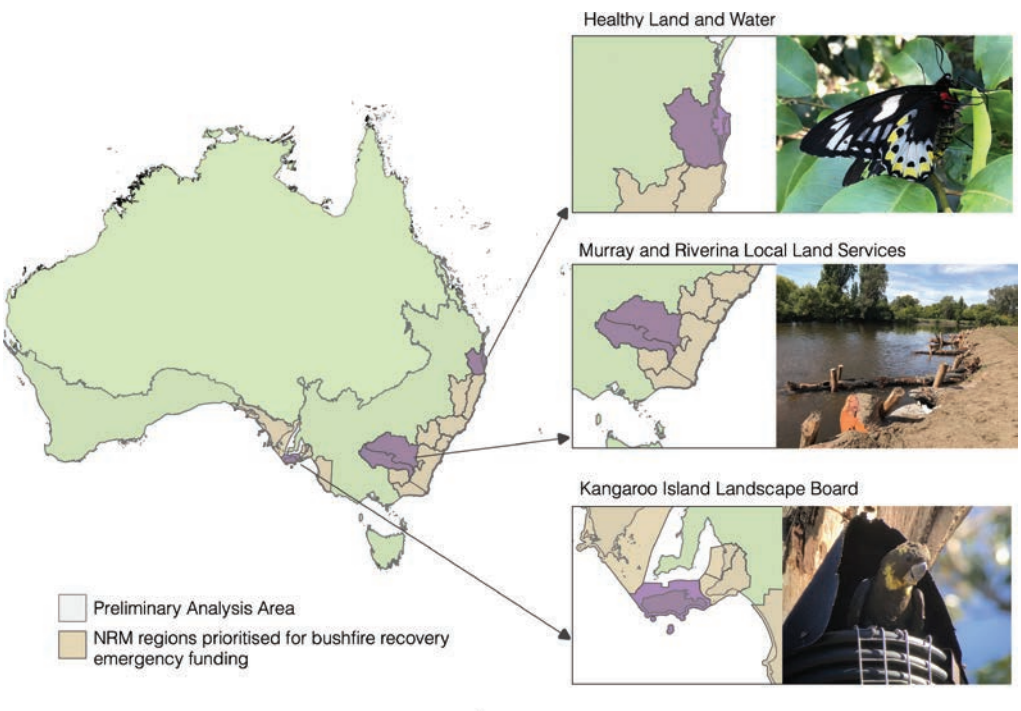

Fig. 25.1. Map of NRM regions prioritised for wildfire recovery, also showing the locations of the three case studies (Boxes 25.1 to 25.3).

In many cases, the biodiversity response of regional NRM organisations has drawn strongly on research and from the knowledge base built from years of experience. Post-fire assessments and monitoring have built further on our understanding of how species and ecosystems respond to and recover from fire, and the effectiveness of certain actions in the immediate aftermath of the wildfires. However, recovery will take many years, and will require ongoing resources for both recovery actions and monitoring to understand effectiveness over the longer term. Longer-term investment is going to be critical if we are to consolidate recovery, learn the lessons from these fires, and prepare the resilience of our ecosystems – and our response systems – for future events.

This chapter explores responses of NRM organisations across different regions in the fire footprint. These responses illustrate the breadth of activities that NRM organisations have been involved in to protect and recover biodiversity in the aftermath of the fires. They highlight the critical role NRM organisations play in coordinating regional networks to assess and prioritise recovery responses and in mobilising local communities in the response. They also show the importance of NRM organisations as repositories of local knowledge of species and ecosystems, to enable development and implementation of rapid and targeted responses to wildfire.

Box 25.1. Communication, coordination and collaboration as key ingredients to mitigate ecological impact of wildfires in Murray and Riverina NRM regions

Recovery efforts by government agencies and community groups to mitigate the ecological impact from the 2019–20 wildfires in the Murray and Riverina NRM regions were both challenging and effective. The collaborative effort demonstrates how communication, coordination and collaboration, with strong support from governments, landholders and the community, can lead to positive outcomes for the recovery of environmental health in the aftermath of large-scale wildfires.

The Dunns Road and Green Valley wildfires started on 30 December 2019, burning out of control for about 2 weeks. The fires covered an area of ~250 000 ha of private land, national park and state forest within the Murray and Riverina NRM regions, linking up with fires in neighbouring regions to form a large fire complex of over 600 000 ha.

Once the fires were under control, Murray Local Land Services (LLS; Fig. 25.1) brought together stakeholders to develop a cross-tenure landscape approach to recovery. It became evident that the scale of the ecological impact was immense and needed prompt attention, but direct impacts on people, stock and wildlife were the highest priority for many agencies. Immediate planning and coordination of the medium to long-term ecological impacts was required, but it was recognised that the wider community would not yet be ready to start these discussions.

Each organisation had its own area of interest, but no single agency held a clear mandate to provide overall leadership in coordinating ecological recovery efforts. At the initial meeting of stakeholders, the group discussed the key issues and what action would be required. The need for a landscape-scale action plan or strategy was identified as a critical component of a successful recovery.

Murray and Riverina Local Land Services negotiated with the Australian Government to allocate a portion of funding from the Wildlife and Habitat Bushfire

Recovery program (Chapter 22) to develop a landscape-scale plan to assist in identifying and prioritising actions. Holbrook Landcare Network and Murrumbidgee Landcare Inc. combined forces to develop this plan, in consultation with government agencies and the wider community. Their involvement in leading this process was an important component in capturing community interests and values, and ensuring these were well represented within the plan.

The group continued to meet on a regular basis with three key objectives: to inform each other of their recovery activities; to identify opportunities for collaboration; and to identify and plan to address priority actions that were not otherwise being undertaken. An online communication tool was set up to provide a platform for the group to communicate and track progress against the plan.

As a result of this communication, coordination, and collaboration many positive outcomes were achieved. Some examples included:

- developing a set of videos for landholders to understand the post-fire erosion process and develop low-cost techniques to reduce the impact on waterways. These were produced through a collaborative effort from North East Catchment Management Authority, Murray and Riverina LLS, Agriculture Victoria and NSW Soil Conservation Service. These were used by landholders in the recovery and are readily available for future events.
- protecting and enhancing native vegetation in key areas of private land through fencing, weed control and revegetation. Holbrook Landcare Network and Murrumbidgee Landcare Inc. played a leading role, working directly with the community and private landholders.
- creating habitat for the Endangered trout cod (*Maccullochella macquariensis*) and stabilising waterways using 65 large burnt trees that were removed from roadsides due to safety concerns (Fig. 25.2). This work was initiated by NSW Fisheries and involved Regional Roads Victoria, NSW Soil Conservation Service, Parks Victoria and Murray LLS.
- reducing sediment through a targeted erosion control program to protect key habitat for the Endangered booroolong frog (*Litoria booroolongensis*) in Gilmore Creek through a partnership with Soil Conservation Service and Riverina LLS.
- rescuing the last remaining population of the Endangered Macquarie perch (*Macquaria australasica*) in the NSW Murray system from Mannus Creek before the creek turned to sludge after the first big rain event following the fires (Fig. 25.3). Led by NSW Fisheries, this has seen the population on the road to recovery, with Charles Sturt University undertaking surveys, controlling pest fish, and developing a management plan; NSW National Parks and Wildlife Service (NPWS) controlling willow regrowth; and Murray LLS coordinating groups and funding. In the Riverina LLS region, a proportion of the Macquarie perch population was translocated into Adjungbilly Creek, part of a broader threatened species program in the creek to improve genetic diversity and restore riparian habitat.
- with reduced canopy cover in the forests, undertaking a successful coordinated aerial control program to control the numbers of pest herbivores, giving native vegetation a chance to recover. Led by NSW NPWS, this collaboration involved Murray LLS working with private landholders bordering national parks to allow the program to extend into private land.
- prioritising properties surrounding Ellerslie Nature Reserve for pest animal and plant control to support the recovery of the threatened box gum grassy woodlands

Fig. 25.2. Timber from wildfire-affected trees removed to maintain road safety used to control erosion and improve the habitat of the endangered trout cod. (Photo: David Thatcher)

ecological community. Riverina LLS led this program, engaging private contractors to assist landholders to undertake this work.
- undertaking a coordinated woody weeds control program by NSW Forestry Corporation, NSW NPWS, Snowy Valleys Council, LLS and private landholders.

The coordinated plan meant that, when funding opportunities arose, investor priorities could be matched with regional needs, and achievements could be tracked. These activities were largely funded through the Australian Government's Wildlife and Habitat Bushfire Recovery investment fund, and NSW Government funding.

Some of the key lessons and insights include the following:

- A regionally focused ecological recovery plan enabled stakeholders to address the issues in a holistic and coordinated manner.
- Collaborative action achieved significant benefits for threatened species and ecosystems.
- A lack of species information, including basic information such as species distribution, limited the ability to make informed decisions about resource allocation and prioritisation.
- A need to protect unburnt areas, or areas of low fire-intensity, as refuges for wildlife and plants was identified, but limited funds were available to implement action.
- Funding opportunities were predominantly limited to nationally threatened species or issues impacting farming production. There were limited opportunities to access funding that would assist regionally identified priorities, such as ecological recovery

of non-listed species or regionally threatened species, monitoring/surveys to establish baseline species information, waterway protection and habitat connectivity.
- Engaging Holbrook Landcare Network and Murrumbidgee Landcare Inc. to lead the development of an ecological recovery plan ensured community values and local knowledge were embedded into the plan.
- A communication and engagement plan would add value to the ecological recovery efforts, providing consistency in messaging and help bring communities along for the journey.

Communication, coordination and collaboration were the keys to success and enabled positive outcomes to be achieved. With improved clarity of leadership responsibility and additional resources to plan, coordinate and foster collaboration, even greater outcomes could be achieved, delivering significant return on a very modest investment.

Fig. 25.3. Local landholder children assisting with the introduction of captive bred Macquarie perch to boost the number and genetic diversity of the local Mannus Creek Macquarie perch population that was severely impacted by the 2019–20 wildfires. (Photo: Karin Willcox)

Box 25.2. Recovering fauna on Kangaroo Island

Between 20 December 2019 and late January 2021, lightning strikes started wildfires that burnt around 211 000 ha of land on Kangaroo Island, almost half the area of the island (Government of South Australia 2020). The wildfires impacted native vegetation and farmland, primarily on the western half and north coast of the island. Immediately, there was concern for two Kangaroo Island Endangered endemics: the South Australian glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*) and the Kangaroo Island dunnart (*Sminthopsis griseoventer aitkeni*). The regional NRM group, Kangaroo Island Landscape Board (KILB), commenced surveys for both the glossy black-cockatoo and dunnart immediately after the fires, and in the 18 months post-fire have implemented a range of management actions aimed at securing both populations from further declines after the fires.

South Australian glossy black-cockatoo

The South Australian glossy black-cockatoo became extinct in mainland South Australia in the 1970s, and has since been restricted to Kangaroo Island (Joseph 1989; Berris *et al.* 2018). A long-term recovery program commenced in 1995, focused on protecting

nests from predation, and provided extra habitat through revegetation and nest box installations. Between 1995 and 2016, the population of glossy black-cockatoos on Kangaroo Island had more than doubled, thanks to this sustained conservation effort (Berris *et al.* 2018). After the 2019–20 wildfires, while surveys concluded that the glossy black-cockatoo populations were not immediately heavily impacted, loss of a large proportion of their feed trees, drooping she-oak (*Allocasuarina verticillata*), could have a long-term impact, and may already be resulting in declines, as detected in subsequent surveys (see also Chapter 15).

Monitoring by KILB indicated there was no evidence of birds relocating out of burnt western areas of the island to habitat further east, and that flocks persisted in all regions they had been recorded pre-fire. However, these flocks were now restricted to the smaller patches of unburnt she-oak remaining. Therefore, post-fire management actions commenced across all seven flock regions on the island.

KILB has focused on revegetation of feeding habitat, providing nest boxes, and predator and competitor control post-fire (Fig. 25.4). This work started immediately after the fireground was declared safe to access. The KILB Native Plant Nursery

Fig. 25.4. Many new nest boxes were established for glossy black-cockatoos after the wildfires on Kangaroo Island. (Photo: Mike Barth, Kangaroo Island Landscape Board)

propagated 6000 she-oak seedlings within a month of the fires ending. Staff built and installed nest boxes, and the Serpentine–Jarrahdale Landcare Group in Western Australia provided 'Cockatubes'. In the 18 months post-fire, more than 13 600 drooping she-oak seedlings have been planted across Kangaroo Island on private properties, and over 60 new nest boxes have been installed to replace nests destroyed in the fires.

In addition, possum exclusion collars on the base of more than 200 nest trees were repaired and canopy isolation pruning undertaken to prevent predators accessing nest trees, giving the glossy black-cockatoo population the best chance of continued high reproductive success. Trials have now commenced with closing off key nest boxes during the non-breeding season (spring) to deter self-colonised nest competitors such as galahs (*Eolophus roseicapillus*) and little corellas (*Cacatua sanguinea*). The competitors, which seem to be impacting some sites more heavily post-fire, caused several glossy black-cockatoo nest failures in 2021. Further research is also being undertaken on the post-fire recovery of drooping she-oak, with the aim to better understand the fire ecology of this tree species, and ultimately understand the fire intervals required to promote high-quality feeding habitat for glossy black-cockatoos.

One constraint has been the labour intensiveness of the work undertaken, given much of it requires tree climbing, and our working area spans the length of the island. Generous support provided by World Wide Fund for Nature and the Australian Government has funded three dedicated glossy black-cockatoo recovery staff for 2 years post-fire. However, given this species is conservation dependent and requires protected nests for adequate recruitment to sustain the population, ongoing funding for management will be needed. COVID-19 restrictions also prevented large volunteer events, limiting the ability to carry out large-scale revegetation projects.

The glossy black-cockatoo is arguably in a tenuous position post-fire, and now has access to less than half of the feeding habitat it had previously. Some flocks lost more than 90% of the available feeding habitat within their home range and are restricted to very small areas post-fire. Therefore, the glossy black-cockatoo population is extremely vulnerable to events that may affect food availability, such as further wildfires or drought. A challenge going forward will be to manage the remaining feeding habitat so that it continues to support the flocks that are reliant on it, and to prevent further habitat burning before habitat burnt in the 2019–20 wildfires regenerates.

Kangaroo Island dunnart

The Kangaroo Island dunnart had only been reported on 46 occasions from 21 sites before the fires, and it was estimated that 96% of the species' known contemporary habitat was burnt during the wildfires (see Chapter 16). At the time, there was very little understanding of how Kangaroo Island dunnarts respond to fire in the landscape; however, evidence from other small mammal species suggests that they were vulnerable not only to direct mortality from the fire but also to increased predation pressure by feral cats after the fire due to a reduction in ground cover that provides refuge. Therefore, the initial monitoring objectives were to improve understanding of the distribution of the dunnart post-fire to reduce predation through targeted and intensive feral cat control in areas where dunnarts were detected, until a better understanding of the status of the species could be ascertained.

Within a month of commencing surveys, dunnarts were detected in some of the few remaining unburnt patches of vegetation within the parks and reserves system on the western end of the island, and subsequently in severely burnt areas where dunnarts

had been detected pre-fire. Survey efforts expanded across burnt and unburnt areas of suitable habitat on both private and public lands and sites of historical dunnart records across the island were re-surveyed. Dunnarts have now been detected at 66 sites from 220 surveyed and have been recorded on over 400 separate occasions across public and private property in both unburnt and burnt habitat, and in a range of habitat types, from the central lateritic plateau to coastal heath at Cape du Couedic and Cape Borda. They have also been more frequently detected from burnt sites than unburnt sites, a result not anticipated when survey efforts began. Sites where dunnarts have been detected are entirely confined to the island's western end, primarily within the protected parks and reserves, which represent some of the largest untouched areas of native vegetation on the island.

Cat management is being directed to areas where dunnarts and other high-priority species are detected (see also Chapter 17). KILB is also undertaking broad-scale control of feral cats across successive management units, which form a progressive front from west to east across the island's fire-affected landscape. This approach uses a combination of cage and padded foothold traps in each management unit. Intensive cat control over 5 or 6 weeks has seen an estimated 70–80% decline in cat activity within management units, based on detection rates on motion-activated camera arrays. Cats remaining in each management unit are then targeted using a combination of thermal night-vision techniques and trained feral cat detector dogs to reduce this number even further. This approach has seen over 750 feral cats removed since the fires.

A Curiosity® feral cat baiting trial was undertaken during the 2020 winter in the West Bay/Breakneck River area within Flinders Chase National Park to determine the efficacy of a broad-scale baiting program, so cat control efforts across fire-affected areas of western Kangaroo Island can be optimised. Curiosity® baits were deployed aerially by helicopter over an 85 km^2 baiting area, with a motion-activated camera array lying at the centre of the treatment area. This trial saw a 75% reduction in feral cat detection rates (i.e. the proportion of camera trap-nights with cat detections) following baiting. This program was expanded to cover a much larger area in the 2021 winter, targeting high-priority unburnt vegetation and the network of roads, tracks and travel ways that feral cats were known to frequent within national parks and wilderness protection areas.

COVID-19 restrictions have had a huge impact on the recruitment of staff and the availability of tools and technology to implement this project. Another constraint was that approvals were not initially in place to undertake rapid surveys and to implement management actions. Emergency response plans for threatened species recovery and rapid assessment would have been invaluable to allow activities to occur immediately and for feral cat control techniques to be pre-approved to maximise impact.

Box 25.3. Strategies to restore Critically Endangered lowland subtropical rainforest following the 2019–20 wildfires

Large areas of the Gondwana Rainforests of Australia World Heritage Area in south-east Queensland, including 70% of both Mt Barney and Main Range national parks and nearly 8% of Lamington National Park, were severely affected by high intensity

wildfires in late 2019. These areas provide habitat for many threatened flora species and one nationally listed ecological community: Critically Endangered lowland subtropical rainforest (see also Chapter 8). The fires damaged rainforest and wet sclerophyll communities, opening up forest canopies and allowing weeds to become established in canopy gaps. However, post-fire there was also significant evidence of natural regeneration – both resprouting (basal, stem and root) and germination from seed (from established soil seed banks).

To maximise limited on-ground funding, the regional NRM organisation, Healthy Land and Water (HLW), sought to identify the post-fire recovery strategies of rainforest flora, and use this information as a basis for identifying the most effective approach to ecosystem restoration. This has required addressing questions about the capacity of rainforest and wet sclerophyll flora to deal with fire events of varying intensity, in particular:

1. Which native flora are regenerating post-fire?
2. What are the mechanisms used by rainforest and wet sclerophyll flora to regenerate post-fire (resprouting, by seed, or both)?
3. What successional category do regenerating species fall into?
4. How does fire intensity affect the capacity of rainforest and wet sclerophyll flora to regenerate post-fire?

Insights into these questions have supported decisions about the strategies needed to regenerate these fire-affected areas, and from this what general strategies need to be considered (such as supplementary planting of select species) when restoring fire-affected rainforest and wet sclerophyll vegetation communities.

Funding of nearly $1 million over 2 years was provided by the Australian Government through the Wildlife and Habitat Bushfire Recovery investment fund (Chapter 22), and enabled HLW to coordinate restoration activities in some of these fire-affected areas (Fig. 25.5). HLW staff have collected imagery of, and described the regeneration strategies used by, 100 rainforest and wet sclerophyll plant species in fire-affected areas of Lamington National Park, predominantly Upper and Lower Illinbah, Caves Circuit, Lower Bellbird Circuit, and Tabletop Mountain (Donatiu and White 2021). Where known, the successional status of these species (Pioneer, Early Secondary, Later Secondary or Mature Phase, as per Kooyman 1996) and their conservation status were recorded.

Fig. 25.5. Sampling impacts of the wildfires on plants in Gondwanan rainforests. (Photo: Paul Donatiu)

Very few species were killed outright by the fires, showing neither capacity to regenerate from seed nor resprout, with bangalow (*Archontophoenix cunninghamiana*) and walking stick palms (*Linospadix monostachyos*) the most notable (though the former were able to survive a trickle fire running through forest litter in the rainforest understorey). Perhaps the most unlikely finding was the high number of Mature Phase species that resprouted post-fire. Although slow-growing, and without the lateral branching structure evident in Pioneer species, their presence provides valuable assurance that large numbers of rainforest species were not lost to fire. Almost 20 Mature Phase species are clearly resprouting – probably a gross underestimate of the total number – providing compelling evidence of both rainforest recovery and resilience in the face of wildfire. For the present, and in the absence of subsequent equally intense and severe wildfire, it appears that additional restoration strategies, such as supplementary planting of select species, are not yet required to repair fire-affected rainforest and wet sclerophyll vegetation communities in places such as Lamington National Park.

Key questions on recovery and succession of species

There is an ongoing need for monitoring to assess regeneration strategies, and particularly restoration of the forest canopy cover.

In high-fire-severity areas, little mass regeneration from seed was observed, contrary to the large amounts of regeneration from seed from Pioneer species often observed following disturbance events such as treefall. It may be that soil seed banks were consumed by high severity fires. Further investigations to understand any correlation between high fire severity, damaged rainforest canopies and loss of soil seed banks would inform rainforest recovery after future wildfires, and if and when supplementary planting may be required.

While a relatively high number of Mature Phase species resprouted, their contribution to canopy formation (percentage cover) over time is unknown. Field observations to date suggest the rapid growth and lateral branching architecture of Pioneer and most Early Secondary species will see this suite of plants contribute most to restoring damaged canopies.

Ongoing need for monitoring and weed management

A priority of management has been to ensure resprouting and germinating native species are protected from weed growth that threatens to overwhelm and inhibit natural regrowth. So-called transformer weeds – such as moth vine (*Araujia sericifera*), white passionflower (*Passiflora subpeltata*), lantana (*Lantana camara*), palm grass (*Setaria palmifolia*) and devil's fig (*Solanum chrysotrichum*) – are encroaching fire-affected areas, particularly those that suffered canopy loss, threatening the habitat quality and ecological integrity of these rainforest and wet sclerophyll communities.

HLW has coordinated substantial weed management in rainforest communities in fire-affected Gondwana national parks to protect rainforest communities in these parks from being compromised by exotic species, and losing the values that make them World Heritage. This work requires continuity over a 3–4-year period to ensure canopies are sufficiently re-established to start to exclude weeds. To date almost $1 million has been invested in weed management, particularly in areas suffering severe scorching and damage. This work is essential to suppress weeds and allow native plant species to resprout and recover.

Emergency bushfire recovery funding has been essential to undertake this management activity and has provided a platform to assess and observe the regeneration strategies of rainforest flora. However, questions remain about the capacity of these species to respond to, and recover from, multiple fire events, as protected area managers continue to navigate the cumulative impacts of a warming and drying climate.

Conclusions

NRM organisations have provided a significant coordinating mechanism in the recovery from the 2019–20 wildfires, mobilising immediate responses and localised and regional networks to understand the impacts of the fires and prioritise and undertake recovery actions. Many NRM organisations were able to mobilise rapidly to respond to needs that emerged in each region. At the same time, the extent and severity of the fires, and their personal and community impacts, placed incredible pressures in some regions on the capacity to assemble the people needed to do the vital work of recovering biodiversity and ecosystems, including placing a deep toll upon NRM staff, some of whom also held emergency roles, and who were often themselves directly affected as community members. One of the critical lessons from these fires is therefore the need to have more of a buffer of organisational capacity in place to manage bushfire recovery, to create resilience in our systems and build surge capacity for emergencies.

The rapid response of NRM organisations was made possible by the very welcome emergency funding from the Australian, state and territory governments. NRM organisations provided a vital mechanism for the rapid identification of needs and deployment of this post-fire emergency response. In some cases, greater flexibility in funding, for example to support coordination, implement management actions at the most useful times, or invest in priority actions that fall through the cracks of existing programs, would have supported even better targeting of these resources.

The 2019–20 wildfires had a particularly profound impact on Country and on the First Nations owners of Country, and drew significant national attention to the need for much greater First Nations involvement in recovery responses and actions to build resilience and preparedness. It is important that the weight of resources and processes addressing these needs are guided by and go directly to First Nations communities (see Chapter 33). At the same time, NRM organisations frequently work with First Nations communities and organisations on integrated landscape management, and provide another mechanism for supporting Indigenous-led recovery actions. Flexibility in the timing and deployment of funding is also important to ensure resources can be directed to the most important, genuine needs and priorities of Indigenous people, at the time they want it.

In some cases, such as the South Australian glossy black-cockatoo, the capacity of species and systems to persist in the face of these fires has depended on vital work undertaken in the past to build up their population and resilience. This work needs to continue if these species and ecosystems are to recover and develop the resilience to withstand future events. Many of the actions needed to recover biodiversity following the 2019–20 wildfires – from weed management to habitat restoration – will take many more years of active management. Regional NRM organisations are embedded in their regions and communities in the long term, and thus are well placed to build resilience and manage the

longer-term recovery needs for ecosystems and species. As critical and valuable as the emergency response has been, the long-term recovery of biodiversity will require ongoing investment and effort.

Critical actions ahead include learning the lessons from these fires and using these to build preparedness for future events within and beyond NRM organisations. Vital knowledge continues to be built, for example on the responses of species and ecosystems to the fires, the impacts on cultural sites and places, and the systems needed to coordinate priority actions. In several of the cases discussed here, knowing what actions to take and developing a rapid response was guided by a strong base of pre-existing knowledge, for example of species populations and ecology, which provided a foundation to build on. But this knowledge base, and our investments in building resilience, is uneven across our species, ecosystems and landscapes. There are gaps in our collective knowledge and management efforts which we need to fill if we are going to be prepared for future events, not least how to build greater long-term resilience in the face of increasing risks emerging from a changing climate. In addition, it will be important to embed this knowledge in pre-approved emergency response and recovery plans to ensure the right actions can be taken as rapidly as possible. There is an urgent need to consolidate the lessons that continue to be learnt through this work, to invest in legacy systems that build and share this knowledge, and to strengthen our organisational and ecological systems, in order to increase our preparedness and build resilience for the future.

Recommendations

- Prepare organisational systems and capacities, including investing in systems resilience such as surge capacity, network-building, knowledge base and legacy knowledge-sharing systems to support prioritisation and action in emergency situations.
- Develop pre-approved, knowledge-based emergency response and assessment plans for species and ecosystems.
- Invest in building capacity and flexibility of funding to support Indigenous-led recovery response within and beyond NRM organisations (see also Chapter 33).
- Improve the rapid deployment and flexibility of emergency funding to ensure funding and timing of expenditure can be tailored to local priorities, conditions and the needs of the situation.
- Ensure funding systems include the capacity to invest in planning, collaboration and coordination activities post-fire to identify priority actions and build networked capacity.
- Address current gaps in funding for recovery and protection actions between major programs, such as to protect refuges, manage waterways, support non-threatened or locally threatened species and restore ecosystem function.
- Identify clearer lines of responsibility for planning and coordination between agencies, including lead agencies and lines of funding.
- Resource recovery actions for the medium to long-term to consolidate the immediate post-fire investments.
- Invest in efforts to build up resilience of populations, ecosystems and natural resources for future catastrophic events and long-term recovery.
- Address gaps in the knowledge base of species populations and ecology, and consolidate and build upon the knowledge gained through these fires to strengthen understanding and preparedness, support rapid response and identify effective action for future events.

Acknowledgements

The projects showcased here are supported by the Australian Government's Bushfire Recovery Package for wildlife and their habitat. The NSW Government supported several initiatives in the Murray and Riverina regions. Habitat restoration for glossy black-cockatoos was also supported by the World Wildlife Fund for Nature. HLW is indebted to the professionalism and competence of the contractors involved.

References

Berris K, Barth M, Mooney T, Paton D, Kinloch M, *et al*. (2018) From the brink of extinction: successful recovery of the glossy black-cockatoo on Kangaroo Island. In *Recovering Australian Threatened Species: A Book of Hope*. (Eds S Garnett, P Latch, D Lindenmayer and J Woinarski) pp. 75–84. CSIRO Publishing, Clayton.

Donatiu P, White J (2021) *Post-fire Regeneration Mechanisms of Rainforest and Wet Sclerophyll Flora in South East Queensland*. Healthy Land and Water, Brisbane, Queensland.

Government of South Australia (2020) *Independent Review into South Australia's Bushfire Season*. Government of South Australia, Adelaide.

Joseph L (1989) The glossy black-cockatoo in the south Mount Lofty Ranges. *South Australian Ornithologist* **30**, 202–204.

Kooyman RM (1996) *Growing Rainforest: Rainforest Restoration and Regeneration: Recommendations for the Humid Subtropical Region of Northern New South Wales and Southeast Queensland*. Greening Australia, Lismore.