Threatened Species Recovery Hub

National Environmental Science Programme

Protecting threatened species and ecological communities before and during bushfire: Learning from the 2019–20 fires

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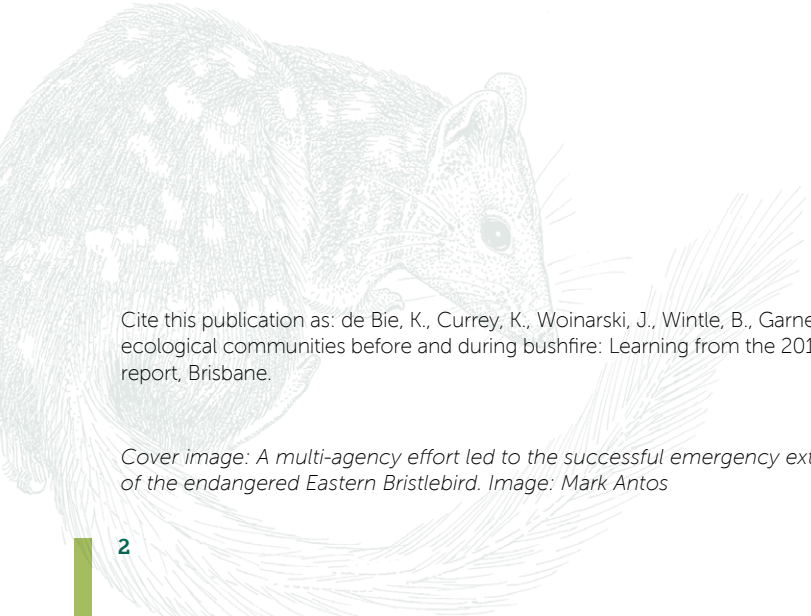

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Cover image: A multi-agency effort led to the successful emergency extraction of individuals from the last known Victorian population of the endangered Eastern Bristlebird. Image: Mark Antos

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Executive summary

The recent catastrophic fires of 2019/20 tested the capacity of people and systems to conserve biodiversity, including threatened species and ecological communities. Responses to protect life and property in preparation for, and during, wildfires have improved greatly in recent decades, but there has been far less progress made for the protection of threatened species and ecological communities before, during and after wildfire. While some populations of threatened species (and in some cases, the entirety of the species' population) were saved by swift and decisive action, other threatened species and ecological communities were severely impacted and their status far more imperilled than before the fires. With large, intense bushfires likely to become more frequent in the Australian landscape, documenting and interpreting knowledge and learning from the recent experience is critical to developing planning and decision-making frameworks to help prioritise and guide protection of biodiversity, including threatened species and ecological communities before, during and in the aftermath of fire events.

The aim of this project is to learn from the practices and experience of conservation managers and fire operations staff during the 2019/20 fire season, to identify what is required to improve outcomes for biodiversity during future large fire events. These lessons will form the basis of a roadmap to inform governance and operational efforts for biodiversity protection and increase preparedness for future catastrophic events. This project was informed by data collected via a quantitative, online survey and semi structured interviews with conservation managers and operational staff across Australia. The research focused on pre-fire planning and during fire operations, as the most critical stages of fire management to avoid or mitigate impacts of severe disturbance events on threatened species and ecological communities.

In preparation for fires, the states and territory agencies had a variety of data, tools and strategies to draw on to guide responses during the fires These were used to varying degrees and with varying degrees of success. However, with regards to specific targeted actions that need to occur during a fire, only two agencies referred to specific emergency planning for threatened species that outlined the actions that could or should be undertaken during a fire, and these were limited to an iconic species (Wollemi Pine) and species identified as high-risk or high value. Where available, mapping and GIS data layers and bushfire mitigation plans were helpful to identify locations and distributions of vulnerable conservation assets. However, these primarily provided guidance on 'what not to do' with respect to firefighting actions (e.g. don't use earth moving equipment or retardant at particular sites). Participants identified the issue of a lack of information around actions that could or should be done to protect threatened species and ecological communities during the fires (i.e. feasible actions), and that there was limited information readily available on what species and conservation assets should be prioritised for action as the fires approached. Not surprisingly, participants suggested a more comprehensive set of fire suppression plans was required to guide actions during the fires, either for single species (for highly threatened or valued species) or via regional or landscape scale plans. In addition, there was acknowledgement that more needed to be done before the fires to 'spread risk' through active management of threatened species and ecological communities such as fire breaks and species translocations.

Even where pre-established fire action plans existed, or vulnerable conservation assets were identified, there were multiple challenges that constrained or determined whether actions to protect such assets during fire operations could be or were implemented. A major challenge recognised by many interviewees was the unprecedented nature of the fires. The scale, intensity and in some instances highly unpredictable behaviour of the fires had significant consequences for control efforts and decision-making, including whether assets could be protected; and fire conditions often precluded the ability to plan or implement actions. This was exacerbated by the inadequacy of resources and capacity directed toward conservation assets, the accessibility, relevance and currency of available ecological data, and challenges with interagency relationships and culture that manifested in a lack of awareness of the location and importance of conservation assets. Actions to protect human life and property were, understandably, always the priority, trumping consideration of biodiversity protection. However, even where resources might have been available, decision frameworks that integrate the protection of conservation assets with other values (e.g. life, property, infrastructure) were lacking.

When threatened species or ecological communities were identified as at risk, there were several factors that helped the targeted protection of these conservation assets. Having biodiversity managers in Incident Control Centres was identified as a key factor in improving outcomes for biodiversity and came in a range of forms, including Natural Values Officers, Wildlife Controller and Parks personnel in senior Incident Management Team roles. This representation was important as it facilitated access to and interpretation of ecological data and increased the awareness within the control team of conservation assets. The contribution of local knowledge, often not captured in plans or mapping, was also important.

Conservation assets were more likely to have targeted protective action if they were located at a single site, had a pre-existing high profile (e.g. an iconic species) and if there was strong advocacy for action, either within the Incident Management Team or from political interest or external stakeholders. In other instances, conservation assets were given greater consideration if the fire was located on National Park estates and the fire was primarily the responsibility of the land manager or Parks agency, if there was a feasible and explicit plan of action for protection and where suitable resources could be secured to implement actions. A summary of the outcomes from the survey and interviews is shown in Table 1.

Several recommendations and improvements to pre-fire planning and during fire operations were identified, many of which are being planned or implemented by agencies in response to the 2019/20 fire season. These recommendations work together to form a roadmap (Section 7) to improve outcomes for biodiversity in a changing climate, and to minimise the risk of future wildfire events resulting in another ecological disaster. The road map outlines two primary components; i) having plans and actions in place to increase the resilience of our ecological landscape *before* wildfire events, and ii) approaches to improve the consideration of conservation assets *during* wildfire events.

Pre-fire planning and action outlines the need for prioritisation and clear spatial circumscription of conservation assets. For those assets, individually and where possible collectively, there is a need to develop and implement targeted and landscape scale management plans that identify actions that need to occur before and during a fire, in a manner that allows their management advice and implications to be readily accessible and interpretable to controllers operating in an emergency context of many competing needs and rapid decision-making. There is also need for scenario and contingency planning, and improved knowledge of priority conservation assets, including their susceptibility to damage from fire control actions.

Though the scale and extent of the 2019/20 fires were always going to be catastrophic for biodiversity, more could have been done to mitigate, or spread risks, and more needs to be done to reduce such losses in future events. During fire operations, our roadmap highlights the need for formal representation of biodiversity interests, with appropriate authority, in Incident Management teams to facilitate the availability of accessible, readily interpretable and relevant ecological data, and to champion protection of conservation assets. There is also need for more adequate costing and resource provision for actions to help safeguard conservation assets. Overarching all of the previous points is the necessity for the protection of conservation assets to be incorporated into relevant emergency management structures, codes of practice, frameworks, regulations and legislation, to ensure the protection of biodiversity during fires is standard best practice, rather than the exception.

The 2019/20 bushfires impacted extensive areas of eastern, south-eastern and south-western Australia. Image: National Interagency Fire Centre, Pubilc Domain

Table 1. Summary of elements of fire management in the 2019/20 fires that benefited the protection of conservation assets during fire operations, difficulties encountered and recommendations that could improve performance during comparable future events, some of which are currently being implemented.

Theme	Beneficial elements	Difficulties encountered	Improvements proposed
Biodiversity managers in Incident Management Teams	• Existing data was available, useable and relevant • A network of experts was accessible • There was advocacy for threatened species (including cultural assets) • Advice was available on impact of firefighting actions	• No formal role in emergency management structure • No decision-making capacity, primarily advice only • Representatives with suitable experience and expertise not always available	• Formalise biodiversity focused role in Emergency Management structure • Train for consistency and increased capacity in this role
Data and Planning	• Databases, maps and modelling showing priority asset location (e.g. GIS / spatial layers, HDM's) • Databases were accessible by multiple agencies • Data management specialists in Incident Management Teams made data relevant and digestible for decision-making.	• Lack of targeted suppression plans / guidelines • Response planning commencing after fires had started • Inadequate data on species location and fire needs and impacts. • Data not easily accessible or useable • Where data was available, not utilised by Incident Management Team • Lack of information on species or action prioritisation • Lack of integration of biodiversity action with life and property planning and prioritisation	• Institute interoperable data systems • Improve baseline and up-to-date data • Establish threatened species and ecological community priorities • Plan at a landscape scale to identify key areas for protection • Create risk assessments and frameworks • Undertake scenario planning • Prepare species specific fire-management plans, including evacuation/rescue plans where appropriate • Review fire access points
Operational factors	• Fire agencies were partially aware of risk to conservation assets • Agencies were willing to protect where possible • Additional resources were available, such as stakeholder groups, volunteers. • "Shovel ready" plans had been created for targeted action	• Lack of capacity to protect conservation assets • Cultural interagency barriers e.g. Fire crews trained for life and property only • Lack of awareness of conservation assets in Incident Management Team and on-ground crew • Lack of knowledge of appropriate response under different fire conditions • Hygiene issues – contamination by equipment (e.g. weeds, phytophthora)	• Incorporate biodiversity specific training for operational personnel and on-ground crews including how to protect / manage (e.g. suppressing fire may not always be the best option) • Increase awareness of need to protect conservation assets for on-ground crews by making part of daily briefing • Improve interagency relationships
Use of retardants	• Some general guidelines available on suitable use, primarily regarding use of retardants near aquatic systems	• Very little data or evidence on impacts	• Conduct further research into impacts, or assess options for developments and use of retardants that pose less risk • Include guidelines into fire management plans
Other aspects	• Single location of species increased likelihood of protection (not widespread) • Iconic and well-known species were protected • Additional funding from governments to respond • Increased public pressure to protect conservation assets	• Unprecedented nature of the fires (widespread, intense, long-lasting) • Terrain and vegetation condition (long unburnt) • Life and property always prioritised	• Ensure tenure blind, landscape approach to fire management • Conduct further research on appropriate fire management for biodiversity under different fire weather conditions

1. Introduction

A catastrophic and unprecedented fire event was experienced across Australia in the summer of 2019/20. Just under 19 million hectares was burnt across all states and territories, with 1.8 million hectares in south-eastern Australia impacted by high intensity fires (Filkov et al., 2020). The impacts to biodiversity were particularly devastating in the eastern states, with approximately 97,000 km2 of forest and woodland burning and large areas of complete vegetation loss (Ward et al., 2020). An estimated 3 billion vertebrate animals were killed or displaced (van Eeden et al., 2020), with at least 349 threatened species impacted, 49 of which had over 80% of their habitat burnt (Wintle, Legge and Woinarski, 2020).

The immense scale, intensity and duration of the fire season tested the capacity of systems to conserve threatened species and ecological communities. With the fire response understandably focused on human life and property, there was little strategic priority for the protection of biodiversity. While some iconic species were able to be saved by a rapid response, many species and ecological communities were severely impacted (Wintle, Legge and Woinarski, 2020). Actions for biodiversity focused on the post fire period, particularly with triage of animals, supplementary feeding and targeted herbivore and predator control. While there has been significant and coordinated investment into biodiversity recovery post-fire, the need to also be proactive, rather than reactive, has been widely recognised (Commonwealth of Australia, 2020). Precautionary actions such as insurance populations, translocations and rapid response teams to better assess and mitigate fire impacts on threatened species and ecosystems during large fire events have been advocated (Dickman et al., 2020; van Eeden et al., 2020; Wintle, Legge and Woinarski, 2020). Of key importance is the need to learn from the experience and improve in the future (Dickman et al., 2020).

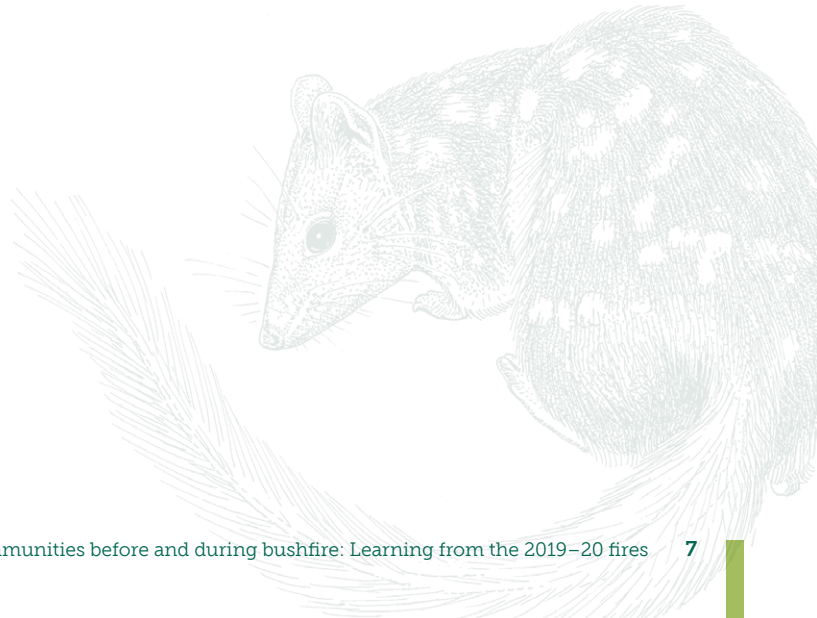
The 2019/20 fire response involved a multitude of agencies and organisations, and extensive professional and volunteer personnel across the states and territories. The experience and learnings of those involved in the fire response affords valuable and unique insights into what worked well with respect to conservation outcomes for threatened species and ecological communities, as well as identifying where the gaps are. This includes both the pre-fire planning stage and during-fire operations, which are critical stages in fire management to avoid or mitigate the impacts of severe disturbance events. As large-scale fires become more frequent with a changing climate (Jan Van Oldenborgh et al., 2021), it is critical to avoid a repeat of the biodiversity impacts of the 2019/20 fires in order to reduce the likelihood of significant losses and extinction of threatened species and ecosystems in future years. Therefore, learning lessons from the 2019/20 fires is crucial to ensure the persistence of Australia's conservation assets in the future, and many of these lessons will be applicable globally as the scale, intensity and frequency of catastrophic events increases.

2. Aims

The aim of this project is to learn from the experience and practices of conservation managers and fire operations staff during the 2019/20 fire season, to identify what is required to improve conservation outcomes. These lessons will form the basis of a roadmap to assist governance and operational efforts for biodiversity conservation to increase preparedness for future catastrophic events.

This project will improve outcomes for biodiversity, especially threatened species and ecological communities, during fire events by informing operational decision making. It will achieve this by providing:

- A more holistic understanding of the challenges managers face during times of extreme crisis such as large-scale fire events and help meet their needs going forward.
- A roadmap for better informed and more effective biodiversity management planning in preparation for similar large-scale emergencies in the future.



3. Context

In developing this project, we reviewed grey literature for Australian bushfire and emergency management and plans, seeking methods and approaches for including conservation assets in such planning. Nineteen documents were reviewed including national (n=1), state (n=10), regional (n=5) and local (n=3) emergency management plans and bushfire plans (Appendix 1). While these strategies and plans identify high-level arrangements, none of the plans reviewed had sections that deal specifically with the management of conservation assets. They primarily provide guidance on governance and co-ordination and focus on identifying risks for mitigation purposes. This lack of direction is reflected in survey and interview responses. Specific conservation assets, including threatened species, were only specifically addressed in local fire management plans and strategies.

We also reviewed the Royal Commission into National Natural Disaster Arrangements (Commonwealth of Australia, 2020) and relevant state level inquiries to identify key recommendations relevant to conservation assets and threatened species and ecological communities in planning and operations. The Royal Commission into National Natural Disaster Arrangements (2020) includes a dedicated chapter on wildlife and heritage. This section acknowledged the numerous efforts that were made to "rescue and protect wildlife, ecosystems and heritage sites during and since 2019-2020 bushfires....(that) relied on expert advice, data and information sharing and fundraising efforts across individuals, communities, not-for-profit organisations, government agencies, environmental experts and the private sector" (pg. 353) and that while "some protection priorities are clearly embedded and formally recognised in emergency management, such as critical infrastructure....(for) sites of environmental and heritage value, emergency services often rely on external information and relationships with other agencies to understand environmental values at risk during disasters" (pg. 355). The report identified the need to:

- better integrate environment into emergency planning and response through collaboration with relevant non-government organisations;
- improve access to high-quality, consistent data on species' distributions, status and key management needs;
- have greater consistency and collaboration in the collation, storage, access and provision of data on the distribution and conservation status of Australian flora and fauna.

In regard to gaps in data and information, it was noted that there is no single agency that has responsibility for collation and maintenance of data at a national level and that little is known about Australia's invertebrates, non-vascular plants and fungi. The importance of rapid determination of environmental priorities to assist in ensuring timely implementation of strategies to recover from natural hazards was noted, however this focused on prioritisation of recovery efforts, rather than prioritisation of conservation assets in pre-fire planning or during-fire operations (Commonwealth of Australia, 2020).

State level reviews into the 2019-20 fire season were conducted in New South Wales, Victoria and South Australia. Overall, these reviews contained little information on managing conservation assets during fire. Relevant findings indicated that area management plans were too broad and non-specific, and that mitigation strategies identified in plans are high level and do not guide specific on-ground actions or display them spatially (Government of South Australia, 2020). The Victorian review identified a concerted effort by key organisations to adapt strategies, structures and plans in preparation for increased pressures associated with climate change and large-scale bushfires (Government of Victoria, 2020). The strategies and plans captured considerable research, planning and coordination to map and identify high priority biodiversity areas, including threatened species and ecological communities. However, biodiversity arrangements were not as well formed as wildlife welfare arrangements (Government of Victoria, 2020). Key gaps identified in the Victorian biodiversity preparedness was the lack of formal structures and biodiversity focused roles embedded within the Australasian Inter-Service Incident Management System (AIIMS) structure and the absence of a biodiversity response plan. The NSW enquiry noted the success of actions to save the Wollemi Pine were supported by the existence of a recovery plan and fire protection strategies (Government of NSW, 2020).

Wintle et al (2020) reviewed the 2019/20 fire season and identified key activities in bushfire preparation and response to minimise the loss of biodiversity. These recommendations centre around knowledge, planning, mapping and conservation actions before and during fires. Key recommendations include precautionary actions such as the establishment of insurance populations, translocations to spread risks, extensive control of other threats and collection of baseline monitoring data to ensure conservation assets can be identified and prioritised. Also highlighted was the need for greater recognition in control centres of the importance of protecting natural assets during fire and the prioritisation of critical biodiversity features for suppression activities in wilderness areas. This could be complemented by the inclusion of conservation assets in fire management plans and fire control operations and useful guidance on how to respond to fire in threatened species recovery plans (Wintle, Legge and Woinarski, 2020).

4. Methodology

The focus of this project was developed in consultation with key stakeholders to determine the priority stages and scope for this research. This involved liaising with the NESP Threatened Species Recovery Hub Knowledge Broker and key contacts within each of the relevant government agencies. We used this process to refine research scope to focus on pre and during fire (rather than post-fire recovery), establish state land management agency's capacity to contribute to the proposed project and develop lists of contacts for data collection. This project focused on the states and territory affected by the 2019/20 fires and does not include input from the Northern Territory.

4.1 Data collection: a survey and interviews

Our project used a mixed method approach to data collection. All data collection was completed under Charles Darwin University Human Ethics Approval (H20104).

We designed an online survey to understand perceptions of the success and failings of the fire response with respect to threatened species and ecological communities and key mechanisms for improvement. Our target group for the survey was conservation practitioners and resource managers; including practitioners from within government, non-government organisations, and private organisations, and those working on public or private land. The survey was sent to 220 email addresses, representing 53 organisations, government departments and councils.

Our survey was combined with another complementary but separate survey. The complementary survey addressed the range of management approaches that are implemented for fauna post wildfire within Australia, and the effectiveness of these actions in supporting fauna conservation and recovery post-fire (NESP project 8.4.4). The surveys were combined due to the similar target audience and a desire to minimise approaching this target group with separate survey requests.

A scoping literature review of published articles was undertaken to identify themes relevant to the development of the interview questions. Studies on planning for prescribed burning were more common, with no studies found that directly focused on wildfire planning or suppression for conservation assets. Although not specific to conservation assets a few studies identified some relevant themes including how limited resources are allocated during fire (e.g. Stonesifer, Calkin and Hand, 2017; Roozbeh, Ozlen and Hearne, 2018), how management teams make decisions during fire events (e.g. (Wilson et al., 2011; Wibbenmeyer et al., 2013; Hand et al., 2017), and to what extent existing planning considers the protection of heritage assets during natural disasters (Laidlaw, Spennemann and Allan, 2008).

We conducted semi-structured online interviews with relevant state agency biodiversity and fire operations staff. Two scripts were developed with questions for staff with a biodiversity focus and staff with a fire operations focus. Core questions were the same across both scripts, however the structure of the interviews varied. Contacts for the interviews were identified through collaboration with executive level staff in each of the target state and territory agencies. An initial list of 13 staff across 8 agencies were contacted to participate in an interview. From there a snowball sampling approach was used where participants were asked to suggest further potential contacts. Interviews took place using Zoom video conferencing and were recorded and professionally transcribed. To clarify our understanding of certain topics some participants were contacted after the interview and asked to provide additional information; this information has been included where relevant. Under ethics approval provisions, all information was de-identified.

The interview data were analysed using a thematic analysis approach. This method aims to identify and interpret patterns of meaning (themes) that are relevant to the research question; the themes are the framework used to organise and report the researchers' analytic observations (Clarke and Braun 2014). Nvivo qualitative software (QSR International Pty. Ltd. 2020) was used to code the interview data and identify themes.

4.2 Research participants

Invitations to participate in the survey were emailed out to 220 contacts across federal, state, and local government land managers, conservation organisations, land manager and wildlife non-government organisations and environmental consultancies. We received 20 survey completions.

A total of 32 participants were interviewed as part of this project, representing 13 land management agencies across six target states and one territory. A breakdown of interview participants by jurisdiction, role and agency type is shown in Table 2. The majority of participants had substantive roles with a biodiversity focus, but 57% of these also held a fire operations role during the 2019/20 fire event.

Table 2. Research participants by location, position and agency.

	Primary role		Agency type	
	Biodiversity (fire operations role during bushfires)	Operations	Environment department	Parks agency
ACT	2 (2)	2	2	2
NSW	5 (1)	2	4	3
Qld	2 (0)	1	0	3
SA	3 (0)		3	0
Tas.	2 (1)		2	0
Vic.	8 (4)	1	7	2
WA	4 (2)		4	0
Total	**26 (15)**	**6**	**22**	**10**

4.3 The Road Map

The knowledge from the interviews was synthesised and posed as a series of recommendations, that provide the basis of a roadmap to enable improved planning and operational processes for future wildfire events. Importantly, these recommendations are aligned with an integrated risk-management framework, and as such form a strategy to improve preparedness.

From interviewees, recommendations are based upon their experiences outlining what happened during the fires, what limited the response to protect conservation assets, and what improvements can be made in preparation for a future where wildfire events of such magnitude are inevitable. Where possible we provide examples of existing tools and approaches that can support future efforts, drawing in knowledge from international sources where appropriate.

A captive population of the Manning River Turtle was established to mitigate the impacts of the 2019/20 fires. Image: Australian Reptile Park

5. Findings

5.1 Consideration of conservation assets during the 2019/20 fires

On the whole, the survey responses demonstrated a perception that threatened species and ecological communities were only partially considered in pre-fire planning and operations, but the results were variable (ranging from scores of 1 (not well considered), to 10 (very well considered) out of 10; Figure 1). Threatened species were reported as being marginally better considered in both pre-fire planning (mean 5.7 compared to 5.3 out of 10) and during-fire operations (mean 5.2 compared to 4.4 out of 10) than ecological communities. Respondents noted issues such as *"the lack of ability to control the fire.... not hav(ing) the ability to implement actions that make a difference"* and that *"plans are useful but often go out the window during emergency response or due to context specific issues"*. The importance of maintaining an *"adaptable and flexible approach to each scenario"* was also mentioned noting that *"sometimes a plan can prevent timely application of needed actions"*.

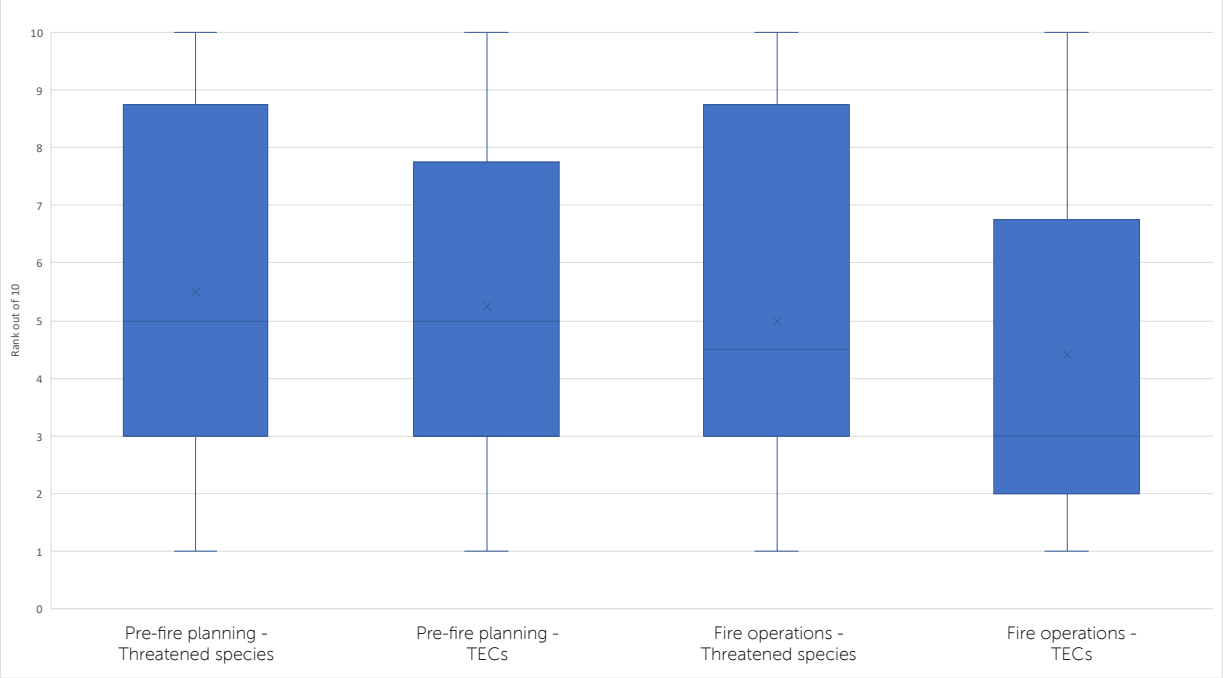


Figure 1: *Boxplot of survey responses demonstrating the spread of scores to "Overall how well do you think threatened species and ecological communities were considered in pre-fire planning and during fire operations with 1 being not well considered and 10 being very well considered" (n=20)*

To understand how interviewees reflected on the consideration and protection of conservation assets during the 2019/20 wildfires, interview participants were asked, *"Thinking about the 19/20 bushfires overall, how well do you think conservation assets were considered and protected during the fire event from zero out of ten?"*. The results were similarly variable to the survey responses, with a mean of 5.7, a maximum of 8.5 and a minimum of 2.5 (n=20). Interviewees who gave a low score generally felt conservation assets were not well considered due to a lack of planning or were not well protected because of the relative lack of focus on and recognition of conservation assets versus life and property. Interviewees who gave higher scores generally felt that conservation assets were adequately considered and that the intent to protect was there, but the conditions prevented better outcomes. Three interviewees did not provide a score – two interviewees' comments aligned with those who provided higher scores, the third recognised that there were vastly different responses in different areas. Three interviewees gave separate scores for the consideration of conservation assets and the protection of conservation assets – all three rated 'consideration' higher than 'protected' and these scores have been averaged for the purposes of analysis.

Low score: *We didn't have an effective natural values checking process in place. It was relying on isolated instances of having the right person in the room at the right point in time, with the right knowledge* (I.07)

High score: *I think they were considered really well, and I think the implementation was probably as good as we could have hoped for* (I.01)

5.2 Assessing preparedness: Pre-fire planning for conservation assets

Interviewees noted some benefits of pre-fire planning where it was available, but it was clear there were limitations and constraints to the usefulness of pre-fire planning tools. These are summarised in Table 3 and discussed in detail in Table 4.

Table 3: Benefits, limitations, improvements and constraints of pre-fire planning.

Benefits of existing pre-fire planning	• Provides species location • Provides 'what not to do' guidance regarding fire suppression activities • Can initiate 'shovel ready' actions during fire • Can assist with prioritising assets for protection • Can identify possible pre-fire actions to spread risk
Limitations of existing pre-fire planning	• No operational guidance about how to protect • No prioritisation of which species to protect when so many may be threatened
Improving pre-fire planning	• Species specific fire management plans (individual or landscape) • Enhance preparedness and capacity using scenario or contingency planning • Risk management frameworks that include conservation assets as well as life and property
Constraints to improving pre-fire planning	• Lack of data • Lack of resources to acquire data as there are numerous species • Complexity of decision-making regarding prioritisation (i.e. which species and actions to prioritise in which contexts)

5.2.1 Existence of pre-fire planning

Ten survey respondents reported that their agency had plans to direct firefighting operations specifically to manage conservation assets. Further information provided by the respondents indicated that the plans were primarily bushfire mitigation guidelines, with the exception of one respondent that referred to a species-specific fire management plan.

Interviewees were asked, *"With regards to planning, does your organisation have emergency fire management plans for any conservation assets"*, and referred to a range of pre-fire planning tools and strategies. Only two agencies had specific emergency planning for threatened species that outlined targeted actions that could be undertaken during a fire. The majority of agencies had some form of strategic planning for prescribed burning and there was a range of opinions as to whether this type of planning was useful for emergency responses to protect threatened species and ecological communities. There were some instances of disparity between interviewees within the same agency who differed in their opinion as to the existence and usefulness of existing pre-fire planning.

5.2.2 How pre-fire planning informed action

A majority of interviewees (20) indicated that existing pre-fire planning data and strategies were useful to varying degrees during the fires. The usefulness of pre-fire planning was primarily ascribed to GIS layers and mapping that provided locations of species as well as providing some guidance on suppression activities that needed to be avoided as they may damage the conservation asset.

> *They are static maps, which are updated periodically. But on top of that, we have those GIS layers which can be pulled up at any time by fire management staff and by values officers to inform response. .... So, I think we're well positioned, in that when it comes to the point of an operation, there's reasonably good available information about where we need to be careful (I.02).*

A few interviewees felt that conservation assets were well considered in bushfire planning. The operational arm of one agency had worked closely with their biodiversity counterparts in developing strategic bushfire mitigation plans. They had embedded one of their fire ecologists into the intra-agency conservation and research department to work with species specialists to consider how planned burns may impact on species. This enabled the creation of ecological guidelines that provided information such as breeding times for key species. Similarly, another interviewee indicated that their agency had developed mapping of fire sensitive values and also identified what the most critical assets were to protect from the fire itself and from fire suppression activities such as control lines. Considerable stakeholder engagement was undertaken during the development of mitigation plans in some instances.

> *We provide (fire agency) with a whole heap of mapping of fire sensitive values ... so they're sort of aware of what's in the path of the fire or potentially threatened, but we provide a lot of advice on (the) things that might be in that landscape, what are the most critical things to protect (I.19)*

Another agency, while lacking species specific emergency planning, had significant information to identify vulnerable conservation assets during fire. This was in the form of extensive pre-fire modelling (habitat distribution modelling) that was viewed as instrumental in helping them establishing which species were highly vulnerable during the fires, and priorities for action (Box 1).

Interviewees from two agencies referred to detailed management plans for a threatened species that included strategies for how to protect them during a fire (Box 6). Another agency had species specific bushfire plans, but these were more general in nature and did not include operational strategies. In another instance extraction plans for a threatened species had not been identified as an emergency response strategy, however the translocation planning had already been undertaken and the existence of permits and resources meant urgent extraction of individuals during the fires was achievable as the situation was 'shovel-ready' (Box 6). In a few other instances, agencies had already undertaken pre-fire actions that negated the need for during fire response (Box 2). A few interviewees referred to strategic slash breaks or mosaic burning to protect conservation assets and to enable safer access points for fire crews.

Box 1: Existing spatial layers and modelling assists with operational decision-making

Department of Environment, Land, Water and Planning, Victoria

Under the Biodiversity 2037 Strategy thousands of habitat distribution models (HDMs) were developed using existing observation data and a range of environmental data sets. During the fire, the agency was able to intersect 4,400 of these HDMs with the extent of the fire footprint to then determine what species were most at risk due to the fire. Results suggested that 215 threatened species would have more than 50% of their state-wide habitat impacted by the fires. These became potential priorities for action and further work was undertaken, including use of existing threat risk and action benefit models supplemented by input from subject matter experts around identifying what the risks were, what actions may be able to be taken during the fires and what actions may be needed post-fire. A seven-day rolling priorities list was established and incorporated into the emergency management response.

> *The great thing about the models that we've developed is that we weren't starting from a blank page so we were able to do that analysis really quickly, but also that became a really great communication and collaboration tool with subject matter experts where they could respond to what the models were telling us, and then provide further information about what they thought was the likelihood of risk, and what the necessary actions might be (I.23).*

Tools:

- Pre-existing Habitat Distribution Models
- Pre-existing threat risk and action benefit models
- Real-time predictive fire mapping
- Rapid input from species experts to inform priorities and actions

Output:

- Biodiversity Bushfire Response and Recovery Plan
- 7-day rolling priorities list

Contributing success factors:

- Pre-existing HDMs and other biodiversity and predictive fire modelling
- Availability of experts
- Significant funding from the State government

Limitations: No formal process for the incorporation of the 7-day rolling priorities into the Incident Management Team. However, this was done via the State-wide Wildlife Controller, which was a position that was deployed for the first time in Victoria during the 19/20 fires.

Box 2: Targeted pre-fire planning for risk mitigation

Case study 1: Coveny's Zieria (Zieria covenyi)

This endangered plant is an erect shrub up to approximately 2 metres high with conspicuous aromatic white / pale pink flowers. It has a very restricted distribution known only from 2 populations in the Blue Mountains. In recognition of the potential threat of fire completely eradicating the two populations, in 2017 a risk mitigation plan was established. This included undertaking translocations to create small insurance populations which were cultivated at some Blue Mountains primary schools, and who continue to care for these species. Other planned actions include the collection of cuttings or tissue culture for storage at botanical gardens, hygiene protocols to protect from *Phytophthora* and hazard reduction burning.

Outcome: Fire burnt through the species locations and a large proportion of the plants were impacted. The establishment of insurance populations and collection of genetic material has helped conserve this species.

Case study 2: Bago (*Prasophyllum bagoense*) & Kelton's (*Prasophyllum keltonii*) Leek Orchids

The Bago and Kelton's leek orchids are both critically endangered orchids with highly restricted distributions comprising single populations in the Australian Alps. Recognising the threat posed by the 2019/20 Dunns Road fire as it moved through south-east NSW, in December 2019, botanists and threatened species experts began hand pollinating and caging these orchids to help increase the chance of being able to collect viable seeds.

Outcome: This action proved to be a lifesaving measure as once the fire passed through, seeds were able to be collected. The seeds from these orchids are stored in freezers at the Australian PlantBank.

Contributing success factors:

* These species were identified as priorities for action under the NSW Saving our Species programme. Knowledge of threats to species enabled planning for risk-spreading strategies.
* Community involvement

Source: Interviewee (I.08) ; NSW Saving our Species Strategy summary 10853, 10938 & 20085

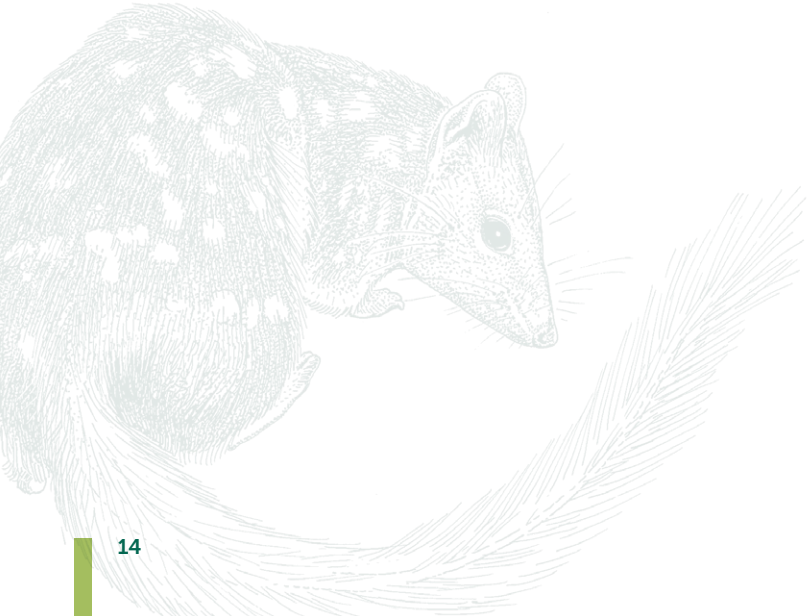


Table 4. Existing pre-fire planning tools and strategies and the limitations and benefits for protecting conservation assets during wildfires. Note: The information in this table has been drawn exclusively from interview data and does not represent a comprehensive summary of the effectiveness of existing pre-fire planning.

Existing pre-fire planning	No. of agencies	What is it?	Scale	Benefit to conservation assets	Main Limitation / Constraint
Risk / Bushfire management plans (Prescribed burning plans)	9	• Strategic plans for where / when / what / how to burn. - Often spatial - Can include Cultural / European heritage assets - May include zones to identify high priority areas for mitigation	• Varied, but primarily at the landscape scale or for particular ecosystems / vegetation classes (e.g. rainforest)	• Some species locations (but not necessarily exact species) • Operational guidance to limit damage from firefighting activities • Assessment of impact based on residual risk analyses • Hygiene protocols for prevention of spreading weeds, pests & diseases	• Useful on a fine scale only (e.g. burning a specific area) • May not include conservation assets • No guidance on how to actively protect threatened species and ecological communities (beyond hygiene protocols) • May not be linked with a decision-making framework i.e., prioritisation to guide management of conservation assets during fires
GIS layers / mapping	6	• Spatial layers or maps • May be: • Based on state-wide biodiversity databases • Can include heritage assets • Combined with guidelines to inform firefighting activities in areas of critical habitat.	• Varied	• Provides species locations - Can be used to extract list of species / assets in fire footprint - May be linked to advice on potential impacts of firefighting activities	• Based on foundational data - may not be current • Layers not consistent between State agencies • May not identify species, only that an important species exists in a certain area • May not be linked with a decision-making framework i.e., prioritisation to guide management of conservation assets during fires
Spatial Modelling	4	• Habitat distribution models • Fire modelling • Residual risk (planned burns)	• Varied	• Assists with prioritisation to inform fire suppression or other actions. • Predictive capability for fire spread and what species will be impacted	• Limited information on many species to enable modelling
Pre-fire targeted actions	3	• Risk spreading activities – e.g. planned translocations	• Local	• Can reduce need for during-fire action	• Requires high level interest, resources and comprehensive planning
Species specific bushfire management plans	3	• Can range from highly detailed plans to one-page documents advising of fire regime requirements	• Local	• Can outline required capacity and resources • Necessary permits are in place	• Only exists for a very few species • May only be part of strategic or preventative planning process rather than for during a fires
Strategic management plans (e.g. Recovery plans)	2	• Primarily regarding fire needs for planned burns (fire frequency)	• Varied (depends on species distribution)	• Provides species locations • Species experts work with fire agency to develop strategy which increases awareness of species value and requirements	• Often high-level plans with little specific detail, not nuanced • Very hard to develop for landscape managed species • May not be linked with a decision-making framework i.e., prioritisation to guide management of conservation assets during fires.

5.2.3 Limitations of existing pre-fire planning

Although many interviewees recognised to varying degrees the usefulness of existing planning during the fires, many also indicated that they did not consider it as being 'fit for purpose' (Table 5). There was recognition that the scale and intensity of the 2019/20 wildfires were unprecedented, making some existing pre-fire planning redundant.

> *It would really start to hit home that these fires were more intense, they were much more extensive … (and) from a biodiversity perspective we felt that the standard processes weren't sufficient to understand what we needed to do, and that we needed to scale up our response and understand the impacts of the bushfire (1.21)*

The two most common concerns related to preplanning for emergency response actions for threatened species and ecological communities were:

1) The lack of information around what could or should be done to protect threatened species and ecological communities, even if they knew where a species was:

> *We do lots of fire planning, and we know where things are in the landscape. But I think what we didn't have is more specific consideration of those high-value, threatened species and other biodiversity values, to say, "What do we do in this scenario?" (I.22)*

2) The existing plans had no or limited information on what species and assets to prioritise, which necessitated planners or biodiversity staff to conduct 'on the fly' prioritisations during the fires with whatever information was available. Where particular species or conservation assets were identified as priorities, there was a lack of clarity around how and why that had been prioritised. One interviewee described it as a *'loose description of conservation value'* as although National and State threatened species are generally considered the highest priorities, regional or local values are valued more highly in other situations.

> *It's something that we developed on the run during the fire - we prioritised the conservation assets. We need to have a plan in place for that and what we can actually do, if anything (I.01)*

> *It's largely geographic polygons, which basically delineate an area. The prioritisation process that sits behind it I couldn't give you much insight into other than it's really an expert opinion derived thing … exactly how that all links back to species distribution models or species distribution records is really down to the operator and the individual who's developed the layer itself (I.17)*

Other key issues raised focused on availability of data and knowledge for species. This includes that there is a general lack of knowledge on fire requirements and appropriate fire regimes for many species which can lead to distorted priorities during fire event. Data are also being collected for different purposes and did not necessarily align. For example, data useful for species strategic management plans were not necessarily useful for fire agencies. Prescribed burn plans were also primarily focused on vegetation communities or ecosystems, so whilst some spatial layers for flora were quite good, there was much less information on fauna, and specific species may not be included.

> *Our fire regime system is based off ecosystems, that's the primary driver in terms of how we determine our fire management zones and we don't complicate that too much with particular species management (I.13)*

A number of improvements were suggested by interviewees to potentially address the two key issues regarding existing pre-fire planning and are summarised in Table 5.

Table 5: *Issues with existing pre-fire planning and suggested, planned or implemented improvements*

Pre-fire planning issue	Improvements
No prioritisation pre-fire	**Adequate data** Ensure priority lists are regularly updated Ensure data layers available for all species or assets of interest (priorities) Ensure data layers are consistent between agencies, collated and up to date Have a consolidated approach at a state level regarding development and maintenance of spatial layers and data Bring all corporate data into central databases – currently spread across individual computers or systems Gather information on species distributions from many sources - e.g. consult with external experts and stakeholders Habitat distribution models (noting there is limited information on population sizes for many / most species) **Risk / vulnerability assessments** Develop risk management frameworks, or include conservation assets in existing risk management frameworks, including scenario analysis Identify priority species, communities, habitat, locations (relative to others) Landscape scale planning that assesses threats (including fire) and includes spatial location of threatened species and ecological communities Undertake meta-population analyses to identify areas that provide important refugia – would include geospatial mapping Parameterisation of species fire regime tolerances to establish priorities Review existing and new information to assess threats, and incorporate into management plans and prioritisation **Gap analysis**
Lack of guidance on how to protect conservation assets during large fires	**Targeted emergency management plans** Develop specific fire response plans that map the values and what actions are needed (such as where to put containment lines or access tracks) Scenario and contingency planning to identify potential actions and capacity / resources required for implementation **Other** Include conservation assets requirements in prescribed burning management plans so they can be used in fire events Adopt a nil-tenure approach to inclusion of conservation assets in strategic planning (i.e. not just those on conservation estates)

5.2.4 Improving pre-fire planning

Interviewees were asked *"Are there any aspects of pre-fire planning that you would change, thinking specifically about protecting conservation assets?"* and *"Are you aware of any planning or procedural changes that have been implemented since the fires that aim to improve outcomes for conservation assets during a fire or disaster event?"*. Three main improvements were identified:

1) Many interviewees recognised the need for species specific fire suppression plans, though the suggested scales of the plans were varied. Some interviewees proposed single species plans (for highly threatened / valued species), whilst other interviewees felt that regional or landscape scale plans were necessary.

> *I think it would be great to have a bit more resource to work through getting fire management (plans) completed for all of the fire sensitive and endangered and critically endangered taxa. (I.10)*

> *We've got 500 threatened species or more … All that stuff's spatially explicit, it's a really complex world out there. In all circumstances, it's not a one species one plan situation. It's about a systems approach. (I.24)*

2) Interviewees recognised the need for increased preparedness for fire by utilising fire and biodiversity models or residual risk modelling to undertake scenario and contingency planning for threatened species and other biodiversity values. This would assist with building capacity pre-fire to support the actions by identifying the resources required:

> *One of the things that we can do now is start to pre-plan for fire in the landscape … (with) the fire models as well as the biodiversity models we should be able to run scenarios for fire in certain parts of the landscape which would then help identify what some of those at-risk species might be … and therefore the actions that might be required to respond to those… And then on the back of that you can build the capability and capacity around what you might need to support those actions should a fire occur (I.23)*

> *(It's) around pre thinking different contingencies and prioritising the significance of different areas … and then working through realistic interventions under different contingencies would be good to do (I.02)*

3) There was recognition of the need to take a risk-based approach to acting before a fire event, to minimise the need to act during a fire event. Thus, to include ecological (and cultural / heritage) assets in risk management frameworks to identify and guide effective actions before fire events. A risk-based approach may include undertaking residual risk modelling and preparatory work / pre-fire actions, such as translocations and seed banks. Other proposed actions for key assets included wetting ephemeral wetlands to reduce risk of intense fire and creating conceptual containment lines that would be enacted before a fire if a bad fire season was predicted. Ideally risk assessments would be undertaken before any actions such as translocations to inform which action/s would provide the better outcome.

> *To me the physical intervention really is the step of last resort … it was a bit of a lack of acknowledgement about the inherent risk of capturing, collecting, moving, husbandry, welfare of animals in captivity … I think there is a role for that emergency intervention, even pre-fire, but I think we've got to be more careful than we have been with the risk (I.10)*

> *So how can we create more populations of things to spread risk? How do we understand where there might be a lower likelihood of fire burning, therefore they'd become important refugia where you might want to consolidate your conservation effort? (I.23)*

Two common constraints to improving pre-fire planning were identified. Firstly, there is a lack of knowledge and data that is needed to inform prioritisation and risk management processes. State databases are not regularly updated and using this data to inform priorities was described as being 'Swiss cheese' by one interviewee. A 'hybrid' approach was proposed that combines the more formal predictive data with updated data derived from ground truthing, expert advice or citizen science. But secondly, there was also recognition that there is a lack of capacity and resources to address this gap given the huge number of threatened or potentially threatened species and ecological communities.

> *We're overwhelmed by the sheer number of things that are a priority, or that we say (are) from our priority spatial overlays (I.11)*

> *That's still foundational data. Somehow, we've got to turn that into a layer that goes into some decision-making tool to say, these are your priorities (I.06)*

> *3,200 reserves, 2000 listed species, limited resources and staffing, how can we even set that prioritisation process? (I.26)*

> *I've gone to prescribed burn planning workshops, working with the community, and they've said to me, the people who knew where these things were, they're long gone. So, unless you guys can provide us with a map and tell us what we have to do, we don't have the ability to plan (I.08)*

Other issues included the loss of knowledge from experts and other people who once knew where species were, and that guidance was lacking in how to prioritise assets as *"there are so many dependent and independent factors driving some of those decisions"* (I.04).

5.3 Fire operations: Challenges for the protection of conservation assets

There were several themes identified by interviewees that constrained the protection of conservation assets during the 2019/20 fires.

5.3.1 Unprecedented nature of the fire

A major challenge recognised by many interviewees was the unprecedented nature of the fires. The scale, intensity and in some instances highly unpredictable behaviour of the fires had significant consequences for whether assets could be protected, and fire conditions often precluded the ability to plan or implement actions.

In some instances, planning for suppression or other mitigation actions was not even attempted, whilst in other areas the planning was not able to keep pace with the conditions. In one instance water bombers had been approved to put in lines of retardants to protect patches of a threatened ecological community and threatened flora. By the time the machines were mobilised the fire had already burned through those areas. In another instance plans were made for the extraction of an endangered amphibian; however, the action was not completed as conditions were assessed as being too dangerous, and fire went through the area.

Additional challenging aspects of the 2019/20 wildfires discussed by interviewees were the landscape, terrain and vegetation types within the fire footprint (e.g. inaccessible or long unburnt), plus the cumulative impact of previous fires and climate change.

> *But mostly because of the nature of the fire itself … it was an absolute ripper and it moved really fast and really hot. And there just wasn't the ability to respond with respect to threatened species populations in that wilderness, given the behaviour of the fire itself (I.15)*

> *It was unbelievable. And it was interesting because it was fire behaviour that nobody expected, it sort of defied all the predictions quite possibly because of three years of dryness and the way the wind behaves under those different topographic features it just blew out well beyond anything we expected or could have predicted (I.32)*

5.3.2 Capacity or resources were inadequate

Interviewees were very aware that life and property are established priorities, but the scale of the fires and limited capacity and resources further constrained the ability to be able to protect conservation assets. As expressed by one interviewee, the lack of adequate resources and funding meant that:

> *we're just not set up for these big landscape style fires, so we have scrambled (I.12).*

One interviewee felt that the lack of capability meant that many ignitions that resulted in the destruction of conservation assets weren't 'quashed', and that 'combat was engaged' only when the fires approached property (I.11).

In instances where planning was being done for targeted action to protect conservation assets, there was a high level of uncertainty as to whether resources would be available. Six interviewees spoke of having to negotiate within the Incident Control Centre for resources, primarily aircraft. Even if aircraft had been allocated for protection of a conservation asset, it would 'disappear' if properties became threatened. In another instance an interviewee spoke of having to 'beg' for a highly qualified person to be included in the Incident Management Team to do a values assessment; he was granted only 8 hours of his time.

> *So under normal circumstances, we would have been able to undertake targeted work to protect ecological assets, but that was just extraordinarily difficult to do this year because of the pressure to dedicate all of our resources to life and property protection (I.05)*

> *The resources were running around doing a whole bunch of other stuff, protecting people's houses and making sure people weren't in their houses, evacuating and things like that. So there were limited opportunity in that kind of situation to get in and protect some of those sites that we knew about even (I.15)*

Suggested improvements from interviewees:

Train staff from other departments or external organisations (e.g. Zoos) to be ready for deployment during fires for targeted actions for threatened species such as species translocations.

5.3.3 Life and property prioritised

A broader issue raised by a few interviewees was the need to expand the focus of protecting life and property to consider the 'equivalency of value of some natural values compared to property' (I.14). One interviewee recounted a situation in an Incident Control Centre in which the decision needed to be made as to which direction a fire would be encouraged to go using back burning techniques. Based on existing frameworks, the decision was made to protect 3 or 4 sheds (not homes) at the expense of 5,000 hectares of national park.

> *I think there's definitely a mindset shift that has to happen across the board about value. A decision has to be made about whether we're going to value environmental and cultural assets in the same way that we value built assets (I.32)*

A few interviewees noted that attitudes had already started changing, particularly as the scale of the fires and realisation of the level of impact on natural systems had triggered unprecedented recognition and concern by local communities and the general public. One participant believed there was a 'cultural shift' happening in society as well as within state agencies and senior ministers that protecting conservation assets is *"equally important to a haystack"* (I.26).

> *I think certainly in the last five to 10 years, that attitude has changed. And the more that we work together, the more they have an understanding and appreciation of managing biodiversity assets within a large-scale complex fire (I.29)'*

Suggested improvements from interviewees:

Decision making about where to direct efforts during the fire considers multiple objectives including ecological objectives.

Discussion and development of metrics that help guide how conservation assets are measured or valued in relation to other assets.

5.3.4 Data accessibility

As discussed in section 5.2, many interviewees felt that pre-fire data and planning was useful during the fires, and that operational agencies and staff were able to access online plans and maps to some degree. One participant advised that maps showing all the ecological and cultural heritage sites were accessible in fire trucks, light units and to aviation crews. However, the majority of interviewees perceived there were considerable issues with operationalising the information due to data accessibility, relevance and currency.

There were three primary constraining aspects to data accessibility:

1) The ability to find and collate the existing data as it was often dispersed among databases, localities (e.g. regions) and individuals. Useful information on species may exist in a spatial form on a regional or local database or may just exist on a spreadsheet on an individual's computer (e.g. risk registers).

2) Available data is sometimes not accessed by operational staff in the Incident Control Centre. One participant believed that the available maps and strategies were 'scantly' used in the Incident Management Team but acknowledged that real-time decision making made it difficult to access this type of information, particularly when life and property were the focus, or the planning time frame allowed for only 'reactive' decisions. One participant who was a planning officer during the fires was unaware of a biodiversity risk layer that had been created by their own agency and only 'stumbled' across it on the internet. There were also concerns that data systems were not interoperable, a consequence of which may be delays in information being accessed and processed.

> *Everyone's got their own system in terms of information management…. We have our own fire management system, (fire agency) have their fire management system and they're doing a major review of theirs and we're looking at how they can incorporate our data more effectively (I.13)*

> *Information would flow from the State Control Centre out to the Regional Control Centres, and then to the Incident Management Team or the Incident Control Centre. So there's three levels of spatial accountability …. and by the time it got down to the Incident Control Centre, it wasn't necessarily timely, and it wasn't necessarily being given the kind of priority that it might otherwise (I.20)*

3) The data was not interpretable by the operations personnel who did not have the necessary skills, or the information was too complex and not designed for emergency management use.

> *They're included as text at the moment, but there's no longer experts that are able to operationally understand what that means (I.06)*

> *And so looking at what better information can we provide around populations and why particular ones are important and what they might do. And then also easy ways to interpret it. Because thinking about, they're in middle of the control centre, they're rushing, they're looking at options. They need to understand, they need quick easy to use information and ability to interpret that information (I.21)*

5.3.5 Data relevance and currency

Where information was available and accessible, there were two issues with the degree to which Incident Management Team personnel were able to use the data in an emergency setting:

1) Information was too broad and provided no detail as to why or how to protect the asset.

> *One of the challenges we face is that when you try and capture all the relevant biodiversity information, it looks really busy, it looks like a lot. And to somebody who's trying to manage stuff on a 24/7 cycle, it kind of looks overwhelming (I.20)*

> *It was a bit of a mystery, because it doesn't say what the thing is you're protecting. It simply says, "These are the mitigations that you have to take notice of." (I.28)*

2) Available information was not current or dynamic. As discussed in Section 5.2.2, biodiversity database records are often the basis for the mapping and GIS layers used in Incident Management Teams, but the databases are not regularly updated. Some plans containing operational guidelines or fire management strategies existed only as static maps (e.g. PDFs) that were not regularly updated before the fire or able to be updated during the fire.

> *I don't think access to it necessarily is a barrier. I think currency, relevance, probably ability, time to use it, is it relevant to use it in the context of the fire in any event? (I.09)*

> *I think the other real issue for me is the accessibility and the awareness of those (fire management) strategies. So, they are online, but just in a PDF version, so we didn't have live data that we could input into IAP's (incident action plans). (I.05)*

Suggested improvements from interviewees:

Making complex information more easily understandable by non-discipline experts / operational personnel.

Ensure data available on conservation assets is available in a format that can be easily imported in operational systems.

Ensure Incident Controllers are made aware of available datasets and have the capacity and skills to interpret and use them.

Include current knowledge (e.g. what areas have been burnt) so that the information is dynamic and able to be updated in response to both prescribed burns and wildfires .

5.3.6 Interagency relationships and culture

Ten interviewees discussed how the relationship between biodiversity management agencies and fire agencies influenced the protection or not of conservation assets. Some interviewees were very positive about interagency cooperation and the goodwill and willingness to assist in protecting conservation assets.

> *The connections across the interagency staff are pretty good, really. And I didn't even feel like I rubbed up against the kind of issues of different personalities. I did feel like there was a legitimate sense of cooperative kind of firefighting (I.09)*
>
> *And I have to say generally across the fire agencies … there was a commitment where possible to try and do work to protect ecological assets. I mean, there wasn't always the resources and there wasn't always the level of prioritization that you would ideally have, but there was an acceptance that it's something that we should try and do (I.05)*

However, other interviewees noted there were interagency cultural differences between land manager and non-land manager fire suppression agencies, that were demonstrated by a lack of interest in, or awareness of, the need to protect conservation assets. It was felt that both on-ground fire fighters and non-land manager operational personnel in Incident Control Centres often did not have an appreciation of the importance of biodiversity, or there was a lack of skills / training in how to protect conservation assets.

> *It's a tricky one because people who are in that operational role, are very hands-on people and (some) don't necessarily want to understand all of the detail around what plant is that, and where does that live, and have an appreciation of the importance of the biodiversity and other values that are there (I.22)*
>
> *There's something about the skill and knowledge of on ground teams, because all of the best planning in the world is no use if somebody doesn't actually execute things properly … And the execution on the ground is dependent on well-trained people as well. (I.22)*

Part of the cultural difference was the belief that it was important for fire agencies to understand that *'not all fire is bad fire'* and that letting a fire burn an area may be less impactful than suppressing the fire (I.03). As expressed by I.28, *"don't trash the environment you're trying to save from the fire"*. However, it was also recognised that a fundamental aspect of fire legislation is that 'every means available' is used to suppress fires, therefore asking Incident Controllers to let a fire burn can be 'confronting' (I.28). Another interviewee felt that *"it takes a very significant biodiversity risk to intervene in those decisions"* (I.24).

Another interviewee reflected on the fact that mindsets regarding timescales were very different, with land managers considering much longer time scales than fire agencies whose primary concern is the incident and immediate outcomes.

Suggested improvements from interviewees:

Education, training and guidelines for operational staff and firefighters regarding the value of conservation assets and what considerations are required for protection. Include a narrative around why threatened species or other ecological assets are important and where they are in the landscape. Information could be presented in daily on ground fire briefings and summaries available in response vehicles.

Ensure the responsibility for threatened species and ecological communities is understood and shared by the fire management sector, not just environment focused areas of government.

Table 6. Themes that constrained the protection of conservation assets, and improvements suggested by interviewees

Theme	Challenges	Improvements
Scale, intensity, duration and unpredictability of fires	Fires conditions often precluded any suppression / mitigation actions The capacity and resources to implement suppression actions were inadequate given the scale of the fires. Life and priority were prioritised thereby further limiting the capacity and resources to protect conservation assets.	Better pre-fire planning and preparedness (see 5.2.4) Use skilled personnel from other departments / agencies to carry out non-fire-fighting duties Cultural shift to increased focus on conservation assets
Lack of integration of conservation assets	Existing data was not able to be utilised in Incident Control Centres because it was: • Dispersed (between agencies or databases) • It was not accessed by personnel in Incident Control Centres • The data was not interpretable in Incident Control Centres • The data was not relevant or current Cultural differences between land managers and fire suppression agencies regarding the value / importance of conservation assets and how to protect them.	Consistent National or State-wide collation of data Training of Incident Control Centre personnel to know where to access and how to interpret ecological data Make data systems interoperable and easy to use NB: Biodiversity representatives are included in Incident Control Centres to assist with awareness and protection of conservation assets (see 5.4.1) Training to raise awareness and appreciation of the value of conservation assets. Training on how to protect conservation assets

5.4 Fire operations: Aspects that helped the targeted protection of conservation assets

5.4.1 Biodiversity representation in Incident Management Teams

As discussed in Section 5.2 many agencies had pre-existing plans or tools (e.g. bushfire mitigation planning, GIS layers, modelling) that helped inform the planning for during fire actions by providing knowledge of species locations. However, a major challenge discussed in section 5.3.4 and 5.3.5 is the accessibility and relevance of available ecological data. Pertinent to this is that 73% of interviewees identified the value of having biodiversity representatives in the Incident Management Teams. This was also supported by survey respondents, who highlighted that plans were made available or accessible to Incident Management Team through biodiversity representatives.

> *Quite clearly there's a strong link to awareness of ecological assets and protection when you've got people in the Incident Management Team that understand those issues (I.05).*

The representation of biodiversity in Incident Management Teams came in a range of forms. A few agencies had created dedicated roles that were stood up for the fire event, such as Natural Values Officers or Natural Values Teams. These roles were seen as coordination and support roles that provided information and recommendations but did not have decision making authority. Despite this, they were considered to be highly beneficial as Natural Values representatives were able to work with those within Incident Management Teams to:

- Access available data and make it useable and relevant.
- Access a network of experts or other resources.
- Advocate for threatened species (can also include cultural assets).
- Advise on the impact of firefighting actions. Providing advice on the use of retardants/gel and the potential impacts of the creation of containment lines were seen as a primary role of Natural Values Officers.

> *It's typically not about fire itself. It's about machines and people activities (I.25).*

Most Natural Values Officers were situated in Incident Management Teams, but one agency also had a Natural Values Officer actively working with fire teams on the ground to assist with the protection of key conservation assets. One state introduced a State-wide Wildlife Controller for the first time (in 2019/20), who worked at the State level, rather than the incident level. One interviewee believed that this provided much needed access to a system that is highly structured and 'militaristic':

> *(it) was an entrée to the way the system works. So you could just stand outside knocking on the door as much as you liked, but once you had someone in there with a coloured vest on, access became much easier. Not to say it necessarily translated into things happening on the ground, but it certainly was critical (I.20).*

Senior ecologists or people with park management background and experience often populated key Incident Management Team roles such as Planning Officers, Mapping Officers or Incident Controllers. Interviewees spoke of the ability of senior biodiversity representatives to 'bridge the gap' between land management and fire operations agencies, as well as being able to bring in high-level expertise. Advocating for the protection of conservation assets and negotiating for resources were critical elements.

> *So for me, it was about making people aware at a high level of the potential threats … It was about trying to negotiate dedicated resources for that kind of work, and then trying to negotiate maintaining those resource commitments in the face of other pressures (I.05)*

Agency staff with specialist skills were deployed to assist in, or provide information to Incident Management Teams, for example, fire prediction staff, spatial analysts, and data management specialists.

> *The other resource we do have is we've got a spatial information team, a data management team … their role is to produce spatial and ecological information from data … they play a really key role during an event in being able to pump out maps rapidly (I.15)*

Common to all the forms of biodiversity representation in Incident Management Teams was the importance of the contribution of local knowledge that is often not captured in plans or mapping.

> *It was relying on isolated instances of having the right person in the room at the right point in time, with the right knowledge (I.24)*

Box 3: Development of a Natural Values Team

Department of Environment and Water (DEW), South Australia

In South Australia, the Country Fire Service (CFS) is the agency responsible for bushfire response in all non-metropolitan areas. For many years DEW has provided SA CFS a range of specialist fire services, including mapping support and trained Incident Management staff and firefighters. Over the last 20 years the support has continued to evolve with DEW's Mapping Support Team working at both State Control Centres and Incident Management Centres. DEW also provides bushfire behaviour and prediction staff. This support functions as part of the SA Emergency Management Plan. Following significant fires in 2008 in the Murraylands Region and the consequent development of a Threatened Mallee Birds program, a more collaborative management approach evolved with fire managers resulting in more effective processes for providing threatened species advice to local fire management staff. In 2018 this process was formally recognised by DEW and SA CFS as the Natural Values Team. This recognition allowed DEW to formally have staff inside the Incident Management Team to work with Planning personnel and provide advice on biodiversity issues. Initially only implemented in one of the nine regions, in 2019/20 it was extended to all regions in SA. DEW currently has nearly 50 staff involved in Natural Values Teams with ongoing training and mentoring of new staff as well as further finetuning of operational procedures. During the 2019/20 bushfires, Natural Values Teams were deployed to assist, particularly for the Kangaroo Island fire where they were able to influence or achieve the following outcomes:

- Provide mapped natural values location data to Planning and Operations teams
- Incorporate and pass on local information (in addition to corporate systems data)
- Identify and act proactively with Operations staff to minimise / avoid significant environment impact of control lines and other suppression activities
- Remind and support implementation of Phytophthora hygiene protocols

Contributing success factors:

- Natural Values Teams played a formally recognised role within the Incident Management Team
- Training and mentoring had occurred to build consistency and capacity

Source: (I.33)

An overarching challenge constraining the inclusion of conservation assets within Incident Management planning was that any prioritisation of assets was undertaken by biodiversity focused departments, outside of the emergency management structure. For example, one department recognised the need for, and instituted, an intense analysis and prioritisation process but this process was not part of the formal decision-making structure for allocation of resources. This information was only able to be incorporated into the emergency management context when a biodiversity representative was situated in the Incident Management Team. A few interviewees commented on the lack of a *'hierarchy of decision making'* regarding protection of conservation assets:

> *Nobody in those Incident Management Teams or Incident Control Centres were the lead on this biodiversity kind of priority … So it was more just emphasis on being harassed by those that were concerned about what was under threat rather than it being structural in the team (I.26).*

A common constraint was whether someone with biodiversity experience was available, and whether they had the confidence and experience to be able to advocate for protection. Personnel from Parks agencies who may populate key officer roles are not always available or rostered on, and there was a limited number of adequately trained Natural Values Officers. Interviewees were very aware that the protection of conservation assets was strongly influenced by who was present in the Incident Management Teams, both at a senior level but also whether the necessary information was able to be accessed, particularly local knowledge of key conservation assets.

> *It really depends on who you're dealing with in the incident. You get some fire managers that are open and willing to consider strategies that will aim to minimise or protect biodiversity assets. And then you would just get hard-nosed fire managers that are very difficult to work with (I.29)*

> *Because people often don't know that (conservation assets) are there. In the way that Incident Management Teams work, if you're in a normal firefighting mode, you're in these 12-hour cycles of people swapping over all the time. And people will come from out of area, and some people might be from in area and they know, and they don't know. So knowledge is a big one (I.09)*

Table 7: Benefits and constraints of having biodiversity representatives in Incident Control Centres

Aspect	Natural Values Officer / Teams Senior environmental / Parks staff in senior Incident Control Centre roles Specialist staff in key Incident Management Team roles
How did it help	Access available data and make it useable and relevant Access network of experts Advocate for threatened species (can also include cultural assets) Advise on impact of firefighting actions Advocate for the needs of conservation assets in planning
Constraints	Not a formal role No decision-making capacity, primarily advice only Representatives from Parks-type agencies not always available / utilised in Incident Management Teams
Improvements	Formalise role in Emergency Management (EM) structure nationally Training for consistency within this role Increase capacity through training

In most instances, the inclusion of a Natural Values Officer in the Incident Management Team was done for the first time in an emergency event setting, and there was some confusion about exactly what role they were or should be performing. One participant spoke of having to negotiate during the fire about having a Natural Values Officer in the Incident Management Team. In another instance interstate personnel were brought in to fill key officer roles in the Incident Management Team to provide relief to local people, but they had no background of why the Natural Values Officers were in the Incident Management Team. There was a perceived difference in how Incident Controllers accessed advice from Natural Values Officers. Some would actively seek advice regarding what ecological considerations need to be considered when, for example, planning for the use of retardant. In other jurisdictions the onus was on the Natural Values Officer to take the advice to the relevant Incident Management Team personnel and there were concerns that the advice would not be taken on board (1.03). There was also some confusion about who the Natural Values Officer could / should report to.

> *The role of the values officer within that framework is not consistently defined anywhere (I.02)*
>
> *Because it is an advisory role, that's where some of that improvement can happen around we how do we ensure at least that there is a clearer line of sight between the natural values officers giving the advice and the Incident Controller manager making those decisions (I.15)*

Suggested improvements from interviewees:

Embed Natural Values representatives in the Australasian Inter-Service Incident Management Structure (AIIMS) for national consistency. Most interviewees accept that the Command and Control hierarchy is necessary and did not think that this role necessarily needed to be a decision-making role but felt that formalising the position for future emergency events was very important.

Consistent training of Natural Values Officers and recruitment of more staff to increase capacity during events. A few agencies had already developed training programs and were training additional personnel to fill this role.

5.4.2 Asset location and responsible agency

Prioritising and achieving protection was considered easier if an asset was located at a single site and not widespread. This was relevant primarily to threatened species that inhabited defined areas (such as the Wollemi Pine). Whether or not the area was defendable was also noted, for example, species that existed at the top of mountains were more difficult to protect, as were large areas of vegetation. Despite this, there were a few instances mentioned in which targeted actions were undertaken to protect broader areas, such as areas containing feeding habitat for a threatened species, or areas containing valued flora or ecological communities. However, the location of the asset could also work against its protection if it was remote from human populations, as resources may not be allocated to it in case they were needed for protection of life and property.

A few participants noted that the consideration of conservation assets was higher where there was less risk to life and property. This provided opportunities for the protection of biodiversity, as Incident Management Teams were more likely to be able to consider protection, and firefighting resources were more readily available.

> *Because there was not a significant loss of life and most of this was on public land it did provide some further opportunities to influence what was happening (I.21)*

On occasion the fire location meant the incident was managed solely by a Parks or environment agency. A few interviewees felt that conservation assets were given greater consideration if the fire was located on National Parks estates and the fire was primarily the responsibility of the land manager or Parks agency.

> *The (Parks agency) there were dealing with some of the fires that were more contained within national parks. And so they're able to self-manage those probably with better outcomes for biodiversity than those that were multi-tenure and encroaching on private property and other community assets (I.29)*

Box 4: Successful implementation of conservation asset protection strategy

Case study 1: Namadgi National Park (NP), ACT

Namadgi NP is considered to be an area of high biodiversity and cultural heritage significance. It is located in south-west ACT and borders the Kosciuszko NP in NSW. In 2003 a large wildfire burnt 90% of the Park. In January 2020 an Australian Defence Force helicopter sparked a fire in the Orroral Valley and the fire rapidly spread into remote areas of Namadgi NP. One section of the Park was considered to be of high ecological value as it was one of the few long unburnt areas. Natural Values Officers and other Incident Management Team personnel in the ACT worked with the Cooma NSW Incident Management Team to lay down containment lines using bulldozers. A Planning Officer in the Cooma Incident Management Team had a Parks background and understood the value of this area.

Outcome: Approximately 78% of Namadgi NP was burnt (>82,000 ha) but the containment lines protected a large portion of the long unburnt section of Namadji NP.

Contributing success factors:

- Highly valued regional asset
- Identified during fire as a key asset for protection
- Biodiversity representatives were involved in the planning and implementation of firefighting actions
- Inter agency co-operation

Sources: ACT Government 2020

Case Study 2: Ginini Flats Wetlands, ACT

Ginini Flats Wetlands is designated as a wetland of international significance under the Ramsar Convention. It is located in the Namadgi National Park, ACT. As well as providing an important hydrological role in maintaining water quality for the catchment area, it is also habitat for important species such as the Northern Corroboree Frog (*Pseudophyrne pengilleyi*) and contains the largest intact high-altitude Sphagnum bog and fen community in the Australian Alps. In January 2020, the Orroral Valley fire spread into the Brindabella Ranges threatening the Wetlands and Sphagnum bogs. With the help of a Natural Values Officer, planning was undertaken to try and protect these areas from the fire by laying down lines of retardant. The Natural Values Officer involved in the implementation of the plan was able to talk with the aircraft personnel to provide further instructions and clarification about preferred location of retardant lines.

Outcome: Action was successfully implemented, though fire didn't reach the site. The effectiveness of the action is therefore unknown, as is the impact of the retardant on vegetation.

Contributing success factors:

- Highly valued regional asset
- Identified pre-fire as a valued asset for protection
- Natural Values Officer were involved in the planning and had direct influence during implementation of the action.

Sources: https://www.environment.act.gov.au/__data/assets/pdf_file/0016/1060036/Ginini-Flats-Ramsar-Site-Management-Plan-Summary-ACCESS.pdf; I.01, I.02

5.4.3 Iconic Species

A species was more likely to be protected during the fires if it was iconic or had a pre-existing high profile. One interviewee referring to the Bristlebird extraction noted that *"if it were a bristle worm, we would've got nothing done"* (I.25). There was also recognition that there was greater knowledge of the threats and exact locations of high-profile species because:

> *where you have the funding and you have the dedicated expertise on ground surveying and with a remit to focus on their little particular area of expertise, you have much more capacity to be managing from the ground up and out (I.18).*

A few interviewees also identified high-level interest and political will as a factor. In one instance this was brought about by helicopter footage showing fire ravaged areas that motivated high level response, and in another the actions undertaken in one state were credited as the motivation for Ministers in another state to emulate direct action. As stated by one interviewee, *"it was as much responding to perceptions of the need to respond"* (I.20). The existence of external stakeholders that raised the profile of the species was also noted, as was the involvement of highly visible partners, such as Zoos. Most of the species that were discussed in the context of having been the focus of targeted actions were listed species (State or Federal), but in a few instances, targeted protection actions were undertaken if the conservation asset was considered rare or unique to a particular region. For example, attempts were made to protect a long unburnt section of a National Park as this unburnt section was considered highly valuable (Box 4).

5.4.4 Advocacy

Advocacy for the protection of conservation assets often occurred within Incident Management Teams (see Section 5.4.1), but it was also recognised that highly passionate and/or knowledgeable individuals or stakeholder groups were able to influence the protection of particular species. Important elements of advocacy were that the person was motivated enough to push for action and knew who to contact to exert influence. *"It comes down to one person having the passion or the drive or whatever. Without that, then the fire can be fought very differently, so it's up to single individuals and A, the relationships you develop with your colleagues, and B, how hard you're prepared to push"* (I.28). However, it was also recognised that relying on passionate individuals created *"single points of failure"* and that the focus should be on the creation of systems (I.24).

Box 5: Advocacy to protect an endangered species

Manning River turtle (*Myuchelys purvisi*), NSW

The Manning River turtle is listed as Threatened in NSW. This medium sized, shorth-necked freshwater turtle is found in the upper and middle reaches of the Manning River catchment area. Threats to this species include predation of nests by foxes and feral pigs, drought and fire run-off impacting on water quality. In December 2019, NSW Parks and Wildlife Service in partnership with Aussie Ark collected over 200 turtles (the Species Project Coordinator from the State environmental agency was also involved). Some were relocated to deeper pools and others were taken into emergency facilities at the Australian Reptile Park. Seven platypus were also removed. The Species Coordinator issued the appropriate licenses.

Outcome: A captive Manning River turtle insurance population has been successfully established by Aussie Ark and a number of baby turtles have recently hatched.

Contributing success factors: Strong advocacy by Australian Reptile Park, Aussie Ark and Manning River Turtle Conservation Group and additional capacity through stakeholder involvement.

Sources: Interviewee (I.10); https://www.rewild.org/news/trial-by-fire; https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20326

5.4.5 Additional resources

As discussed in 5.3.2 and 5.3.3, interviewees were very aware that life and property are established priorities, and in the past, there had been little resourcing for emergency actions for conservation assets. In instances where additional funding or resources were available, it was recognised as a vital aspect that either enabled emergency planning (see Box 1 and section 5.3.2), or the implementation of emergency response actions (Box 6).

> *I think what would have happened, if that money wouldn't have been provided, I guess we could have still got some things done, but it would have been more difficult, and there are some things that might not have actually occurred because they literally take money to pay people to do things.(I.23)*

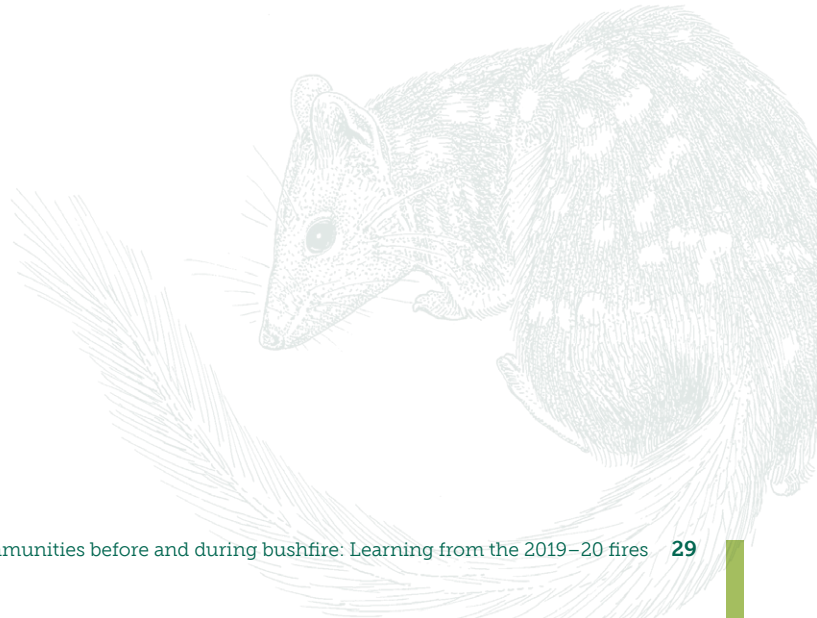
In a few instances, external resources that would not compromise the firefighting effort were able to be accessed. This included staff from other departments, contractors, or personnel from other organisations such as Zoos. Due to the iconic nature of one of the species, there were unlimited offers of assistance with the interviewee describing it as *'fighting them off'* (I.05).

5.4.6 Pre-existing planning

There were two cases where the existence of a translocation plan (Case Study 1) and a detailed fire management plan (Case Study 2) enabled successful during-fire responses (Box 6 and see also section 5.2.2). In Table 8 we highlight how each of the aspects that helped the targeted protection of conservation assets enabled successful implementation of management during the fires.

Table 8: *Aspects that contributed to the targeted protection of assets during the 2019/20 fires with a successful outcome.*

Species	Wollemi Pine	Bristlebird	Namadji NP
Targeted action	✓	✓	✓
Pre-fire planning	✓	✓	×
During fire planning	✓	✓	✓
Biodiv. Rep in IMT	✓	✓	✓
Advocacy & support	✓	✓	×
External resources	✓	✓	✓
Conservation tenure	✓	✓	✓
Additional funding	✓	✓	×
Single location	✓	✓	×
Ecological knowledge and data	✓	✓	✓



Box 6: Targeted action during fires for protection of a threatened species

Case Study 1: Eastern Bristlebird (*Dasyornis brachypterus*)

Context: The last known population of the critically endangered Eastern Bristlebirds in Victoria is located in Howe Flat, Croajingolong National Park. In 2017/18 a translocation development project began for the establishment of an insurance population as part of the overall management strategy for this species, including fire management. The translocation process had been approved by an animal ethics committee and the necessary permits for the translocation of individuals from Howe Flat were in place. In January 2020, realisation of the extent and intensity of the fires triggered intensive analysis of the likely impact of fires on biodiversity (particularly in biodiversity hotspots such as East Gippsland) resulting in the development of the Bushfire Biodiversity Response and Early Recovery Plan (BBRER). Significant state funding was released to assist with priority response, relief and recovery actions. The Plan identified the Eastern Bristlebird as a high priority and the seven day rolling priority list identified emergency extraction as the key action. Concurrent to this was the establishment of a Statewide Wildlife Controller role, that facilitated the incorporation of biodiversity priorities for emergency response. The first response was strategic water bombing around Cape Howe to try and protect the Eastern Bristlebird site. The decision to extract was made at the State level, but planning was done by the regional Incident Control Centre. An options analysis was undertaken in the Incident Control Centre to decide on the preferred option which was then signed off by the Incident Controller and allowed resources to be allocated to it. Regional planners had extensive experience with Eastern Bristlebirds and were able to 'piggyback' existing permits and get immediate authorisations (which would normally take months). The Australian Defence Force provided a helicopter, fixed wing aircraft and resources that enabled skilled personnel to be able to access and catch 15 individuals. Zoos Victoria were integral in providing technical expertise, resources and a home for the captive birds. A number of other agencies contributed to the extraction including DELWP, Parks Victoria, Monash University, University of Wollongong, Currumbin Sanctuary and Bird Life Australia.

Outcome: Successfully extracted 15 birds. Fires did not reach Howe Flat. Survivng birds were re-introduced post fire (Parrott et al., 2021). The planned translocation site(s) burnt.

Tools:

- HDMs and species data that enabled the development of the BBRER plan
- Monitoring data, Recovery / action plan
- Regional planning team with experience / skills

Contributing success factors:

- High-profile species with pre-existing translocation plans *"We learnt that none of this is possible without preplanning"* (I.25).
- Interagency collaboration (*"coalition of the willing"* I.26)
- Public awareness / interest
- High-level interest and political will
- Funding
- Local knowledge / expertise and highly skilled people
- Strong advocates within DELWP, Incident Management Team and external agencies

Limitations:

- No formal structure within the existing emergency framework for protecting threatened species but required significant direct advocacy. Seven-day rolling priorities list / plan was done outside of the EM framework
- Success was reliant on resources being available, and subject to negotiation

Box 6: Targeted action during fires for protection of a threatened species (continued)

Case study 2: Wollemi Pine (*Wollemia nobilis*)

Context: The Wollemi Pine is one of the world's oldest and rarest tree species. It is currently known to exist at only four sites located close together in Wollemi National Park, NSW. The four populations consist of approximately 40 adult plants. Species experts became concerned prior to the fire reaching the Wollemi Pine sites. To protect the species, three targeted actions were implemented:

1. A sprinkler system was installed 3 weeks before the fire impact to moisten the fuels in the immediate vicinity of the pines. This effort was made more challenging by a lack of a permanent water supply and required daily pumping from a small pool. Crews were required to run the irrigation system, however, smoke impacted significantly on visibility so crews could only access the location for approximately 12 days.

2. Retardant lines were put in above the canyon system, but fire burnt through the retardant lines due to the extremely dry conditions.

3. Targeted, strategic tactical water bombing with helicopters then occurred when conditions allowed. Turnaround time was impacted by there being little available water in the landscape, requiring water sources to be set up as close as possible. Visibility due to smoke was an ongoing challenge.

Despite these efforts, fire still reached the site but fortuitously burnt through with less intensity at night, and most trees survived. The day after, agency staff helicoptered in, mended and used the fire damaged irrigation system as a hose and put out remaining fire spots in the site.

Outcome: Fire went through the site, but most adult Wollemi Pines were not burnt. Some adult trees were scorched or charred and the long-term impacts of this damage are unknown. Juvenile seedlings were killed.

Tools:

- A dedicated fire management plan

Contributing success factors:

- Iconic, high-profile species
- Used external resources (species experts, contractors, irrigation experts) to set up irrigation system so as not to compromise scarce fire-fighting effort multiple protective response actions that provided back-ups should one mechanism fail
- Presence of Parks personnel in Incident Management Team
- Irrigation equipment on hand
- Managed at a National Parks level primarily by Parks personnel, though as part of the broader fire management control
- In a single, discrete location
- Public awareness / interest
- Funding was available/not a constraint
- Strong advocates that raised awareness of threat to species three weeks before fire impact

Limitations:

- Required advocacy from Parks personnel to raise awareness of the need for action
- Success was reliant on resources being available, and subject to negotiation
- Drought conditions limited the availability of water on site
- Smoke impeded access

Suggested improvements from survey respondents

When considering the factors that would improve conservation outcomes 'pre-fire plans for threatened species and ecological communities was ranked the highest (average 9.0/10), followed by a 'planning framework to guide efforts during the fire' (average 8.6/10). All factors rated as important on average, with species experts in control centres the lowest with an average of 7.4/10 (Figure 2). Additional factors suggested by respondents include:

- Training for key Incident Management Team positions on strategies and resources available to inform decision making about biodiversity asset.
- Training for on ground firefighting staff on protection of biodiversity assets
- Good relationships between agencies.
- Suppression actions informed by land managers with conservation background rather than fires services.
- Strategic emergency management plans with implemented actions for species, communities and populations which may include ongoing contingency management actions which need to be supported by whole-of-government.

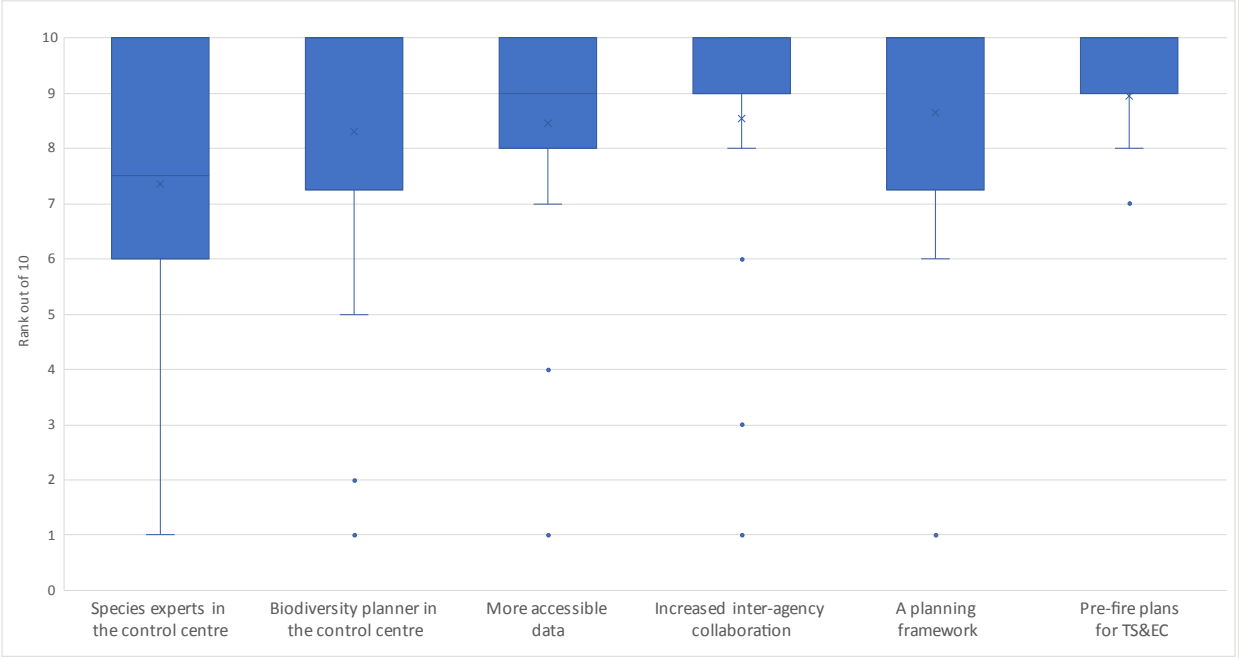


Figure 2: *Boxplot of survey responses to "What do you consider most important for ensuring on ground firefighting operations considered threatened species and ecological communities" with 1 being not important of 10 being very important (n=20)*

5.5 Fire operations: Actions and considerations

Interviewees were asked to reflect on what the main operational considerations are that influence the protection of conservation assets, and to comment on any improvements or changes that may improve outcomes for biodiversity. The most common responses included whether or not resources were available, the importance of operational personnel knowing where conservation assets were, that they understood the importance of those assets, and had the knowledge of how to protect them.

Protection of conservation assets during fires can be covered in governing legislative and regulatory frameworks to improve outcomes during fire operations. Fire services, such as South Australian Country Fire Service, have a legislative responsibility to incorporate the environment and conservation assets into decision making. Legislation has recently been implemented in Western Australia that requires ministerial approval for any actions that result in a take of threatened species and covers prescribed burning activities and emergency situations. This delegation can be given to incident controllers or senior agency staff in emergencies. This mechanism ensures consideration is given to if and how activities may impact threatened species.

> *they have an enacted it a few times over the last couple of years (in emergency situations). It hasn't always gone according to plan, but again, I think there's a discussion around 'okay, this is going to happen. Does it have to happen?' because most of it is putting in tracks, that sort of thing. It's activities that they're doing that aren't immediate. They're planned activities so there can be some thought that goes into how can we best do it to protect the biodiversity value (I.30).*

Further detail on the main operational considerations that influence the protection of conservation assets are discussed in Section 5.4 and Table 9 provides a summary of all aspects. Examples of successful implementation of conservation asset protection strategies are outlined in Box 6.

Table 9: *The main operational considerations that influence the protection of conservation assets*

Operational consideration	Issue	Potential solutions
Incident Control Centre personnel are aware of conservation asset	Can be a lack of awareness of risk to and importance of conservation assets Lack of knowledge of existence of data and skills to access and utilise	Education and training for operational staff from senior levels through to on ground crews Biodiversity representatives are present in Incident Control Centres
Resources are available	Life and property are prioritised Not enough biodiversity personnel to fill Incident Management Team roles Equipment is not available	Conservation assets considered in decision making Dedicated natural values officer training available across agencies Pre-positioned equipment (such as irrigation components) at easily accessible points. Access to resources dedicated to conservation assets (e.g. volunteers, interest groups)
More species are considered for protection	Unless a species is high profile or has strong advocates, it may be overlooked for protection	More comprehensive pre-fire planning that identifies key conservation assets including most critical sites for protection (e.g. refugia) and the resources required to protect them during fire
Decisions on prioritisation of conservation assets are within the EM structure	Prioritisation work done by biodiversity agency	Formalise where prioritisation of protection of conservation assets fits within decision making framework
Processes are streamlined	Permits to remove threatened species are time consuming Maps provided to on ground crews are not able to be used at appropriate scales	Review permit authorisation requirements to enable quick approval for emergency species extraction Necessary information is available on-ground via phones and tablets

5.6 Risk assessments for firefighting actions

If potential risks of firefighting actions had not already been discussed, interviewees were asked *"Have you done any risk assessments that consider how firefighting actions might impact conservation assets?"* and were generally prompted regarding the use of retardants and gels. Most interviewees were not aware of any specific risk assessments for wildfires, but a few mentioned that guidelines on the use of containment lines and retardants and gels were considered in prescribed fire activities. However, it was also recognised that the guidelines will not necessarily apply during wildfire suppression as the urgency to fight the fires may preclude considered decisions. As expressed by one participant, the potential impact of firefighting actions on conservation assets *'gets weighed up with the urgency of getting in there to do the work versus making those sorts of decisions'* (I.30)

5.6.1 Retardants and gels

A few interviewees were aware of guidelines around the use of retardants during planned burns, primarily near water bodies. One participant reported that they had to come up with some rules during the fire. In general, interviewees advised that they consider the impact of retardants and gels, but there is a lack of research on what the impacts will be on many species. Three agencies were undertaking research; two were focused on looking at the effects of retardants on vegetation and soils, particularly the effect of retardants as fertilisers. The other had a written procedural guidelines that included the chemistry of retardants and considered the risks to the environment. Another agency was reviewing the current authorisation for the fire agency to use retardant indiscriminately; instead key areas would be identified and explicitly excluded from the use of retardants. Two participants discussed the complexity of decision-making around the use of retardants and having to consider trade-offs and a 'hierarchy' of risks. For example, considering the risk of using retardant in a catchment area containing threatened species versus not using it and risking the entire catchment being burnt.

5.6.2 Containment lines

Mineral earth containment lines were recognised by many interviewees as being a useful firefighting action to protect conservation assets, but also that this action could also be potentially damaging to threatened species either by the direct impact of machinery or by fragmenting habitat. As discussed in Section 5.4.1, a primary role for Natural Values Officers or other land managers in Incident Management Teams was advising on the use of containment lines. In one instance a decision was made to use retardant rather than creating a containment line using earth moving equipment due to concerns i) the hydrology of the area would be impacted, and ii) that the containment line may not be effective in stopping the fire front.

5.6.3 Weeds and disease

A few interviewees mentioned the risk of firefighting equipment contaminating sites with weeds or pathogens and disease via the movement of water. One participant mentioned that hygiene processes are outlined in management plans, and another agency has hygiene officers who check and clean all machinery. This agency also advises contractors pre-season to have their machines cleaned.

Suggested improvements from interviewees:

Develop Standard Operating Procedures and Guidelines for during incidents regarding weed and disease hygiene.

Pre-determine staging areas that do not contain weeds.

Education for firefighting personnel regarding hygiene protocols and the need for them.

Review network of fire trails to strategically evaluate where the best points are for suppression and to limit breaking up of the landscape.

Clearly identify key areas / assets to be excluded from containment lines and/or retardants / gel application

Further research on the impacts of gels / retardants.

6. What can we learn from other contexts?

6.1 Pre-fire planning at the landscape scale

A landscape scale approach to pre-fire planning can offer a more feasible and effective way to integrate multiple values into a risk management framework. The Rocky Mountain Research Station Wildfire Risk Management Science team have been involved in developing a pre-planning process at a landscape scale, using spatially defined units called Potential Operations Delineations (PODS; O'Connor et al 2016; USDA 2021). PODS are defined by potential control boundaries (i.e. roads, ridges), and described according to a set of risk variables (i.e. forest type, potential for fire etc), and ecological values.

These units are used within a structured pre-fire planning framework to develop management options that best achieve outcomes for the objectives or goals of that area. Objectives may relate to specific conservation assets, like threatened species, or more strategic objectives like ecosystem condition, wildfire risk, or future fire management costs. Spatial analysis and local expert judgement underpins the data required to identify assets and evaluate options. It provides a framework for developing and evaluating options for managing risk before a wildfire event, but also facilitates more effective management of fire during a fire event (i.e. rather than focusing solely on suppression). The framework does not treat PODS as isolated units, but instead recognises the cross-landscape risks and benefits, facilitating collaborative planning with adjacent regions (USDA 2021).

6.2 Management thresholds to inform wildfire management response

Detailed understanding of species ecology and pre-fire planning is key to the success of managing conservation assets during fire. This includes species recovery or management plans that identify fire as a risk to species persistence and incorporate an understanding of the species ecology into a proposed management approach. A comprehensive international example of this approach is the management of the iconic Canadian species, the Woodland Caribou (*Rangifer tarandus caribou*). Management of this species is governed by the "Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*) Boreal Population in Canada" (Environment Canada, 2011). Wildland fire is recognised as the dominant natural disturbance in northern Canada. While it is essential for ecosystem maintenance, it disrupts important Caribou habitat, as Caribou prefer long unburnt forests (40 plus years post fire). In order to guide wildfire suppression efforts in Caribou habitat, the strategy identifies a management threshold of maintaining 65% undisturbed Caribou habitat across the landscape. This threshold was developed based on an understanding of the relationship between the amount of undisturbed habitat in a range and the likelihood of a local population being self-sustaining (Environment Canada, 2011). This management threshold is used to inform and prioritise wildfire suppression activities in critical Caribou habitat.

6.3 Biodiversity representation in emergency response

Biodiversity representation in the emergency response structure facilitates the consideration of conservation assets in operational decision making. This approach is successfully demonstrated in New Zealand. Fire and Emergency New Zealand was established in 2018, through the amalgamation of urban and rural fire services into a single, integrated fire and emergency services organisation. Fire and Emergency NZ are responsible for response to built asset and wildfire and have the principal objectives of 1) reducing the incidence of unwanted fires and the associated risk to life and property and 2) protecting and preserving life, and preventing or limiting injury, damage to property, land and the environment. When dealing with a wildfire event, Fire and Emergency NZ collaborate with the Department of Conservation (DOC) to facilitate the protection of conservation assets. This involves a local DOC representative being embedded in the planning unit in the Incident Management Team. This allows for the local ecological knowledge and data to be incorporated into the incident action planning, in collaboration with operations and fed into the options analysis presented to the Incident Commander. This example highlights the benefits of formal recognition of the role of ecological representation in the Incident Management Structure.

6.4 Marine Environmental Emergencies

Australia has a robust and well-established approach to oil spills in the marine environment developed through dedicated research and successful collaboration between government and industry. A National Plan for Maritime Environmental Emergencies has been established that identifies the national arrangements, policies and principles for the management of maritime environmental emergencies in Australia (Australian Maritime Safety Authority, 2020). The plan is informed by, and compliant, with multiple existing international conventions on oil spill pollution. A key tenet of the plan is the provision of a comprehensive management arrangement that includes governance and policy conditions and covers prevention, preparedness, response and recovery from marine pollution. Importantly, the plan is underpinned by formal risk assessment at the Commonwealth, state and territory, regional and local scale.

The Australian Marine Oil Spill Centre (AMOSC) was established by the oil industry in 1991 to support the National Plan for Maritime Environmental Emergencies. AMOSC owns and operates the major oil spill response facilities, including stockpiles of oil spill response equipment that is available for deployment around the Australian Coast. AMOSC has a key role in training and coordinating industry personnel ready to provide immediate emergency oil spill response. AMOSC has 13 permanent staff available for oil spill response. In case of an incident, these permanent staff are supplemented by participating oil company staff specially trained for marine oil spill response. Staff receive support and training in excess of usual industry-based oil spill response courses and refresher training every two years. These staff are available to all AMOSC Member Companies and others through the National Plan.

7. Recommendations: A roadmap to improve preparedness for an uncertain future.

The following is a roadmap of the elements required to ensure maximised outcomes for biodiversity in a changing climate, and to minimise the risk of future wildfire events resulting in another ecological disaster. It brings together the considerable knowledge and experiences of those who were involved in the protection of conservation assets during the 2019-20 fires. Our recommendations below are based upon their experiences outlining what happened during the fires, what limited the response to protect conservation assets, and what improvements can be made in preparation for a future where wildfire events of such magnitude are inevitable. Where possible we provide examples of existing tools and approaches that can support future efforts, drawing in knowledge from international sources where appropriate.

There are two primary components i) having plans and actions in place to increase the resilience of our ecological landscape *before* wildfire events, and ii) having plans and actions that can be implemented *during* wildfire events. The recommendations are integrated and posed as a series of actions that work together as a strategy. For recommendations on immediate to longer-term post-fire response to promote recovery of biodiversity and ecosystem health *after* a wildfire event, refer to the NESP "After the catastrophe: a blueprint for a conservation response to large-scale ecological disaster" (Dickman et al., 2020).

It is important to note upfront that there is a clear recognition from all interviewees that protection of human life during wildfire events is a priority. However, plans and processes to minimise risk to biodiversity during the fires were lacking, and this was recognised as a serious limitation to the ability the protect conservation assets.

The overarching recommendations within this roadmap require support and resourcing by decision makers. Such additional support represents a precautionary investment that will help reduce future biodiversity loss and reduce the need for massive post-fire recovery funding. For biodiversity and operational staff, some of the tools, approaches and case studies may provide useful information. However, there was a clear recognition from interviewees of what is needed to improve protection of conservation assets before and during fire events; we have simply provided the synthesis.

7.1 Improve preparedness before fire events

Objective: To spread risk before fire events, to both increase resilience of the environment, and reduce biodiversity losses during fire events.

Investment in planning to improve preparedness for how to act during a fire event is critical. It was quite clear from interviewees that considerable risks and constraints limit the ability to act during a wildfire event, whether that be an issue of access, available resources or safety, or other constraints on decision-making. Given the precarious post fire environment, rescue operations are really a last resort. Investment in strategic and targeted planning and active management actions to spread risk before wildfire events is critically important to mitigate the adverse impacts of wildfire. This obviously requires significant investment, but presumably the costs of post fire recovery actions are far greater.

There are a series of steps necessary to improve pre-fire planning outlined in Figure 3. The specific recommendations of improving preparedness are as follows:

1. Knowledge and data

A fundamental aspect of planning is having the necessary data to support the development of prioritisation frameworks and management plans, including management thresholds (recommendations 2-5) and have this available in an inter-operable database. This may include data on the status of species or ecological communities, the ecological needs of the species (especially their responses to fire, and to fire regimes), and the consequences of actions (including costs). Data may be field based, published information, or (structured or unstructured) judgements from experts. To prioritise the collection of new data it is worth exploring whether gaps in knowledge preclude identification of an effective management option (i.e. critical uncertainty). A planning process that seeks to identify critical places for high priority protection would likely reveal critical knowledge gaps about the distribution of priority species and ecosystems, or places of high endemism. Such a process would provide a sound basis for investing in future data collection.

2. Assessment and prioritisation of conservation assets, to inform priorities for action before, or during a fire event.

Recognition of the value of conservation assets, and then prioritisation among those assets, is critical within a risk management framework. It provides a structured process for thinking through the vulnerability of assets, how actions can be implemented to benefit or mitigate risks either before, or during a fire event (i.e. the benefits of acting, vs not acting), and then assessing what actions can be implemented, given constraints and available resources. Prioritisation requires explicit consideration of objective(s), actions and their consequences (e.g. estimates of benefit/risk), and any constraints (e.g. available resources, costs).

A key component is identifying the species that are most vulnerable and in need of protection, using available data (i.e. a vulnerability assessment; Box 1). It is an important source of information before and during a fire event, as it helps identify key species, habitat and important populations. However, a list of vulnerable species does not guarantee action.

By assessing the consequences of action (versus not acting) both before, and during a fire event, a prioritisation process can help identify how best to reduce risks to key assets. For instance, it could be used to help identify and differentiate which assets require targeted plans for action during a fire event (e.g. Eastern Bristlebird, Wollemi pine; Box 6), which require risk mitigation via targeted action before a fire event (e.g. Coveny's Zieria, Bago and Kelton's Leek Orchids; Box 2), and where benefit can be maximised across assets or landscapes via strategic actions (e.g. PODs; Section 6.1).

Though this was acknowledged as a gap by many interviewees, many agencies have existing prioritisation approaches, which could be applied and adapted in this context. There exists an opportunity to take a more long-term strategic approach to pre-fire planning, which may involve identifying places of high endemism, critical habitat for multiple species, or climate refuges.

3. Proactive pre-fire planning and reducing risk to mitigate the need for reactive action during fire

From above, pre-fire planning should involve identification of actions that reduce risk and can be implemented before a fire, to reduce the need for emergency responses during a fire. Examples include targeted prescribed burning, threat management, germplasm collection and translocation.

Risk assessments should be undertaken to assess the relative risks and benefits of potential management strategies. Consequences can be evaluated in relation to the specific objectives for an asset or area, but can also include assessment of the cost-effectiveness of acting, versus not acting, for different fire and management scenarios.

4. Management plans for key conservation assets that identify actions for mitigating fire risk during a fire event

Pre-fire planning should include targeted fire management plans for priority species, key conservation assets, or landscapes. Ideally, a combination of landscape planning and species or asset specific (targeted) plans will be required. Where possible such plans for individual priority species or other assets should be carefully packaged together and integrated at landscape or regional scale to allow for the considered and timely development of coordinated responses, and resolution of potentially conflicting advice, across species – rather than overwhelming incident controllers with a large array of inconsistent or ill-fitting species plans during fire emergencies.

As with recommendation 3, development of plans will involve specification of objective(s) and constraints, and the identification and evaluation (risks and benefits) of alternative management options. Planning is likely to involve multiple objectives, particularly at the landscape scale, which may result in the need for an assessment of trade-offs to identify a suite of preferred actions.

Ecological knowledge should also be built into the plans in the form of management (or decision) thresholds to provide trigger points for action (e.g. the proportion of old growth Caribou habitat remaining is an important threshold to prioritise wildfire suppression activities; Section 6.2) Where available, the use of fire models and tools such as species distribution models can be used to assess the potential risks to species and assets in particular parts of the landscape, which can help tailor and inform action using spatially explicit management plans.

Management plans are critical sources of information to assist with decision making during a fire. To be 'shovel-ready', plans need to both clearly identify actions, but also identify the components (e.g. skilled personnel, equipment, permits) needed to assist with the rapid implementation of the plan in an emergency setting. They should also recognise the context and be capable of docking onto other plans that relate to fire management in the appropriate area, such that land managers and incident controllers aren't faced with competing and incompatible planning advice.

Currently, many of the most important planning documents for threatened species (e.g., recovery plans) are highly generic and non-prioritised in their description of actions. Even in fire-prone regions and for fire-susceptible species, there is little guidance information in such plans relating to priority pre-emptive actions that need to be taken to reduce the risks posed by fire, or specific advice on actions that should or should not be taken to safeguard populations during fire. The conservation costs of the 2019/20 fires should prompt improvements in the quality and specificity of such planning to necessarily provide appropriate detailed and practical material, in a manner that is most readily usable to relevant land managers and fire authorities. Furthermore, there may be benefit in ensuring that such plans are developed with due liaison with land managers and authorities.

5. Scenario or contingency planning to improve preparedness and capacity during fire

Development of management plans should involve the exploration of different scenarios, to help determine the potential benefits, risks and feasibility of acting in different conditions. Importantly, it can assist in the development of different contingency management options for fire events. Contingency plans may be developed for different fire conditions, and/or for different resource availability conditions.

An endangered Eastern Bristlebird. Image: (C)Ian Wilson 2019 birdlifephotography.org.au

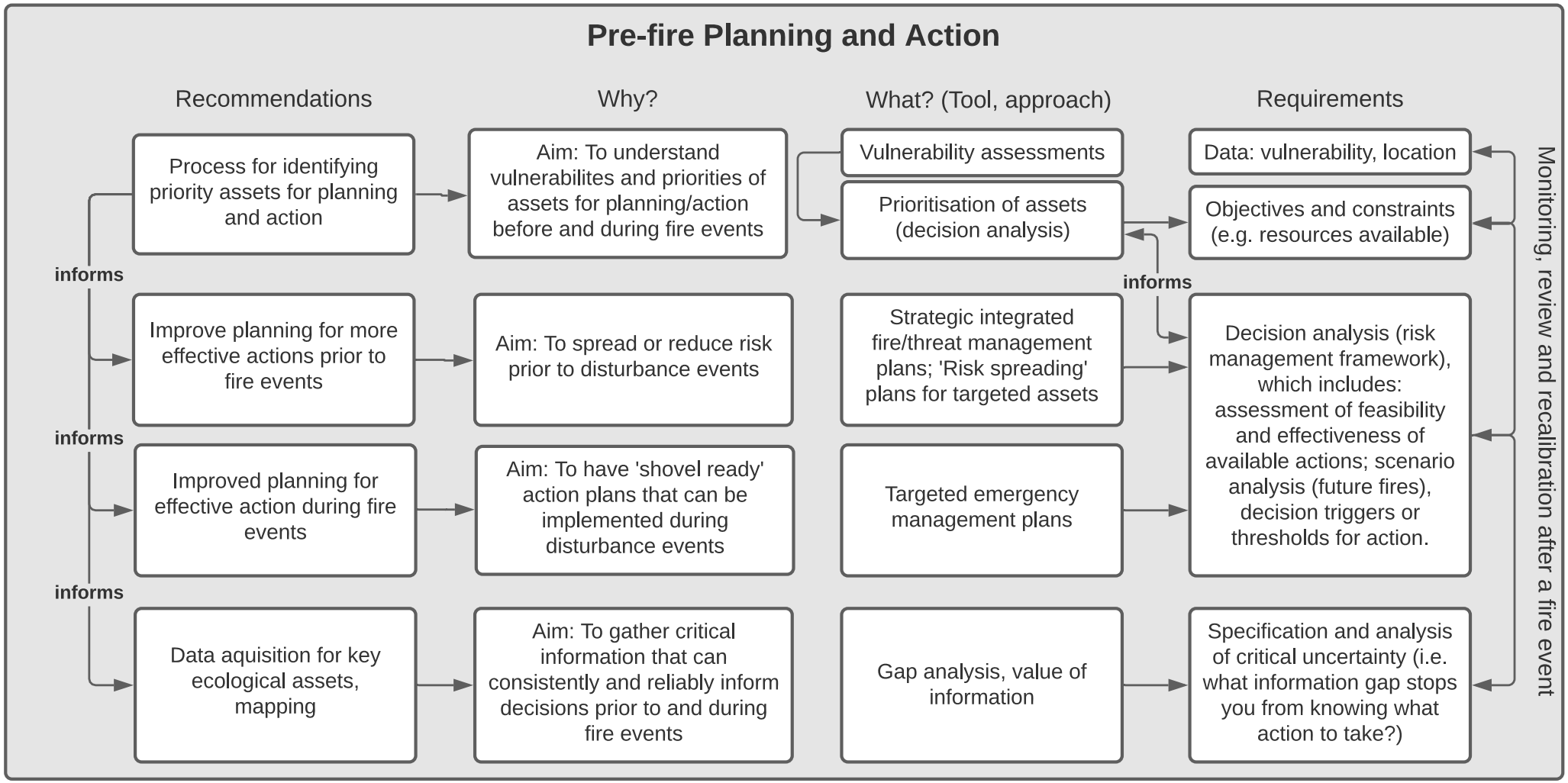


Figure 3: *Pre-fire planning roadmap to reduce risk before fire events, increase resilience of environments and reduce conservation losses during fire. There is an overarching need to ensure that resources are made available to allow this process to operate appropriately. In addition, it is critical that monitoring, review and recalibration of every component is done after a fire event, to ensure the process continuously evolves and improves.*

7.2 Improve operational emergency management processes to integrate protection of conservation assets

Objective: To maximise conservation outcomes and minimise risk of serious impacts to conservation assets during fire events.

This report clearly highlights that the conservation assets that were a focus of emergency fire management response were exceptions. Most conservation assets were not explicitly prioritised for protection in fire operational responses, and this lack of prioritisation contributed to the exceptional losses of biodiversity in the 2019/20 fires. In those limited number of cases where implementation of emergency management responses for conservation assets was considered successful, there were a number of key factors contributing to that success. From these case studies, we can learn lessons for guiding future response. However, there was no precedent for integrating conservation assets into the existing decision-making structures. As such, interviewees identified many areas for improvement to ensure more explicit, widespread, prioritised and structured consideration of conservation assets as the norm in emergency response.

The following recommendations are a synthesis of the essential requirements for protecting conservation assets during a fire event. In Figure 4, we highlight these recommendations in relation to a series of steps that form a rapid decision-making process.

1. The protection of conservation assets is formalised as a priority in the emergency management framework

The overarching recommendation is that the protection of conservation assets is incorporated into all relevant governance structures and frameworks (Figure 4).

Vital planning processes (e.g. vulnerability assessments, pre-prepared action plans, metrics for facilitating decision making in relation to other assets) should be incorporated into the management and decision-making structure, rather than occurring outside of the Incident Management Team. A priority is embedding biodiversity representatives to help interpret and communicate information to decision-makers and developing national training standards for this role.

Formally recognising the requirement for the consideration of conservation assets in emergency events will also spread the responsibility for its protection beyond the domain of biodiversity agencies, such as found in oil spill response (section 6.4).

This recommendation can be extended further to consider fungibility and societal values. The current prevailing operational rule accords pre-eminent need to safeguarding human life and infrastructure, with conservation assets deemed a more discretionary consideration. This preferencing has contributed to the unprecedented extent of biodiversity loss in the 2019/20 fire, including of conservation assets that are irreplaceable. As evident in the interviews, there were instances where protection of a few sheds came at the expense of loss of large areas of native forest and its associated biodiversity. Trying to resolve such questions merits more consideration, by society generally, at times that are outside of the pressures that influence decision-making during fire events.

2. Integrated risk management and decision-making frameworks

Conservation and cultural assets should be integrated with other assets (e.g. cultural, property, infrastructure) in existing risk management frameworks. This is not about reinventing the wheel, but about formalising consideration of conservation assets into decision-making at the landscape scale. Rapid, emergency response frameworks exist in all agencies, but to our knowledge, none explicitly integrate conservation assets.

The steps in a rapid decision-making (or risk) framework are highlighted in Figure 4, and these are aligned with hazard, exposure, vulnerability, and effects assessments. Core components to support these steps include i) rapidly updated spatial information (maps) on the location and vulnerability of priority assets; ii) a range of feasible ('shovel ready') management actions that can be implemented under different conditions (see recommendation 3, above); iii) development of coherent, complete performance metrics for ecological values, such that risks can be understood and evaluated alongside other values.

3. Formalised representation of biodiversity personnel in Incident Management Teams

Formalising biodiversity representation, with local knowledge and appropriate authority, into the emergency management structure, likely in the planning unit, has multiple benefits. The vulnerability and management needs of conservation assets can be interpreted and clearly communicated within Incident Management Teams to be considered for protection. Representatives can also play a role in networking with experts and other departments or organisations to provide further information and support and provide advice on the risks of firefighting actions to conservation assets. Support and coordination at the Federal level, for instance through the development of national training standards, is considered crucial to build consistency and capacity, consistent with that found in marine environmental emergencies (section 6.4).

4. Ecological data needs to be in interoperable systems that can be accessed and utilised by non-land manager personnel.

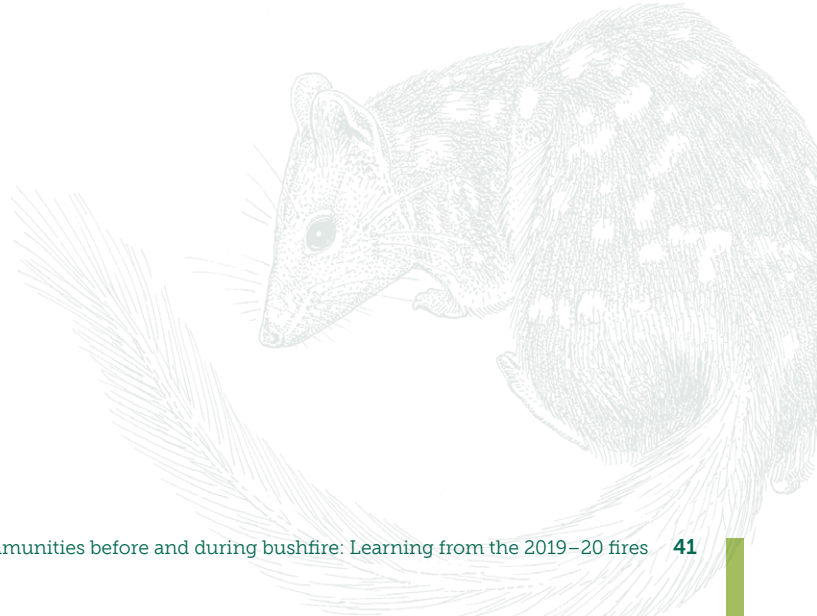
Emergency planning is reactive, highly time-constrained and dynamic. Information must be in formats appropriate to this context (e.g. updatable and scalable). Different data will be required at different stages of risk-management process: i) spatial information on the location of priority assets; ii) management plans, including resources required for implementation, and key risks associated with firefighting efforts; and iii) ecological metrics to inform rapid and integrated decision-making.

To be useful in supporting pre-fire planning and emergency response efforts, there are several key considerations:

- The relevant data need to be available. Given the large number of threatened species and other conservation assets, and the paucity of current information, this is a critical gap.
- The data need to be hierarchical and capable of readily responsive prioritisation. In an emergency setting operating over many arenas and with potentially competing objectives, operators must be able to interrogate data to rapidly determine what is most important, rather than be faced with a maze of many overlapping and unprioritized assets. In part, such prioritisation in the data should reflect the consequences of actions and inactions, and the irreplaceability of the asset.
- The data need to be current. In an emergency management situation, information needs to be dynamic. The development and maintenance of data layers should have a consolidated approach at a state level to ensure data layers are created for all conservation assets of interest.
- The data need to be readily accessible. Information may be available from many sources including external experts and other stakeholders and may be dispersed between agencies, departments, regions, organisations and individuals. Consistent, centralised databases are required.
- The data need to be interoperable. Data on conservation assets needs to be available in a format that can be easily imported in operational systems
- Data need to be interpretable and relevant to the decision-making context. Incident Controllers need to be made aware of available datasets and have the capacity and skills to interpret and use the data to make decisions. Ideally, they should be familiar with the databases and their interpretation through training or test-driving in periods outside of fire events.

Biodiversity representation in Incident Management Teams is vital for assisting with data collation and interpretation. However, Incident Controller personnel need to have increased capacity (via training) to access and interpret the available information in the event that representatives are not present.

Data on the location of conservation assets must also be able to be accessed by on-ground crews (see recommendation 5).



5. Training and guidance for fire operations staff

It is critical that provision of data is accompanied by specific guidance on actions (general and targeted) and risks, and training to improve understanding, capacity and effectiveness.

Fire operations staff are traditionally trained primarily for the protection of human life and property. Training needs to be updated to include an understanding of the value of conservation assets, how they may be protected and how they may be jeopardised by fire or by particular fire control actions; so that they are more readily included in decision-making. Where possible, such training should be extended beyond the theoretical to also encompass some on-ground experience of operational staff with sites supporting conservation asset.

Between fire incidents relevant controllers and operational staff could become familiar with biodiversity resources and information, through ongoing training and test-driving in practice scenarios. This will allow for identifying any shortcomings within a context that is not critical. This can be achieved through gaming and scenario development as used in preparation for oil spills (Leschine et al., 2015).

6. Adequate resources to carry out planned protection strategies and actions

On-ground and incident control capacity can be supplemented by training additional personnel in State agency departments or species experts in relevant organisations (e.g. Zoos, Botanic gardens, friends groups) to undertake specific roles. Biodiversity representatives can then play an important networking role, in accessing additional expertise and capacity, when required.

Management plans need to identify what resources (people, equipment and funds) are required to implement actions, in different contexts. This information can then be pre-positioned at accessible points to support decision-making for multiple objectives.

7. Risks and effectiveness of firefighting actions are considered

Management plans need to provide clear guidance on the specific risks of firefighting actions, and biodiversity representativeness present to communicate those risks to decision-makers. There is a clear recognition of the risks of earthmoving equipment and introduction of weeds and diseases such as *Phytophthora*. However, there is little knowledge regarding the impacts of retardants on ecosystems, which requires monitoring and research, including in the development and trialling of retardants that pose less environmental risks.

Mt Clear, Namadji National Park (ACT). Targeted action was undertaken to protect high value sections of the park during the 2019/20 bushfires. Image: Percita, CC BY SA 2.0, Flickr

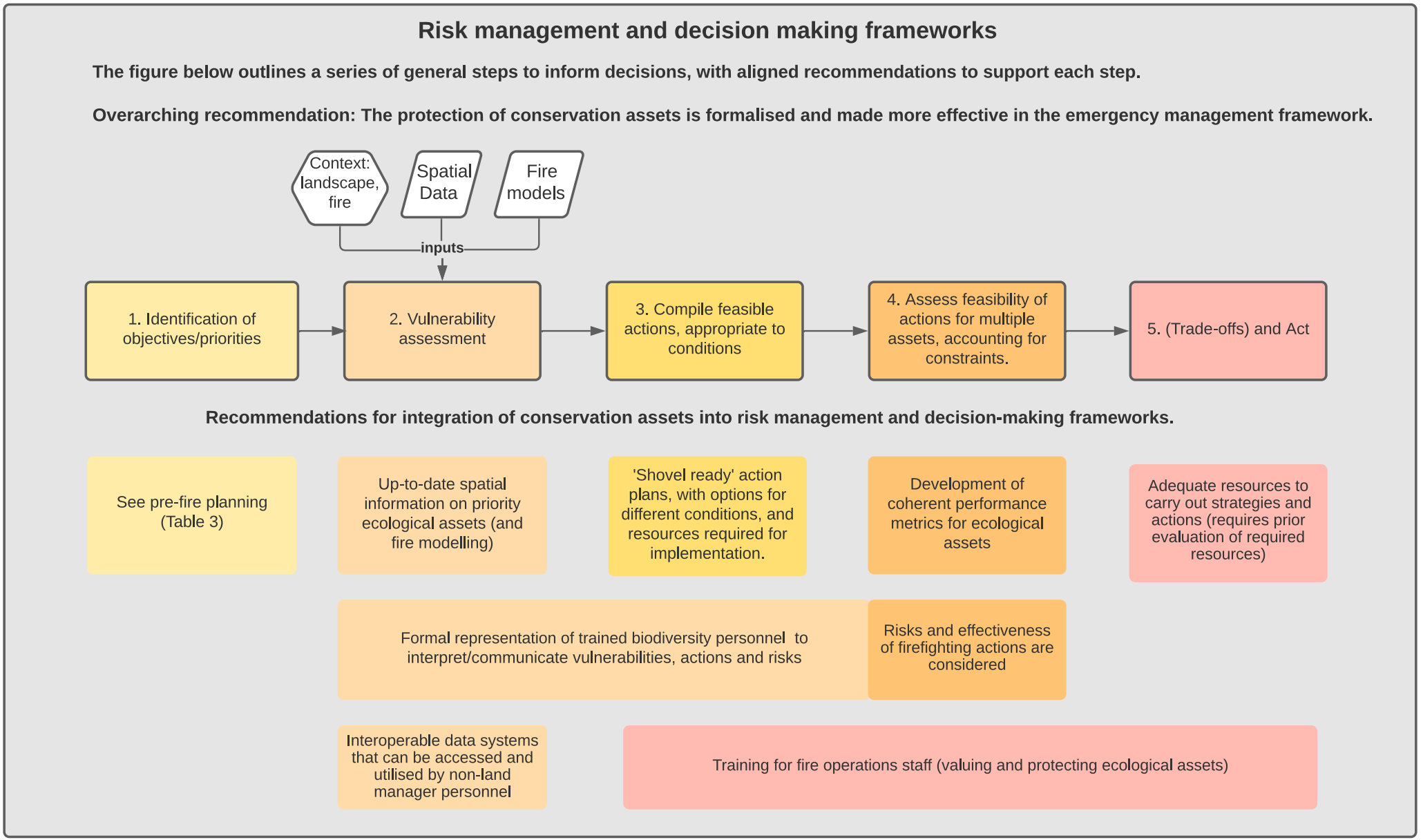


Figure 4: *A roadmap to improve operational processes to integrate conservation assets into the emergency management framework. The figure outlines a series of steps in a decision-making process that are required to support integration of conservation assets into existing frameworks. Colour-coded recommendations are below and aligned with each step. In a risk management framework, Step 1 is aligned with the problem formulation stage, the inputs to Step 2 are used in an exposure assessment 2; Step 3 and 4 are aligned with an effects analysis, and Step 4 involves characterisation of risk and decision-making.*

7.3 Supporting legislative framework

This project focused mostly on management issues, constraints and necessary improvements to process, and governance. However, there are further dimensions that are important given the operational shortcomings identified by interviewees that we explore here. Biodiversity loss during the 2019-20 fires revealed shortcomings in the governing legislative and regulatory framework relating to biodiversity conservation and its management. Firstly, there is no explicit accountability (or it is not defined clearly) in the national legislation, the *Environment Protection and Biodiversity Conservation Act*, relating to decisions taken, or not taken, that may cause extinction (Woinarski et al., 2017). Actions taken – or actions not taken – on the ground or in control centres, in wildfire events may lead to irreplaceable biodiversity loss, including the extinction of threatened species (Moir, 2021). However, those making such fateful decisions currently appear to operate beyond any legislative framework relevant to biodiversity conservation. In the control-and-command approach that characterises the management response to fire, a more explicit legislated accountability for irreplaceable biodiversity loss may be required.

Another legislative change that has been suggested to better safeguard conservation assets in pre-fire planning and in-fire operations is to amend the EPBC Act to broaden the use and application of its current Critical Habitat provisions (Fitzsimons, 2020). The general intent of critical habitat listing is to identify, delineate and prioritise for protection the most important sites for listed threatened species; however this intent is currently constrained by the restriction of its regulatory application to Commonwealth lands only. The Critical Habitat approach fits well with the needs identified by managers interviewed in our project to be more spatially explicit about where in the landscape the most important conservation assets are, and reform of the legislation would ensure that there was some formal recognition of the priority need to try to protect such sites in fire planning and operation.

A regulatory change that may help better safeguard conservation assets before and during wildfire events is the recognition of changed fire regimes as a national Key Threatening Process and any consequent implementation of a Threat Abatement Plan that would describe fire risks to (and needs of) the most significant conservation assets, detail how such risks could be most effectively managed, and provide a robust legislatively supported foundation for fire operations that are appropriately attuned to the need to protect biodiversity.

Legislative compulsion for fire management plans to be implemented through the fire control centre would increase the likelihood that biodiversity assets are given due consideration before, during and immediately following catastrophic fire events. We make no recommendation on the specific instrument, but a range of different options are available, including the addition of specific regulations under the EPBC Act and relevant state level instruments. There is a risk that improvements to planning and decision-making processes (as suggested in this report) may not result in meaningful outcomes for biodiversity, unless accompanied by legislative change.

One further area warranting consideration in fire planning is the nexus between fire management, insurance and litigation. Because of the insurance implications, minor infrastructure assets, particularly those privately owned, may be prioritised for fire protection over conservation assets that are not insured. This may act as a constraint on the flexibility needed by management when having to prioritise asset protection. There would be benefits from obtaining legal clarity on potential liabilities so Incident Controllers are protected from litigation if they take advice from conservation advisors that results in a loss of insured property.

8. Conclusion

We knew that the catastrophic fires of 2019/20 tested the capacity of people and systems to conserve biodiversity, including threatened species and ecological communities. The aim of this project was to learn from the practices and experience of conservation managers and fire operations staff who were active during the 2019/20 fire season, to identify what is required to improve outcomes for biodiversity during future large fire events. So what did we learn?

There were several factors that helped the targeted protection of these conservation assets. Assets were more likely to have targeted action if they were located at a single site, had a pre-existing high profile (e.g. an iconic species), and if there was strong advocacy for action. Having biodiversity representation in Incident Control Centres was identified as a crucial factor in improving outcomes for biodiversity. In addition, implementation of actions for conservation was more likely if the fire was located on National Park estates, and the fire was primarily the responsibility of the land manager or Parks agency. Unsurprisingly, success was greater when there was a feasible plan of action for protection (which was generally not the case), and where suitable resources could be secured to implement actions.

Several recommendations for improvements to pre-fire planning and during fire operations were identified, many of which are being planned or implemented by agencies in response to the 2019/20 fire season.

The first key recommendation of this research is the need to improve preparedness before fire events. There is a need for improved pre-fire planning, that includes (i) more explicitly identifying and delineating priority conservation assets for planning and action, (ii) identifying effective management actions to safeguard those assets for pre-fire and during fire, and (iii) improved data acquisition and more readily accessible mapping for conservation assets. There is also more need for management to reduce risk before fire events, to both increase resilience of conservation assets, and reduce conservation losses during fire events.

The second key recommendation focuses on formalising the protection of conservation assets from wildfire into emergency management processes and structures. Integration of conservation assets into existing decision-making frameworks requires pre-fire planning to provide lists of priority assets and areas, and 'shovel ready' management plans. Within the control room, having up to date, accessible and interpretable data systems is critical, as are performance metrics and risk assessments for conservation assets that can be used in decision making. This requires increased training and capacity for biodiversity representatives (with appropriate authority) in control centres, and among operational staff.

These recommendations can be strengthened by a supporting legislative framework to ensure all improvements made result in positive ongoing and long-term change. Together, these recommendations form a strategy, or roadmap, that will enable improved outcomes for biodiversity in a changing climate, and minimise the risk of future wildfire events resulting in another ecological disaster.

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- Queensland Parks and Wildlife Service and Partnerships
- SA Department of Environment and Water
- Tasmanian Department of Primary Industries, Parks, Water and Environment
- Victorian Department of Environment, Land, Water and Planning
- Parks Victoria
- WA Department of Biodiversity, Conservation and Attractions
- WA Parks and Wildlife Service

We wish to thank researchers from NESP Threatened Species Recovery Hub Project 8.4.4 for their collaboration with the survey component of this research.

10. Ethics statement

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Appendix 1

List of reviewed grey literature for Australian bushfire and emergency management and plans.

National

National Emergency Risk Assessment Guidelines (NERAG)
https://www.aidr.org.au/media/7600/aidr_handbookcollection_nerag_2020-02-05_v10.pdf

State

Victorian State Bushfire Plan (EMV, 2014)
https://www.emv.vic.gov.au/sites/default/files/embridge_cache/emshare/original/public/2020/09/33/29f1bddbc/State-Bush-Fire-Plan-2014.pdf

Victorian State Emergency Management Plan
https://www.emv.vic.gov.au/sites/default/files/embridge_cache/emshare/original/public/2020/09/78/c1b7be551/Victorian%20State%20Emergency%20Management%20Plan%20%28SEMP%29.pdf

Code of practice for bushfire management on public land (2012, DSE)
https://www.ffm.vic.gov.au/__data/assets/pdf_file/0006/21300/Code-of-Practice-for-Bushfire-Management-on-Public-Land.pdf

Emergency Management Team Arrangements – for all emergencies (December 2014)
https://files-em.em.vic.gov.au/public/EMV-web/Emergency-Management-Team-Arrangements-Dec2014.pdf

Victorian Emergency Operations Handbook (December 2019)
https://files-em.em.vic.gov.au/public/EMV-web/Victorian-Emergency-Operations-Handbook-Edition-2-December-2019.pdf

NSW State Emergency Management Plan (December 2018)
https://www.emergency.nsw.gov.au/Documents/publications/20181207-NSW-state-emergency-management-plan.pdf

NSW State Bush Fire Plan – A Sub Plan of the State Emergency Management Plan (December 2017)
https://www.emergency.nsw.gov.au/Documents/plans/sub-plans/state-bush-fire-plan.pdf

Living with Fire in NSW National Parks – A strategy for managing bushfires in national parks and reserves 2012-21 (produced by NPWS)
https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and-protected-areas/Fire/living-with-fire-in-nsw-national-parks-strategy-2012-2021-120690.pdf

Fire Management Manual (for NSW NPWS land)
https://www.environment.nsw.gov.au/research-and-publications/publications-search/fire-management-manual

Guidelines for preparing a bushfire risk management plan
https://www.dfes.wa.gov.au/waemergencyandriskmanagement/obrm/Documents/OBRM-Guidelines-for-Preparing-a-Bushfire-Risk-Management.pdf

Region

Strategic bushfire management plans–e.g. East Central Victoria
https://www.safertogether.vic.gov.au/__data/assets/pdf_file/0026/129725/DELWP0016F_BMP15_EastCentral_web_v2.pdf

Grampians Regional Strategic Fire Management Plans
https://www.emv.vic.gov.au/sites/default/files/embridge_cache/emshare/original/public/2020/06/eb/f506e952e/Grampians-Regional-Strategic-Fire-Management-Plan.pdf

Yellingbo Bushfire Risk Management Plan
https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/7515/3473/1828/YCA_Bushfire_Risk_Management_Plan_FINAL_2.pdf

Bankstown / Hurstville, NSW
https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0005/28625/Bankstown-Hurstville-BFRMP.pdf

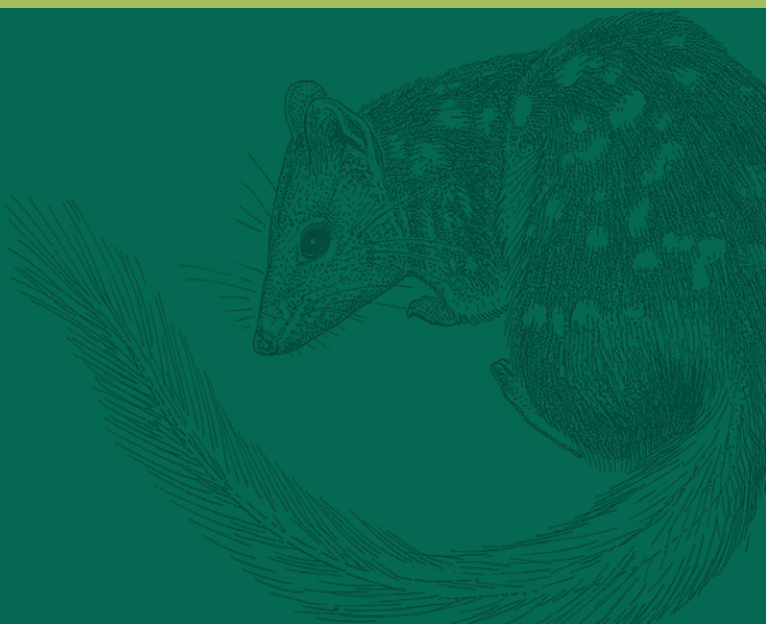
Individual fire management strategies for NSW National Parks and reserves
https://www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/fire/fire-management-strategies

Mount Lofty Ranges Bushfire Management Area Plan
https://cfs.geohub.sa.gov.au/portal/sharing/rest/content/items/77f10cb8fbcd4588b7d41b8b533ddd8d/data (also available as an interactive map)

Alice Springs Bushfire Management Plan
https://denr.nt.gov.au/__data/assets/pdf_file/0009/575577/Alice-Springs-Regional-Bushfire-Management-Plan-2018.pdf

City of Karratha Bushfire Risk Management Plan
https://karratha.wa.gov.au/sites/default/files/uploads/Bushfire%20Risk%20Management%20Plan%20-%20version%20approved%20by%20OBRM%20for%20Council%20endorsement.pdf

Targeted suppression is an action that can be used to protect assets. Image: Parks Victoria



Further information:
http://www.nespthreatenedspecies.edu.au

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