

## Rapid analysis of impacts of the 2019-20 fires on animal species, and prioritisation of species for management response

Report prepared for the Wildlife and Threatened Species Bushfire Recovery Expert Panel  
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**This report supersedes the 11 February 2020 report that supported the initial provisional list of 113 species.**

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## 1. Summary

The 2019-20 bushfires have had severe impacts on many animal species. The fires have covered an unusually large spatial extent, and in many areas they have burnt with unusually high intensity. Some species were considered threatened before the fires, and the fires have now likely brought them even closer to extinction. Many other fire-affected animal species were considered secure and not threatened before the fires, but have now lost much of their habitat and may be imperiled. To support recovery of these species, conservation action will be needed for many species, at many sites, and such informed management will be carried out by a wide range of government agencies, non-government conservation organisations, university researchers, community groups and the public. However, some species are in need of more urgent help than others.

This paper presents a draft framework to rapidly evaluate which animal species are in most urgent need of emergency action over the coming weeks and months, viewed at a national scale. Using this framework, we assessed all reptile, frog, bird and mammal species whose distributions were substantially fire-affected. We also assessed all fire-affected fish taxa that are listed, or proposed for listing, by either the IUCN or by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Finally, we assessed fire susceptibility in a small number of invertebrate species: all fire-affected terrestrial invertebrates listed by the EPBC Act, and all crayfish in the genus *Euastacus*, a genus whose taxonomy, status and distribution has been recently reviewed by IUCN and taxon experts.

On 11 February 2020, the assessment produced a provisional list of 113 species (20 reptile species, 17 frog species, 13 bird species, 19 mammal species, 5 invertebrates, 22 crayfish and 17 fish) that are identified as having the highest priority for management intervention.

Following the release of the provisional list, improved spatial data and some field reports resulted in minor changes to the list, with the addition of 8 species (3 reptile, 1 mammal and 4 bird species), and the removal of 1 fish species and 1 frog species. **The revised provisional list therefore comprises 119 species (23 reptile species, 16 frog species, 17 bird species, 20 mammal species, 5 invertebrates, 22 crayfish and 16 fish) that are identified as having the highest priority for management intervention.**

This revised list is subject to further change as information from on-ground assessments and improved spatial data continue to accrue. The broad mix of actions required to support those species is also indicated, but specific interventions at sites should be informed by local experts and responsible agencies.

Assessment of other invertebrates and vascular plants is an important next step. These assessments are underway but require more time because of the large number of species being assessed.

### Limitations of this report

- The assessment seeks to identify the species in most urgent need of management action, but many other species will also need support to recover from the 2019-20 bushfire event and the drought that preceded it.
- The 2019-20 fire season is not yet over, and the assessment (currently including fires that burned between 1 July 2019 and 11 February 2020) will need to be updated as new data becomes available on fire extent and severity.
- This assessment does not yet consider fire impact for the many invertebrate species that are not nationally listed as threatened (except crayfish in the genus *Euastacus*); completing this assessment for unlisted invertebrates will be a very large task.

- This assessment does not include freshwater fish that were not identified as threatened in a 2019 IUCN Redlist workshop (which included described taxa plus taxa in the process of being described), or which are not listed as threatened by the EPBC Act.
- The framework and assessment are preliminary, and we expect to continually revise and improve both the approach and the quality of data used in the assessment, for example by incorporating:
  - Additional consultation with colleagues on the approach, and with taxonomic experts to improve the list of traits considered, and the accuracy of the trait information.
  - Evolving (and improving) data on fire extent and intensity, including spatial data more suitable for aquatic species that can be impacted by fire and flooding events occurring far upstream.
  - Improved species distribution maps.
  - Ground assessments of population status.
  - Other contextual factors that could modify the response of species to the fire event (e.g. the fire regime prior to the recent fire event, drought stress, levels of other threats).

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## 2. Background

The ongoing fires of 2019-20 are having severe impacts on many species and ecosystems. Urgent actions are needed over the coming weeks and months to reduce the chance of extinctions, and to support ecological recovery. On the 15 January 2020, the Wildlife and Threatened Species Bushfire Recovery Expert Panel set a series of Objectives and Priority Activities to guide immediate recovery activities (<http://www.environment.gov.au/biodiversity/bushfire-recovery/expert-panel>).

### Objectives

- Prevent extinction and limit decline of native species.
- Reduce the immediate suffering of native animals directly impacted by the fires.
- Maximise the chances for long term recovery of native species and communities.
- Ensure learning and continual improvement is at the core of the response.

### Priority activities

- Protecting unburnt areas within or adjacent to recently burnt ground that provide refuges.
- Feral predator and herbivore control to reduce the pressure on native species where appropriate.
- Emergency salvage of plant and animal species for ex-situ conservation or wild-to-wild translocation.
- Rapid on-ground assessment for species and communities of concern.
- Supplementary shelter, food, and water for animals where appropriate.

In addition, the Panel sought to identify which species are priorities for management intervention. The first step in this process was a spatial assessment to find those species whose distributions overlapped with fires in the bioregions that have been most severely affected (Figure 1). On 20 January 2020, the then Department of the Environment and Energy (DoEE, which changed to the Department of Agriculture, Water and the Environment from 1 February) released a preliminary list of threatened and migratory taxa that have more than 10% of their known and likely distribution in fire-affected areas (<http://www.environment.gov.au/biodiversity/bushfire-recovery/research-and-resources>). This preliminary list included 55 threatened and migratory animal species, as well as 272 threatened plant species. This assessment excluded fires in most of tropical and arid Australia, where the 2019-20 fires were less exceptional, and considered only those taxa listed as threatened or migratory under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

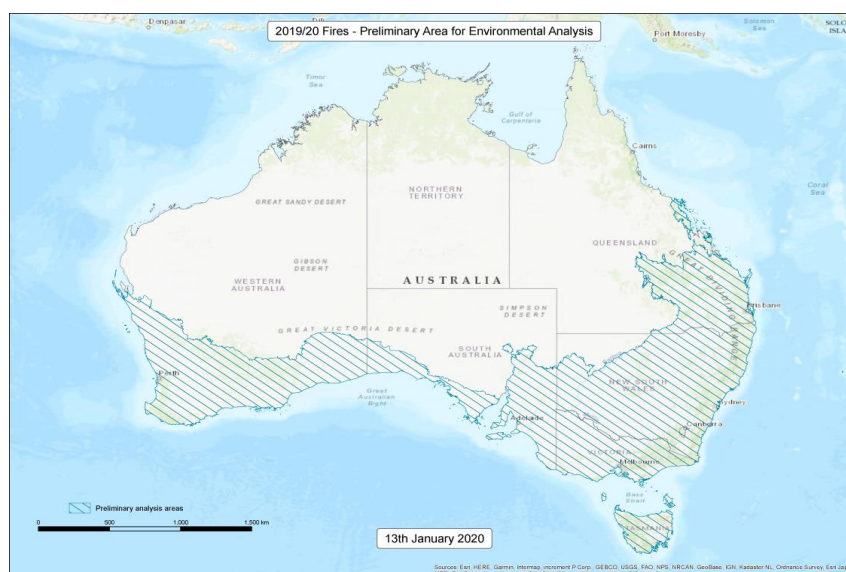


Figure 1. Area included in this assessment, following bioregional boundaries.

BirdLife Australia carried out a similar analysis of the spatial overlap between bird distributions and fire extent, relying on bird presence data from their own databases, and fire extent data from Fire Information for Resource Management (<https://firms.modaps.eosdis.nasa.gov/>). The Birdlife analysis identified 53 listed and unlisted bird taxa that have distributions which overlap with the 2019-20 bushfires, with a threshold of 10% for listed taxa, and 30% for unlisted taxa (see Figure 4 for more information on the thresholds). Their analysis comprised both species and subspecies; if all subspecies in a species had fire overlap estimates higher than the thresholds, then the species was used instead.

However, the impact of fire on animal populations (and species) depends not just on the overlap between their distributions and fire, but also on:

- The spatial variation in the severity of the fire;
- Contextual factors (e.g. the fire regime (including attributes like fire frequency, time since last fire, previous fire intensity, and so on) leading up to the 2019-20 fire event, the cumulative and compounding impact of drought, the extent of other threats that put pressure on the species of interest); and
- The physical, behavioural, ecological and life history traits that influence a species' response to fire and the capacity of populations to recover by increasing their abundance and recolonising habitat as it becomes available.

Information on fire severity and some of the additional potential contextual factors should become available in the near-medium future.

In this rapid evaluation, we aim to build on the analysis of fire overlaps with species distribution carried out so far by:

1. Extending the analysis of fire overlap with species distributions to include unlisted taxa (except invertebrates and fish, and noting that such birds have already been so-analysed by BirdLife Australia).
2. Incorporating variation in species' responses to fire by collating a series of physical, behavioural, ecological and life history traits across species that influence the vulnerabilities of species at three stages:
  - Fire: the ability of individuals of a species to escape being killed or severely injured *during* the fire
    - some physical, behavioural and ecological attributes of species influence the chance of being killed directly by fire.
  - Post-fire: the short- to medium-term risk of mortality *after* fire from lack of resources and shelter
    - some physical, behavioural and ecological attributes of species affect the chance of survival in the weeks and months following the fire, including their susceptibility to other threats that may compound fire impacts – such as introduced and native predators.
  - Recovery: the capacity of populations to recover after a fire event
    - recovery capacity will be influenced by the extent of mortality occurring during and immediately after the fire.
    - some ecological and life history attributes (reproductive and dispersal patterns) will influence the chances of population recovery. For example, species with restricted diets may face a more challenging recovery (e.g. glossy black-cockatoos depend on the seeds of mature casuarinas, and fire-affected habitat may not provide required resources for

>10 years), whereas species with high reproductive output and capability for dispersal may recover more rapidly.

Considering vulnerabilities at these different stages is important because they inform the most relevant management interventions, and their timing. For example, emergency surveys, or salvage or supplementary feeding are relevant to the period weeks and months after the fire, whereas actions for supporting longer-term recovery (such as translocations) may need a more enduring response. In this preliminary report, we focus on vulnerability to fire and post-fire mortality, as these periods are more relevant to management interventions in the first 12 months after fire.

### 3. Aims

1. **Create a list of animal species whose distribution overlap with fire, with a threshold of >10% overlap for nationally listed species (EPBCA or IUCN), and >30% overlap for unlisted species. As noted above, this aim could not be met for unlisted invertebrates.**
2. **For the each of fire-affected species, collate and attribute physical, behavioural, ecological and life history traits, so that likely fire impacts (and required management responses) can be better resolved.**
3. **Develop a framework that identifies priority species for action in the next 0-12 months, and the actions that may be considered for these species, based on the degree of their pre-fire imperilment, the extent of fire overlap, and the species traits that make them more or less vulnerable to fire impacts.**
4. **Use the collation of species traits to indicate the broad range of actions required to support the priority species over the next 12 months.**

### 4. Data sourcing and compilation

#### Spatial data

Fire extent data was based on:

- For all groups except birds – the *National Indicative Aggregated Fire Extent Dataset* collated by ERIN from data provided by the Emergency Management Spatial Information Network Australia (EMSINA) supplemented with spatial data from state and territory environment and emergency management agencies, for fires from 1 July 2019 to 28 January 2020. For freshwater fish the extent of waterways 80 km downstream of burnt areas was also considered.
- For birds – spatial information downloaded from Fire Information for Resource Management (<https://firms.modaps.eosdis.nasa.gov/>)
- For freshwater fish – to account for the impacts of mass sedimentation events downstream of burnt areas that can severely affect fish, we considered the downstream catchment of fires, by modelling from river and stream segments 80 kilometres downstream of the fire affected area using <http://www.bom.gov.au/water/geofabric/index.shtml>. Perennial stream types were used.

Species distribution information was available from different of datasets, as shown in Table 1.

Table 1. Source data for distributions of nationally listed and unlisted species, in each animal group.

Animal group	EPBC Act listed species	Non EPBC Act listed species
Mammals	Existing DAWE species distribution models (including listed subspecies) showing 'known' and 'likely to occur'.	Alpha hull around observation points; and gridded observation points analysis (1 x 1 km cell); using point records extracted from the DAWE Species Observation System (SOS) sourced from States, Territories, Herbaria and Museums; for 1 mammal, point records were extracted from the Atlas of Living Australia.
Reptiles	Existing DAWE species distribution models (including listed subspecies) showing 'known' and 'likely to occur'.	Species distribution polygons for reptiles compiled during the 2017 reptile assessment carried out by IUCN, and modified by expert opinion (R. Tingley).( <a href="https://datadryad.org/stash/data_paper/doi:10.5061/dryad.83s7k?">https://datadryad.org/stash/data_paper/doi:10.5061/dryad.83s7k?</a> ).
Frogs	Existing DAWE species distribution models (including listed subspecies) showing 'known' and 'likely to occur'.	Alpha hull around observation points; and gridded observation points analysis (1 x 1 km cell); using point records extracted from the DAWE Species Observation System (SOS) sourced from States, Territories, Herbaria and Museums; for 1 frog, point records were extracted from the Atlas of Living Australia.
Birds (by BirdLife Australia)	Gridded observation points analysis from records held by BirdLife Australia – 1 x 1 km cell (including listed subspecies)	
Crayfish	Gridded observation points analysis – 2 x 2 km cell, using point records extracted from the DAWE Species Observation System (SOS) sourced from States, Territories, Herbaria and Museums; for 3 crayfish, point records were extracted from the Atlas of Living Australia. Visual inspection of species distribution and fire extent maps to check estimates. Species distribution polygons provided by Rob McCormack.	
Freshwater fish	IUCN Fish sub-catchment distributions, from data compiled during the 2019 IUCN Red List assessment for Australian freshwater fish ( <a href="https://www.iucnredlist.org/">https://www.iucnredlist.org/</a> )	

The spatial intersect analyses varied depending on the species distribution data available, and they each introduce different sources of bias:

#### Species distribution models

- 100m resolution of known and likely modelled data.
- Percentage overlap with fire extent calculated.

*This analysis can both overestimate or underestimate the fire overlap.*

#### Alpha hull analysis and gridded observation points analysis – 1 x 1 km cell

- Data extracted from the DAWE Species Observation System (ERIN), and BirdLife database (for birds).
- Year range from 1996 -2018 (nominally 20 years).
- If no data in SOS – supplementary data sought from ALA (5 species only).
- Raw point data undergo basic quality checks:
  - Name checks and synonyms

- Coordinate precision  $\geq \sim 1\text{km}$  (2 decimal places minimum)
- Obvious geospatial errors (continental extent)
- Terms that imply the record relates to an ex situ population.
- For alpha hull analysis: intersect of the polygon with the fire extent map.
- For gridded observation analysis: individual observations gridded to 1 km (2 km for crayfish) to remove risk of inflated counts based on duplicate points. A gridded cell that intersects partly with the fire is included in the intersect count. Number of cells intersecting fire as a percentage of the total.

*This analysis may slightly overestimate the fire overlap, because alpha hulls can extend over unoccupied areas, and because grid cells that only partially intersect the fire extent are scored as burnt.*

#### **Reptile distribution polygons from IUCN, and modified by expert opinion.**

- Calculate percentage of each species area that overlaps with the fire.

*This distribution data provides a broad range envelope and may overpredict total species extent; this could lead to both under- and overestimates of the proportion of a distribution that is burnt.*

#### **Fish distribution data at sub-catchment scale from IUCN**

- Intersect fire extent with the all catchments where a species is present to get approximate proportion of the total distribution that is fire-affected.
- To account for the potential impacts of flooding rain after fires upstream of fish populations, streams up to 40 and 80 km downstream of fires were identified. The number of these streams that are perennial in a species distribution was used to help identify species at risk.

The various datasets, and the intersect analyses, suffer from idiosyncratic biases. We recognise the limitations this introduces when attempting to compare fire overlaps across and even within groups; further resolution of such foibles is desirable, but is unlikely to substantially change the initial prioritisation described here.

#### **Crayfish distribution polygons from R. McCormack**

- Calculate percentage of each species area that overlaps with the fire.

*This distribution data provides a broad range envelope and may overpredict total species extent; this could lead to both under- and overestimates of the proportion of a distribution that is burnt.*

### **Trait information**

- From aim 1 above, we took the set of listed species (or subspecies) with distributions that overlap with fire-affected areas by 10% or more, and unlisted species with distributions that overlap with fire-affected areas by 30% or more. The 30% threshold for unlisted species was chosen because it mirrors the lowest threshold used in categorising conservation status based on extent of population loss (30% population decline is a threshold used to recognise Vulnerable by both EPBCA and IUCN). For species already nationally listed, a more precautionary threshold (10%) was used because even this (smaller) additional decline could potentially cause a species to change listing categories.
- For these species, we assembled relevant information on pre-fire imperilment, fire overlap, and the physical, behavioural, ecological and life history traits of species. Not all traits are relevant for all species; the combinations of traits used for each animal group are summarised in Table A1.



*Pre-fire imperilment, using highest listing available, and giving a score from 0 (not imperilled) to 4 (highly imperilled)*

- EPBC Act Listing: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), migratory.
- IUCN listing: CR, EN, VU, Near Threatened (NT), Data Deficient (DD), Least Concern (LC); with DD scored as VU.
- The imperilment score integrates extinctions risks across multiple features (e.g. AoO, decline, population size). However, the listings for threatened species are not always a good match for their true imperilment, and inconsistently so among animal groups. In some groups, we drew in additional information to refine the score:
  - For frogs and crayfish: also include pre-fire population trajectory and degree of range restriction, because listing status is poorly matched to conservation status and high fire overlaps with small distributions are potentially more serious.
  - For fish: also include degree of range restriction, because high fire overlaps with small distributions are potentially catastrophic.

*Extent of fire overlap, converted into a score from 1 (10-30% overlap) to 4 (>80% overlap)*

- % overlap of species distribution with fire-affected area.
- For fish, also consider the populations downstream from fire, given that entire populations can be extirpated by a single large sedimentation event following heavy rain.

*Physical attributes (higher scores for higher susceptibility during and after fire)*

- Size (larger animals score higher because they may find it more difficult to obtain sufficient resources post fire than smaller animals).
- Ability to flee fire (animals with less capability to flee score higher).

*Behavioural and ecological attributes (higher scores for higher susceptibility during and after fire)*

- Shelter site (hollow in tree, hollow in log, under bark, under veg, in deep/shallow burrow, in rocks, in water, no shelter), with these offering differential protection from fire.
- Diet (scavenger, predator, insectivore, granivore, herbivore, nectarivore, frugivore, omnivore, fungivore), with scavengers and predators more likely to find food post-fire.
- Dietary specialisation (generalist, intermediate, specialised) with higher scores for more specialisation.
- Dominant habitat (indicative of the usual occurrence of fire, and thus the sensitivity of constituent species to fire events) with higher scores for habitat that less usually/often burn. For fish: vegetation requirements on the stream bank, with species requiring riparian vegetation to filter sediment scoring more highly.
- Habitat specificity (generalist, intermediate, specialised) with higher scores for more specialisation.
- Postfire vegetation age specificity (recently burnt, no known preference, mid-aged, long unburnt, never burnt), based on documentation or expert opinion of responses to previous fire events, with higher scores for species with preferences for longer-unburnt vegetation.
- Rarity of individuals within the population (crayfish only), with a higher score for rarity.
- Barriers to dispersal (crayfish only), with higher scores for barriers.
- Home range (small, medium, large; scaled for group); higher scores for larger ranges because species with small home ranges may be more able to use small unburnt patches than those with requirements for large home ranges.
- Dispersiveness (dispersive, not dispersive); some highly mobile species can move away from burnt areas, whereas others are more tied to place and could be more susceptible to fire impacts (and

were given higher scores). For fish: whether the species has a marine life history phase, as species with a marine component are more likely to have an unimpacted portion of the population (and these are scored lower).

- Susceptibility to predators in a post-fire environment (not, low, high-extreme) with higher scores for greater susceptibility, and with a focus on introduced predators.
- Susceptibility to competition or habitat degradation by herbivores in a post-fire environment (e.g. feral horses for corroboree frog habitat) (not, low, high-extreme) with higher scores for greater susceptibility, and with a focus on introduced herbivores.
- Sociality and symbiotic relationships (pair-living or solitary, group-living) with higher scores for social or complex symbiotic relationships.

*Dispersal and reproductive capacity (higher scores for poorer dispersal and reproductive capacity). Note we do not use these traits to assess species vulnerabilities to fire- and post-fire mortality, but they are highly relevant to the capability of recovery.*

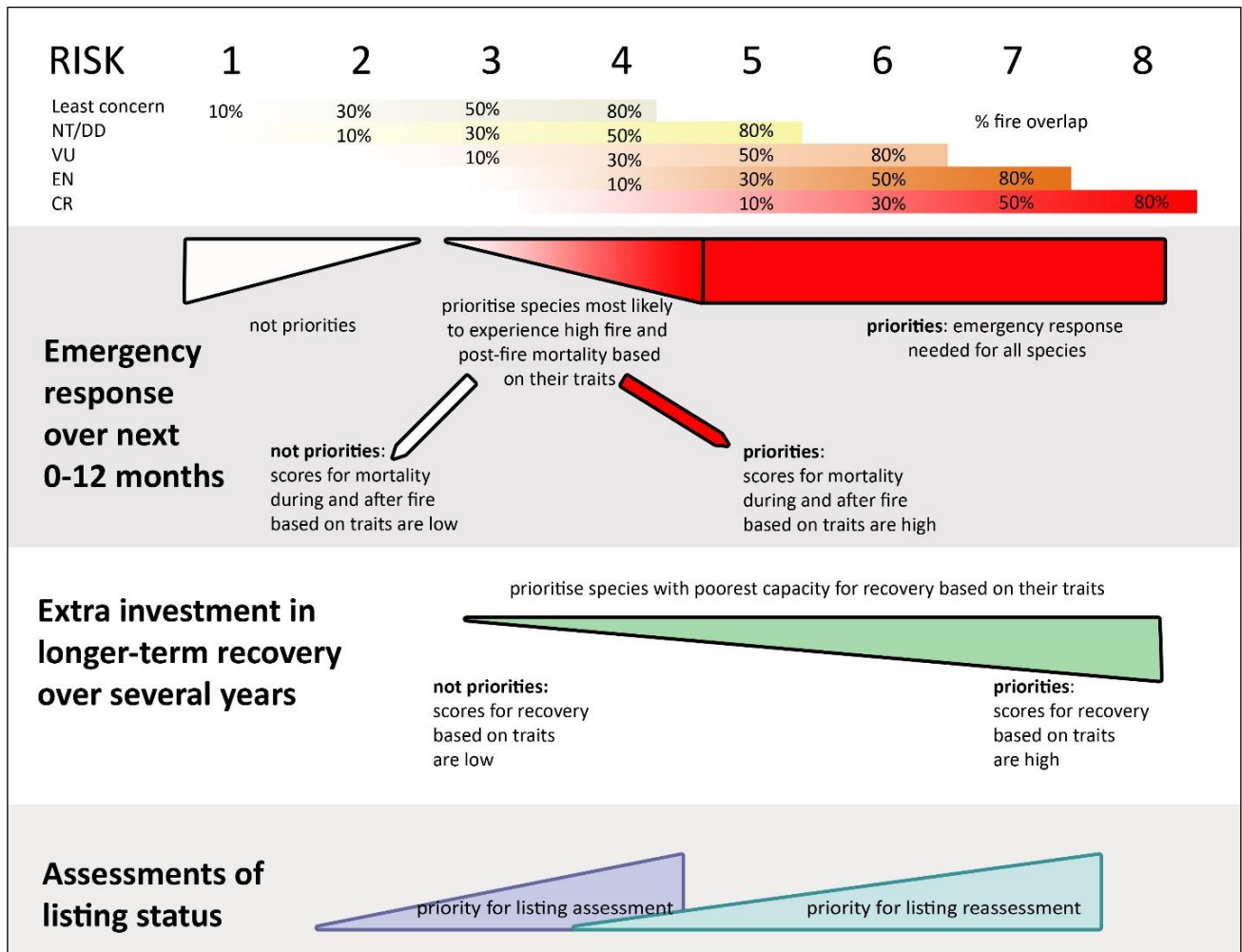
- Subadult dispersal distance (known or estimated) (short, medium, long).
  - Breeding capacity
    - Number of breeding events per year (less than once a year, to continuous).
    - Number of young per year (using a measure relevant to the group, such as independent young for mammals, or clutch size for frogs).
    - Minimum age of first reproduction.
    - Generation time/average lifespan.
    - For fish, the egg laying site (with fish using demersal sites scoring higher than those with pelagic egg, as demersal eggs are more sensitive to low levels of dissolved oxygen and sediment).
- We created a Risk score for each species. The Risk score is the sum of the score for pre-fire imperilment and the extent of the fire overlap (1 to 8, with 8 being maximum Risk).
- To estimate variability in Fire and Post-fire Mortality, we took the set of traits that influence the chance of mortality during and after fire. If required, traits that were thought to be particularly important, or otherwise, were weighted appropriately. See Table A1 for a summary of the traits included for each animal group.
- We combined the weighted scores across the relevant traits for the fire and post-fire stages.
- We used the framework developed below, and trait attribution for each species, to identify the highest priority species for urgent management intervention, and to indicate which actions may be required for each priority species, within the scope of the Priority Activities identified by the Wildlife and Threatened Species Bushfire Recovery Expert Panel.
- We will revise the scores as new information (e.g. fire extent) becomes available, and after additional consultation with experts.

## 5. A framework for identifying the species in greatest need of management intervention

We developed a framework to help identify the species in most urgent need of management intervention, based on their Risk (pre-fire imperilment and fire overlap), and their score for Fire- and Post-fire Mortality (Figure 2). The framework identifies high priority species via two decision steps:

- Species with a Risk score of 5 or above (indicating either high pre-fire imperilment and/or high fire overlap values) are prioritised for immediate action.
- Species with intermediate Risk scores (indicating moderate pre-fire imperilment and/or moderate fire overlap values) are ordered according to their trait score for fire- and post-fire mortality. Species with trait scores greater than the mean for the considered set of species, are also prioritised for immediate action.

The ordering of species, especially near the lower cut-off boundary, is checked by taxon experts for placements that seem misplaced (species ranked too high, or too low).



**Figure 2. Identifying high priority species for management response.** The diagram illustrates how the combination of pre-fire imperilment, fire overlap, and species traits can be used to help identify species in most urgent need of emergency intervention (0-12 month timeframe); those that need additional investment to ensure longer-term recovery (over several to many years), and also the species that could be prioritised for conservation status assessment and re-assessment.

## 6. Taxa considered in the assessment

We assessed fire susceptibility for all reptile, frog, bird and mammal taxa whose distributions were fire-affected by at least 10% (if listed by IUCN or the EPBCA), or 30% (if unlisted). We also assessed fire susceptibility for all potentially fire-affected fish taxa that are listed, or proposed for listing, by either the IUCN or by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Finally, we assessed fire susceptibility in a very small number of fire-affected invertebrate species: all terrestrial invertebrates listed by the EPBC Act, and all crayfish in the genus *Euastacus*, a genus whose taxonomy, status and distribution has been recently reviewed by IUCN and taxon experts. We note that an assessment on the impacts of the 2019-20 fires on all invertebrates (c. 300,000, most of which are undescribed) is underway.

The DAWE and Birdlife fire extent and species distribution overlap analyses showed that, for species recognised as threatened under the EPBC Act, 5 invertebrate, 8 fish (plus one population), 15 frog, 9 reptile (including 1 subspecies), 7 bird (including three subspecies) and 16 mammal (including five subspecies), taxa have distributions for which at least 10% has been affected by fire. An additional 4 listed migratory bird species with 10% fire-overlap are not listed as threatened. Subsequently, we added one more threatened mammal species (the silver-headed antechinus) that field reports suggest has had a large proportion of its distribution fire-affected. A further 64 species that are listed by the IUCN have distributions that overlapped with fire by over 10%. We identified 94 taxa, not listed under either the EPBC Act or the IUCN Redlist, which have distributions that overlap with fire-affected areas by at least 30% (Table 2).

Fish are a problematic group, because of taxonomic uncertainties (estimated that 25-30% are still undescribed) and because the EPBCA list is especially mismatched to the real conservation status. We included all fish taxa that are described or are in the process of being described, and that are listed by EPBCA, or by IUCN, or by a range state, or that are considered to be eligible for listing by experts.

Table 2. For each animal group, a summary of the number of taxa listed under the EPBC Act, the number of those that are fire-affected (i.e. with over 10% of their distributions overlapping the fire extent), and the number of fire-affected unlisted taxa (with over 30% of their distributions overlapping the fire extent). Note that these tallies will change as fires continue to burn and spatial overlaps with fire increase. Tbd = to be determined. DD = data deficient.

	Number listed taxa (EPBC Act)	EPBC Act-listed taxa with distributions are >10% fire-affected	Additional IUCN-listed species with distributions that are >10% fire-affected	Unlisted species with distributions that are >30% fire-affected
Mammals	107	17	4	20
Birds	134	7 (+ 4 migratory spp.)	4	38
Reptiles	61	9	5 (+ 4 DD sp.)	16
Frogs	37	15	9 (+ 2 DD sp.)	11
Freshwater fish	38	8 (+ 1 population)	11	2
Invertebrates (other than crayfish)	65	5	tbd	tbd
Crayfish ( <i>Euastacus</i> genus)	12	0	25	7

## 7. Priorities for management intervention 0-12 months

The species likely to be in most urgent need of management action are those with high scores both for Risk, and also for Fire and Post-Fire Mortality. Figure 3 shows the scores for Fire and Post-fire Mortality graphed against the Risk score, for each species in each of the assessed animal groups. Listed and unlisted species are shown with different symbols. Some patterns that emerge from these graphs are:

- In each animal group, listed species cluster towards the upper right quadrant more than unlisted species, as expected.
- Most of the listed species in our assessment have a Risk score greater than 4 (e.g. representing a species that is Critically Endangered with over 10% of its distribution fire-affected; Endangered with over 30% of the distribution fire-affected; Vulnerable with over 50% of their distribution fire-affected; or Near Threatened with over 80% of the distribution fire-affected).

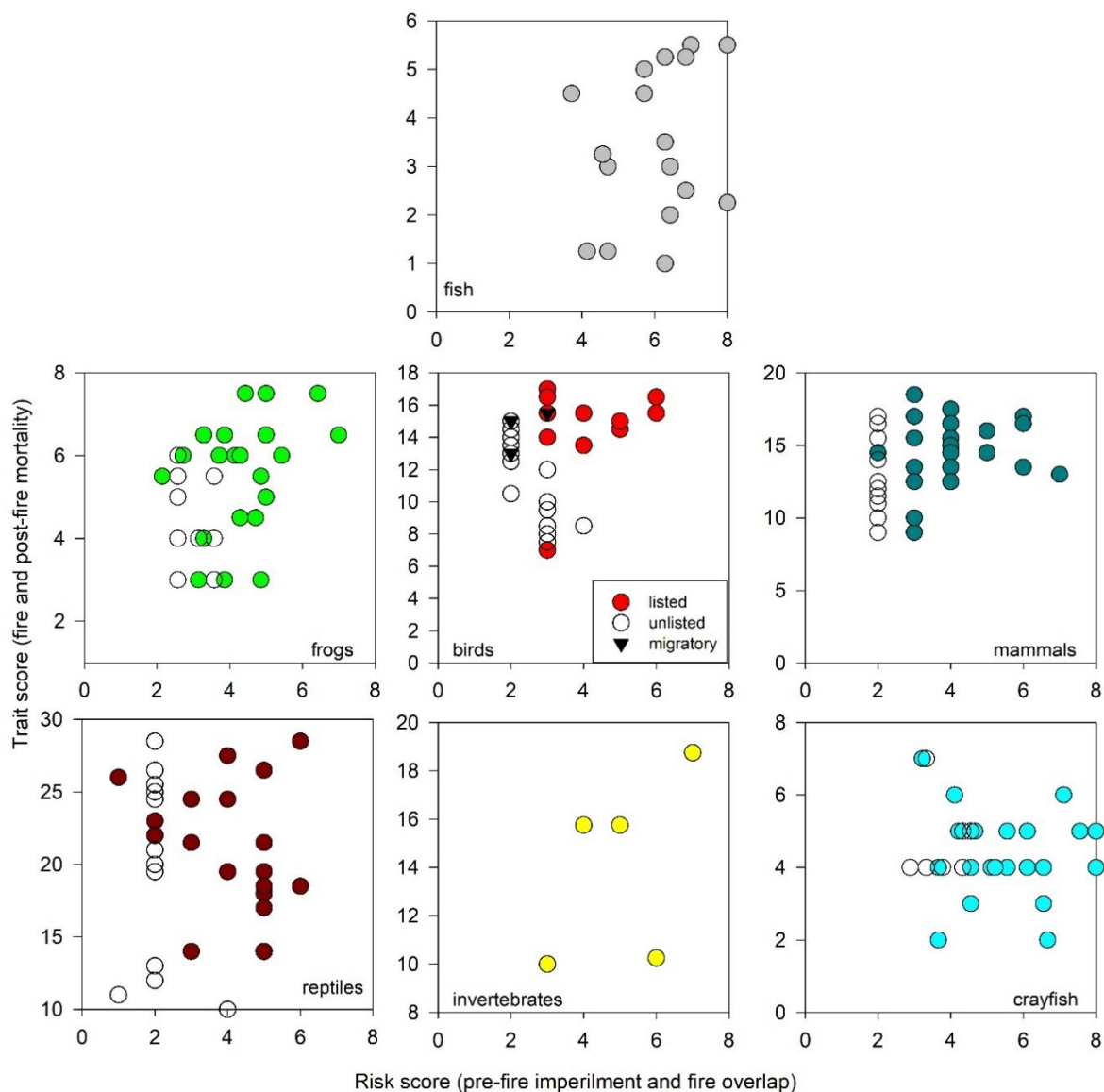


Figure 3. Graphs of Fire and Post-fire Mortality score against Risk (imperilment and fire overlap), for each animal group. Open circles are unlisted species; filled circles are listed (by EPBC Act and/or IUCN). Note that unlisted invertebrates were not evaluated, and the only two unlisted fish species are undescribed taxa that have never been assessed for listing, so we have not separated them here.

These graphs illustrate that there is a broad continuum of species severely affected by these fires, rather than a distinctive definitive subset of priority species for which the detrimental impacts of fire are a step-change greater than the other species considered here: many species need priority management responses.

Below we present the preliminary animal groups that we have assessed. We reiterate these scores will continue to change as the fire season progresses, and as ground inspection of fire impact becomes available.

## Birds

Using the framework shown in Figure 2, a total of **17 bird taxa are considered high priority**:

53 taxa including subspecies have distributions that have been fire-affected (by at least 10% if listed, or 30% if unlisted)



13 taxa are high priorities for urgent management intervention, either because they have high Risk values (4 taxa), or they have intermediate Risk values plus high trait scores for Fire-and Post-fire mortality (9 taxa)



4 additional taxa could also be considered as high priorities for urgent management intervention because they are very close to the thresholds for intermediate risk and high trait scores

Bird taxa considered in the assessment are shown in Table 2. The top-ranked bird taxa are the Western Ground Parrot, Kangaroo Island Glossy Black-Cockatoo and Rufous Scrub-bird (especially the southern subspecies).

Two additional species, Pilotbird and Superb Lyrebird, have fire overlap values (48% and 46% respectively) very close to the next fire overlap category up, which would elevate them to intermediate Risk. They each have constituent subspecies that, if assessed separately, would qualify for high priority: the Upland Pilotbird *Pycnoptilus floccosus floccosus*, and the Northern and Central subspecies of the Superb Lyrebird *Menura novaehollandiae novaehollandiae*, *Menura novaehollandiae edwardi*. The Rock Warbler and the Red-browed Treecreeper have both had almost 50% of their ranges burnt, and may also be considered as high priority. We propose these four species (i.e. Pilotbird, Superb Lyrebird, Red-browed Treecreeper and Rock Warbler) are included in the priority list, with attention focussed on the subspecies of Superb Lyrebird and Pilotbird that may be most heavily impacted.

**Table 2. Priority list for birds requiring urgent management action in the next 12 months.** The table includes listed taxa with at least 10% of fire-affected distributions, and unlisted taxa with at least 30% of fire-affected distributions, that meet the thresholds for priority species. Following the schematic in Figure 2, species with a Risk score of 5 and above are prioritised; species with intermediate Risk scores (3 and 4) and ordered according to the Fire and Post-fire Mortality score; those with scores greater than the average are also prioritised. Four species close to the thresholds for qualifying as priority are also included in this list (Superb Lyrebird, Pilotbird, Rock Warbler, Red-browed Treecreeper). The full list of species assessed, including species that were assessed but did not meet the criteria for priority are shown in Table A2. \*Rate of decline pre-fire over 40%, based on expert opinion.

Common name	Genus	EPBC Act listing	IUCN Listing for species; Action Plan for subspecies	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Western Ground Parrot	<i>Pezoporus wallicus flaviventris</i>	CR	CR (AP)	4	2	6	15.5
Kangaroo Island Glossy Black-Cockatoo	<i>Calyptorhynchus lathami halmaturinus</i>	EN	EN (AP)	3	3	6	14.5
Rufous Scrub-bird	<i>Atrichornis rufescens</i>	EN	EN	3	2	5	14.5
Regent Honeyeater	<i>Anthochaera phrygia</i>	CR	CR	4	1	5	12.0
Eastern Bristlebird	<i>Dasyornis brachypterus</i>	EN	EN	3	1	4	15.5
Albert's Lyrebird	<i>Menura alberti</i>		NT	1	2	3	16.0
Mainland Ground Parrot	<i>Pezoporus wallicus wallicus</i>		NT (AP)	1	2	3	15.5
Western Bassian Thrush	<i>Zoothera lunulata halmaturina</i>	VU	VU (AP)	2	1	3	13.0
Black-faced Monarch	<i>Monarcha melanopsis</i>	migratory	LC	1	2	3	12.5
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>		LC*	2	1	3	12.5
South-eastern Glossy Black-Cockatoo	<i>Calyptorhynchus lathami lathami</i>		NT	1	2	3	16.5
Kangaroo Island Western Whipbird	<i>Psophodes nigrogularis lashmari</i>		NT	1	3	4	13.5
Kangaroo Island Southern Emu-wren	<i>Stipiturus malachurus halmaturinus</i>		LC	0	4	4	13.5
<b>Species that are provisionally included as high priority whilst more information is gathered</b>							
Rockwarbler	<i>Origma solitaria</i>		LC	0	3	3	12.0
Pilotbird	<i>Pycnoptilus floccosus</i>		LC	0	2	2	14.5
Superb Lyrebird	<i>Menura novaehollandiae</i>		LC	0	2	2	14.0
Red-browed Treecreeper	<i>Climacteris erythroptus</i>		LC	0	2	2	12.5

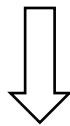
## Mammals

Using the framework shown in Figure 2, a total of **20 mammal taxa are considered high priority**:

41 taxa have distributions that have been  
fire-affected (by at least 10% if listed, or at  
least 30% if not listed)



17 taxa are high priorities for urgent  
management intervention, either because  
they have high Risk values (6 taxa), or they  
have intermediate Risk values plus high trait  
scores for Fire-and Post-fire mortality (11  
taxa)



3 additional taxa should also be considered as  
high priorities for urgent management  
intervention because they are very close to  
the thresholds for intermediate risk and high  
trait scores

The top-ranked mammal taxon is the Kangaroo island Dunnart, followed by Hastings River Mouse, Long-footed Potoroo and Kangaroo Island Echidna (Table 3).

Two species (Golden-tipped Bat and Platypus) have Risk values lower than the threshold for intermediate Risk, but we propose including them in the high priority species list. The fire overlap estimate (for the bat) is very close to the next category up. The fire mapping may under-estimate impact on the aquatic Platypus and there are reports that its pre-fire imperilment was worse than the listing status suggests; its inclusion on the high priority list is provisional and subject to further assessment for pre-fire imperilment and the extent of fire impact. A third species, the Grey-headed Flying-fox, is also close to the threshold for inclusion, and given its known sensitivity to extreme heat and reports of mass die-offs associated with heat waves in the 2019-20 summer and previously, this species has also been included as high priority.

Note that the assessment for Koala given in Table 2 relates to the EPBC Act listed population of New South Wales, Queensland and the ACT. The fire overlap figure for the species as a whole (10.2%) is very close to that of the listed range states (12.5%), so the assessment for the species as a whole will be similar.



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**Table 3. List for priority mammals for urgent management action in the next 12 months.** Following the schematic in Figure 2, species with a Risk score of 5 and above are prioritised; species with intermediate Risk scores (3 and 4) and ordered according to the Fire and Post-fire Mortality score, and those with scores greater than the average are also prioritised. Three species very close to the thresholds for qualifying as priority as also included in this list in yellow highlight (Grey-headed Flying-fox, Golden-tipped Bat and Platypus). The full list of species assessed, including species that were assessed but did not meet the criteria for priority are shown in Table A3. [\* NT in Mammal Action Plan]

Common name	Scientific Name	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Kangaroo Island Dunnart	<i>Sminthopsis griseoventer aitkeni</i>	EN	n/a	3	4	7	13.0
Hastings River Mouse, Koontoo	<i>Pseudomys oralis</i>	EN	VU	3	3	6	17.0
Long-footed Potoroo	<i>Potorous longipes</i>	EN	VU	3	3	6	16.5
Kangaroo Island Echidna	<i>Tachyglossus aculeatus multiaculeatus</i>	EN	n/a	3	3	6	13.5
Mountain Pygmy-possum	<i>Burramys parvus</i>	EN	CR	4	1	5	16.0
Silver-headed Antechinus	<i>Antechinus argentus</i>	EN		3	2	5	14.5
Broad-toothed Rat (mainland), Tooarrana	<i>Mastacomys fuscus mordicus</i>	VU	n/a	2	1	3	18.5
Smoky Mouse, Konoom	<i>Pseudomys fumeus</i>	EN	VU	3	1	4	17.5
Koala	<i>Phascolarctos cinereus (combined populations of Qld, NSW, ACT)</i>	VU	n/a	2	1	3	17.0
Parma Wallaby	<i>Notomacropus parma</i>	not listed	NT	1	3	4	16.5
Yellow-bellied Glider	<i>Petaurus australis</i>	not listed	NT	1	3	4	15.5
Greater Glider	<i>Petauroides volans</i>	VU	VU	2	1	3	15.5
Brush-tailed Rock-wallaby	<i>Petrogale penicillata</i>	VU	VU	2	2	4	15.0
Long-nosed Potoroo (SE Mainland)	<i>Potorous tridactylus tridactylus</i>	VU	n/a	2	2	4	14.5
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll	<i>Dasyurus maculatus maculatus (SE mainland population)</i>	EN	n/a	3	1	4	13.5
New Holland Mouse, Pookila	<i>Pseudomys novaehollandiae</i>	VU	VU	2	2	4	13.5
Mainland Dusky Antechinus*	<i>Antechinus mimetes</i>		LC	1	2	3	13.5
<b>Species that are provisionally included as high priority whilst more information is gathered</b>							
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	VU	VU	2	1	3	12.5
Golden-tipped Bat	<i>Phoniscus papuensis</i>	not listed	LC	0	2	2	17.0
Platypus	<i>Ornithorhynchus anatinus</i>	not listed	NT	1	1	2	14.5

## Reptiles

Using the framework shown in Figure 2, a total of **23 reptile taxa are considered high priority**:

35 taxa have distributions that have been fire-affected (by at least 10% if listed, or at least 30% if not listed)



14 of these taxa are high priorities for urgent management intervention, either because they have high Risk values (9 taxa), or they have intermediate Risk values plus high trait scores for Fire and Post-fire mortality (5 taxa)



9 additional taxa should also be considered as high priorities for urgent management intervention because they are close to the thresholds for intermediate risk and high trait scores; more information on their status is required

High priority reptile taxa shown in Table 4. The top-ranked reptile taxa are the Blue Mountains Water Skink and George's Snapping Turtle. There are eight reptile taxa that are near the thresholds for inclusion on the priority list (shown in yellow highlight in Table 4), and they have been included to be precautionary. A ninth species, the Southern Water Skink, meets the priority thresholds, but has a large distribution and impacts may be lower than for other species. In contrast, the Granite Leaf-tailed Gecko and the Broad-tailed Gecko have very small distributions, about a quarter of which has burnt. If the fire overlaps are higher than estimated, the impacts on these species could be large, so they have been added to the priority list as a precaution.

**Table 4. List for priority reptiles for urgent management action in the next 12 months.** Following the schematic in Figure 2, species with a Risk score of 5 and above are prioritised; species with intermediate Risk scores (3 and 4) and ordered according to the Fire and Post-fire Mortality score, and those with scores greater than the average are also prioritised. Species that are provisionally included on the priority list, pending more information, are shown in yellow highlight. The full list of species assessed, including species that were assessed but did not meet the criteria for priority, are shown in Table A4.

Common name	Scientific name	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Blue Mountains Water Skink	<i>Eulamprus leuraensis</i>	EN	EN	3	3	6	28.5
Georges' Snapping Turtle	<i>Wollumbinia georgesi</i>	CR	DD	4	2	6	18.5
Long Sunskink	<i>Lampropholis elongata</i>		DD	2	3	5	26.5
Nangur Spiny Skink	<i>Nangura spinosa</i>	CR	EN	4	1	5	22.5
Bell's Turtle	<i>Wollumbinia belli</i>	VU	CR	4	1	5	19.5
Manning River Helmeted Turtle	<i>Myuchelys purvisi</i>		DD	2	3	5	18.5
Broad-headed Snake	<i>Hoplocephalus bungaroides</i>	VU	VU	2	3	5	18
Kaputar Rock Skink	<i>Egernia roomi</i>		not assessed	2	3	5	15
Guthega Skink	<i>Liopholis guthega</i>	EN	EN	3	2	5	15
Alpine She-oak Skink	<i>Cyclodomorphus praealtus</i>	EN	EN	3	1	4	27.5
Alpine Bog Skink	<i>Pseudemoia cryodroma</i>		EN	3	1	4	24.5
Three-toed Snake-tooth Skink	<i>Coeranoscincus reticulatus</i>	VU	LC	2	1	3	21.5
Oakview Leaf-tailed Gecko	<i>Phyllurus kabikabi</i>		CR	4	1	5	17
Kate's Leaf-tail Gecko	<i>Saltuarius kateae</i>		LC	0	4	4	10
<b>Species that are provisionally included as high priority whilst more information is gathered</b>							
Rainforest Cool-skink	<i>Harrisioniascincus zia</i>		LC	0	2	2	28.5
Southern Water-skink	<i>Eulamprus tympanum</i>	1 subsp listed EN	LC	0	1	1	26
Glossy Grass Skink	<i>Pseudemoia rawlinsoni</i>		DD	2	1	3	24.5
Moritz's Leaf-tailed Gecko	<i>Saltuarius moritzi</i>		LC	0	2	2	22
Ringed thin-tail gecko	<i>Phyllurus caudiannulatus</i>		NT	1	1	2	22
Mustard-bellied Snake	<i>Drysdalia rhodogaster</i>		LC	0	2	2	20
Red-tailed Calyptotis	<i>Calyptotis ruficauda</i>		LC	0	2	2	19.5
Granite leaf-tailed gecko	<i>Saltuarius wyberba</i>		LC	0	1	1	11
Broad-tailed Gecko	<i>Phyllurus platurus</i>		LC	0	1	1	9

## Frogs

Using the framework shown in Figure 2, a total of **16 frog taxa are considered high priority:**

37 taxa have distributions that have been  
fire-affected (by at least 10% if listed, or at  
least 30% if not listed)



16 of these taxa are high priorities for urgent  
management intervention, either because  
they have high Risk values (11 taxa), or they  
have intermediate Risk values plus high trait  
scores for Fire and Post-fire mortality (5 taxa)

High priority frog taxa are shown in Table 5. The top-ranked frog taxon is the Northern Corroboree Frog. Two species (the Mountain Frog and the Giant Burrowing Frog) contain populations that are currently being described as separate species, that may be at even higher risk. The Koombit Tinker Frog may have been minimally affected by fire in 2019-20, but is retained here until better information from on-ground assessment is available.

**Table 5. List for priority frogs for urgent management action in the next 12 months.** Following the schematic in Figure 2, species with a Risk score of 5 and above are prioritised; species with intermediate Risk scores (3 and 4) and ordered according to the Fire and Post-fire Mortality score, and those with scores greater than the average are also prioritised. The full list of species assessed, including species that were assessed but did not meet the criteria for priority are shown in Table A5. Two species, the Mountain Frog and the Giant Burrowing Frog are likely to each be split into two species, in which case all four species would be priorities.

Common name	Scientific Name	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Northern Corroboree Frog	<i>Pseudophryne pengilleyi</i>	CR	EN	4.0	3	7	6.5
Mountain frog	<i>Philoria kundagungan</i>		EN	3.4	3	6	7.5
Pugh's frog	<i>Philoria pughi</i>		EN	3.4	3	6	7.5
Sphagnum frog	<i>Philoria sphagnicola</i>		EN	3.4	3	6	7.5
Peppered Tree Frog	<i>Litoria piperata</i>	VU	CR	3.4	2	5	6.0
Southern Corroboree Frog	<i>Pseudophryne corroboree</i>	CR	CR	4.0	1	5	6.5
Spotted Tree Frog	<i>Litoria spenceri</i>	EN	CR	4.0	1	5	5.0
Kroombit Tinker Frog	<i>Taudactylus pleione</i>	CR	CR	4.0	1	5	7.5
Giant Burrowing Frog	<i>Heleioporus australiacus</i>	VU	VU	2.9	2	5	5.5
New England treefrog, Glandular frog	<i>Litoria subglandulosa</i>		VU	2.9	2	5	3.0
Littlejohn's Tree Frog, Heath Frog	<i>Litoria littlejohni</i>		LC	1.7	3	5	4.5
Richmond Range Sphagnum Frog	<i>Philoria richmondensis</i>		EN	3.4	1	4	7.5
Davies' Tree frog	<i>Litoria daviesae</i>		VU	2.3	2	4	6.0
Stuttering Frog, Southern Barred Frog (Victoria)	<i>Mixophyes balbus</i>	VU	VU	1.1	3	4	6.0
Giant Barred Frog	<i>Mixophyes iteratus</i>		EN	1.7	2	4	6.0
Fleay's Frog	<i>Mixophyes fleayi</i>		EN	1.7	1	3	6.0

## EPBC Act-listed invertebrates (except crayfish)

Using the framework shown in Figure 2, **five invertebrate taxa are considered high priority:**

5 threatened taxa have distributions that have been fire-affected (by at least 10%). Two further threatened invertebrates (the bees *Neopasiphae simplicior* and *Leioproctus douglasiellus*) were considered in the initial DAWE analysis to have >10% of their very limited range burnt, but subsequent onground reports indicated that the actual burnt area was smaller than this threshold, so they are not considered further.



All 5 of these taxa are high priorities for urgent management intervention, given their high degree of pre-fire imperilment, and because of the extent of fire across their very small distributions

High priority invertebrate taxa are shown in Table 6. The top-ranked taxon is the Banksia montana mealybug. The Alpine Stonefly and the Bathurst Copper Butterfly have intermediate scores for Risk, but given their small distributions, fire could have a substantial impact on these species. Ground assessments are needed to check their status.

There are tens of thousands of unlisted invertebrate species, many of which have very small distributions that may have been almost or entirely burnt in the 2019-20 fires. Carrying out a thorough assessment on this group is important, and will take considerable time and collaboration.

**Table 6. List for priority nationally listed invertebrates for urgent management action in the next 12 months.** The table shows EPBC Act-listed taxa with at least 10% of fire-affected distributions. Following the schematic in Figure 2, species with a Risk score of 5 and above are immediately prioritised. Species with intermediate Risk scores (3 and 4) and ordered according to the Fire-and Post-fire Mortality score. The full risk and trait assessment is provided in Table A6.

Common name	Scientific Name	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Banksia montana mealybug	<i>Pseudococcus markharveyi</i>	CR	CR	4	3	7	18.8
Eastern Stirling Range Pygmy Trapdoor Spider	<i>Bertmainius colonus</i>	VU	not assessed	2	4	6	10.3
Banksia brownii plant louse	<i>Trioza barrettae</i>	EN	CR	3	2	5	15.8
Bathurst Copper Butterfly	<i>Paralucia spinifera</i>	VU	EN	2	1	3	10.0
Alpine Stonefly	<i>Thaumatoperla alpina</i>	EN	not assessed	3	1	4	15.8

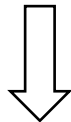
## Crayfish (in the genus *Euastacus*)

Using the framework shown in Figure 2, **22 crayfish taxa are considered high priority:**

32 taxa have distributions that have been fire-affected (25 IUCN-listed taxa by at least 10%, and 6 non-threatened plus 1 not-assessed taxa by at least 30%)



15 of these taxa are high priorities for urgent management intervention because they have high Risk values



7 additional taxa should also be considered as high priorities because they have intermediate Risk scores and the fire overlap may be higher than desktop analysis suggests

High priority crayfish taxa are shown in Table 7. There are many taxa with the very high scores for Risk, from a combination of high pre-fire imperilment and large fire overlaps.

This list of high priority crayfish is tentative, and has only considered *Euastacus* spp.. Given the small distributions of many *Euastacus* species, and errors in fire mapping, the degree of fire impact on species in this group needs on-ground verification because some species listed as high priority may be less impacted than the analysis suggests, and vice versa. For example, the fire overlap estimate for the *Euastacus dharawalus* Fitzroy Falls Spiny Crayfish, is unclear: initial spatial analysis suggests 100% overlap, but on-ground reports suggest 0% fire overlap. The species is not included as a priority here, but this status will be adjusted if further on-ground reports indicate a fire overlap.



**Table 7. List for priority crayfish (*Euastacus* spp.) for urgent management action in the next 12 months.** The table shows IUCN-listed taxa (none of the crayfish considered here are listed under the EPBC Act) with at least 10% of fire-affected distributions, and unlisted taxa with at least 30% of their distributions fire-affected. Species with a Risk score of 5 and above are immediately prioritised. Seven additional species with intermediate Risk scores have been provisionally added; surveys are needed to verify the fire overlap estimates. Table A7 shows the full list of species assessed; most of them require on-ground assessment to check their status.

Common name	Scientific Name	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
<i>Euastacus</i> sp. 1	Arte Spiny Crayfish		CR	4.0	4	8.0	5
<i>Euastacus</i> sp. 2	Cann Spiny Crayfish		CR	4.0	4	8.0	5
<i>Euastacus</i> sp. 3	West Snowy Spiny Crayfish		CR	4.0	4	8.0	4
<i>Euastacus guwinus</i>	Tianjara Crayfish		CR	3.6	4	7.6	5
<i>Euastacus clarkae</i>	Ellen Clark's Crayfish		EN	3.1	4	7.1	6
<i>Euastacus bidawalus</i>	East Gippsland Spiny Crayfish		EN	2.7	4	6.7	2
<i>Euastacus spinichelatus</i>	Small Crayfish		EN	3.6	3	6.6	4
<i>Euastacus girurmulayn</i>	Smooth Crayfish		CR	3.6	3	6.6	3
<i>Euastacus diversus</i>	Orbost Spiny Crayfish		EN	3.1	3	6.1	5
<i>Euastacus pilosus</i>	Hairy Cataract Crayfish		EN	3.1	3	6.1	4
<i>Euastacus gamilaroi</i>	Gamilaroi Spiny Crayfish		CR	3.6	2	5.6	5
<i>Euastacus jagara</i>	Jagara Hairy Crayfish		CR	3.6	2	5.6	4
<i>Euastacus suttoni</i>	Sutton's Crayfish		VU	2.2	3	5.2	4
<i>Euastacus claytoni</i>	Clayton's Spiny Crayfish		EN	3.1	2	5.1	4
<i>Euastacus gumar</i>	Bloodclaw Crayfish		EN	3.1	2	5.1	4
<b>Species that are provisionally included as high priority whilst more information is gathered</b>							
<i>Euastacus crassus</i>	Alpine Crayfish		EN	2.7	3	4.7	5
<i>Euastacus jagabar</i>	Blue-Black Crayfish		CR	3.6	2	4.6	4
<i>Euastacus morgani</i>	Morgan's Crayfish		not assessed	3.6	2	4.6	5
<i>Euastacus polysetosus</i>	Many-bristled Crayfish		EN	3.6	1	4.6	4
<i>Euastacus dalagarbe</i>	Mud Gully Crayfish		CR	3.6	1	4.6	3
<i>Euastacus simplex</i>	Small Mountain Crayfish		VU	2.2	2	4.2	5
<i>Euastacus rieki</i>	Riek's Spiny Crayfish		EN	3.1	1	4.1	6

Using the framework shown in Figure 2, **16 fish taxa are considered high priority:**

21 taxa have distributions that have been fire-affected (8 EPBCA-listed and an additional 11 IUCN-listed taxa by at least 10%, and 2 non-listed taxa by at least 30%)



16 of these taxa are high priorities for urgent management intervention, because they have high Risk values



5 additional taxa are noted as potentially fire-affected, but more on-ground information is required to gauge their status

High priority fish taxa are shown in Table 8. There are many taxa with the high scores for Risk, from a combination of high pre-fire imperilment and large fire overlaps. We reiterate that heavy sedimentation events in fire-affected areas, and downstream from those areas, can extirpate entire populations of fish. The intervention most likely to save vulnerable species is pre-emptively rescuing individuals into ex situ facilities before sedimentation events occur.

**Table 8. Summary of the assessment for fish requiring urgent management action in the next 12 months.** The table shows threatened taxa (listed by the EPBCA, IUCN, or by states) with at least 10% of fire-affected distributions. Species with a Risk score of 6 and above are immediately prioritised. Four additional species (in grey shading) have intermediate Risk scores (between 3 and 5); surveys are needed to assess impacts on these species. Table A8 shows the full assessment.

Common name	Scientific Name	Taxon level	EPBC Act listing	IUCN Listing	Score for pre-fire imperilment	Score for fire overlap	RISK due to imperilment and fire overlap	Score for Fire and Post-fire mortality
Yalmy Galaxias	<i>Galaxias sp. nov. 'yalmy'</i>	undescribed		CR	4.0	4	8.0	5.5
McDowall's Galaxias	<i>Galaxias mcdowalli</i>	species		CR	4.0	4	8.0	5.5
East Gippsland Galaxias	<i>Galaxias aequipinnis</i>	species		CR	4.0	4	8.0	5.5
Stocky Galaxias	<i>Galaxias tantangara</i>	species		CR	4.0	4	8.0	5.5
Dargo Galaxias	<i>Galaxias mungadhan</i>	species		CR	4.0	4	8.0	5.5
Short-tail Galaxias	<i>Galaxias brevissimus</i>	species		CR	4.0	4	8.0	2.25
Flathead Galaxia	<i>Galaxias rostratus</i>	species	CR	CR	4.0	3	7.0	5.5
Honey Blue-eye	<i>Pseudomugil mellis</i>	species	VU	EN	2.9	4	6.9	5.25
Roundsnout Galaxias	<i>Galaxias terenasus</i>	species		EN	2.9	4	6.9	2.5
SW Victorian Blackfish	<i>Gadopsis sp. nov. 'Western Victoria'</i>	undescribed		EN	3.4	3	6.4	3
Oxleyan Pygmy Perch	<i>Nannoperca oxleyana</i>	species	EN	EN	2.3	4	6.3	5.25
Non-parasitic Lamprey	<i>Mordacia praecox</i>	species		EN	2.3	4	6.3	3.5
Clarence River Cod	<i>Maccullochella ikei</i>	species	EN	EN	2.3	4	6.3	1
Macquarie Perch	<i>Macquaria australasica (MDB)</i>	species	EN	EN	1.7	4	5.7	5
Cann Galaxias	<i>Galaxias sp. 17 'Cann'</i>	undescribed		not assessed	1.7	4	5.7	4.5
Blue Mountains Perch	<i>Macquaria sp. nov. 'hawkesbury taxon'</i>	undescribed		VU	1.7	2	5.3	4.5
<b>Species that are not included as high priority, but this status could change with more information</b>								
Swan Galaxias	<i>Galaxias fontanus</i>	species	EN	EN	3.4	3	6.4	2
SE Victorian Blackfish	<i>Gadopsis sp. nov. SE Victoria</i>	undescribed		not assessed	1.7	3	4.7	3
Trout Cod	<i>Maccullochella macquariensis</i>	species	EN	VU	1.7	3	4.7	1.25
Twospine Blackfish	<i>Gadopsis bispinosus</i>	species		NT	0.6	4	4.6	3.25
Australian Grayling	<i>Prototroctes maraena</i>	species	VU	VU	1.1	3	4.1	1.25

## Summary of fire overlaps across animal groups

The division of the high priority species across the fire overlap categories was roughly even, with slightly more species in two lowest categories.

Table 7. Summary of the fire overlaps for the priority species.

% fire overlap	Inverts	Crayfish	Fish	Frogs	Reptiles	Birds	Mammals	Total
>80	1	6	13	1	1	1	1	24
50-80	1	5	3	6	5	3	5	28
30-50	1	6	0	5	6	9	6	33
10-30	2	5	0	5	11	4	8	35

## 9. Which actions?

The specific interventions required for each species are best informed by species experts, and a detailed suite of actions at local and regional scales should be (and in many cases, is being) developed by state agencies and other relevant land managers. However, the trait information collated for each species provides indications of the type of actions likely to be required for any species. For example, if a species scores highly for susceptibility to introduced predators in the post-fire period, then some form of predator control or exclusion is indicated. If a species scores highly for diet and dietary specialisation, then supplementary feeding may be considered.

Figure 3 summarises a pathway for considering which actions are likely to benefit a particular species. Note that in all cases it is highly likely that

- Protecting unburnt habitats, especially unburnt habitat patches within, or adjacent to, burnt areas, is a high priority.
- Carrying out rapid ground assessments of population status are crucial for understanding which management actions can be considered, and also to provide baseline data against which management intervention effectiveness can be measured, and the population trajectory can be monitored.
- Actions required in burnt areas, and in unburnt remnant patches, may differ.
- Likewise, actions required for remnant populations of the same species may differ, depending on context.
- Salvage and ex situ actions are likely to be used in a relatively small number of situations and should be preceded by a risk assessment. They are more likely options for fish populations threatened by massive sedimentation events, and for very small populations of highly threatened species, or very small populations of high genetic value.

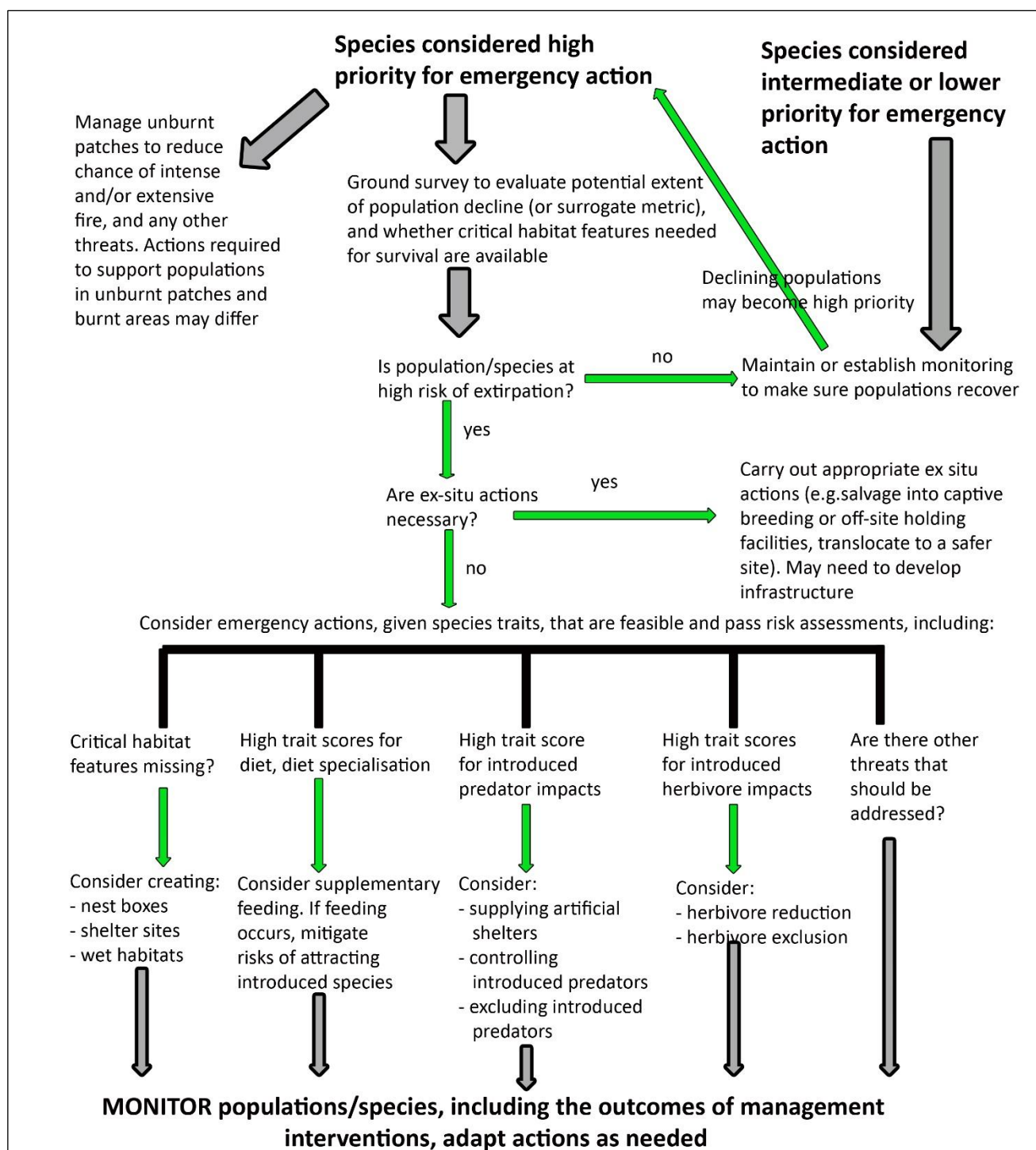


Figure 3. Schematic to illustrate a pathway for identifying likely management actions needed for high priority species. Note that two priority actions should be carried out for all species: 1) Rapid on-ground surveys to establish extent of population loss, and establish a baseline for ongoing monitoring. 2) Protecting unburnt areas within or adjacent to recently burnt ground that provide refuge, as well as unburnt areas that are not adjacent to burnt areas, especially from extensive, intense fire. The priority activities identified by the Expert Panel are listed here, with examples of the priority species, or species groups, that are likely to benefit from management aligned with that priority activity.

**Protecting unburnt areas within or adjacent to recently burnt ground that provide refuges.**

- Essential for all priority taxa.

**Rapid on-ground assessment for species and communities of concern (survey to establish extent of pop loss, and establish baseline for ongoing monitoring).**

- Essential for all priority taxa.

**Supplementary shelter, food, and water for animals where appropriate.**

- Supplementary feeding for bird and mammal herbivores or dietary specialists that are clumped or than can clump, so food can be provided efficiently, such as:
  - Brush-tailed Rock-wallaby (short term feeding an option until vegetation regenerates, but only required where fire has been intense).
  - Kangaroo Island Glossy Black-Cockatoo (supplementary feeding with fresh casuarina cones from off island could be attempted).
  - Mountain Pygmy-possum (some supplementary feeding already in place).
- Provision of artificial nest hollows for birds and mammals that are hollow-dependent, especially if they need large hollows, such as:
  - Kangaroo Island Glossy Black-Cockatoo.
  - Yellow-bellied Glider, Greater Glider.

**Feral predator and herbivore control to reduce the pressure on native species where appropriate.**

- Control of introduced predators for species that are highly susceptible to predation, especially after fire (loss of cover). Actions could include provision of artificial shelters, or predation exclusion (by fencing) as well as, or instead of, reducing predator numbers. Examples include:
  - All 14 ground-dwelling priority mammals (although potentially less critical for some species).
  - All ground-dwelling birds (e.g. Eastern Bristlebird, Rufous Scrub-bird, Western and Mainland Ground Parrots).
  - Most reptiles are vulnerable to cats and foxes after fire, less so for rock-dwellers such as Broad-headed Snake. Turtle nests may be highly vulnerable to predation by foxes and pigs.
  - Less critical for frogs, which are preyed on by cats and foxes, but risks from post-fire predation unclear.
- Control of introduced herbivores, by exclusion or by reducing numbers. Examples include:
  - All invertebrates (they all have specialised vegetation requirements).
  - All ground-dwelling mammals (herbivores need food; all species need cover).
  - All ground-dwelling birds that require cover to reduce predation risk (e.g. Western Ground Parrot, Eastern Bristlebird).
  - Most reptiles, including turtles (herbivores degrade riparian areas).
  - Some frogs that are affected by habitat degradation from introduced herbivores.

**Emergency salvage of plant and animal species for ex-situ conservation or wild-to-wild translocation.**

- **Consider** salvage into ex situ for species with very small populations or distributions with very high fire overlaps, especially if they are habitat or diet specialists, for example:
  - all EPBCA-listed invertebrates (they have very small distributions, and are extreme habitat specialists).
  - Kangaroo Island Dunnart, Qld population of the Eastern Bristlebird.
  - Fish populations threatened with large sedimentation events from upstream fires, which can potentially cause mass mortality.
- **Consider** salvage to nearby unburnt habitat
  - Usually not an option, as suitable unburnt habitat will usually be occupied.