Threatened Species Recovery Hub

National Environmental Science Programme

Kangaroo Island Wildlife and Habitat Recovery Planning Workshop

Workshop Summary Report

Dan Rogers, Libby Rumpff and Jenny Huang

October 2021

Large areas of critical habitat for threatened species were severely burnt during the fires, including this nesting site for the Glossy Black-Cockatoo. Image: Libby Rumpff

Cite this publication as: Rogers, D., Rumpff, L., Huang, J., 2021. Kangaroo Island Wildlife and Habitat Recovery Planning Workshop - Workshop Summary Report. NESP Threatened Species Recovery Hub Project 8.0, Report, Brisbane.

Cover image: Early signs of regeneration in the weeks following the 2019/20 wildfires, which burnt 97% of the Flinders Chase National Park. Image: Dan Rogers

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Summary

In January 2020, wildfires burnt over 200,000 hectares of Kangaroo Island, and had a significant impact on native wildlife and habitats, including threatened species. Among the immediate recovery actions was an agreement between the Australian Government, the Threatened Species Recovery Hub, the South Australian Government, and the Kangaroo Island Natural Resources Management Board, to host an expert workshop on the recovery of Kangaroo Island's Wildlife and Habitats from these fires. The purpose of this workshop was to bring together local, state and national expertise and decision-makers, and document the best available evidence to inform a Fire Recovery Plan for Kangaroo Island's wildlife and habitats.

A range of priority recovery actions and knowledge gaps were identified in this workshop, the details of which are presented in this report. Among the key strategic actions were:

- Identification of the distribution of unburnt habitat and extant populations of priority species;
- Targeted management of feral cats in order to reduce predation pressure on remnant fauna populations within the fire ground;
- Targeted management of herbivores (particularly through feral pig management, and fencing to exclude domestic herbivores);
- Protecting unburnt remnants across Kangaroo Island from the risk of subsequent fires over the coming decade;
- A range of specific actions designed to support the recovery of individual species or species groups.

In addition to documenting these priority actions, by bringing together over 80 researchers, policy makers, managers and community members, the workshop established a foundation for long-term partnership and collaboration, to ensure the recovery of Kangaroo Island's unique wildlife and habitat.

Background

On 30 December 2019, lightning strikes ignited multiple fires in Ravine Des Casoars Wilderness Protection Area (WPA), north-western Kangaroo Island, with the majority of the fire area being burnt from January 3, 2020. This followed a fire that began near the Western River Wilderness Protection Area on 20 December 2019.

In total, the 2019-2020 Kangaroo Island wildfires ultimately burnt 211,000 ha over a period of ~18 days. This included 97% of the Flinders Chase National Park and Ravine Des Casoars WPA. Two people lost their lives as a result of the 2019-2020 Kangaroo Island Wildfires. In addition to the significant extent of the wildfires, the fire burnt very hot in some areas, particularly in the south-west. The extent and severity of the fires are presented in Figure 1.

Among the impacts was the destruction of a significant proportion of the habitat for a range of flora and fauna species, many of which were already threatened with extinction prior to the fires. These included the EPBC-listed Kangaroo Island Dunnart *Sminthopsis aitkeni*, and Kangaroo Island Glossy Black Cockatoo *Calyptorhyncus lathami halmaturinus*, but also includes a range of taxa unique to Kangaroo Island, and some of the most intact areas of native vegetation in the southern agricultural landscapes of South Australia.

Among the immediate responses to the wildfires was the need to develop a Wildlife and Habitat Recovery Plan for Kangaroo Island's species and ecosystems. As a result, the Kangaroo Island Natural Resources Management Board, The Department for Environment and Water (South Australian Government), the Threatened Species Commissioner, the Department of Agriculture, Water and the Environment (Australian Government) and the National Environmental Science Program (NESP) Threatened Species Recovery Hub collectively agreed to host a workshop in order to inform this recovery planning process. The aims of the workshop were twofold:

- to understand impacts to natural values, threats, and recovery actions, that inform and enable wildlife and habitat recovery in response to the 2019–20 Kangaroo Island wildfires, by drawing on the expertise of researchers, government and non-government staff, and sectors of the Kangaroo Island community
- to improve collaboration among participants toward the development and implementation of wildlife and habitat recovery in response to the 2019–20 Kangaroo Island wildfire.

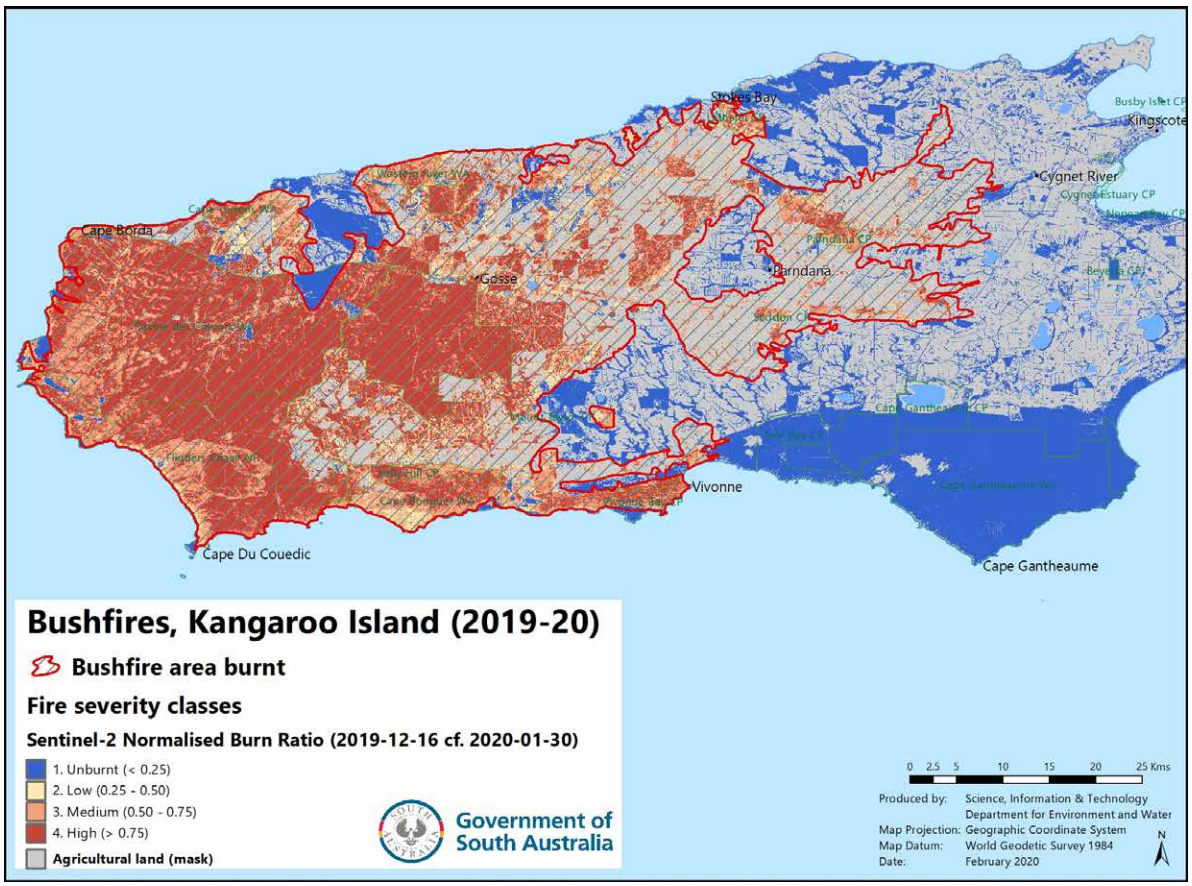


Figure 1. *Map showing the extent and severity (as expressed by the normalised burn ratio) of the 2019-2020 Kangaroo Island wildfires.*

Approach

The overall aim of the workshop was to inform a 10 year planning process that enables the recovery of native wildlife and wildlife habitat in response to the 2019-2020 Kangaroo Island wildfires. A workshop was held in American River, Kangaroo Island, between 25 February and 27 February 2020 to bring together experts and undertake a participatory approach to informing the recovery plan. Over 80 participants attended the workshop, representing the university research sector, Natural Resources Kangaroo Island, the South Australian and Australian Governments, environmental non-government organisations, and stakeholders from the Kangaroo Island community (Appendix One).

To develop a 10 year recovery plan for Kangaroo Island's biodiversity (including threatened species) in response to the wildfires, we undertook a structured expert elicitation approach to:

Step 1) Summarise the current state of knowledge of the impact of these wildfires on species, communities and ecosystems, by assessing:

a. an estimated time to recovery for critical habitat features or processes, pre-fire and post-fire status, and traits affecting recovery (vulnerability)

b. Hazards, or key threats impeding recovery;

Step 2) Develop and evaluate 10-year management strategies that aim to maximise resilience of biodiversity across Kangaroo Island (considering effectiveness and feasibility of actions), and;

Step 3) Identify the knowledge gaps impeding effective management, and subsequent priorities for research

Importantly, this synthesis attempts to identify those actions that contribute to recovery at the ecosystem level of organisation. This recognises that recovery at the ecosystem and landscape level will provide significant benefit to those species (including threatened species) that depend on these ecosystems and landscapes. However, where needed, the approach is designed to highlight species specific needs - where needed.

To understand the actions that would constitute an effective recovery strategy for the island, we focused on similarities and differences highlighted by experts across broad taxonomic groups, including:

- Mammals (excl. Kangaroo Island Dunnart and Echidnas)
- Birds (excl. Kangaroo Island Glossy Black Cockatoo)
- Reptiles and Amphibians[1]
- Invertebrates[2]
- Threatened Plant Species

Additional groups either focused on ecosystems, or individual species identified as initial priorities for urgent management intervention by the Federal government's wildlife and threatened species bushfire recovery expert panel:

- Priority Ecosystems (particularly mallee-heath on sandy lateritic soils)
- Kangaroo Island Dunnart
- Kangaroo Island Glossy-Black Cockatoo

During the workshop, groups of experts addressed each of the three steps (see Appendix One. Workshop Approach), which were aligned with steps in a risk management framework. The steps were designed to get experts to think through the recovery process from pre-fire status, through to how the fires may have differentially impacted certain species or communities (i.e. due to vulnerability to fire, and impacts to habitat, processes and threats). Once experts had made judgements on the magnitude and drivers (threats) of post-fire impact, they were asked to think through how best to mitigate impacts through action over the next 10 years. Ultimately, we wanted to focus experts on the key threats, to ensure there were associated management actions (i.e. avoid status quo bias). This was an iterative process, where we asked experts to assess the consequences of individual actions, consider the effectiveness of those actions, and then come up with three and six action strategies that could be implemented to maximise the resilience of their relevant species or community. In the absence of a budget constraint, we asked for both three and six actions strategies and assumed those actions would represent those under a low and high budget scenario for each group.

We utilized a rapid structured expert elicitation throughout the workshop to elicit pre and post fire impacts, and the effectiveness and feasibility of management. Given there were many questions and limited time available, we attempted to minimize the elicitation burden by providing well defined categories for experts (that could be translated into quantitative estimates; see Appendix One. Ideally, experts would have been asked to provide individual quantitative judgements, followed by discussion and revision (e.g. IDEA protocol, Hemming et al., 2017), but due to time constraints judgements were often discussed within the groups and provided as an individual group judgement.

During the elicitation, we asked for uncertainty to be specified around judgements. The reasons for this were twofold. First, to promote discussion and avoid overconfidence in judgements, and second, to get experts to focus on the uncertainty impeding effective management. The last task of the workshop was asking experts to identify the reasoning behind their uncertainty, and the relevant research questions that could be posed to resolve that uncertainty.

The final step in the workshop was to discuss similarities and differences across the groups. The aim of the workshop was to work toward development of a recovery plan for the island, so an understanding of which threats and effective actions were consistently identified by groups was essential. Similarly, it was important to understand where specific actions were required to address the needs of particular species or groups.

A summary of findings is provided below, with more detail on individual table results in Appendix Two.

[1] Due to the membership of this group including expertise on Kangaroo Island Echidna, this subspecies was also included in their deliberations

[2] The group later distinguished the Green Carpenter bee as a species-specific focus

Summary of outcomes

A full assessment of pre and post fire impacts is presented in Appendix Two. In this section, we focus on the threats (Step 1) and actions (Step 2) that can be utilized to assist recovery and resilience, followed by a summary of research priorities (Step 3).

Summary of key threats

Threats were categorized into themes after the workshop (Appendix Two), to highlight the key threats acting across the groups. Figure 2 highlights that habitat loss and fragmentation was the most commonly identified threat, followed by inappropriate fire regimes and cat predation.

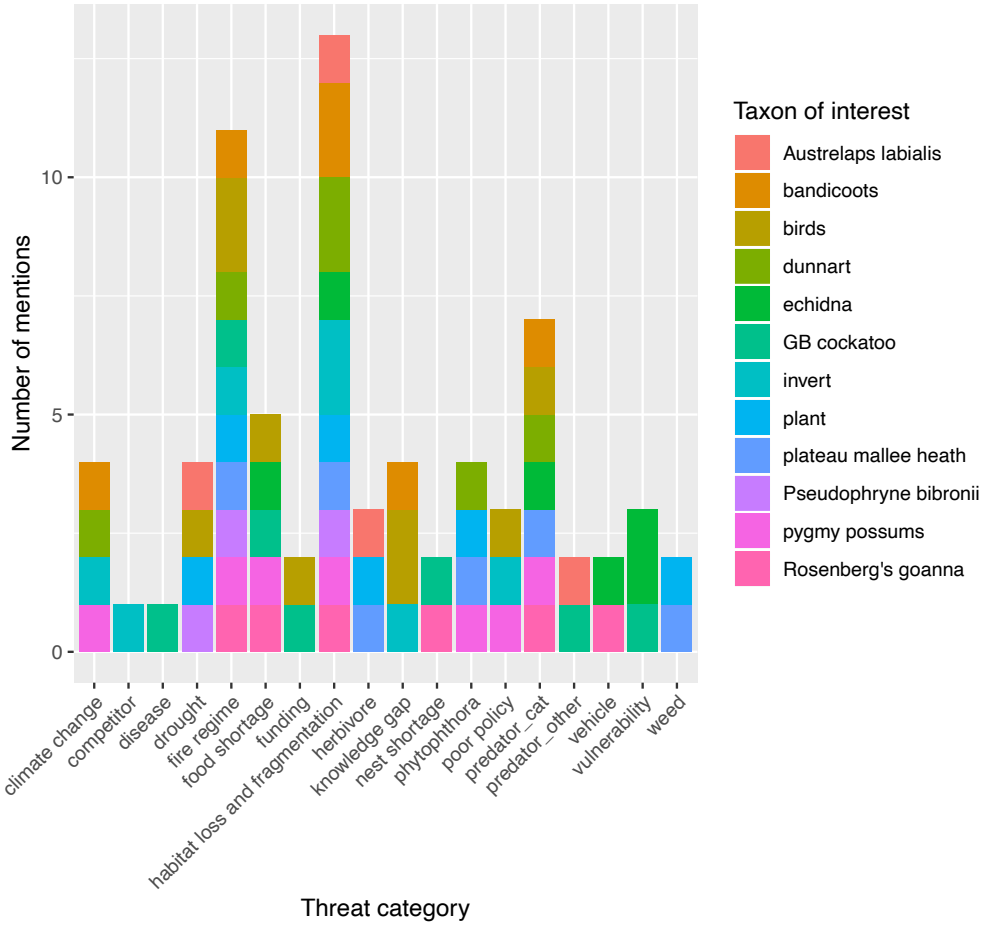


Figure 2. A summary of the key threats, summarised according to the number of 'mentions' during strategy development across the expert groups (species, taxon groups and ecosystem).

Summary of actions

We asked experts to focus on addressing the key threats in developing a three (low budget) and six action (high budget) strategy (Figure 3). Unsurprisingly, the top action across strategies was to improve fire management practices. This encompassed development of fire management plans, that included actions such as suppression of fire around ecological assets (i.e. beyond life and property protection), and strategic planned burning across the island (i.e. protection of old growth, maximizing diversity of habitats etc.) that integrates ecological values.

Experts addressed the issue of habitat loss and fragmentation through posing a range of actions, like improving connectivity through revegetation ('revegetation/restoration') and fencing remnants ('protection/exclusion'). It should be noted that actions associated with improving connectivity often were scored low in terms of feasibility (<50% chance of implementation), indicating significant implementation issues in addressing the threat of habitat loss.

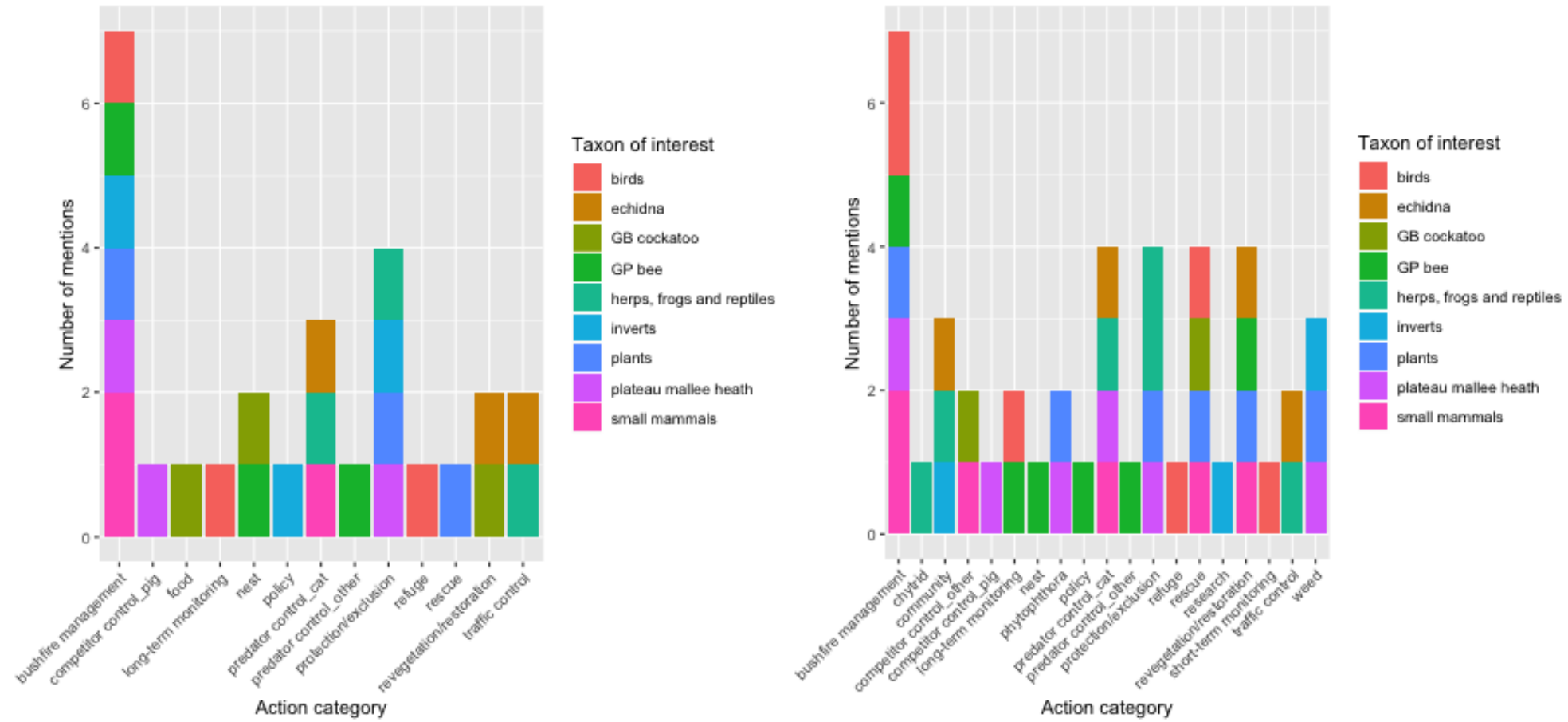


Figure 3. *A summary of the key actions, as specified in the three (plot a) and six (plot b) action strategies. Again, actions are summarised according to the number of 'mentions' in strategy development across the expert groups (species, taxon groups and ecosystem).*

Cat control was also mentioned but only in 3-4 strategies (Figure 3), which does not necessarily reflect the significance of the threat but does speak to experts' judgements on effectiveness and feasibility (e.g. for most species there was <25% improvement in population status, and a <50% chance of implementation, except in specific targeted situations e.g. Dunnart).

When experts were given the opportunity to include more actions in their strategies (Figure 3), habitat restoration featured more frequently, as did community education campaigns and 'rescue' actions (e.g. ex-situ actions such as captive breeding, insurance populations and translocation). The latter was discussed as a means to deal with threats that were inevitable, but difficult to mitigate (i.e. drought, increased fire frequency, and habitat loss). Experts felt that the next 10 years (i.e. the length of the plan) should be about attempting to manage and assess values and threats, in order to develop and instigate ex-situ management plans if necessary.

Summary: Effectiveness (benefit) of actions

A full summary is shown in Appendix Two for each group. We do not go into a detailed analysis of risk (benefit x likelihood of implementation) in this report. Here, we just present some key findings, and assistance with interpretation of results.

The Figures below represent judgements from experts about the expected percentage change in the population size (or distribution) after the wildfires if the status quo management strategy was implemented for the next ten years, compared to implementation of a series of individual actions. In many cases, 'status quo' management amounted to a 'do nothing' scenario (i.e. for many plant and invertebrate species). We did ask experts to provide judgements for a three and six action strategy (i.e. groups of actions), but not all groups had time to complete the task.

Uncertainty is specified as lower and upper bounds, and the red dot indicates the nominal (best guess) estimate. Paying attention to the bounds is important, because it indicates the possible best and worst case outcomes. When making decisions about management, a risk averse manager will be wanting to avoid the worst case outcomes (lower bounds) but may also seek to avoid actions with high uncertainty (large bounds). In comparison, a risk seeking manager might look to the best case outcomes, and those neutral to risk would focus on the best guess estimates (the red dots).

The results showed that the status quo (or do nothing) management strategy was outperformed by other actions across all groups. In most instances, the imperative to act and the benefits of intervening were substantial (e.g. as shown for the Green Carpenter Bee, Figure 4).

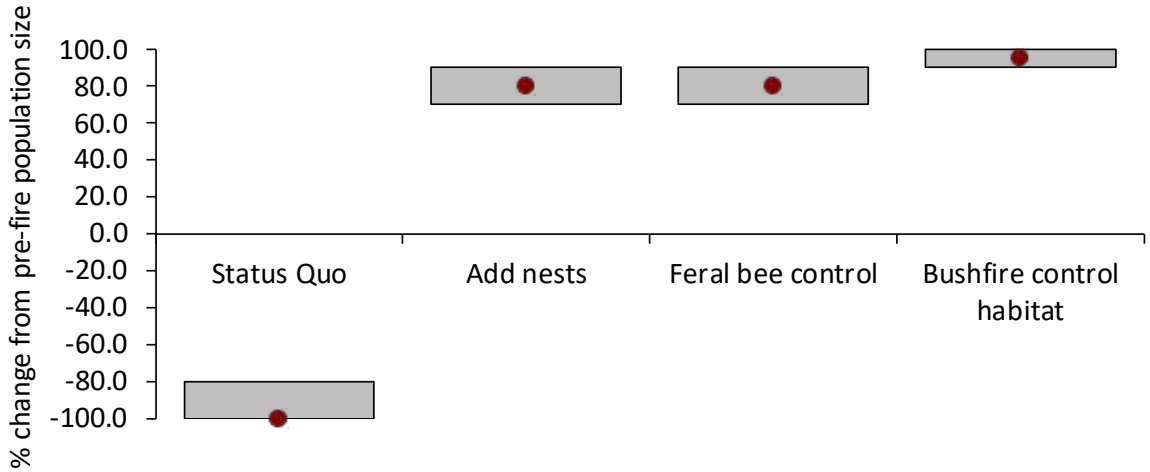


Figure 4. *Effectiveness of actions compared to the status quo for the green carpenter bee.*

In two expert groups, the status quo management strategy performed reasonably in relation to other actions. For the Glossy Black Cockatoo (Figure 5), this potentially highlights the level and effectiveness of effort invested in recovering the species to date, but also clearly demonstrates there is uncertainty around the effectiveness of actions that could be resolved to maximise persistence of the species. Given the imperative to act, a learning while doing approach (i.e. adaptive management) may be warranted.

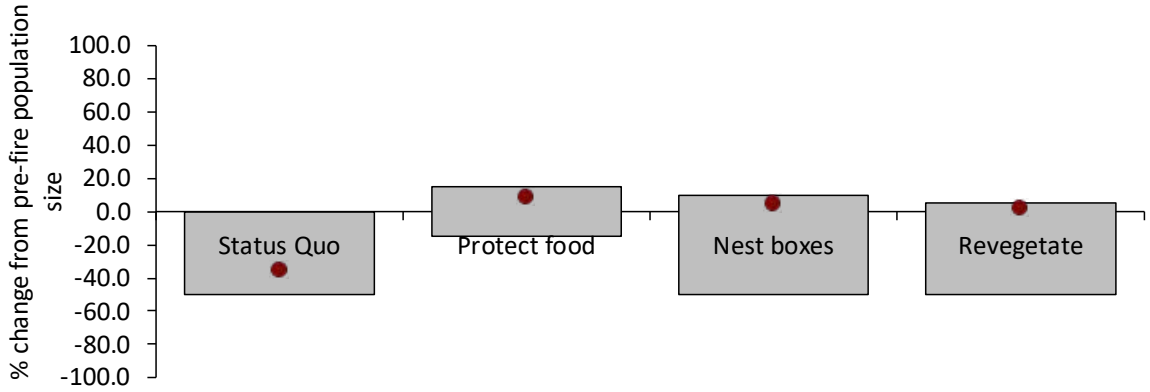


Figure 5. *Effectiveness of actions compared to the status quo for the glossy black cockatoo.*

In the second group, plants, the variability around a 'do nothing' scenario simply reflects high uncertainty around the status of many plant species (i.e. the first 8 bars in Figure 6), and the fact that fire is likely to be beneficial for some of the species (e.g. Eucalyptus spp., Logania spp.). Figure 6 shows that despite the uncertainty, action is likely to improve the status of species, though the effectiveness of many of these actions is questionable. Note here that the judgements about effectiveness of actions was made for plant species as a group, not individual species (as per the do nothing scenario).

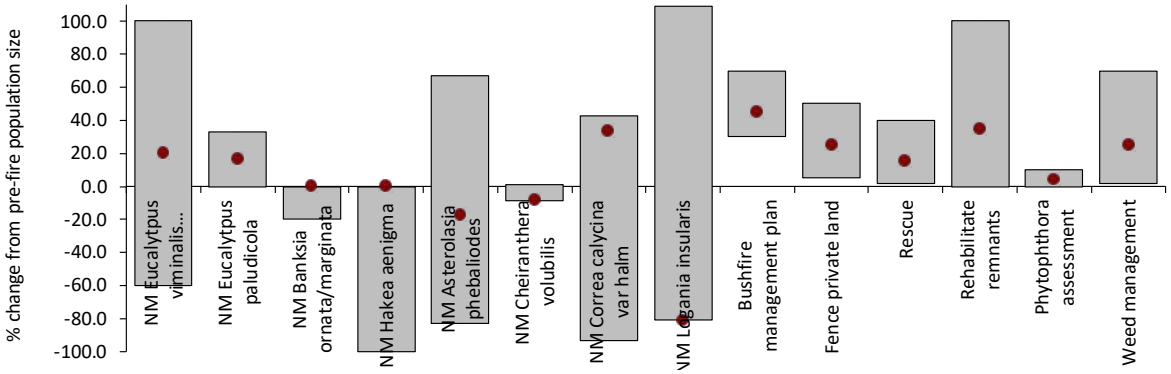


Figure 6. *Effectiveness of actions compared to the do nothing for plant species. Note that the actions were assessed for plant species as a whole, rather than individual species (as per do nothing).*

For some species, it is unclear which action to take to best improve outcomes for the species or community. A good example of this is for Rosenberg's Goanna, where all actions improve the status of the species, but it is unclear which action is best. In this instance, understanding feasibility (in this case, likelihood of implementation) and cost is critical. Experts suggested that fencing roadsides and cat control had a low likelihood of implementation (<40%) compared to the other actions (~80-100%), so habitat protection, traffic control, revegetation and community education are likely to be better options.

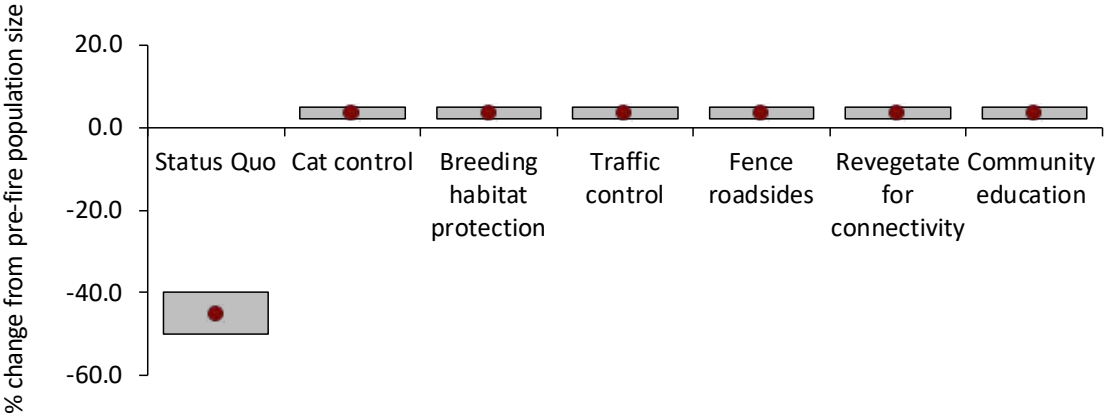


Figure 7. *Effectiveness of actions compared to the status quo for Rosenberg's goanna.*

Toward development of the recovery plan

As a summary, these overarching threats and actions have been grouped hierarchically, at landscape/ecosystem level, and, where species-specific threats were identified, at species level. A flow chart summarising the key recovery actions, and how they relate to the recovery of priority species and ecosystems, is presented in Figure 8.

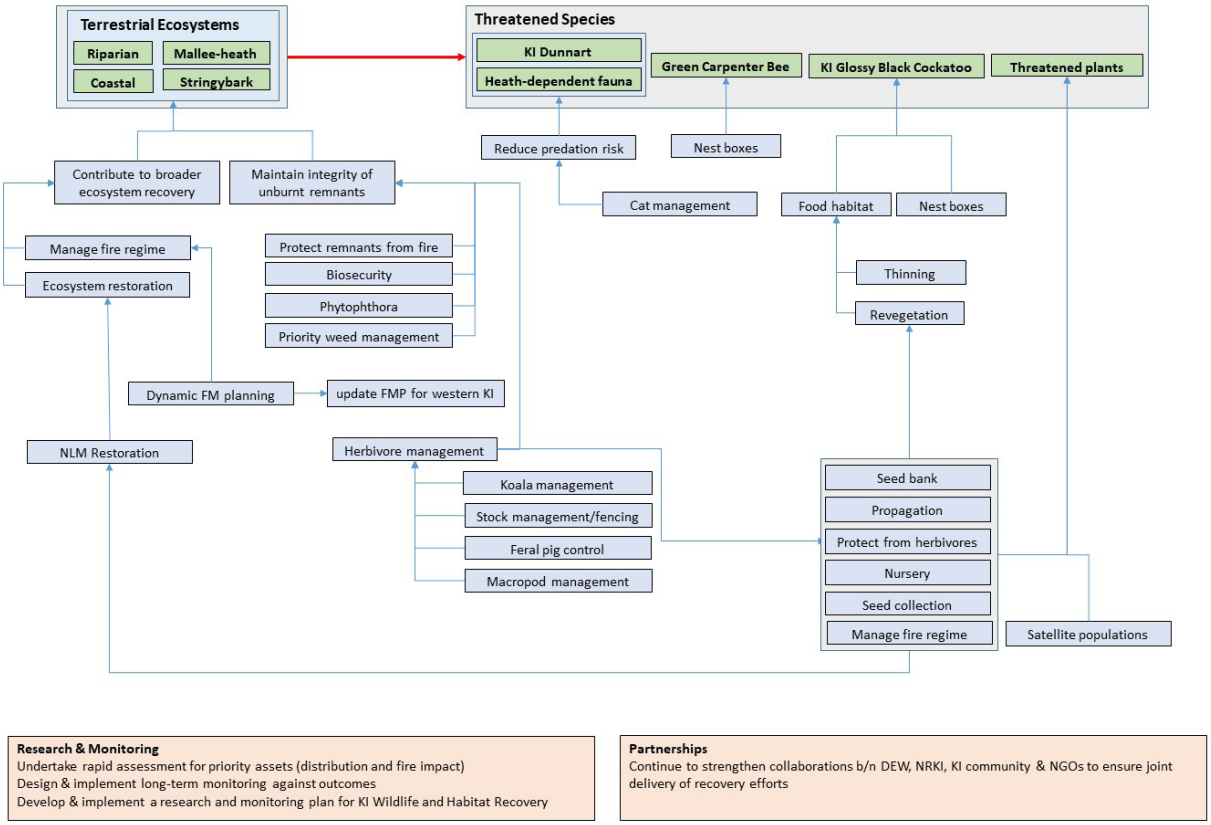


Figure 8. *A diagrammatic representation of the key recovery actions, and how they relate to the recovery of priority species and ecosystems, outlined in this report. For clarities sake, this is not comprehensive, but particularly focuses on those actions that benefit multiple species. "NLM restoration" – restoration of narrow-leaf mallee threatened ecological community; "dynamic FM planning" – dynamic fire management planning; "FMP" – fire management plan.*

Systemic, strategic and multi-species recovery actions

The strategic actions listed below, where implemented adequately, will provide significant benefit to remnant populations of priority flora and fauna, along with, in most cases, broader ecosystem benefits. By addressing the systemic issues that have impacted on the landscape, this ecosystem approach to recovery planning addresses many of the collective recovery needs of known species of concern. In particular, these actions will reduce the risk of extinction for priority threatened species. These include:

- Kangaroo Island Dunnart *Sminthopsis aitkeni*
- Kangaroo Island Echidna *Tachyglossus aculeatus multiaculeatus*
- Shrub-dependent threatened endemic birds:
    - Kangaroo Island Southern Emu-wren *Stipiturus malachurus halmaturinus*
    - Kangaroo Island Shy Hylacola *Hylacola cauta halmaturina*
    - Kangaroo Island Whipbird *Psophodes nigrogularis lashmari*
    - South-eastern Bassian Thrush *Zoothera lunulata halmaturina*[3]

[3] Bassian Thrush are more dependent on leaf litter than dense shrub cover; however it still requires some cover, and both cover and leaf litter have been similarly affected by these bushfires

- Threatened flora, including (but not limited to):
  - Kangaroo Island Ground-Berry *Acrotriche halmaturina*
  - Kangaroo Island Gland Flower *Adenanthos macropodianus*
  - Kangaroo Island Heath-myrtle Calytrix smeatoniana
  - De Mole River Correa Correa *calycina var. halmaturorum*
  - Kangaroo Island Dampiera *Dampiera lanceolata var. insularis*
  - Kangaroo Island Ash *Eucalyptus remota*
  - Rogers' Grevillea *Grevillea lavandulacea ssp. rogersii*
  - Kangaroo Island *Phebalium Leionema equestre*
  - Kangaroo Island *Logania Logania insularis*
- Threatened and endemic invertebrates:
  - Green Carpenter Bee *Xylocopa aeratus*
  - Enigma Moth *Aenigmatinea glatzella*
  - Assassin Spider *Zephyrarchaea austini*

Furthermore, we make the assumption that this approach to planning will also at least partly meet the recovery needs of other species dependent on these habitats, for which we have less knowledge.

The strategic actions described below will subsequently require an understanding of the known spatial distribution of priority species, and the distribution of the identified threats. This is currently being addressed for many species through rapid assessment; however important knowledge gaps exist, particularly for priority invertebrate species and plants.

Develop long-term, dynamic fire management planning for Kangaroo Island

The most fundamental impact of these wildfires on wildlife and habitat has been the scale of burnt habitat. Along with temporarily removing that area of habitat for dependent species, these wildfires have also "reset" large areas of native vegetation to a single fire-age. A future, long-term aim of fire management should be to support the development of a mosaic of fire ages and intensities across western Kangaroo Island. This will both ensure that suitably aged habitat for different species is always available somewhere in the landscape, but, where planned appropriately, will also minimise the risk of single, large-scale wildfires in the future.

This will be especially critical under future climates, where the likelihood of extreme fire conditions will increase.

While the implementation of strategic fire management across western Kangaroo Island is only to be initiated in 5-10 years, an opportunity exists to build the planning tools, and fire management capability on Kangaroo Island, to prepare for the implementation of this planning. This would require a multi-disciplinary approach, including land managers, ecologists and fire management professionals, with the support of the Kangaroo Island and broader conservation communities.

This requires the development of a multidisciplinary approach to dynamic fire management for western Kangaroo Island, that has the technical and human capability to be implemented over multiple decades.

Protect remnant, unburnt vegetation from fire and other impacts across Kangaroo Island

Both within the existing fire scar, and elsewhere on Kangaroo Island, significant remnant, unburnt patches of native habitat remain. These patches are critical refugia for threatened flora and fauna impacted by the fires, and their persistence is central to the recovery of their populations as fire-affected habitat recovers. Actions include:

- Identification of remnant patches that are occupied by priority flora and fauna species;
- Pro-active protection (through prescribed burns, fire breaks etc.) of these remnants
- Protection of unburnt native vegetation from illegal clearance
- Protection of unburnt and recovering native vegetation from Phytophthora cinnamoni dieback through hygiene protocols etc.

Note that targeted, well-designed prescribed ecological burns may also need to be undertaken in unburnt native vegetation elsewhere on Kangaroo Island, where fire has been excluded for too long to meet the habitat requirements of some species affected by the fires on western Kangaroo Island (e.g. Cape Gantheume). This requires further investigation to determine these requirements.

Manage the impacts of feral cats on remnant small vertebrate populations

While feral cat populations are likely to have been impacted by the wildfires, remaining cats have the potential to significantly impact on remnant small vertebrate populations remaining in unburnt vegetation. These include Kangaroo Island Dunnart, as well as a number of bird species (Kangaroo Island Southern Emu-wren, Kangaroo Island Whipbird, Bassian Thrush), Kangaroo Island Echidna, small mammals (e.g. Little Pygmy Possum, Swamp Rat, Bush Rat) and Rosenberg's Goanna. Actions within this strategy include:

- Identification of remnant patches that are occupied by priority flora and fauna species;
- Assess and reduce cat density within and in the vicinity of unburnt vegetation on western Kangaroo Island, through a combination of traps, Felixer devices, detector dogs, and baiting;
- Protect priority remnant vegetation from cat predation through the establishment of cat-proof reserves (using cat-proof fencing);
- Reduce the overall pressure of cat predation through the ongoing implementation of the Kangaroo Island Feral Cat Eradication Program

Manage the impacts of large herbivores on remnant, unburnt vegetation, and recovering vegetation

As with cats, populations of non-domestic herbivores have been reduced by wildfire. However remaining unburnt vegetation is potentially at risk of damage from surviving feral pigs and macropods. The surviving feral pig population in particular has concentrated within unburnt remnants on western Kangaroo Island , and there have been some observations of significant local impacts. These have the potential to impact on the small areas of remaining habitat where threatened species are persisting. Herbivory also has the potential to directly impact remaining populations of threatened flora species, including nationally-listed species (see list above). Herbivory has the potential to impact on remnant adult populations directly, but will also impact on recruitment, the latter which is particularly important as populations recover from the wildfires. On private land, there is also a need to reinstate fencing to prevent domestic stock (sheep) browsing in recovering and unburnt native vegetation.

Actions within this strategy include:

- Assessing and reducing the impacts of feral pigs (including potential eradication);
- Monitoring the impact of large native herbivores (Kangaroo Island Western Grey Kangaroo, Tammar Wallaby) on recovering vegetation, and designing appropriate interventions to reduce undesirable impacts;
- Fencing high quality unburnt remnants and recovering vegetation (where warranted) to reduce impact of large herbivores, and domestic stock in particular (on private land)

Design and implement integrated, multi-species recovery monitoring across Kangaroo Island

The intent is to:

- directly understand the response of species and ecosystems to the 2019-2020 Kangaroo Island wildfires (and the context of other variables such as spatial configuration of unburnt habitat, geography and historic fire regime);
- assess the effectiveness of recovery interventions (fire planning and management, vegetation protection, predator management etc.), and use this information to adapt recovery interventions appropriately;
- use this information to generate new interventions and design relevant, targeted research where ecological knowledge remains a barrier to recovery.

While integration of monitoring designs (particularly spatially) for different taxonomic groups is required, the design for different groups will be appropriate for that group or species (e.g. terrestrial birds, small mammals, different invertebrate groups etc.). These taxa-specific designs are already progressing with relevant expertise (e.g. Birdlife Australia for terrestrial birds). These designs will be undertaken in collaboration with research partners and non-government organisations, with details to be documented in a separate monitoring plan/s.

Restore Narrow-leaf Mallee shrubland ecosystems on eastern Kangaroo Island

Narrow-leaf mallee ecosystems, when restored, have the potential to contribute to habitat for some of those species dependent on western mallee-heath ecosystems, by providing analogous structural features (although the two systems are different in elements of their floristics and function). An opportunity potentially exists to increase the diversity and extent of these mallee shrubland habitats across Kangaroo Island , thereby increasing the resilience of species that depend on them. This would build on a recent legacy of research and management into the narrow-leaf mallee Threatened Ecological Community.

However, further research would be required to assess the value of these restored habitats for species that are otherwise currently only found in coastal and other mallee-heaths on western Kangaroo Island . Furthermore, community support may be relatively low in the immediate future, as narrow-leaf mallee restoration relies largely on reintroducing fire into existing remnants, along with herbivore management and revegetation.

Targeted Species-specific Actions

The actions described above are designed to address systemic risks to wildlife and habitat during the fire recovery period, and as described above, we assume these systemic actions will meet the majority of the recovery requirements for species that depend on these habitats. However, additional species-specific actions are also required, where these specific needs are not met by the systemic actions listed above. Additional actions, directed specifically toward some of these species where appropriate, are listed in the section following.

Kangaroo Island Glossy Black Cockatoo

The 2019-2020 Kangaroo Island wildfires on Kangaroo Island had a significant impact both on the specialised foraging habitat of Kangaroo Island Glossy Black Cockatoo, and known nesting hollows, with the western flocks of the subspecies being most significantly affected. Because of these specialized ecological requirements, many of the recovery actions required to conserve the subspecies on Kangaroo Island specifically target only Kangaroo Island glossy Black Cockatoo recovery. These actions build on the long-term recovery planning and implementation that has already been occurring. The Kangaroo Island Glossy Black Cockatoo Recovery Team will continue to adapt and refine these recovery actions as part of the broader recovery planning process.

Actions include:

- Undertake surveys of remaining Glossy Black Cockatoo populations to assess short- and medium-term recovery, breeding success, recruitment and post-fire habitat use
- Improve the distribution and quality of she-oak seed, through the protection and restoration of she-oak woodlands. This includes:
    - undertaking experimental thinning of recruits in she-oak woodlands recovering from fire;
    - undertaking targeted she-oak woodland revegetation;
    - protecting high quality remnant she-oak woodlands from fire;
    - protecting high quality remnant she-oak woodlands from herbivory;
    - investigating options for the development of climate-ready she-oak woodlands on Kangaroo Island
- Install artificial nest hollows in targeted areas (e.g. close to remnant or recovering foraging habitat

Green Carpenter Bee

Workshop participants in the Invertebrate group determined that the Green Carpenter Bee required specialised actions due it its specialised nesting habitat requirements. This is also partly driven by the relatively good ecological information available for this species (relative to other invertebrate species on Kangaroo Island). The priority actions for Green Carpenter Bee included:

- Undertake surveys of remnant Green Carpenter Bee populations
- Install artificial nest hollows in suitable areas

Threatened flora

A number of endemic flora species, including nationally threatened taxa, were impacted by the wildfires. In addition to the actions described at an ecosystem level, a number of additional actions were identified by the workshop participants that could additionally improve the persistence of these species:

- Maintain nursery capacity on Kangaroo Island (Kingscote and Cygnet Park nurseries)
- Undertake propagation trials for priority species
- Develop and/or contribute to a propagule bank for priority species
- Assess the potential for satellite populations of priority species in order spread the risk local extinction

Kangaroo Island Echidna

In addition to the priority actions described above at the ecosystem level (particularly regarding habitat recovery and reducing the impact of predation by cats), the workshop participants identified the management of vehicle strikes as an approach to improving the persistence of Kangaroo Island Echidna populations. Recommended approaches to vehicle strike management included the potential for speed limit management, particularly in high risk areas, and improving signage, education and engagement with visitors that encourage care with wildlife while driving.

Knowledge Gaps

In addition to identifying systemic and species-specific recovery interventions, the workshop was designed to identify and document important knowledge gaps, particularly where these uncertainties were seen as important barriers to managed recovery. In practice there will be overlap between the implementation of these research activities, and the integrated monitoring design documented above. As with the structure of recovery interventions above, these knowledge gaps have been grouped hierarchically, at ecosystem, taxonomic group, and species levels.

Note that knowledge gaps with an asterisk (*) were identified through follow up discussions after the workshop.

Ecosystems – Mallee-Heath

While a number of ecosystems were directly impacted by the wildfires, the majority of the area burnt was mallee-heath on sandy lateritic soils. Furthermore, many of the threatened and impacted species discussed here are at least partially dependent on this ecosystem. This was the focus of ecosystem-level discussions at the workshop. Knowledge gaps identified in this section typically cover ecosystem-level ecological questions, but also questions that relate to many of the flora and fauna species that depend on these ecosystems.

- Establishment of long-term experimental monitoring to determine the response of mallee-heath ecosystems to fire regime (frequency, time-since-fire, intensity and extent), from the perspective of structure, function and composition, and their relationship to the habitat requirements of dependent flora and fauna;
- Develop fire response models that support dynamic fire planning models, by incorporating response information into long-term fire planning, wildfire and prescribe burn implementation
- Develop scenario models that incorporate alternative fire management response strategies, along with the likely impacts of climate change on fire regime in western Kangaroo Island
- Improve understanding of historic fire regimes on Kangaroo Island, particularly prior to the 1950s, through a combination of written and oral historic records, charcoal and pollen analysis of core samples etc.
- Spatial modelling to identify where threat mitigation (predation, herbivory) should be prioritized
- Improve understanding of post-fire ecology of introduced (esp. pigs) and native herbivores to optimise strategies for managing the impact of herbivory on post-fire recovery
- Understand the spatial and temporal distribution of key food resources (in particular nectar resources), and identify potential gaps in resource availability, and opportunities to mitigate the impact of these gaps*
- Understand whether key components of the ecosystem have been disproportionately impacted (e.g. obligate seeding species, or particular structures such as nesting hollows), and the implications on broader ecosystem function, such as nectar availability for nectarivorous fauna*
- Understand the landscape role of Narrow-leaf mallee restoration in eastern Kangaroo Island , on heath-dependent species*
- Understand the impact of introduced plant species on flora and fauna, particularly on roadsides*

Taxonomic Groups – Birds

- Improved understanding of habitat requirements of priority species, and how these habitat features vary with fire regime
- Spatial ecology of heath-dependent species, including persistence of small populations and its relation to remnant size; reproductive capacity in small remnants; movement ecology and its relation to unburnt patch distribution and habitat recovery
- Improve understanding of impact of fire on food availability for honeyeaters*
- Improve understanding of the impact of cats on remnant bird populations

Taxonomic Groups - Threatened Plants

- Better understanding "optimum" fire management for threatened plant species and their habitats
- Improve understanding of fire response (seed survival, aerial and soil seed bank persistence, relationship between fire regime and seed bank development)*
- Improve understanding of the impact of herbivory on threatened species recovery*
- Understand current post-fire distribution, including historic (known) sites for species, complemented by additional survey in likely (but unsurveyed) habitat
- Fire recovery response of threatened species through stratified monitoring
- Improved taxonomic resolution of threatened taxa (and other, potentially unrecognised taxa, threatened by wildfire) through genetic and other approaches
- Improved understanding of propagation techniques for threatened species that are currently difficult to propagate
- Spatial modelling to identify opportunities for the establishment of new "insurance" populations of priority species*

Taxonomic Groups - Small mammals (ex. Kangaroo Island Dunnart)

- Response of cat populations and behaviour to fire (distribution, abundance, activity)
- Improved understanding of the impact of cats (and other predators) on small mammals in postfire landscape
- Improved understanding of postfire distribution and abundance of priority species
- Identification of ecological traps for cats in the postfire landscape to improve opportunities for management
- Improved understanding of habitat requirements of priority species, and how these habitat features vary with fire regime, including habitat requirements of microbats*
- Improved understanding of the impact of fire-related fragmentation on behaviour and demographics of priority species*

Taxonomic Groups - Reptiles and amphibians

- Improved understanding of the distribution and abundance of priority species
- Response of cat populations and behaviour to fire (distribution, abundance, activity)
- Improved understanding of the impact of cats (and other predators) on small mammals in postfire landscape
- Improved taxonomic resolution of threatened taxa (e.g. Pseudophryne bibronii) through genetic and other approaches

Taxonomic Groups – Invertebrates

- Improve understanding of distribution and abundance of all priority species, and their response to fire regime
- Improve understanding of relationships between invertebrate species and plant species (pollinators etc.)
- Improve understanding of habitat requirements of priority invertebrate species, and how these might change with fire regime and climate change
- Improve taxonomic understanding of invertebrates of Kangaroo Island, and use this to establish better understanding of taxonomic and threat status
- Improve understanding of use by Green Carpenter Bee of artificial next boxes

Priority Species - Kangaroo Island Glossy Black Cockatoo

- Improved understanding of the impact of the 19-20 fire on Kangaroo Island GBC populations (direct and indirect mortality, short-term (10 year) habitat distribution, distribution of breeding habitat and breeding events)
- Improve understanding of the impact of climate change on food tree (*A. verticillata*) distribution, demographics and seed production
- Improve understanding of the impact of extreme events (drought, fire) on food tree distribution, demographics and seed production
- Improve understanding of food tree and cone/seed production response to fire regime, particularly fire intensity
- Improve understanding of cone/seed production response to tree density, and particularly through revegetation density and thinning of postfire regeneration
- Improve understanding of response of Kangaroo Island GBC to fire, particularly with respect to movement and breeding success
- Improve understanding of post-fire impact of nest competitors and predators on breeding success
- Improve understanding of within-population genetics and implications for management
- Improve resolution of taxonomic status of subspecies, using genetic comparison with other subspecies
- Spatial optimisation modelling to inform post-fire sheoak revegetation*
- Understand variability in drought tolerance of *Allocasuarina verticillata* on and off the island, in case translocation later becomes necessary*

Priority Species – Kangaroo Island Echidna

- Impact of cats on Kangaroo Island Echidna, particularly in response to post-fire recovery
- Improve understanding of the impacts of vehicle collision on Kangaroo Island Echidna population
- Improve understanding of impact of fire on ant and termite colonies*

Priority Species – Kangaroo Island Dunnart

- Improve understanding of the post-fire extent, distribution and population size
- Impact of cats on Kangaroo Island Dunnart, particularly in response to post-fire recovery
- Improve understanding of habitat requirements, including structure, diet and food availability, and how these vary in response to post-fire recovery and fire regime
- Improve understanding of population structure, genetic fragmentation etc.:
  - are populations naturally fragmented by distance;
  - how mobile are dunnarts;
  - how has the fire impacted this population structure
- Predict impact of climate change in habitat availability

Many areas were severely burnt in the fires, with complete canopy scorch and removal of the ground layer. Though some habitat attributes will recover in the short-term (e.g. ground cover), others, like hollows, will take decades or even centuries to recover. Image: Libby Rumpff

Appendix One

Name	Organisation
David Ball	Kangaroo Island community member
Mike Barth	Natural Resources Kangaroo Island
Veronica Bates	Natural Resources Kangaroo Island
Karleah Berris	Natural Resources Kangaroo Island
Sally Box	Department of Agriculture, Water & Environment, Australian Government
Corey Bradshaw	Flinders University
Melissa Burford	Department for Environment & Water, SA Government
Sandy Carruthers	Department for Environment & Water, SA Government
Peter Copley	Department for Environment & Water, SA Government
Gabriel Crowley	University of Queensland
Chris Dickman	NESP Threatened Species Recovery Hub, University of Sydney
Steve Donnellan	South Australian Museum
Damon Ezis	Department for Environment & Water, SA Government
Jennie Fluin	Department for Environment & Water, SA Government
Jody Gates	Department for Environment & Water, SA Government
Richard Glatz	Kangaroo Island community member
Janice Goodwins	Department for Environment & Water, SA Government
Heidi Groffen	Land For Wildlife, Kangaroo Island
Peter Hammond	Kangaroo Island community member
Matt Heard	Department for Environment & Water, SA Government
Andrew Heinrich	Kangaroo Island Landscapes Board
Jason Higham	Department for Environment & Water, SA Government
Bob Hill	University of Adelaide
Pat Hodgens	Land for Wildlife, Kangaroo Island
Katja Hogendoorn	University of Adelaide
Rosemary Hohnen	NESP Threatened Species Recovery Hub, Charles Darwin University
Phillippa Holden	Natural Resources Kangaroo Island
Program Delivery North & West Section	Department of Agriculture, Water & Environment, Australian Government
Paul Jennings	Natural Resources Kangaroo Island
Luke Kelly	NESP Threatened Species Recovery Hub, University of Melbourne
Heinrich Klein	Department for Environment & Water, SA Government
Felicity-Ann Lewis	South Australian Wildlife & Habitat Recovery Taskforce
Lisien Loan	Department for Environment & Water, SA Government

Name	Organisation
Danny Male	Natural Resources Kangaroo Island
Jess Marsh	Kangaroo Island community member
Matthew Miles	Department for Environment & Water, SA Government
Liberty Olds	Zoos South Australia
Pip Masters	Kangaroo Island community member
Damien Miley	Natural Resources Kangaroo Island
Robyn Molsher	Natural Resources Adelaide & Mt Lofty Ranges
Trish Mooney	Natural Resources Kangaroo Island
David Paton	University of Adelaide
Thomas Prowse	University of Adelaide
Marilyn Remfree	University of Melbourne
Peggy Rismiller	Kangaroo Island community member
Tony Robinson	Kangaroo Island community member
Dan Rogers	Department for Environment & Water, SA Government
Libby Rumpff	NESP Threatened Species Recovery Hub, University of Melbourne
Vicki-Jo Russell	Trees for Life
Nirbeeja Saraswati	Kangaroo Island community member
Ian Sellar	Department for Environment & Water, SA Government
James Smith	Natural Resources Kangaroo Island
Richard Southgate	Kangaroo Island community member
David Taylor	Australian National University
Jasper Taylor	Kangaroo Island community member
Office of the Threatened Species Commissioner	Department of Agriculture, Water & Environment, Australian Government
Daniella Texieira	NESP Threatened Species Recovery Hub, University of Queensland
Janelle Thomas	Birdlife Australia
Jason van Weenen	Natural Resources Adelaide & Mt Lofty Ranges
Andrew West	Department for Environment & Water, SA Government
Brendan Wintle	NESP Threatened Species Recovery Hub, University of Melbourne
John Woinarski	NESP Threatened Species Recovery Hub, Charles Darwin University

Example questions for participants (from mammals spreadsheet)

1. Assets review

Questions	Activity for fauna groups: We want to know what your community looks like, what the critical habitat requirements are, and when these requirements are available post-fire? Later, we will get you to think of this at a landscape scale (i.e. in relation to how much habitat is left).
1	Describe your community - what are the different guilds? Is there a representative species for each guild? (i.e. if habitat requirements are met for this species, the rest of the guild is doing ok). If no, list up to 3 species
2	Looking to the future, what are the (3) critical habitat features required to ensure persistence of that guild on the island? Break into guild groups if you have to.
3	Imagine the typical burnt patch of habitat, when will these features be available (in months or years)? Then provide a range (next column), accounting for severity

2. Condition of assets

Questions	Activity for fauna groups: We want to get a sense of how vulnerable the key species are, 10 years into the future.
1	What is the state threat status (pre-fire) for this species?
2	Provide an estimate of population size (numbers of individuals) pre-fire, as a range.
3	What % of habitat was burnt in the fires? (<10%, 10-30%, 30-50%, 50-80%, >80%).
4	What % of habitat was severely burnt in the fires? (<10%, 10-30%, 30-50%, 50-80%, >80%).
5	Does the species have traits that make it more vulnerable to fire? If yes, list top 3. If disagreement, note varying traits. See worksheet
6	Looking 10 years into the future, how much do you think the size of the population will change across the island, **with status quo management**. Use categories below, indicating best guess, and category range in brackets to capture uncertainty.

3. Hazard assessment

1	List and rank up to 6 key specific threats e.g. lack of breeding sites, lack of food, predation by cats, herbivory by deer, repeat high intensity fires, intense drought etc. Are these immediate, short-term, medium term or long-term threats?
2	For key threats, what ex-situ and in-situ actions (**maximum 6**, see examples below) would you implement in 10 years (think about how long and where)? Specify cost category for each
3	For top 6 actions, please discuss in your group how you would implement (e.g. spatial scale, intensity, duration). Take some notes here if you like

4. Actions assessment

1. Looking 10 years into the future, how much do you think the species/population/ecosystem will change across the island, under each action. Use categories below, indicate best guess and uncertainty.

		From Ex 2: Consequences _ no action (% change)			Consequences _ action implemented (% change)		
Action	Feasibility within 10 years (%)	Lower bound	Upper bound	Best estimate	Lower bound	Upper bound	Best estimate
A1							
A2							
A3							
A4							
A5							
A6							

% CHANGE

For species: % change in population size

For ecosystems: % change in distribution of the system

Category -	& Population decline	Category +	& Popuplation increase
0	No change from current population size (or no populations)		
-1	<2%	1	<2%
-2	2-5%	2	2-5%
-3	5-10%	3	5-10%
-4	10-20%	4	10-20%
-5	20-30%	5	20-30%
-6	30-40%	6	30-40%
-7	40-50%	7	40-50%
-8	50-70%	8	50-70%
-9	70-90%	9	70-90%
-10	>90%	10	>90%
-11	Species/community/ecosystem no longer in the wild on KI		

FEASIBILITY

Over the planned timeframe for response it's realistic to anticipate...

A full (100%) implementation

B 80 - 99% implementation

C 60 - 79 implementation

D 40 – 59% implementation

E 20 – 39% implementation

F < 20% implementation

5. Strategy development

1	Develop a 3-action strategy. For each action selected as part of the strategy, please provide (a) a brief description of its implementation (e.g. spatial scale, intensity, duration, location), and (b) Effort (specify proportion of 100)
2	Looking 10 years into the future, how much do you think the species/population/ecosystem will change across the island, under this strategy. a. For species: % change in population size = b. For ecosystems: % change in distribution of the system =
3	What is the % chance this strategy will be implemented? Indicate score (A-F)
4.	Develop a 6-action strategy. For each action selected as part of the strategy, please provide (a) a brief description of its implementation (e.g. spatial scale, intensity, duration, location), and (b) Effort (specify proportion of 100)
5.	Looking 10 years into the future, how much do you think the species/population/ecosystem will change across the island, under this strategy. a. For species: % change in population size = b. For ecosystems: % change in distribution of the system =
6.	What is the % chance this strategy will be implemented? Indicate score (A-F).

6. Uncertainty

Discuss the key reasons for uncertainty. Is this implementation uncertainty or effectiveness uncertainty? What's the relevant research question?

Workshop participants visit the Western River Refuge, a feral predator-free exclosure constructed shortly after the fires, to support threatened species such as the Kangaroo Island Dunnart. Image: Dan Rogers

Appendix Two

Threat and action categories

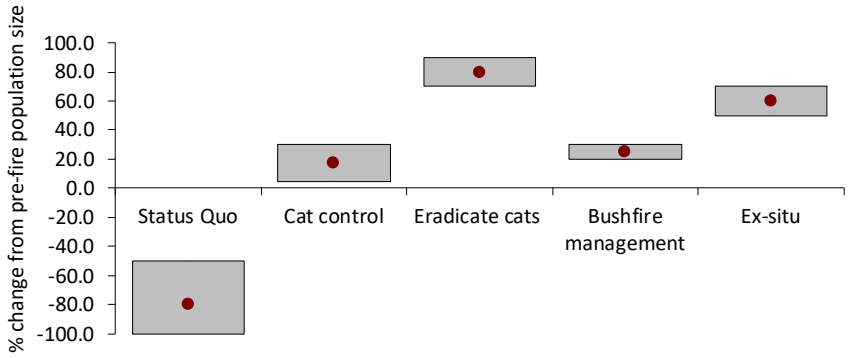
Category	Threat
Fire regime	High intensity fire Large fire Multiple fires Fire near assets
Drought	
Predator_cat	Cats
Predator_others	Possums Goannas
Competitor_pig	Modification of habitat (feral pig) Over-grazing
Competitor_honeybee	Swarming
Livestock	Stock from private land straying into protected area Grazing pressure
Competitor_others	Competitor_others Koalas: over-grazing
Phytophthora	
Weed incursion	
Food shortage	Loss of food source from fire Food shortage due to drought Food shortage due to land clearance
Habitat (loss and fragmentation)	Land clearing Roadside vegetation clearance Community backlash against native vegetation Soil erosion Seed bank loss Poor recovery of pollinator Loss of connecting habitat
Knowledge gap	Poor understanding of species or ecosystem processes
Climate change	
Vehicle	Increase in collision rate
Funding	Lack of funding
Poor policy	Single-species conservation Lack of compliance with policy (unspecified)
Vulnerability	Traits conferring higher vulnerability, including low fecundity, high age of maturity Low genetic diversity
Disease	
Nest shortage	Possums: compete for nest boxes Shortage of termite mound nest sites
Bushfire management	Develop fire management plan Fuel reduction Fire prevention Fire response (incl building capacity for response)

Category	Threat
Prescribed burns	Burn for heterogeneity Reduce planned burn near assets
Short-term monitoring	Rapid survey post-fire
Long-term monitoring	
Predator control_cat	Cat control
Predator control_others	Possums
Competitor control_pig	
Competitor control_others	Possum guard Koala population control Honeybee control
Protection/exclusion	Grazer exclusion Fencing private property and NP boundary to control stock movement Prevent further clearing, especially of old remnant veg Maintain habitat quality Prevent erosion
Weed control	Identify high priority area Weed removal Post-fire bushcare and weed management
Revegetation/restoration	Revegetation and restoration of recently burnt or highly degraded sites Revegetation in corridors
Refuge	refuge
Rescue	Translocation if population is too low Translocation to unburnt site Ex-situ breeding/insurance population Ex-situ seed collection and propagation trial
Rood	Revegetate to create food source Let natural regeneration occur Supplementary feeding
Phytophthera control	Hygiene protocol Restriction to access Map phytophthera distribution
Nest	Provide nest boxes Protect existing nest from predation Place substrate in bee nesting habitat
Traffic control	Reduce speed limit Increase signage
Community	Community engagement Increase transparency
Policy change	
Research	Research into reproductive biology Research into population size and dynamic Research into animal behaviour

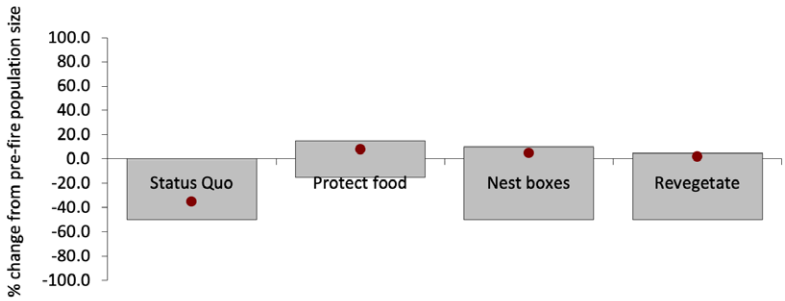
Table summaries

The following section of this report provides a detailed summary of the structured discussion that occurred within each workshop group. This was the information from which the summaries presented above were drawn, but provide additional, specific information that provides more context and detail as required.

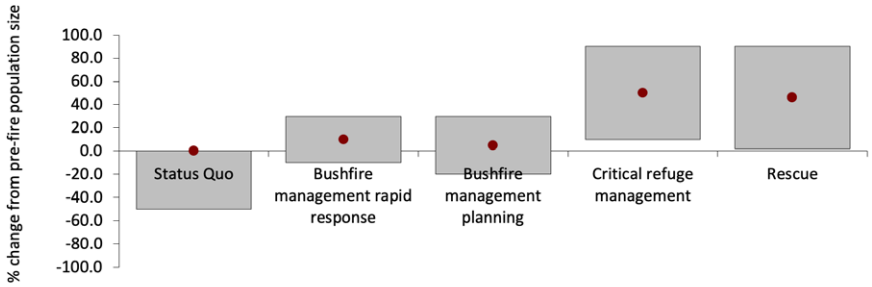
Kangaroo Island Dunnart (*Sminthopsis aitkeni*)

<table>
<tr><th>Steps</th><th>Estimates</th></tr>
<tr><td>Step 1.
Critical habitat features</td><td>
<table>
<tr><th></th><th>Feature</th><th>Time to recovery (range)</th></tr>
<tr><td>1</td><td>Habitat structure/shelter (Vegetation age)</td><td>20 years (0-40)</td></tr>
<tr><td>2</td><td>High Rainfall</td><td></td></tr>
<tr><td>3</td><td>Density of invertebrates (Food)</td><td></td></tr>
</table>
</td></tr>
<tr><td rowspan="4">Step 2.
Vulnerability</td><td>Threat status:
1. En (EPBC),
2. Cr (IUCN),
3. NPPW (SA)</td></tr>
<tr><td>Habitat burnt: >80%</td></tr>
<tr><td>Habitat severely burnt: >80%</td></tr>
<tr><td>Traits that make species more susceptible to fire:
1. Ability to flee fire,
2. Susceptibility to predators,
3. Lack of shelter</td></tr>
<tr><td>Step 3
Hazard assessment</td><td>1. Large scale bushfire
2. Predation - Cats and Natives
3. Climate Change
4. Phytophthora
5. Population Fragmentation
6. Land Clearance</td></tr>
<tr><td>Step 4
Key Actions (feasibility, $)</td><td>1. Control of cats
2. Eradicate cats from western Kangaroo Island
3. Create fire-age-class mosaic in western Kangaroo Island (Bushfire management)
4. Ex-situ/insurance population
5. Implement Monitoring program
6. Habitat Protection - control of Phythophthera</td></tr>
<tr><td>Step 5
Estimated consequences of key actions</td><td>Estimate of population pre-fire: 500-1000 individuals
 
</td></tr>
<tr><td>Step 6.
Uncertainty and research</td><td>Key Uncertainty and Research
Population Distribution and Size: What is the extent/distribution of the population post fire?
What is the susceptibility to predators and other threats (Toxo, Pc)
Habitat requirements (structure, prey): What is 'good dunnart habitat'?
Life History / Reproduction: Reproduction, Home range size, Movement patterns etc
Genetic diversity across Kangaroo Island: How fragmented are the populations, separation from other species?</td></tr>
</table>

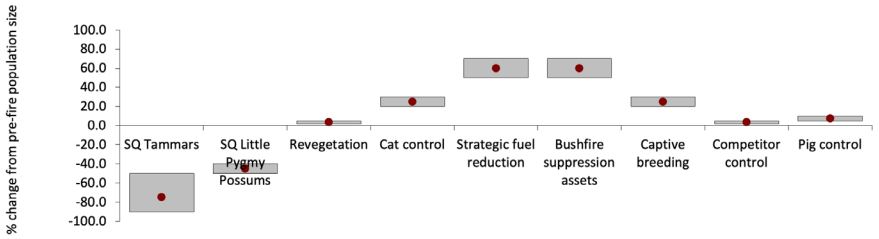
Kangaroo Island Glossy Black Cockatoo (*Calyptorhynchus lathami halmaturinus*)

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 High quality drooping sheoak feeding habitat) — 10-20 years 2 Nesting habitat in close proximity to sheoak and protected from possums — Up to hundreds of years 3 Available water
Step 2. **Vulnerability**	Threat status: En (EPBC), N/A (IUCN), En (NPWA SA)
	Habitat burnt: 50-80%
	Habitat severely burnt: 50-80%
	Traits that make species more susceptible to fire: Diet specialisation Susceptibility to predators at nest, Postfire age specificity
Step 3 **Hazard assessment**	1. Lack of food 2. Lack of (and competition for) suitable nesting hollows 3. Nest predation by possums 4. Multiple high intensity fires 5. Disease 6. Reduced genetic diversity 7. Lack of funding
Step 4 **Key Actions**	1. Revegetation at priority sites 2. Install nest boxes, and control competition by invasive species 3. Protect individual nest trees from possums 4. Identify and protect remaining foraging habitat from fire 5. Create insurance population against disease risk
Step 5 **Estimated consequences of key actions**	Estimate of population pre-fire: possibly 400 individuals 
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Impact of the 19-20 fire on populations (direct and indirect mortality, short-term (10 year) habitat distribution, distribution of breeding habitat and breeding events) - Impact of climate change on food tree (*A. verticillata*) distribution, demographics and seed production - Impact of extreme events (drought, fire) on food tree distribution, demographics and seed production - Food tree and cone/seed production response to fire regime, particularly fire intensity - Cone/seed production response to tree density, and particularly through revegetation density and thinning of postfire regeneration - Improve understanding of Movement and breeding response to fire - Post-fire impact of nest competitors and predators on breeding success - Within-population genetics and implications for management, and taxonomic status

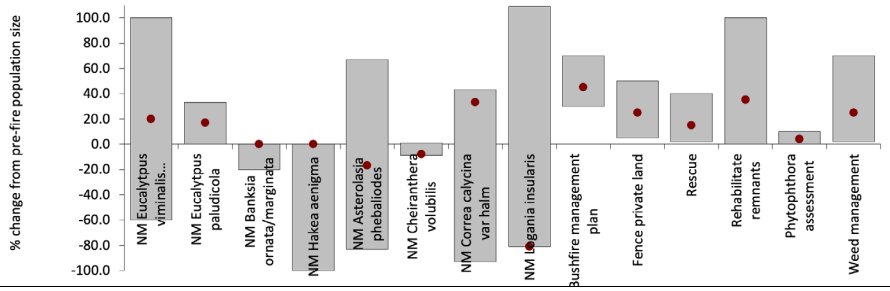
Birds (ex. Kangaroo Island Glossy Black Cockatoo)

<table>
<tr><th>Steps</th><th>Estimates</th></tr>
<tr><td>Step 1.
Critical habitat features</td><td>
<table>
<tr><th></th><th>Feature</th><th>Time to recovery (range)</th></tr>
<tr><td>1</td><td>Intact shrubland</td><td>5-15 years</td></tr>
<tr><td>2</td><td>Food (nectar)</td><td>5-20 years</td></tr>
<tr><td>3</td><td>Food (seed)</td><td>6 months – 10 years</td></tr>
<tr><td>4</td><td>Leaf litter</td><td>20-30 years</td></tr>
</table>
</td></tr>
<tr><td rowspan="4">Step 2.
Vulnerability</td><td></td></tr>
<tr><td>Habitat burnt: 70-90%</td></tr>
<tr><td>Habitat severely burnt: 70-90%</td></tr>
<tr><td>Traits that make species more susceptible to fire:
Small home ranges, limited dispersal, small populations, suitable habitat can take years-decades to recover</td></tr>
<tr><td>Step 3
Hazard assessment</td><td>1. Wildfire – small area unburnt
2. Wildfire – repeat burnt areas
3. Postfire predation (e.g. cats)
4. Lack of monitoring/learning
5. Inadequate resources/capacity to respond
6. Drought
7. Poor recovery of food (insects, nectar)</td></tr>
<tr><td>Step 4
Key Actions</td><td>6. Protect critical unburnt areas from fire in the near- mid-term
7. Implement strategic predator management
8. Design and implement long-term monitoring
9. Develop plans to secure and increase funding
10. Monitor food availability
11. Translocation if required (within fire ground and from unburnt areas on KI)</td></tr>
<tr><td>Step 5
Estimated 35consequence of key actions</td><td> 
</td></tr>
<tr><td>Step 6.
Uncertainty and research</td><td>Key Uncertainty and Research
- Improve understanding of habitat features and how their relationship to fire regime
- Understand population demography in relation to configuration of unburnt patches
- Improve understanding of the impact of cats on birds in unburnt remnants
- Test relationship between fire management and suitable fire regimes in space and time
- Improve understanding of climate impacts on fire regime and habitat suitability</td></tr>
</table>

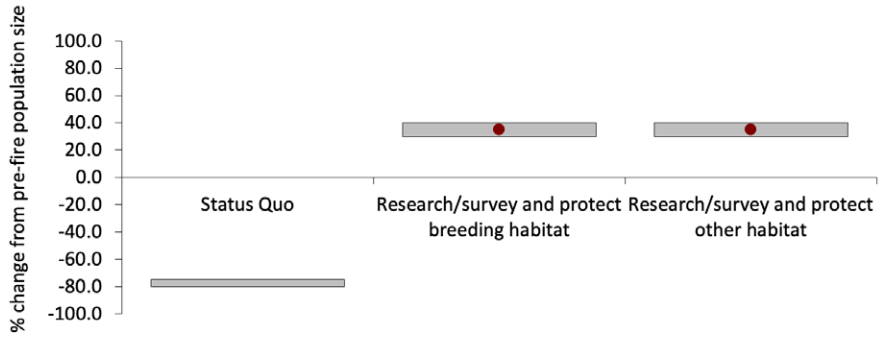
Small mammals (ex. Kangaroo Island Dunnart)

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Macropods – dense vegetation adjacent to pasture — 6 months – 5 years 2 Bandicoots – structural complexity, dense shrub layer — 2-5 years (fungi will be available within months) 3 Pygmy Possum – All-year nectar resources — 2-5 years
Step 2. **Vulnerability**	
	Habitat burnt: 50-80%
	Habitat severely burnt: 50-80%
	Traits that make species more susceptible to fire: Loss of structural features (bandicoots, pygmy possums) Risk of cat predation (bandicoots, pygmy possums)
Step 3 **Hazard assessment**	1. Predation (bandicoots, pygmy possums) 2. Increase in fire frequency (bandicoots, pygmy possums) 3. Vegetation clearance 4. *P. cinnamoni* 5. Lack of knowledge
Step 4 **Key Actions**	12. Strategic management of predation risk (cats) 13. Strategic fire management and protection of remnants from fire in short term 14. Prevent clearance of native vegetation, including compliance 15. Enable *P. cinnamoni* hygiene 16. Improve monitoring and research
Step 5 **Estimated consequences of key actions**	Estimate of population pre-fire: ~2,500 (Little Pygmy Possum); ~25,000 (bandicoot); ~200,000 (Tammar Wallaby) 
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of distribution and abundance - Improve understanding of relationship between habitat and fire regime - Improve understanding of impact of climate change - Improve understanding of impact of cat predation in burnt landscape - Improve understanding of cat management

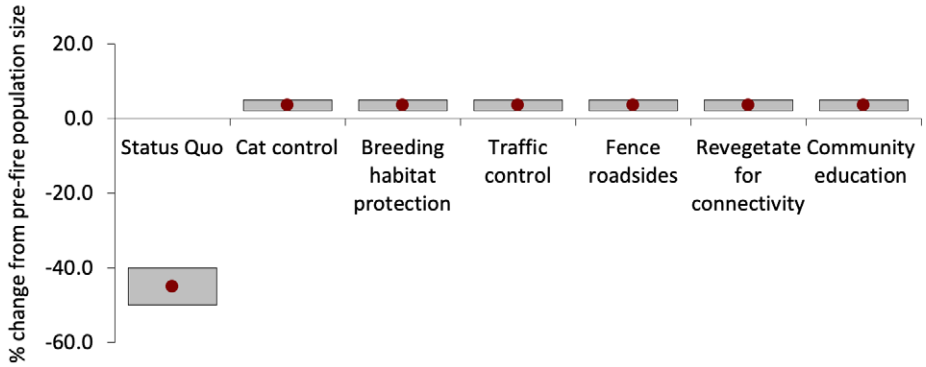
Plant species

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Eucalypt spp. — 10-15 years 2 Banksia spp. — 15-30 years (min) 3 Seedbank dependent shrubs — 15 years (min)
Step 2. **Vulnerability**	Species range from not listed, through VU (EPBC) to EN (EPBC)
	Habitat severely burnt: 45% to 100% (*Logania insularis*)
	Traits that make species more susceptible to fire: Limited range (*Correa calycina*) Aerial seedbank (*Eucalyptus viminalis*) Fire frequency prevents development of seedbank (e.g. *Banksia* spp)
Step 3 **Hazard assessment**	1. Fire frequency 2. Browsing by overabundant herbivores 3. Prolonged drought 4. *P. cinnamoni* 5. Weed incursion 6. Roadside vegetation management (incl. clearance)
Step 4 **Key Actions**	1. Rehabilitation of roadside vegetation post-chaining 2. Restore fencing of native vegetation on private land (stock protection) 3. Ex situ conservation (seed orchards, translocation, seed banks) 4. Enable *P. cinnamoni* assessment and hygiene 5. Weed management and bushcare 6. Strategic fire management 7. Koala management to reduce overbrowsing (*Eucalyptus* spp)
Step 5 **Estimated consequences of key actions**	
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of propagation and ex situ conservation for many species - Improve understanding of optimal fire management for species' habitat - Improve understanding of distribution and abundance postfire - Improve understanding of population genetics and taxonomic status

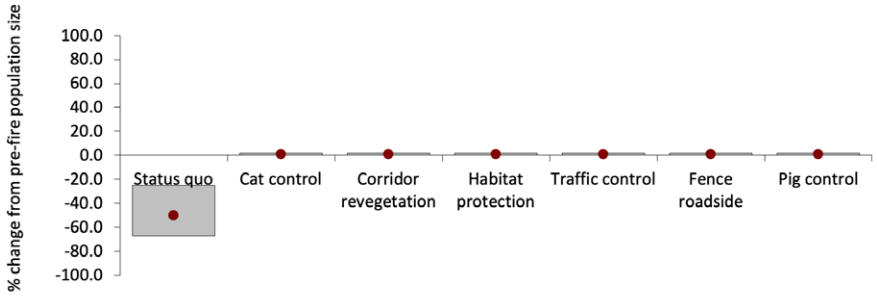
Bibron's Toadlet

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Swamps and wetlands — Months – post winter 2 Damp low vegetation — Months – post winter
Step 2. **Vulnerability**	Data deficient
	Habitat burnt: 50-80%
	Habitat severely burnt: 50-80%
	Traits that make species more susceptible to fire: Potential loss of non-breeding habitat Sensitivity to water quality Timing of breeding relative to fire (Autumn-Winter)
Step 3 **Hazard assessment**	1. Fire frequency 2. Vegetation clearance 3. Prolonged drought
Step 4 **Key Actions**	8. Identification and protection of breeding habitat 9. Protection of non-breeding habitat 10. Undertake surveys of breeding habitat
Step 5 **Estimated consequences of key actions**	
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of taxonomic status of KI population - Improve understanding of habitat requirements in relation to fire regime - Improve understanding of distribution and abundance, including breeding and non-breeding habitats

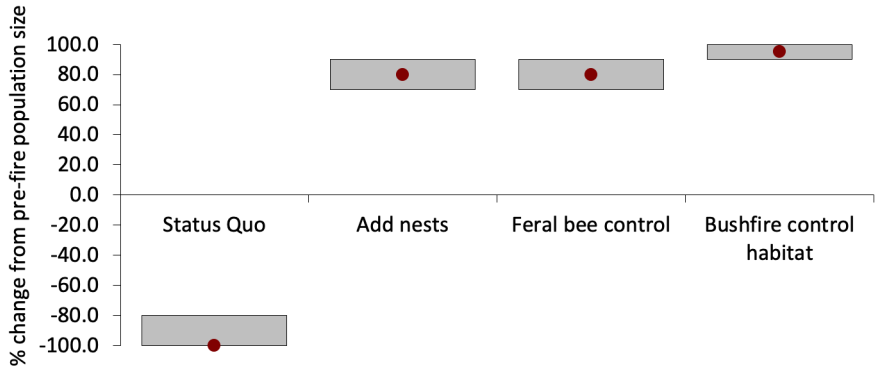
Rosenberg's Goanna

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Termite mounds — Immediate
Step 2. **Vulnerability**	VU (NPWA)
	Habitat burnt: 50%
	Habitat severely burnt: 50-80%
	Traits that make species more susceptible to fire: Loss of termite mounds for nesting Potential loss of food resources Increase risk of predation
Step 3 **Hazard assessment**	1. Lack of food (post removal of carcasses as a direct result of fire) 2. Predation by cats 3. Roadkill 4. Increased habitat fragmentation 5. Shortage of nest sites
Step 4 **Key Actions**	11. Strategic management of cats (focus on western KI) 12. Reduce roadkill risks (speed limits, signage) 13. Revegetation and roadside vegetation protection
Step 5 **Estimated consequences of key actions**	
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of effectiveness of traffic management in reducing roadkill - Improve understanding of direct and indirect impact of cats

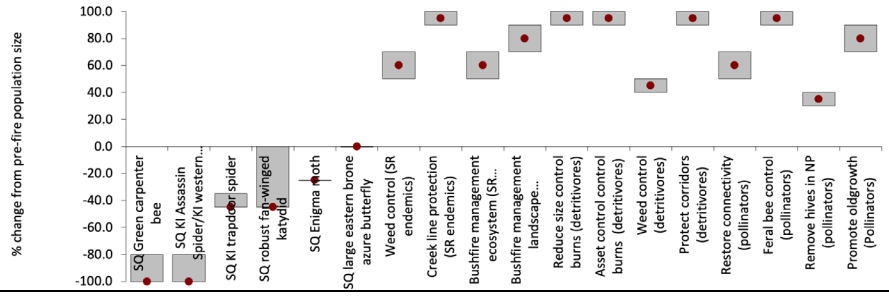
Kangaroo Island Echidna

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Invertebrate populations — Immediate, but will change through time 2 Roadside vegetation — Immediate – 6 months 3 Remnant vegetation — Immediate
Step 2. **Vulnerability**	EN (EPBC)
	Habitat burnt: 50%
	Habitat severely burnt: 50-80%
	Traits that make species more susceptible to fire: Loss of food resources Slow reproductive rate (slow replacement of adults that died in fire) Increase risk of predation
Step 3 **Hazard assessment**	1. Habitat fragmentation 2. Predation by cats 3. Roadkill 4. Loss of food resources
Step 4 **Key Actions**	1. Strategic management of cats (focus on western KI) 2. Reduce roadkill risks (speed limits, signage) 3. Revegetation and roadside vegetation protection 4. Strategic management of feral pigs
Step 5 **Estimated consequences of key actions**	Estimated pre-fire population size 4,000-6,000 
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of effectiveness of traffic management in reducing roadkill - Improve understanding of direct and indirect impact of cats and cat management effectiveness

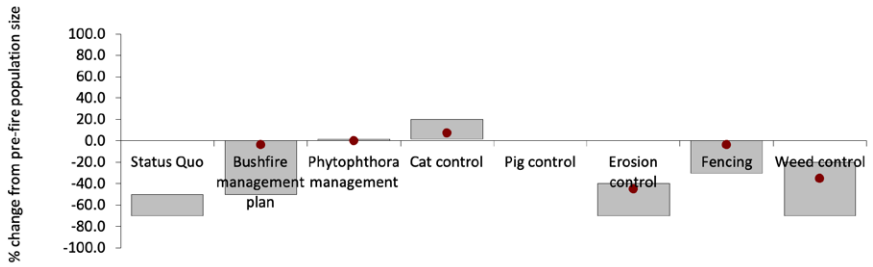
Green Carpenter Bee

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Year-round flowering resources — Unknown 2 Nesting habitat — 30-50 years
Step 2. **Vulnerability**	Not listed (but possibly EN)
	Habitat burnt: >90%
	Habitat severely burnt: >90%
	Traits that make species more susceptible to fire: Nest sites require long recovery time Requirement for year-round floral resources
Step 3 **Hazard assessment**	1. Habitat fragmentation 2. Invasive honeybees 3. Increase fire frequency 4. Lack of knowledge 5. Climate change 6. Poor government policy
Step 4 **Key Actions**	5. Targeted revegetation, and artificial nests 6. Management of feral honeybees 7. Avoid honeybees in national parks 8. Strategic fire management
Step 5 **Estimated consequences of key actions**	Estimated pre-fire population size 1,000 
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of distribution and abundance - Improve understanding of impact of fragmentation on populations and individual movements - Improve understanding of direct and indirect effects of honeybees on food competition - Improve understanding of taxonomic status - Improve understanding of relationship between climate change and fire regime

Kangaroo Island endemic invertebrates (ex. Green Carpenter Bee)

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Specialised habitat features — 30 years
Step 2. **Vulnerability**	
	Habitat burnt: 10-30% (enigma moth) to >80% (KI Assassin Spider)
	Habitat severely burnt: 10-30% (enigma moth) to >80% (KI Assassin Spider)
	Traits that make species more susceptible to fire: Typically very restricted distribution Typically very specialised habitat requirements Typically very poor dispersal
Step 3 **Hazard assessment**	1. Habitat fragmentation 2. Increase fire frequency 3. Increase in invasive weeds 4. Lack of knowledge 5. Climate change 6. Increased risk of community demands for vegetation removal
Step 4 **Key Actions**	9. Manage environmental weeds 10. Strategic fire management 11. Protect unburnt and other remnant vegetation 12. Improve monitoring and research
Step 5 **Estimated consequences of key actions**	
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of distribution and abundance - Improve understanding of species' ecology and habitat requirements

Mallee-heath ecosystem

Steps	Estimates
Step 1. **Critical habitat features**	**Feature** — **Time to recovery (range)** 1 Key habitat features may be impacted by changes in fire regime — 24 (20-50) years
Step 2. **Vulnerability**	
	Habitat that remains in "good state" post-fire: 10-30%
	Traits that make species more susceptible to fire: May be structural and composition changes postfire in areas that were also burnt in 2007
Step 3 **Hazard assessment**	1. Fire regime 2. *P. cinnamoni* 3. Feral animals 4. Loss of seed banks 5. Soil erosion 6. Overgrazing 7. Weeds
Step 4 **Key Actions**	1. Strategic fire management 2. P. cinnamon hygiene 3. Reduce erosion risk (drift fencing) 4. Feral animal management 5. Weed management 6. Reduce stock movement through fencing
Step 5 **Estimated consequences of key actions**	
Step 6. **Uncertainty and research**	**Key Uncertainty and Research** - Improve understanding of ecosystem responses to fire regime - Scenario modelling of alternative fire regimes and their implications for ecosystem - Improve understanding of past fire regimes - Improve understanding of impact of herbivores

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

This project is supported through funding from the
Australian Government's National Environmental Science Program.

Threatened Species Recovery Hub

National Environmental Science Programme