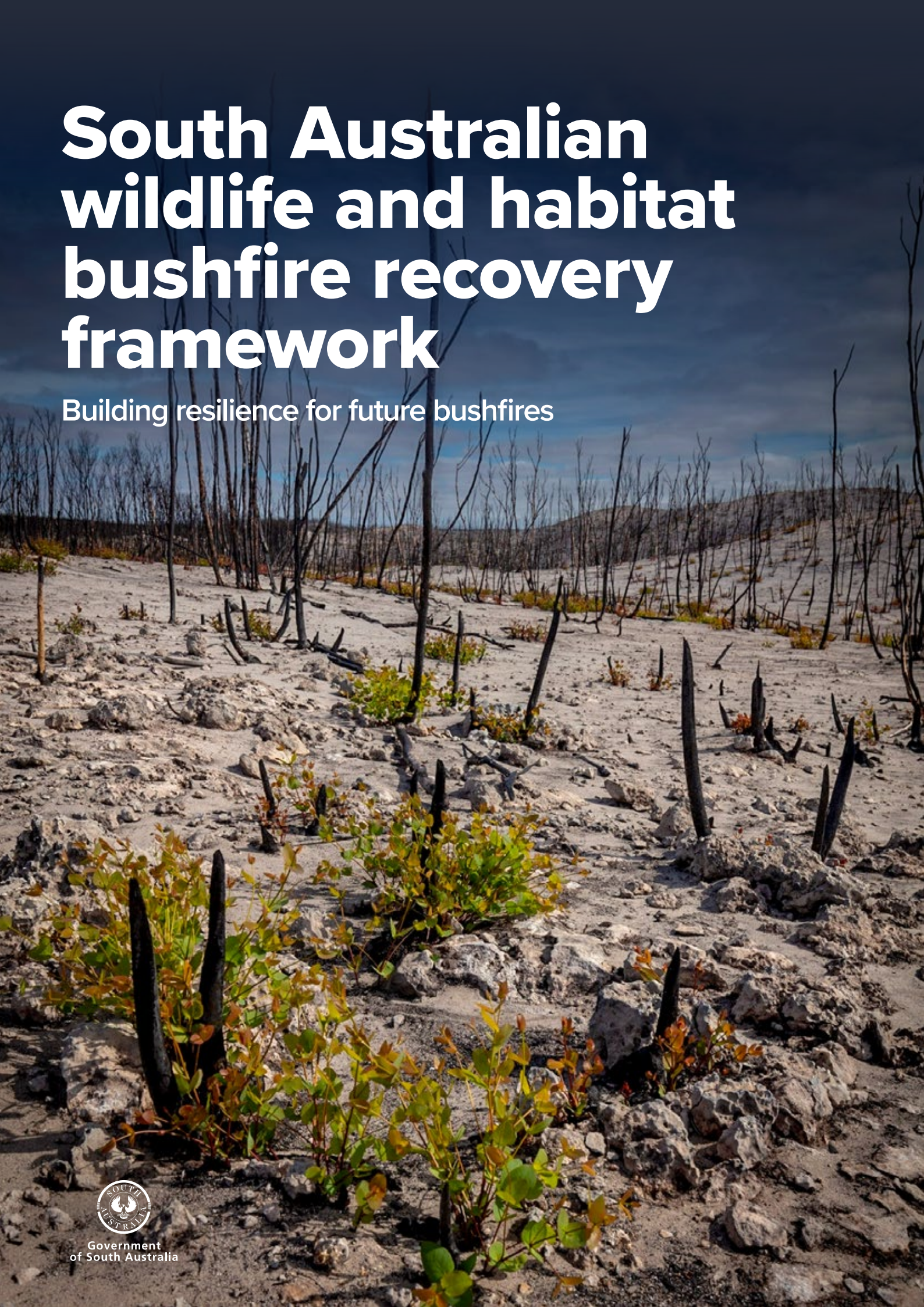
South Australian wildlife and habitat bushfire recovery framework

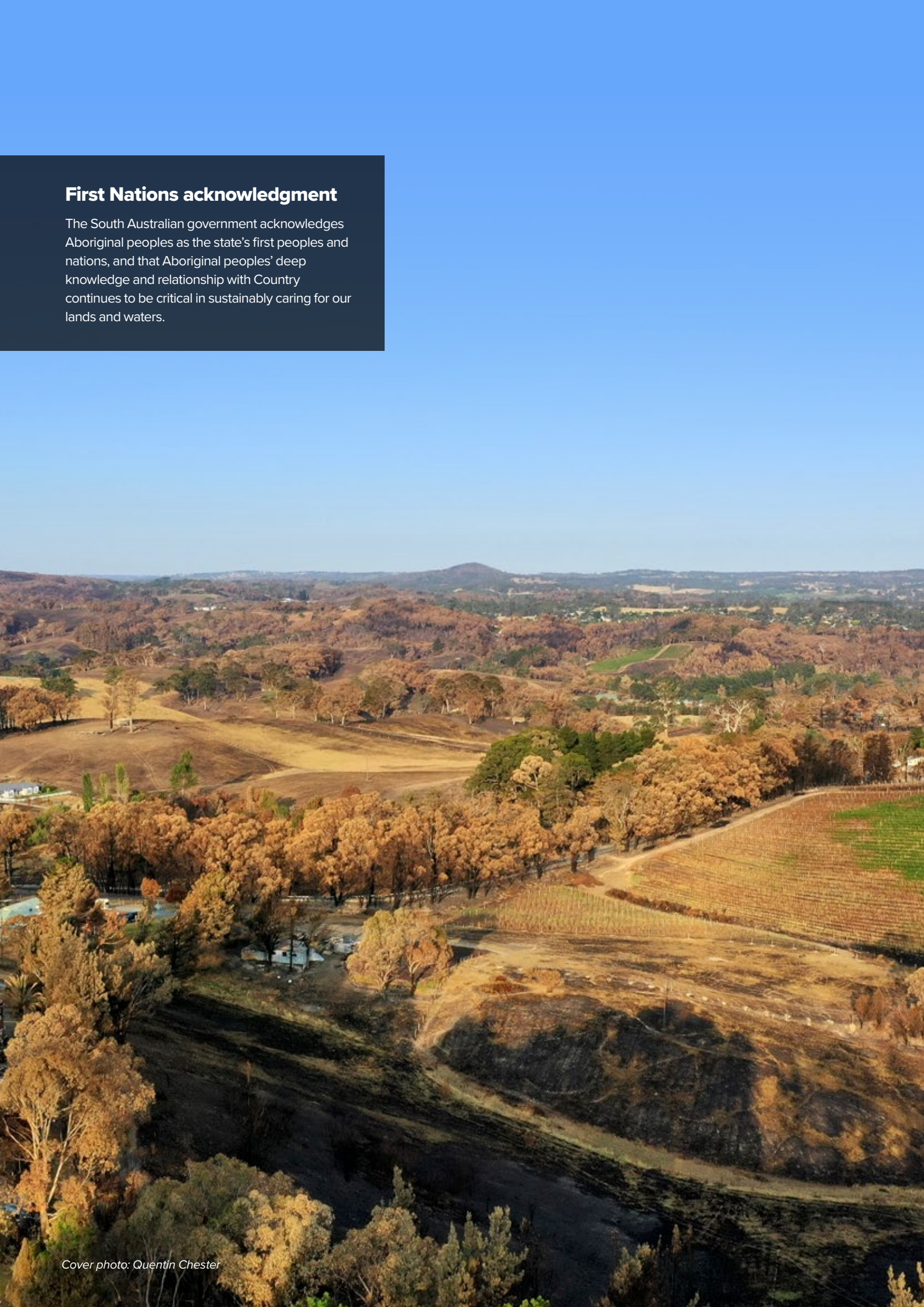
Building resilience for future bushfires



Government of South Australia

First Nations acknowledgment

The South Australian government acknowledges Aboriginal peoples as the state's first peoples and nations, and that Aboriginal peoples' deep knowledge and relationship with Country continues to be critical in sustainably caring for our lands and waters.



Cover photo: Quentin Chester

Minister's foreword

On the 5th of January 2020, I stood with Premier Steven Marshall and Deputy Premier Vickie Chapman on a roadside in the middle of Kangaroo Island. For as far as the eye could see, in every direction, the landscape was charred black. Still smouldering. Everywhere I looked I saw death and I will never forget the sight of a blackened koala sitting in the fork of a tree, one of tens of thousands of animals to die on the island that week.

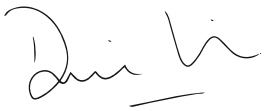
That was my first of seven trips to Kangaroo Island in 2020 and I made as many to the Adelaide Hills, the sites of South Australia's most devastating bushfires for a generation. The destruction was unimaginable, lives were lost and hundreds of homes and livelihoods destroyed.

Our tourism and agricultural sectors felt drastic impacts of the summer bushfires with huge numbers of livestock killed, thousands of bookings cancelled and a landscape left fire ravaged. These sectors are underpinned by diverse and healthy natural environments, but increasing pressures on ecosystems from a changing climate and worsening fires is undermining their resilience. By getting actively involved in the management of our environment, we can underpin the sustainability of these vital sectors.

As South Australia's Minister responsible for the conservation of our native flora and fauna, it was quickly apparent to me that we needed a very specific response to how we supported the post-bushfire environmental recovery. As a state we have been fortunate to receive generous financial support from the Federal Government, but this funding had to be specifically and strategically directed, ensuring that it supported scientifically-verified priorities, leveraged private and NGO investment and achieved practical outcomes on the ground – always my number one priority.

To guide this work I established the Wildlife and Habitat Recovery Taskforce chaired by Dr Felicity-Ann Lewis. I am delighted at how quickly Felicity and her diverse team deployed their knowledge, skills and networks to support the work of the Department for Environment and Water. The framework sets out a clear direction as to how government, the NGO sector and the community must work together to respond to the fires, outlining a range of actions, from immediate to long term. This is not a document to sit on a shelf, it's one to refer to continually over the coming months and years as we guide this recovery, and it's a document to refer to in the future when we will inevitably experience the destruction of bushfires again.

Australia's landscape is used to fire. It's part of our heritage and part of our ecology, but in a world where temperatures are increasing and where our precious wildlife and habitat is fragmented and in decline, fires are having a disproportionate impact and this puts our natural world under incredible pressure. I have every confidence that our landscape can and will recover, but it will need a helping hand along the way. This framework maps out what that helping hand looks like and I sincerely thank the Wildlife and Habitat Recovery Taskforce for the huge effort they put in to establish it.



David Speirs MP
Minister for Environment and Water

Taskforce Chair foreword

The 2019–20 summer bushfires took a terrible toll on our built and natural environment. The impact on our native wildlife was shocking. Therefore I was very pleased to be invited to lead a taskforce to assist with planning for the immense recovery effort. We know fires will remain a feature of our lives and we must be better prepared for future events. The Wildlife and Habitat Bushfire Recovery Taskforce has brought together a diverse group of experts to provide important strategic oversight and coordination for the recovery of South Australia's natural environment after the bushfires.

The unprecedented nature of the fires, and the devastation they caused, require an ongoing coordinated approach. The success of our response to major fires, and indeed to any natural disaster, depends a great deal on effective collaboration and partnerships across all levels of government and non-government organisations.

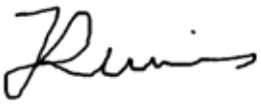
I commend the many individuals and partners from local communities, business and industry, universities, local government, non-government organisations and government agencies who have come together to support the recovery of our unique habitat and wildlife. The recovery process has brought together people with many different interests and has cultivated new partnerships. It is through these that we can build the capacity to respond to future fires.

This framework builds on the experience and expertise of the many partners and people involved in the recovery process. It is intended to be a guiding document, not prescriptive, and to provide a planning framework for future fire events that will ensure that response actions address immediate needs while also planning for short-term recovery and long-term resilience.

The Taskforce members are:

- Dr Felicity-ann Lewis, former mayor of the City of Marion and SA's 2014 Australian of the Year
- Craig Wilkins, Chief Executive of the Conservation Council of SA
- Parry Agius, Managing Director of Linking Futures
- Joanne Davidson, Research and Policy Manager at South Australian Tourism Commission
- Professor Bob Hill, Director of Adelaide University's Environment Institute
- Joe Keynes, President of Livestock SA
- Susannah Eliott, Chief Executive Officer of Australian Science Media Centre
- Paul Stevenson, Chief Executive Officer of RSPCA South Australia
- Wendy Campana, former Chief Executive Officer of the Local Government Association SA and Kangaroo Island Commissioner

The Taskforce intends to release additional reports and findings aimed at improving future preparedness, with specific reference to animal welfare and rescue.



Dr Felicity-ann Lewis
Chairperson

Executive summary

Purpose and objectives

This South Australian wildlife and habitat bushfire recovery framework provides a framework of phased actions to support the recovery of the plants, animals and natural environment affected by large bushfires, using lessons learned from an analysis of the impacts of and responses to the devastating 2019–20 bushfires and from existing fire management expertise.

The overarching framework can be tailored to response planning for individual fires, which will vary for the different landscapes and ecological communities in which they occur. In this way, the document provides a blueprint for future fire recovery responses, with guidance from an understanding of the activities implemented across the 2019–20 firegrounds and associated activities since the fires. Although this framework is not formally linked to the State Emergency Management Plan, this framework provides additional information under the theme of 'natural environment' for anyone engaged in the recovery process.

This document was prepared by the SA Wildlife and Habitat Bushfire Recovery Taskforce and the Department for Environment and Water, with input from the relevant regional landscape boards.

The process of learning is vital to this document and to building capacity and resilience within communities to enable them to cope with, and respond positively to, similar events in the future.

The outcomes sought from this framework are to:

1. Prevent extinction and limit the decline of native species affected by bushfire
2. Mitigate threats to the natural resource base from bushfires, particularly wildlife, native vegetation and habitats that underpin local economies and provide ecosystem services
3. Maximise the chances of long-term recovery after bushfires of native species, communities and other natural assets
4. Ensure learning and continual improvement are at the core of bushfire responses
5. Provide educational and volunteering opportunities for the wider community to improve understanding of bushfire impacts and recovery actions required
6. Support direct and indirect investment to create economic outcomes from bushfire responses.

2019–20 bushfires

The summer of 2019–20 saw 48 bushfires in South Australia, six of which were of particular concern. The fires were complex, unpredictable and difficult to fight, due to challenging weather conditions and terrain, and resulted in the loss of three lives. Fire burned through 17 parks and reserves, including Flinders Chase National Park and Ravine des Casoars Wilderness Protection Area on western Kangaroo Island, and Charleston and Porter's Scrub Conservation Parks in the Mount Lofty Ranges. Fires also had impacts on other high-value native vegetation and many significant private conservation areas across the state. Forty state and nationally threatened species (27 plant and 13 animal) had more than half of their known habitat destroyed on Kangaroo Island, and dozens of listed species were affected by other fires.

Many wildlife response actions commenced before the fires were extinguished, and there has been extensive work since then planning, securing funding, and implementing works. Importantly, response actions are addressing immediate needs as well as medium-term recovery and long-term resilience needs.

This recovery framework establishes a general framework and process for wildlife and habitat recovery to be applied for future major fires, building on experiences and maximising the lessons that are learned from the 2019–20 events and from existing expertise in South Australia and nationally.

Recovery phases

Wildlife and habitat recovery after future bushfires in South Australia will be guided by four phases, as shown opposite. Each phase has an associated outcome, which show how the purpose of response actions changes with time since fire.

Throughout these four phases, communication with the public and stakeholders, including the research community, needs to be ongoing in order to maintain their support for actions, to enlist their involvement where possible and appropriate, and to ensure learning to support and build capacity for responding to future events.

Recovery framework

For each phase, a set of objectives and a list of possible actions has been defined. After a major fire incident, response actions should be developed and framed in the context of the four phases. Designing actions to meet the outcome and objectives for each phase will assist with ensuring that planning considers requirements from immediate responses through to managing for long-term resilience.

The list of possible actions is not exhaustive and is intended as a guide and a prompt for planners. It is vital that recovery planning considers the conservation values, impacts and recovery needs that are specific to the locality and region in which the fire occurred.

The framework is presented in association with 14 case studies that provide examples of existing initiatives and projects and some lessons that have been learned from these to inform the framework.

Recovery phases for responding to bushfires

PHASE 1	PHASE 2	PHASE 3	PHASE 4
Immediate localised response	*Short term up to 1 year*	*Medium term 1 to 3 years*	*Longer term beyond 3 years*
OUTCOME: Impacts of fires on priority values assessed and targeted threat management actions initiated to secure values at risk	**OUTCOME:** Priority species, threatened species and habitats persist through the first 12 months after fire	**OUTCOME:** Priority species, threatened species and habitats maintained or improved through ongoing management	**OUTCOME:** Priority threatened species and habitats have long-term resilience

COMMUNICATIONS MESSAGING; STORIES OF RECOVERY AND HOPE

EVALUATION, LEARNING AND REPORTING

The objectives for each recovery phase are provided below. Actions are provided in the body of the report.

Phase 1: Immediate localised response (0–3 months post-fire)

Outcome	**Impacts of fires on priority values assessed and targeted threat management actions initiated to secure values at risk**	
Objectives	1.1	To assess impacts via desktop analyses and rapid assessment surveys
	1.2	To prioritise species and sites for surveys and critical threat management
	1.3	To undertake rapid surveys to determine the status of priority species, threatened species and habitats within the fire areas
	1.4	To initiate no-regrets threat management programs (such as feral animal control)
	1.5	To where possible, provide required care to animals adversely impacted by the bushfires.

Phase 2: Short-term actions (3–12 months)

Outcome	**Priority species, threatened species and habitats persist through the first 12 months after fire**	
Objectives	2.1	To repeat surveys to determine the survival of priority species
	2.2	To undertake surveys to establish baseline information to inform recovery trajectories
	2.3	To maintain and expand no-regrets threat management programs (such as feral animal control)
	2.4	To adapt survey and management actions based on new information and results
	2.5	To engage community and business/industry in collaborative efforts for mutual benefit

Phase 3: Medium-term actions (1–3 years)

Outcome	**Priority species, threatened species and habitats maintained or improved through ongoing management**	
Objectives	3.1	To repeat surveys to determine the survival of priority species
	3.2	To maintain threat management programs (such as feral animal control)
	3.3	To adapt survey and management actions based on results
	3.4	To engage community and business/industry in collaborative efforts for mutual benefits

Phase 4: Longer-term actions (beyond 3 years)

Outcome	**Priority threatened species and habitats have long-term resilience**	
Objectives	4.1	To secure outcomes achieved in first three years
	4.2	To develop dynamic tools to guide fire management actions
	4.3	To build resilience into social, economic and ecological systems by learning from the recovery process and building capacity to respond positively to future events

Contents

Purpose

This South Australian wildlife and habitat bushfire recovery framework provides an outline of phased actions to support the recovery of the plants, animals and natural environment affected by large bushfires, using lessons learned from an analysis of the impacts of and responses to the devastating 2019–20 bushfires and from existing fire management expertise. The overarching framework can be tailored to response planning for individual fires, which will vary for the different landscapes and ecological communities in which they occur. In this way, the framework provides a blueprint for future fire recovery responses, with guidance from an understanding of the activities implemented across the 2019–20 firegrounds and associated activities since the fires.

The framework will:

- guide implementation of on-ground activities to support fire recovery
- be consistent with national priorities, including those of the Wildlife and Threatened Species Bushfire Recovery Expert Panel
- identify actions that could support and stimulate beneficial economic outcomes (e.g. through tourism)
- inform improvements for existing management practices, in addition to recovery, that will build resilience for future events
- provide a coordinated set of activities that supports stakeholders to come together and collaborate on recovery actions
- provide information and lead to opportunities to improve the wider community's understanding of the impacts of natural disasters on wildlife and habitat, and the recovery actions needed
- provide a framework for undertaking deliberate and collective learning from the successes achieved and from initiatives that were not successful and for documenting what has been learned to inform future recovery responses.

The process of learning is vital to building capacity and resilience within communities to enable them to cope with, and respond positively to, similar events in the future.

Ownership

This document was prepared by the SA Wildlife and Habitat Bushfire Recovery Taskforce and the Department for Environment and Water, with input from the relevant regional landscape boards. The Department is the 'owner' of this framework and will oversee its implementation.

Partnerships

Implementation of this framework requires a partnership between government agencies, landscape boards, research institutions, non-government organisations, community- and industry-based associations and organisations and, critically, landholders. These collaborative partnerships will ensure that the necessary technical advice and physical and financial resources are applied, to realise the recovery of the natural environment affected by a fire event and also the communities, businesses and industries that depend upon that natural environment.

Objectives

The outcomes sought from this framework are to:

Prevent extinction and limit the decline of native species affected by bushfire

Mitigate threats to the natural resource base from bushfires, particularly wildlife, native vegetation and habitats that underpin local economies and provide ecosystem services

Maximise the chances of long-term recovery after bushfires of native species, habitats and other natural assets

Ensure learning and continual improvement are at the core of bushfire responses

Provide educational and volunteering opportunities for the wider community to improve understanding of bushfire impacts and recovery actions required

Support direct and indirect investment to create economic outcomes from bushfire responses.

Cultivating resilience requires a focus on deliberate learning

The notion of building resilience, and the importance of structured and deliberate learning to help achieve this, are foundational to this recovery framework. But what does this really mean?

The multiple and confounded impacts on people, industry, businesses and the wider community resulting from the unprecedented fires of the summer of 2019–20 mean that many things will change. 'Resilience' is a cornerstone concept for managing an uncertain future in which change is constant. Resilience is the capacity to cope with a rapidly changing and complex world and to continue to evolve in positive ways. Resilience can take many forms: it can look like bouncing back to how things were (persist), improving on the present (adapt) or changing fundamentally (transform). However, it is not dogged maintenance of the current situation or a return to the past.

The opposite of resilience is:

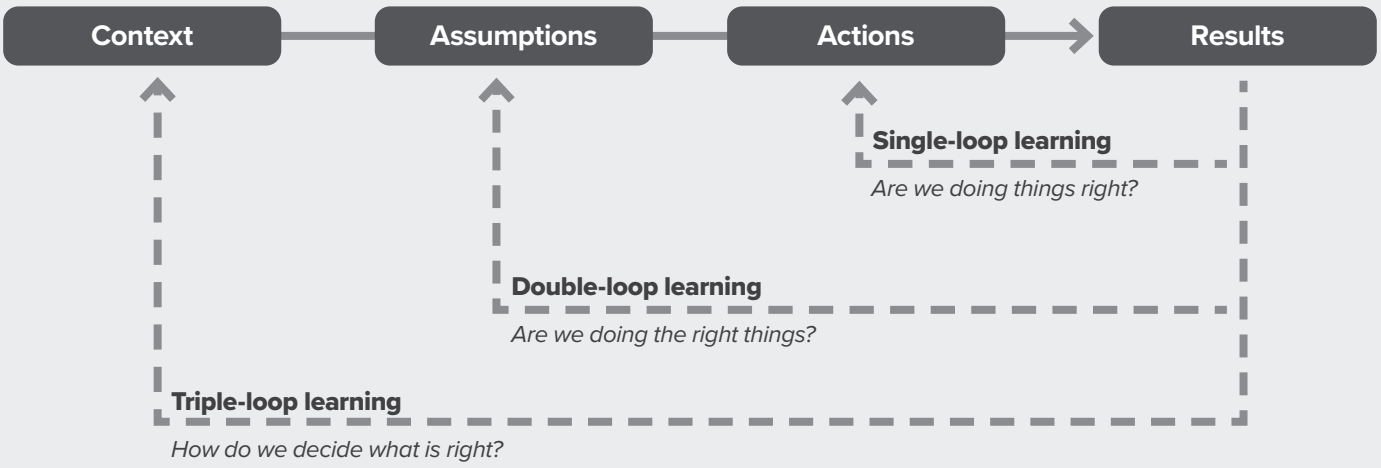
- being inflexible – a characteristic of fixed systems where efficiency is prioritised
- being defeatist – there is no hope, so why bother?
- being complacent – keep doing what has always been done, stay with busines as usual
- being disconnected – when people, industries, agencies and places are divided and disengaged.

Building a 'learning culture' is one of the most critical things we can do to build resilience. Although we know that learning is fundamental, it is often difficult to see where and how we are explicitly cultivating learning from the work we do.

Learning needs to be an active process of acquiring knowledge that is integrated with and builds on existing understanding. We are all constantly learning new things as we go about our daily work, but this is often ad hoc learning. Being deliberate about learning requires us to be strategic: we must plan what we want to learn, who needs to learn it, how and when. Effective learning also needs to focus across multiple levels – as individuals, in projects and as organisations.

A key learning concept underpinning this document is that of 'triple loop' learning. This type of learning focuses on moving through progressively more reflective and deeper thinking about what is known and what is done – how, why and by whom. Using triple-loop thinking, we can structure our learning to move from relatively shallow evaluative learning to being strategic and reflective, as outlined below.

- First loop – evaluative. How well did we do it? Was it effective and efficient? Did we achieve our objective?
- Second loop – strategic. Are there other ways to achieve the objective? How could we do this better in the future? Were the objectives the right ones? How did we set the objectives?
- Third loop – reflective. How did we decide what to do? Is our organisation working on the right things? Do we have the right vision for our organisation? Are we thinking about this problem in the right way? Are there alternative ways to think about this problem? Are we the right organisation to address this problem?



Source: Adaptive Learning Guide, Paul Ryan, Australian Resilience Centre 2020.

Background

South Australia's nature is of global significance

South Australia has a vast diversity of landscapes, ecosystems and associated species, including many species that are found nowhere else in the world. This means that South Australians are custodians of nature that is important both nationally and globally.

Our natural landscapes and the plants and animals they contain are important components of our South Australian identity. We value this nature for its inherent beauty and inspiration, the opportunities it offers for fun, wonder and relaxation, and the livelihoods it supports.

Many of these natural systems are being challenged by more severe and extensive bushfires as our climate becomes hotter and drier due to climate change. It is important to build the resilience of these systems – the ability to recover from the impacts of threats, pressures and disasters. Maintaining and restoring the health of these ecosystems and their biota is the best way to build their resilience.

Nature underpins South Australia's economy

Nature provides the foundation for healthy thriving societies and prosperous economies. It plays a critical role in maintaining the function of ecological systems, which underpins human wellbeing, livelihoods and lifestyles. Healthy ecosystems provide ecosystem services, such as clean water, pollination, and native pastures for grazing, which underpin economies and societies.

In South Australia, industries such as agriculture, fisheries, forestry and beekeeping depend directly on healthy nature and ecosystems. Native vegetation and natural landscapes provide places of scenic beauty and habitat for wildlife that are central to our tourism industry. Nature is also an economic resource for genetic, biochemical and agricultural products, such as bush foods, and native vegetation protects landscapes against land and water degradation.

We have built a strong international reputation for clean, green products from high-quality industries based on our healthy ecosystems.

These industries are relatively simple to value. For example, in 2018–19, South Australia's agriculture, aquaculture, food, wine and forestry industries contributed $19.7 billion[1] to the state's economy and tourism contributing $8.1 billion in the 12 months prior to December 2019[2].

Restoring the environment and its associated wildlife and ecosystem services after bushfires has both a direct economic benefit to reliant industries and an indirect economic benefit due to the effect on the health and wellbeing of South Australians and visitors to our state.

Encouraging sensitive tourism in bushfire-affected regions will rebuild their status as treasured destinations. Visitation will provide mutually beneficial outcomes, enabling economic restoration that supports local communities in their efforts to rebuild after bushfires.

South Australian Wildlife and Habitat Bushfire Recovery Taskforce

The South Australian Wildlife and Habitat Bushfire Recovery Taskforce was formed to provide advice to the Minister for Environment and Water and to give input into guiding the recovery planning for environmental assets after bushfires, including habitats, ecosystems and wildlife. Its key role is to work with bushfire-affected communities and stakeholders to build capacity, knowledge and resources to support the recovery process now and in the future.

The role of the Taskforce is not to replace or manage detailed species or operational recovery planning and programs that occur at a regional and local level (e.g. threatened species recovery teams). The committee will provide insights on aspects of those programs, while providing additional overarching input to support and augment work at a strategic level. The Taskforce has been considering a range of timeframes in its work: short, medium and long. Where possible, the Taskforce has built on existing and ongoing recovery efforts for nationally listed species.

The Taskforce's findings have informed this Framework, which provides a legacy for the future by:

- informing the strategic challenges and opportunities relating to long-term resilience of wildlife and habitat recovery
- providing advice on how to strategically approach conservation and wildlife recovery efforts given changing climate and fire regimes
- providing strategic advice on partnerships, funding opportunities, priorities and strategies to support recovery
- identifying and advising on priorities for recovery, including the development of the South Australian wildlife and habitat bushfire recovery framework
- supporting the involvement of the non-government organisation and research sectors, ensuring recovery efforts are coordinated, consistent and complementary
- advising on managing the challenges identified and providing advice on how to improve future preparedness, including by building on previous reviews.

[1] Budget Paper 3 2019-20 Budget Statement. Presented by the Honourable Rob Lucas MLC Treasurer of South Australia on the occasion of the Budget for 2019-20. Published 18 June 2019. ISSN 1440-8589

[2] see https://tourism.sa.gov.au/

2019–20 bushfires

The summer of 2019–20 saw 48 bushfires in South Australia, six of which were of particular concern (Figure 1). The fires were complex, unpredictable and difficult to fight, due to challenging weather conditions and terrain, and resulted in the tragic loss of three lives. Many houses and outbuildings were destroyed and almost 285,000 ha of land was burned, of which over 90,000 ha was national parks and reserves. Following the fires, the South Australian government commissioned an independent review to examine the circumstances surrounding the unprecedented fires. The review was broad and focused on 'twelve factors across Prevention, Preparedness, Response and Recovery (PPRR) that all impact positively on reducing the impact of bushfire and keeping communities safer'[3]. The review provides a thorough synopsis of the events and impacts and seeks to guide policymakers in managing future fires. This will obviously have important implications for the recovery and future conservation of wildlife and habitat.

These fires affected very large areas of agricultural land and had direct impacts on primary production, destroying crops, forestry plantations, livestock and many other related enterprises such as beekeeping. The fires also prevented visitors from entering many of these areas during peak tourism season, compounding the economic impacts for many of the people in these regions. Fire burned through 17 parks and reserves, including Flinders Chase National Park and Ravine des Casoars Wilderness Protection Area on western Kangaroo Island (KI), and Charleston and Porter's Scrub Conservation Parks in the Mount Lofty Ranges. Fires also had impacts on other high-value native vegetation and many significant private conservation areas, including Secret Rocks on Eyre Peninsula (Figure 1) and over 100 Heritage Agreements on Kangaroo Island.

Forty state and nationally threatened species (27 plant and 13 animal) had more than half of their known habitat destroyed on Kangaroo Island, and dozens of other listed species were affected by the fires at Cudlee Creek, Secret Rocks, Bunbury and Keilira.

The threatened animal species affected on Kangaroo Island were from a range of groups, including mammals (KI Dunnart, southern brown bandicoot), birds (KI glossy black cockatoo, Western Bassian Thrush, KI western whipbird, KI southern emu-wren) and invertebrates (such as the metallic green carpenter bee and the Kangaroo Island assassin spider). A large number of other important birds and mammals were affected by the summer bushfires in the Mount Lofty Ranges, including the southern brown bandicoot and Mount Lofty Ranges chestnut-rumped heathwren. The malleefowl and sandhill dunnart are other threatened species that were affected by at least one of the 2019–20 fires.

Important habitats for fauna species were also negatively affected by the bushfires, such as the endemic Kangaroo Island mallee ash woodland of western Kangaroo Island, which provides vital habitat for the KI dunnart, many endemic subspecies of bush birds and the southern brown bandicoot; and significant areas of drooping sheoak woodland and sugar gum woodland, which provide feeding and nesting habitat respectively for the glossy black cockatoo.

Of great concern is that 90% of the known locations of threatened plant species on Kangaroo Island occur within the recently burnt area. In the Cudlee Creek fire, over 15 species of threatened plants (including orchids) were affected by the fires, as were areas of peppermint box grassy woodland and manna gum woodland, which are likely to suffer significant tree death. Finally, there have been negative impacts on nationally threatened plants in the Secret Rocks, Bunbury and Keilira fires.

Some of the more widespread, abundant and mobile native species, such as koalas, kangaroos and wallabies, suffered significant levels of mortality, but their populations are expected to recover as habitat recovers.

Some platypus are known to have survived the fires in Flinders Chase National Park (where it is an introduced species), despite 100% of the habitat being burned.

The koala population on Kangaroo Island (where it is an introduced species) is estimated to have been reduced from 50,000 to between 5000 and 10,000. Many koalas also died in the Cudlee Creek fire. Despite these mortality levels, the Koala populations in the Mount Lofty Ranges and Kangaroo Island remain secure. An insurance population of Kangaroo Island koalas has been established at Cleland Wildlife Park (see Case Study 4: Koalas).

[3] Keelty *et al.* (2020) Independent Review into South Australia's 2019-20 Bushfire Season. Government of South Australia www.safecom.sa.gov.au/site/independent_review_sa_201920_bushfires.jsp.

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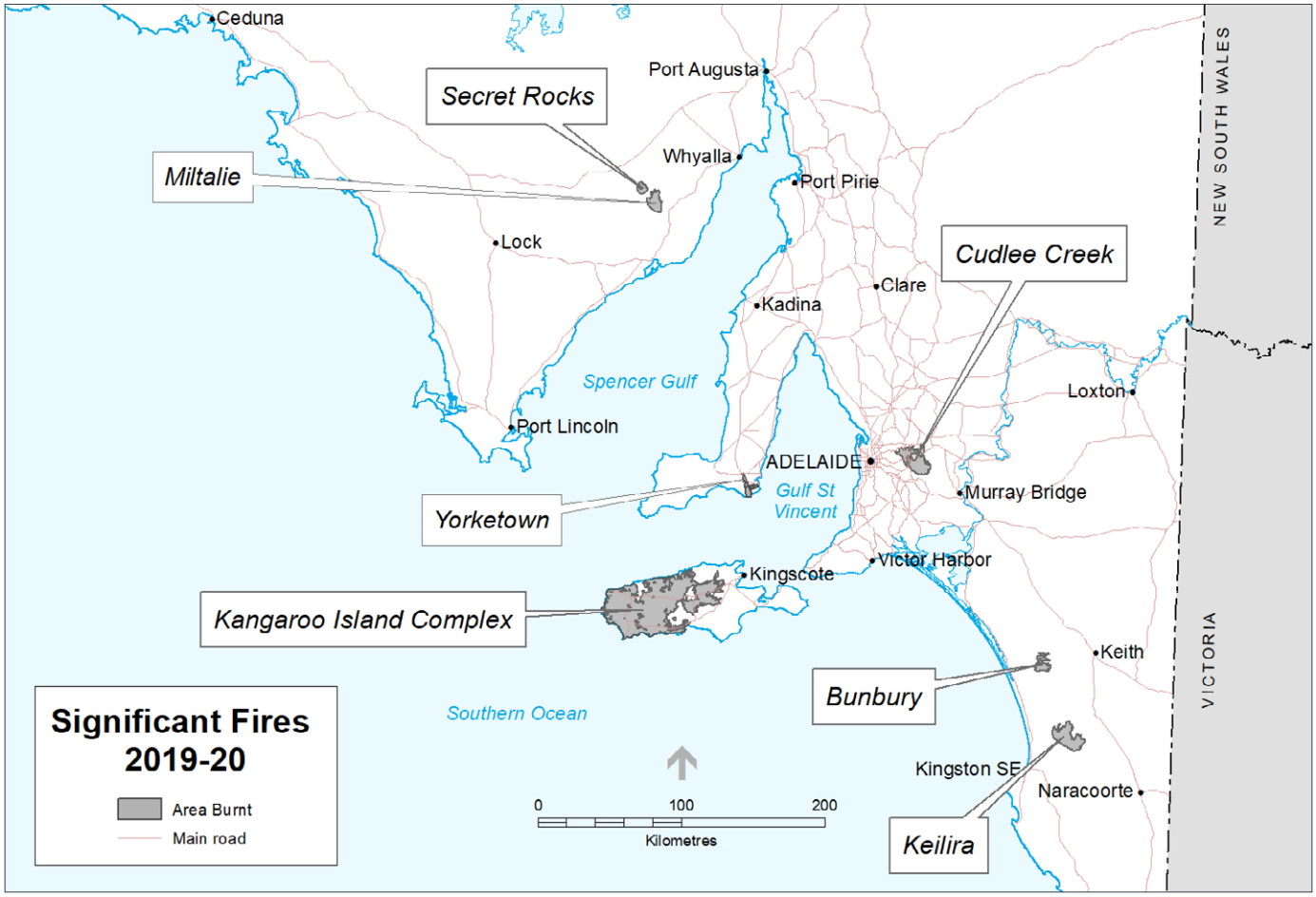
Figure 1: Locations of 2019–20 bushfires



Priority species impacted by the bushfires on Kangaroo Island that require ongoing bushfire recovery efforts include (clockwise from top left) Kangaroo Island dunnart; Koala; Kangaroo Island echidna).

Approaches to ecological recovery after bushfires

While the fires were burning in South Australia during the summer of 2019–20, fires of unprecedented scale, intensity and ecological impact were burning elsewhere in Australia, especially in NSW and Victoria.

In January 2020, when this national bushfire crisis was still unfolding and before the Kangaroo Island fire had been extinguished, national experts from the Threatened Species Hub of the National Environmental Science Program published a blueprint for a conservation response to large-scale ecological disaster. This blueprint[4] emphasised the importance of planning recovery actions as linked responses over three timeframes: immediate, short-term and long-term. Seventeen general responses were listed and described, in approximate temporal order, and for each of these an objective and an indicative list of priority actions was presented.

This conservation response blueprint provided valuable guidance for the response to the impacts of the 2019–20 bushfires in South Australia.

In addition, given the major impacts on Kangaroo Island, a special workshop was held on the island in February to identify specific recovery actions for the key species at risk

Planning for bushfire recovery must consider the threats that are operating in the affected ecological systems or species. Threats such as habitat loss, grazing pressure, predation and competition are the leading causes of extinctions in Australia, and these threats are often exacerbated and compounded following a bushfire, demanding urgent responses. Threats faced by wildlife and habitat following bushfires include:

- loss of food sources
- loss of critical habitat features (e.g. dense cover, hollows, leaf litter)
- increased predation pressure/effectiveness
- increased competition from introduced herbivores
- increased grazing pressure on plants by native herbivores
- loss of critical seedbanks and vegetation due to the direct impacts of fire
- increased competition from invasive plants including weeds
- reduced water quality
- increased risk of disease
- small population size effects (e.g. inbreeding depression, vulnerability to localised disturbances).

There is a wide range of potential response actions that can be undertaken to assist the recovery of natural values in ecological systems, and many of these actions become more urgent following a major fire. Actions aimed at supporting recovery after a bushfire must address one or more of the threats to the wildlife and habitats affected by that fire, according to the ecological values and other context of the location.

[4] Chris Dickman, Don Driscoll, Stephen Garnett, David Keith, Sarah Legge, David Lindenmayer, Martine Maron, April Reside, Euan Ritchie, James Watson, Brendan Wintle, John Woinarski (2020) After the catastrophe: a blueprint for a conservation response to large-scale ecological disaster, Threatened Species Recovery Hub, January 2020.

A wildlife and habitat bushfire recovery framework for SA

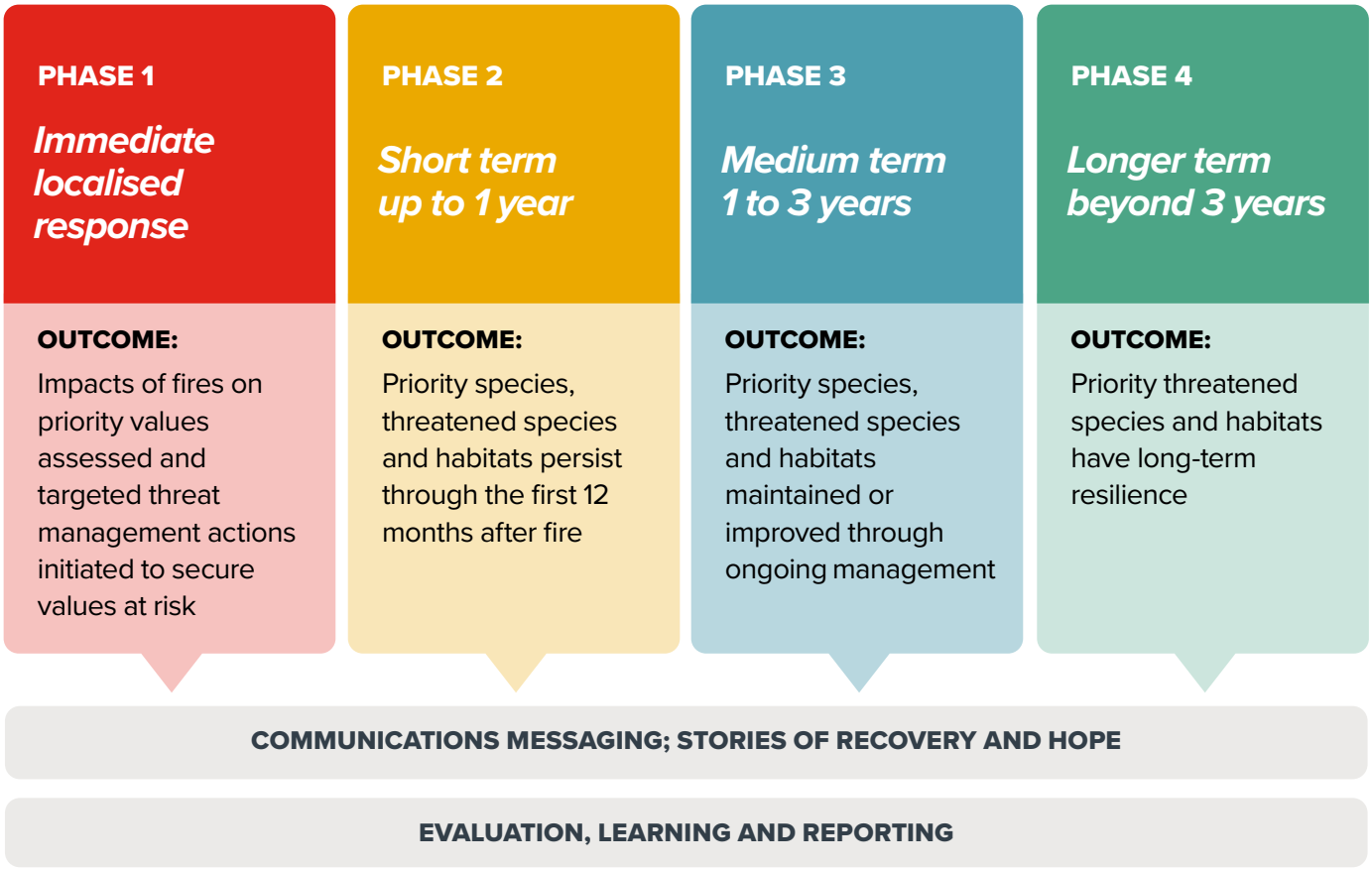
A wildlife and habitat bushfire recovery framework has been developed for South Australia, using guidance from national experts—particularly the conservation response blueprint described above—and incorporating the extensive existing knowledge in South Australia and recent lessons that have been learned during and since the 2019–20 fires.

In South Australia the State Emergency Management Plan[5] sets out the state's comprehensive emergency management arrangements, including for recovery. The Plan recognises that in assisting individuals and communities to manage their own recovery, recovery activities need to be delivered holistically and in an integrated manner across four environments - social, economic, built and natural. This framework provides additional information under the theme of 'natural environment' for anyone engaged in the recovery process.

Recovery phases

Wildlife and habitat recovery after future bushfires in South Australia will be guided by four phases, as shown below. Each phase has an associated outcome, which show how the purpose of response actions changes with time since fire.

Throughout these four phases, communication with the public and stakeholders, including the research community, must be ongoing in order to maintain their support for actions, enlist their involvement where possible and appropriate, and ensure learning to support and build capacity for responding to future events.



[5] State Emergency Management Committee (2019) State Emergency Management Plan. Department for Premier and Cabinet. Adelaide.

Recovery framework

For each phase, a set of objectives and a list of possible actions has been defined. After a major fire incident, response actions should be developed and framed in the context of the four phases. Designing actions to meet the outcome and objectives for each phase will assist with ensuring that planning considers requirements from immediate responses through to managing for long-term resilience.

The list of possible actions is not exhaustive and is intended as a guide and a prompt for planners. It is vital that recovery planning considers the conservation values, impacts and recovery needs that are specific to the locality and region in which the fire occurred.

The framework is presented here in association with 14 case studies that provide examples of existing initiatives and projects and some lessons that have been learned from these to inform the framework. The case studies are grouped with the recovery phase with which most of the actions are associated, although there is extensive overlap.

At the early stages of recovery, some of these actions may be hindered by poor knowledge of the distribution and ecology of species and habitats. The process of recovery combines actions that address these knowledge gaps, inform effectiveness of actions, and allow the program to be adapted and improved through deliberate learning. In some cases, additional actions will need to specifically address knowledge gaps, as this can be the major barrier to recovery. This is particularly the case for groups such as invertebrates (e.g. bees, spiders, butterflies), for which we typically have limited ecological knowledge to inform management; however, even for relatively well-known groups like birds, our understanding of their distribution, habitat needs and response to fire is often rudimentary.

Response actions should be undertaken at a range of scales, from landscape scale to site scales relevant to the species or habitat of concern. All stakeholders, including local communities, non-government organisations, business, industry and government, can come together to play a role in implementation. Planning and decision-making should be devolved to locally based governance groups wherever possible. Governance that integrates across different sectors, rather than reinforcing silos, also leads to better outcomes through shared learning and increased understanding of each other's issues, challenges, constraints and threats.

Phase 1: Immediate localised response (0–3 months post-fire)		
Outcome	**Impacts of fires on priority values assessed and targeted threat management actions initiated to secure values at risk**	
Objectives	1.1	To assess impacts via desktop analyses and rapid assessment surveys
	1.2	To prioritise species and sites for surveys and critical threat management
	1.3	To undertake rapid surveys to determine the status of priority species, threatened species and habitats within the fire areas
	1.4	To initiate no-regrets threat management programs (such as feral animal control)
	1.5	To where possible, provide required care to animals adversely impacted by the bushfires.
Possible actions	1.1	Protect key unburnt habitat and populations, through measures such as fire suppression
	1.2	Conduct emergency wildlife rescue
	1.3	Conduct livestock assessment, humane destruction and safe carcasse disposal
	1.4	Identify natural values at risk
	1.5	Identify spatial extent of fire impacts and burn severity
	1.6	Conduct rapid assessment of post-fire species survival
	1.7	Implement emergency salvage of species at risk of future fires
	1.8	Augment habitat for at-risk species (e.g. nest boxes)
	1.9	Conduct targeted supplementary feeding of wildlife
	1.10	Implement intensified and sustained predator control within burnt and adjacent areas
	1.11	Implement intensified and sustained competitor herbivore control within burnt and adjacent areas
	1.12	Protect and manage key unburnt habitat and populations through fire suppression and recovery
	1.13	Fence priority localised/remnant plant populations
	1.14	Liaise with landholders to assess damage and support recovery, including livestock containment fencing
	1.5	Control sediment and erosion to protect water and soil resources
	1.16	Safely remove and dispose of waste
	1.17	Rehabilitate fire containment lines
	1.18	Identify and remove unsafe trees
	1.19	Engage with community to inform, involve and collaborate

‘No regrets’ actions

No-regrets actions err on the side of caution, taking a precautionary approach because specific information is lacking. For example, in the absence of specific data, we can assume that cats will predate on wildlife in critical unburnt patches and that reducing cat numbers will reduce predation impacts; therefore, controlling cats would be a ‘no-regrets’ action. In this example, even if our assumptions prove to be wrong, ‘no-regrets’ actions do not result in bad outcomes and by taking these actions and monitoring the results we learn valuable lessons to apply in the future.

CASE STUDY 1: Kangaroo Island wildlife and habitat recovery planning workshop

Over 80 researchers, policymakers, park managers, community members, and animal and plant experts came together at American River in February 2020 to identify priority recovery actions and key knowledge gaps following the unprecedented bushfires on Kangaroo Island. The aim of the workshop was to identify both strategic actions that support habitat recovery across the entire Kangaroo Island landscape and actions that support the recovery of individual threatened species.

The need for a workshop was identified before the Kangaroo Island fires had been extinguished, with leaders from the Australian Government, the Threatened Species Recovery Hub, the South Australian government and the Kangaroo Island Natural Resources Management Board coming together to lead the workshop.

At the workshop, groups were formed to focus on priority species including: the KI dunnart, KI glossy black cockatoo, other small mammals (e.g. pygmy-possums and southern brown bandicoot), other birds (e.g. KI western whipbird and KI southern emu-wren), Bibron's toadlet, Rosenberg's goanna, KI echidna, green carpenter bee, other endemic invertebrates, and priority threatened plant species. The mallee-heath ecosystem was also considered as a whole.

To develop a recovery plan, each group worked through a structured process of expert elicitation. The steps were designed to guide people to think though the recovery process from pre-fire status to 10 years post-fire and to document confidence in the effectiveness of identified actions. Each group summarised known impacts resulting from the fire, developed and evaluated 10-year strategies, and identified key knowledge gaps that impede effective management and, therefore, form priorities for research.

Key strategic actions identified at the workshop were:

- identification of the distribution of unburnt habitat and surviving populations of priority species
- targeted management of feral cats to reduce fire pressure on small and isolated native fauna populations within the fire ground
- targeted management of herbivores (especially feral pig control and re-establishment of fencing to exclude stock from recovering habitat)
- protection of unburnt remnants across the island from the risk of fire over the coming decade
- species-specific actions designed to support the recovery of species or species groups over the coming decade (e.g. replacement of KI Glossy black cockatoo nest boxes).

Ultimately, successful recovery requires coordinated and integrated efforts that are based on the best available evidence. The final workshop report[6] provides an important point of reference for anyone seeking to contribute to the wildlife recovery efforts on the island as it is based on the best available knowledge. Most importantly, the workshop brought together a diverse group who shared a common passion for conserving the unique biodiversity on Kangaroo Island. The partnerships and collaborations formed as a result are at least as important as the plan itself, and these will help to ensure that the recovery of Kangaroo Island's wildlife and habitat is given the best possible chance.

Images: The workshop was attended by over 80 participants with many leaders from the local community and the Australian ecological community in attendance.

[6] Rogers, D. et al. (2020) Kangaroo Island Wildlife and Habitat Recovery Workshop. Workshop Summary Report. National Environmental Science Program, Threatened Species Recovery Hub. Australian Government.

CASE STUDY 2: Kangaroo Island dunnart recovery – out of the ashes

The Kangaroo Island dunnart is a small mammal that is endemic to Kangaroo Island, which means that it occurs nowhere else. Their precise distribution on Kangaroo Island is not clear, although since 1990 all records are from the western end of the island, within Flinders Chase National Park, Ravine des Casoars Wilderness Protection Area and surrounding areas of remnant native vegetation on private land. The KI dunnart is listed as nationally Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which indicates that it is at a very high risk of extinction. Prior to the recent bushfires, KI dunnarts were believed to be elusive or in very low numbers across their known range (Hohnen *et al.* 2019[7]). It is estimated that the recent catastrophic bushfires burned approximately 93% of the predicted area of occurrence of the KI dunnart, creating a dire situation for the species. In addition to the likely loss of individual dunnarts and their habitat in the fires, the threat of predation from feral cats likely increased within the burnt area. In response to this, feral cat control was initiated across the region in February 2020 (see Case Study 7).

KI dunnarts were detected immediately after the bushfires by KI Land for Wildlife staff, in a very small (~1 ha) unburnt area of a Heritage Agreement on private property adjacent to the Western River Wilderness Protection Area. KI Land for Wildlife responded very quickly to protect the dunnarts at this site, and, with the support of the Australian Wildlife Conservancy, erected a cat proof fence around 13 ha to help to protect the surviving individuals. Intensive cat control was undertaken prior to the fence being completed.

Based on early reconnaissance flights and satellite imagery, unburnt patches within the Flinders Chase National Park and Ravine des Casoars Wilderness Protection Area were identified and prioritised for rapid surveys and assessment.

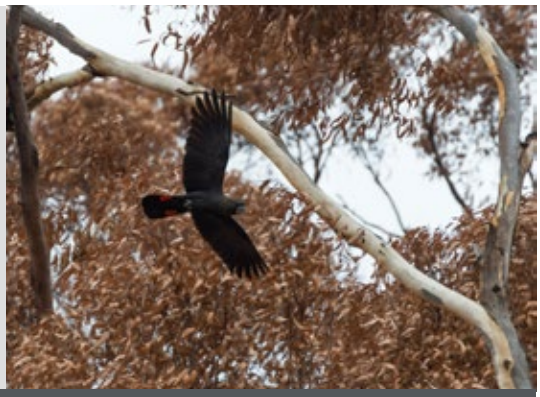
Since February 2020 over 60 monitoring sites for KI dunnarts have been established using motion-detection cameras, initially focusing on the unburnt patches and subsequently including burnt sites where dunnarts were previously recorded. To the great relief of all those involved, dunnart records started to be received, both from private land being surveyed by KI Land for Wildlife and from within the Flinders Chase area. Remarkably, dunnarts were detected on private property at a site that was completely burned by the Ravine fire. Dunnarts were subsequently detected during surveys at other burnt sites. This showed that the dunnarts had not only survived the fire, they had also persisted at these sites for several months. At the time of writing, KI dunnarts have been detected at sites on private land and sites within national parks. Over the same period, approximately 250 feral cats have been captured and culled.

Despite the positive results of surveys and the intensive cat control, it is still early in the fire recovery and there are likely to be very few individual dunnarts remaining; therefore, their longer-term fate is still precarious. Ongoing surveys and monitoring and management of threats, particularly feral cat control, is essential.

Monitoring for the KI dunnart and feral cat control across the bushfire-affected area is being conducted by the Kangaroo Island Landscape Board, KI Land for Wildlife and the South Australian National Parks and Wildlife Service, in collaboration with the Australian Wildlife Conservancy and private landholders. Funding for these projects has been provided through the Australian Government's National Landcare Program and Wildlife and Habitat Bushfire Recovery Program, and through the World Wide Fund for Nature Australia (WWF).

Images: Dunnarts caught by 'camera traps'; Recovery workshop participants (see Case Study 1) learning about the cat proof refuge erected to protect what was at the time the only known site with dunnarts immediately after the bushfire.

[7] Hohnen *et al.* (2019) Detecting and protecting the threatened Kangaroo Island dunnart (Sminthopsis fuliginosus aitkeni). *Conservation Science and Practice.* https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/csp2.4.



CASE STUDY 3: Kangaroo Island glossy black cockatoo Recovery

The Kangaroo Island glossy black cockatoo (GBC) is an endemic subspecies that is listed as nationally Endangered under the EPBC Act. Recovery activities for the GBC have been underway for many years.

Post-fire recovery actions for the GBC are being delivered by the Kangaroo Island Landscape Board, with funding from WWF, the Glossy Black Rescue Fund (with Nature Foundation) and the Kangaroo Island Wildlife Network.

Prior to the 2019–20 bushfires, there were 4885 ha of mapped remnant drooping sheoak woodland habitat on Kangaroo Island, the GBC's feeding habitat. Of this, 2252 ha (46.1%) was verified to be unburnt, through a combination of spatial analysis and on-ground surveys of habitat. Therefore, it is estimated that 2633 ha (53.9%) of drooping sheoak woodlands were burned to an extent that makes them unavailable to GBCs as a food source until they regenerate.

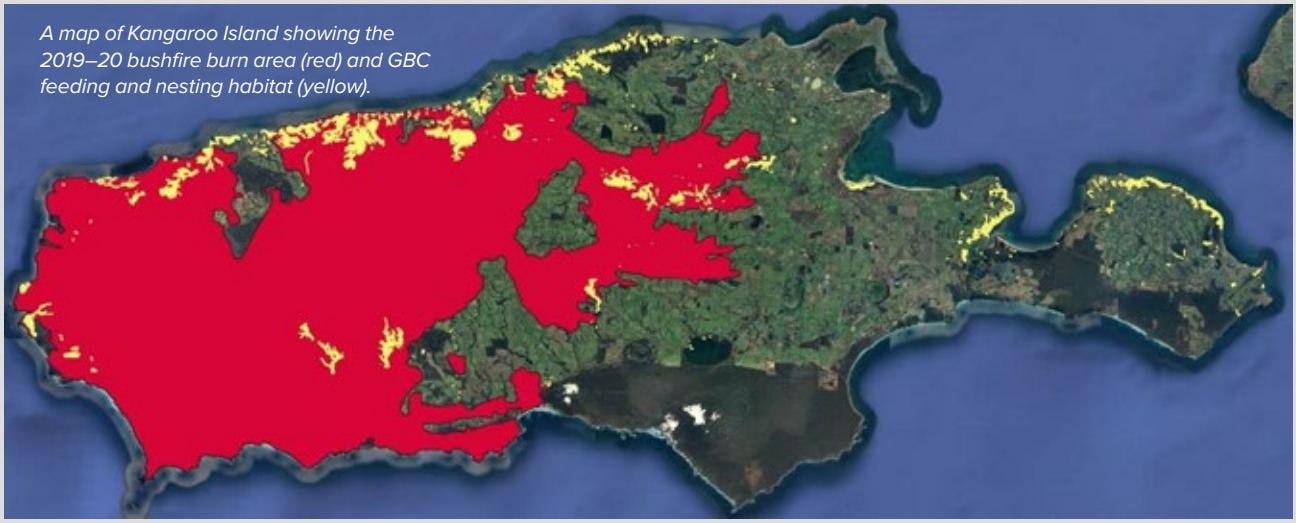
It is estimated that it will take 10–20 years for burnt sheoak woodland to recover to be suitable as GBC feeding habitat, while planted sheoak takes 6–10 years before it is suitable for use by GBCs. Protection of remaining drooping sheoak woodlands from further fires—importantly, including revegetated drooping sheoak areas—is clearly a high priority in the immediate future.

Prior to the 2019–20 bushfires, there were at least 283 known nests that were believed to be functional for use by GBCs, including natural hollows and artificial nest boxes installed by the recovery program. In total, 38.5% of known nests were destroyed by the 2019–20 bushfires, comprising 44.4% of known natural hollows, 29.5% of PVC nest boxes and 50% of timber nest boxes. New nest boxes can be installed to supplement natural nesting habitat, and new natural hollows are likely to be formed over time as a result of fire.

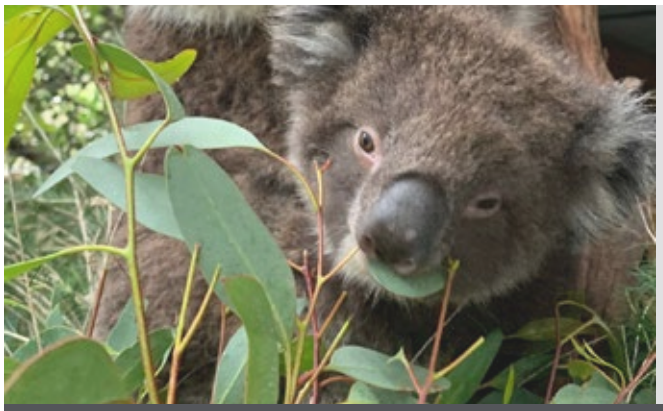
Nest use since the fires

Five of the seven GBC flocks on Kangaroo Island had significant areas of feeding and nesting habitat negatively affected during the 2019–20 bushfires. While breeding has since been recorded by members of three of those five flocks, GBCs of two flocks have not returned since the fire to their usual nesting areas to breed. Further work, including the upcoming population census in spring 2020, will provide information on the mortality associated with the fire and whether survivors in some flock regions have relocated to other areas.

Images: Some glossy black cockatoos returned to their usual nesting areas after the fire and continued to make use of nest boxes that were left intact.



A map of Kangaroo Island showing the 2019–20 bushfire burn area (red) and GBC feeding and nesting habitat (yellow).



CASE STUDY 4: Koalas

The Kangaroo Island population of the koala (*Phascolarctos cinereus*) has been identified as the only isolated, chlamydia-free population in South Australia and, possibly, Australia. Chlamydia (*Chlamydia percorum*) is an established and prevalent infection in koalas that can cause severe clinical disease, with symptoms including blindness, bladder inflammation, infertility and death. The disease has contributed to the decline of koalas in other mainland states where it occurs.

A chlamydia-free koala population has been established at Cleland Wildlife Park, using 28 koalas rescued from Hanson Bay Wildlife Sanctuary during the 2019–20 Kangaroo Island fires. These rescued koalas may have otherwise died from starvation given the significant loss of koala habitat across Kangaroo Island.

Koalas across Australia, including those on Kangaroo Island, also suffer from koala retrovirus (KoRV), which has been linked with diseases such as chlamydia, lymphoma and leukaemia. There is significant research effort underway to learn more about KoRV, especially its origin, transmission and impact on the koala. The koalas at Cleland Wildlife Park that were recently rescued from Kangaroo Island are also free from KoRV. Therefore, these Kangaroo Island koalas, free from chlamydia and KoRV, form the basis of a valuable captive-managed disease-free koala population.

The establishment of this population presents a unique opportunity to leverage the tragic circumstances of the Kangaroo Island fires, by contributing to the national conversation around koala conservation and management, particularly those populations in the eastern states that are most at risk of decline. Establishing a captive-managed disease-free population can provide an avenue for research into areas such as epidemiology, vaccine development, population management, captive management and genetics. It is anticipated that research using this Cleland population, in collaboration with the International Koala Centre of Excellence and other institutions, will enable tangible research outcomes that will contribute to the national conservation and management of the koala.

CASE STUDY 5: Weed control for Western Bassian thrush in the Cudlee Creek fire area

The Western Bassian thrush is classified as Vulnerable under the *EPBC Act 1999* due to its declining population. The South Australian subspecies of Western Bassian thrush (*Zoothera lunulata halmaturina*) has a population in the Mount Lofty Ranges that is disjunct from other occurrences in the state. The Mount Lofty Ranges population has a very restricted area of occupancy.

The recent bushfires burnt ~10% of the Western Bassian thrush's habitat in the Mount Lofty Ranges, and future fires will continue to pose a significant threat. Therefore, it is critically important to protect and improve the quality of burnt Western Bassian thrush habitat as it regenerates after the Cudlee Creek fire.

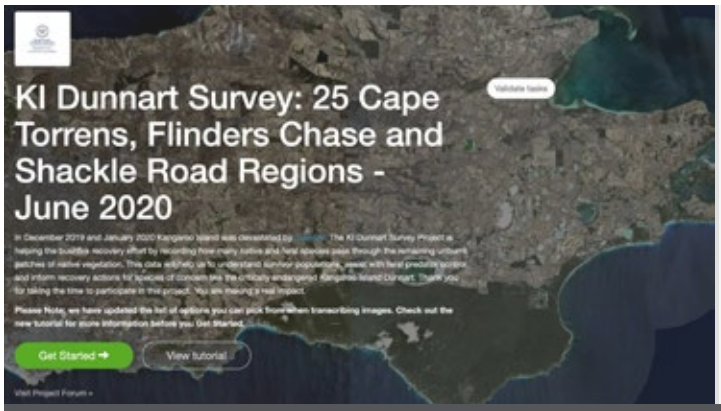
The Conservation Advice[8] for this species highlighted the vulnerability of the species to fire, with the species disappearing from several known locations after the 1983 bushfires where it had previously been common. We also know that modification of habitat by weed invasion is a key threat, and many problem weeds respond well after fires.

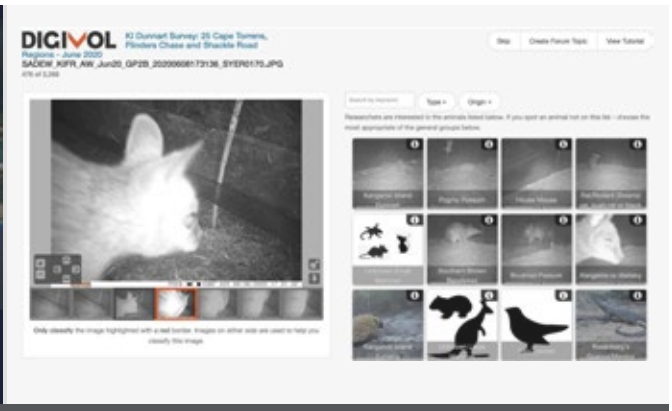
Weed control is occurring to maximise the habitat quality in the Cudlee Creek fire scar to give the species the best chance of recovering and re-occupying regenerating habitats and to reduce the risk of species extinction.

Sites for weed control have been chosen based on their habitat suitability and records of the Western Bassian thrush, ensuring that effort will be invested in the most important sites for this species. This will help ensure that burnt habitats regenerate in a way that provides habitat for these species, improving the future prospects for the species and reducing the risk of local extinction.

Images: (L-R) Western Bassian thrush; dense post-fire regeneration of the weed broom at a site that provided habitat for the thrush prior to the Cudlee Creek fire. The Western Bassian thrush needs open ground with leaf litter for foraging.

[8] Department of the Environment (2015) Conservation Advice Zoothera lunulata halmaturina Bassian thrush (South Australian). Australian Government Canberra





CASE STUDY 6: Volunteer effort critical to assessment of fire impact

Over 900 people from all parts of Australia and other countries across the globe have logged on to the KI Dunnart Survey via DigiVOL to assist with the identification of wildlife captured on motion detection cameras in the fire area on Kangaroo Island.

Over 60 camera 'trap-lines' have been established, each with two cameras, and have been operating since soon after the fire. These have become invaluable field assistants, allowing us to detect many elusive species including Kangaroo Island dunnarts, pygmy-possums, bush rats, birds and reptiles, and feral cats. This information has been crucial in helping us to assess the impacts of the fire, determine where priority species such as dunnarts still occur, and target our cat control efforts to these sites.

There is one real challenge with this survey method: between February and June 2020 the cameras captured a combined total of over 56,000 images, which all need sorting and cataloguing. This is where the DigiVOL tool comes in. DigiVOL is an online crowdsourcing platform developed as part of the Atlas of Living Australia by the Australian Museum, CSIRO and Australian Government. The platform allows organisations to combine the efforts of many volunteers to digitise their data.

Volunteers can join the digital expeditions online and with the help of a short tutorial they can start identifying the wildlife captured in the images. This is not always easy, as many of our small mammals are quite similar in appearance, and strange angles and fast moving animals add to the difficulty of the task. Each image is assessed by up to eight volunteers and an identification is validated when five people select the same ID. Following this, experts from the Department for Environment and Water (DEW) identify any images that have proven too difficult for the volunteers, and double-check that extremely rare animals like the KI dunnart are correctly identified.

Through the DigiVOL platform DEW has been able to tap into the high level of public interest and goodwill following the bushfires and increase engagement with people who are concerned about the impacts of the fires and want to make a contribution. It has provided a very effective to involve these people, to increase their knowledge of the wildlife on Kangaroo Island and promote efforts to support its recovery.

The use of cameras has been a 'game changer' for wildlife surveys, particularly as DEW no longer undertakes standardised biological surveys across the state using experts in fauna and flora. DEW is now working towards standardising the survey technique and streamlining the image management process through DigiVOL to maximise the benefits obtained, both in terms of providing important and current information on where species still occur and for ongoing engagement of volunteers. Ultimately, this survey method could be deployed consistently by researchers and community groups across the state, with volunteers then also assessing the images, thereby providing South Australians with current records of our unique wildlife and allowing us to monitor trends through time.

Phase 2: Short-term actions (3–12 months)

Outcome	**Priority species threatened species and habitats persist through the first 12 months after fire**	
Objectives	2.1	To repeat surveys to determine the survival of priority species
	2.2	To undertake surveys to establish baseline information to inform recovery trajectories
	2.3	To maintain and expand no-regrets threat management programs (such as feral animal control)
	2.4	To adapt survey and management actions based on new information and results
	2.5	To engage community and business/industry in collaborative efforts for mutual benefit
Possible actions	2.1	Conduct rapid assessment of post-fire species survival
	2.2	Conduct targeted supplementary feeding of wildlife
	2.3	Augment habitat for at-risk species (e.g. nest boxes)
	2.4	Conduct rapid assessment of post-fire survival
	2.5	Implement emergency salvage of species at risk of future fires
	2.6	Implement intensified and sustained predator control within burnt and adjacent areas
	2.7	Implement intensified and sustained competitor herbivore control within burnt and adjacent areas
	2.8	Protect and manage key unburnt habitat and populations through fire suppression and recovery
	2.9	Fence localised/remnant plant populations, including riparian habitat and shade trees
	2.10	Propagate and establish plants
	2.11	Liaise with landholders to provide ongoing support and advice
	2.12	Control sediment and erosion to protect water and soil resources
	2.13	Safely remove and dispose of waste
	2.14	Rehabilitate fire containment lines
	2.15	Establish monitoring to guide adaptive management
	2.16	Identify data systems and services required to collect and share monitoring data and other data from response activities
	2.17	Adapt recovery actions and/or project proposals to match funding/grant opportunities and update accordingly as funding is secured
	2.18	Identify research collaborations and implement research program
	2.19	Pursue nature-based tourism linked to recovery (‘voluntourism’)
	2.20	Share learnings from initial recovery
	2.21	Incorporate new knowledge and implications into park management plans
	2.22	Engage with community and industry to inform, involve and collaborate
	2.23	Build capacity for proactive fire management to enable adaptive fire planning to be implemented across SA
	2.24	Investigate opportunities to secure long-term resourcing for the management and recovery of threatened species, to improve their resilience to fires and other crises

CASE STUDY 7: The ongoing challenge of controlling feral cats after fire

Predation by feral cats is recognised as a key threatening process for many small mammal species (including KI dunnart, KI echidna, southern brown bandicoot) and bird species (including KI western whipbird, KI southern emu-wren, shy heath-wren and Western Bassian thrush) on Kangaroo Island. The threat posed by feral cats was exacerbated by the 2019–20 bushfires, which burned more than 90% of known habitat for some threatened species, such as the KI dunnart.

High cat density poses a formidable threat to wildlife survival during the post-fire period, because there is little vegetation remaining to provide cover for wildlife and because cats are known to travel large distances to hunt within recent fire scars.

Recent research has shown that the average number of cats per square kilometre on Kangaroo Island is more than double that on the mainland (0.37 cats per square km, range 0.06–3.27 cats per square km[9]). Furthermore, in areas on the island where the availability of animal carcasses is relatively high, such as on farmland and along roads, the density of feral cats may be more than ten times that of mainland estimates[10].

Controlling cats to allow recovery of native species now represents a significant biodiversity challenge for the partners involved in Kangaroo Island wildlife recovery. Large-scale and sustained cat control is currently underway in many of the unburnt remnants and along the roads, tracks and wildlife corridors that link these habitats and act as 'highways' for cats.

The cat control projects are using a variety of traditional and novel tools to effectively target cats in this recently modified landscape. This includes the use of cage and soft-jawed leg-hold traps, Felixer® grooming traps, targeted shooting using thermal scopes and spotlights at night when cats are most active, and the use of feral cat detector dog teams. The feral cat bait Curiosity® is also being trialled, and it is hoped that this will be an effective, long-term strategy to target cats in remote areas far from roads.

Since the fire, the Kangaroo Island Landscape Board and National Parks and Wildlife Service have culled 102 feral cats on park and KI Land for Wildlife have culled 130 cats to the north of Flinders Chase on private land. Cat densities will be monitored to determine how the fires have changed cat numbers and which control techniques are most effective, to help develop longer-term strategies for cat management in the future.

Images: Feral cats have been recorded by camera traps preying on native animals – a crescent honeyeater (left) and a bush rat (right).

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[9] Hohnen *et al.* (2020) Pre-eradication assessment of feral cat density and population size across Kangaroo Island, South Australia. Wildlife Research, in press. www.publish.csiro.au/wr/WR19137.

[10] Taggart *et al.* (2019) Evidence of significantly higher island feral cat abundance compared with the adjacent mainland. Wildlife Research 46, 378-385 www.publish.csiro.au/WR/WR18118.

CASE STUDY 8: Herbivore impacts – kangaroo management

Concerns have been expressed for over a decade about the unnaturally high grazing impacts of western grey kangaroos in many reserves in the Adelaide Hills, including Charleston Conservation Park (CP).

Charleston CP conserves several threatened ecosystems, including woodlands of blue gum, manna gum, red gum, silver banksia and drooping sheoak. Aerial imagery shows us that, historically, the park had large areas with a dense shrub and groundcover layer, including many herbs, grasses, sedges and lilies. However, because it is a small park surrounded by agricultural land that is mostly cleared, kangaroo grazing pressure has been at very high levels for several decades, leading to a major reduction in understory plants.

To investigate these impacts further, long-term monitoring in Charleston CP was established in 2008, which includes a record of the number of heavily, severely and lightly grazed plants of all species present.

Between 2008 and 2018, the monitoring showed a significant reduction in palatable species and increased evidence of grazing pressure. By 2018 the live banksias and sheoaks were gone and there was no evidence of recruitment from either species. Also, the heath tea-tree (*Melaleuca myrsinoides*) in the shrub layer declined from 5% cover of the survey quadrat in 2008 to being absent in 2018. Only a small number of heavily grazed plants could be found outside the quadrat. Similarly, during the most recent survey the cranberry heath (*Astroloma humifusum*) and hairy guinea-flower (*Hibbertia crinita*) had been grazed close to ground level. In contrast, these plants had proliferated in an adjoining grazing exclosure.

In 2014 a wildfire from lightning strike burned a small patch of Charleston CP and, due to heavy grazing by kangaroos, the site has never recovered. This was a clear indicator of what would occur after a large-scale fire event. Also, the high grazing pressure has precluded the option of using prescribed burning to regenerate the silver banksia population and reverse its continuing decline.

The 2019 Cudlee Creek bushfire burned all of Charleston CP and post-fire regeneration of native plants was vulnerable to grazing by overabundant kangaroos. In an attempt to protect the regenerating vegetation, the damaged boundary fence was replaced with a kangaroo exclusion fence to minimise grazing pressure.

A survey in July 2020 indicated there were between 100 and 150 kangaroos within the 100-ha fenced reserve. The kangaroo population within the fenced area will now be reduced via shooting to achieve a more natural density of kangaroos and give this important ecosystem an opportunity to recover. The recovering woodland should also provide important habitat for a wide range of declining woodland birds in the Mount Lofty Ranges.

Images: (L-R) A heavily grazed drooping sheoak seedling; exclosure showing the impacts of grazing prior to the fire – within the fenced area there is clearly a high diversity and density of native plant species that are not present outside the fence; the new fence on the boundary of Charleston CP.

CASE STUDY 9: Paddock tree replacement after the Cudlee Creek fire

Trees For Life's Bushfire Recovery Paddock Tree Project is establishing the next generation of paddock trees in the area affected by the December 2019 Cudlee Creek bushfire, providing critical habitat for many woodland bird species whose numbers were already declining prior to the fire.

The project is funded by the Woodland Bird Resilience Program, a joint initiative of the Australian and South Australian governments in response to the Cudlee Creek bushfire. The project will be delivered over the next two years, in partnership with the Hills and Fleurieu Landscape Board.

Trees For Life has been delivering the Paddock Tree Project in partnership with the Adelaide and Mt Lofty Ranges Natural Resources Management Board since 2016. Over the last four years, over 18,500 eucalypts, sheoaks, acacias and native pines have been planted in the eastern Mount Lofty Ranges. Part of this project area was burned in the Cudlee Creek bushfire, affecting over 400 previously planted saplings and many long-standing paddock trees.

Scattered paddock trees are critical to the health of Australian farming landscapes and provide a range of environmental and production benefits. They provide shade and shelter for stock, improve soil condition and invertebrate diversity, and are an iconic feature of the South Australian farming landscape.

A critical objective of this project is to safeguard the long-term survival of a number of threatened woodland bird species, including the diamond firetail, red-rumped parrot and red-capped robin. Woodland bird numbers have declined significantly in the past 10 years, and some species have disappeared from parts of the Adelaide Hills. This coincides with paddock tree numbers declining due to poor health, old age and fire.

The Bushfire Recovery Paddock Tree Project will replace previously planted paddock trees that did not survive the recent fires. The planting and guarding of the trees is carried out at no cost to the grazier, who commits to caring for the trees into the future. Planting plans for each property are designed in consultation with the landholder, informed by detailed field surveys, mapping and analysis. This ensures the best possible outcomes for the landholders and the region's biodiversity.

Images: (L-R) This post-fire photo from near Harrogate shows the need to replace paddock trees in this landscape; seedlings are guarded from stock and feral grazers; the paddock trees program in the eastern Mount Lofty Ranges has been supported by many landholders, including the Atkinson family near Harrogate, shown here with Geoff Hodgson from Trees For Life (on right).

CASE STUDY 10: Evidence-based recovery – research partnerships

Wildlife and habitat recovery needs to be informed by the best available evidence, to ensure that the impacts of fire are well understood, and that our responses are effective and efficient. Strong and ongoing partnerships between managers, researchers and the community are critical to the delivery and interpretation of relevant and timely evidence to support these decisions.

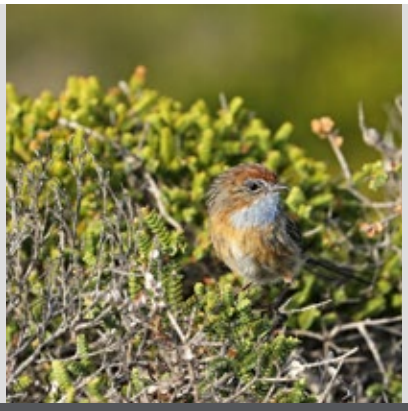
On Kangaroo Island, KI Landscapes Board and the Department for Environment and Water established a research partnership with the National Environmental Science Program (NESP) Threatened Species Recovery (TSR) Hub, in order to investigate the ecology and distribution of the Endangered Kangaroo Island dunnart, and the potential impact of feral cats on this species. This research, initiated in 2017, significantly improved our ability to find dunnarts in the wild through the development of new survey techniques, and to predict the distribution of dunnart habitat. Both of these research outcomes dramatically improved the emergency response to the conservation of this species during and immediately following the wildfires.

Furthermore, the long-term partnerships developed with the NESP TSR Hub meant that those involved with the response were able to rapidly access the knowledge and experience of some of Australia's best ecologists, several of whom were on the national Wildlife and Threatened Species Bushfire Recovery Expert Panel established by the Australian Government. As a result of their existing connection with Kangaroo Island, these experts reached out before the fires were even controlled, enabling decisions to be informed by their expertise.

Image: Personnel from SA Department for Environment, National Parks and Wildlife SA and KI Landscape Board came together with the National Environmental Science Program Threatened Species Hub in 2017 to support the recovery of the KI dunnart. This existing partnership helped ensure that KI received significant attention nationally after the 2019–20 bushfires.

Phase 3: Medium-term actions (1–3 years)

Outcome	**Priority species, threatened species and habitats maintained or improved through ongoing management**	
Objectives	3.1	To repeat surveys to determine the survival of priority species
	3.2	To maintain threat management programs (such as feral animal control)
	3.3	To adapt survey and management actions based on results
	3.4	To engage community and business/industry in collaborative efforts for mutual benefits
Possible actions	3.1	Establish protected locations for additional populations of range-restricted species
	3.2	Implement population management for priority animal species, such as • translocation to alternative habitat • captive breeding • reintroductions
	3.3	Protect key unburnt habitat
	3.4	Restore and augment habitat, such as • revegetation and other plantings • nest boxes • other artificial habitat
	3.5	Monitor recovery of populations of key species
	3.6	Implement intensified and sustained predator control within burnt and adjacent areas
	3.7	Implement intensified and sustained weed control within burnt and adjacent areas
	3.8	Maintain intensified and sustained competitor herbivore control within burnt and adjacent areas
	3.9	Liaise with landholders to provide ongoing support and advice
	3.10	Fence localised/remnant populations including riparian habitat and shade trees
	3.11	Liaise with landholders to provide ongoing support and advice
	3.12	Control sediment and erosion to protect water and soil resources
	3.13	Monitor water resources
	3.14	Maintain data systems and services required to collect and share monitoring data and other data from response activities
	3.15	Review and improve effectiveness of data systems and services
	3.16	Pursue nature-based tourism linked to recovery ('voluntourism')
	3.17	Engage with community and industry to inform, involve and collaborate
	3.18	Build capacity for proactive fire management to enable adaptive fire planning to be implemented across SA
	3.19	Secure long-term and adequate resourcing for the management and recovery of threatened species, to improve their resilience to fires and other crises


CASE STUDY 11: Assessment and listing of affected species

It is important to maintain accurate lists of threatened species and their conservation status, to guide management, conservation planning and investment.

A number of species were severely affected by the 2019–20 bushfires in South Australia, particularly on Kangaroo Island, where many species had a large proportion of their distribution burned; some species had their entire known distribution burned.

It is important to assess any changes to species' conservation status (risk of extinction) as a result of the fires, so that this can be considered when prioritising recovery efforts and when developing conservation and management strategies, including fire management.

Updates will be required to threatened species listings under both South Australia's *National Parks and Wildlife Act 1972* (NPW Act), and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This will include:

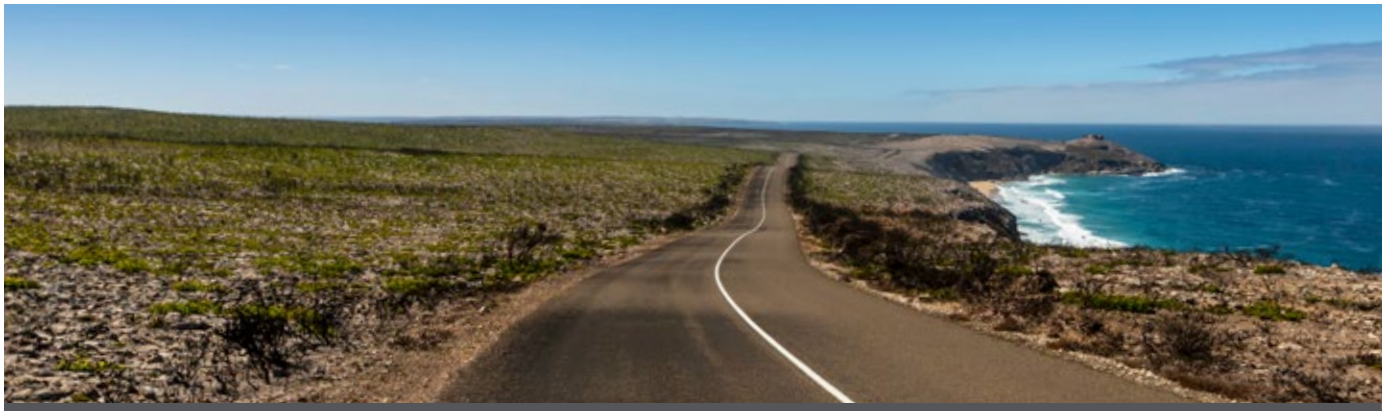
- species that are endemic to South Australia, requiring assessment for listing under both the NPW Act and EPBC Act
- species that occur in South Australia and one or more other states or territories, including other fire-affected regions, and will require reassessment of their national status under the EPBC Act
- species that are not nationally threatened but have become more threatened in South Australia as a result of the fires and may require listing under the NPW Act.

Work is currently underway to identify those species requiring assessment as a result of the 2019–20 fires. For some species, on-ground surveys will be required to determine the impacts of the fire, including the magnitude of population declines and habitat loss. These surveys will also help identify priority short-term actions to support recovery.

Longer-term monitoring may be required to improve our understanding of some impacts. For example, resumption of flowering of some eucalypts may take several years following high-intensity fires, which will have impacts on long-term population recovery for nectar-feeding birds and pygmy-possums.

The fires also provide an important opportunity for surveys and status assessments of cryptic plant species that respond to fire or are more easily detectable following fire. Some of these species were previously classified as 'data deficient', as little was known about their distribution and population size. The post-fire period provides an opportunity to survey and clarify the status of these species, so that important populations can be documented and conserved through future management arrangements.

Images: The Kangaroo Island bushfires severely affected many species, requiring a reassessment of their conservation status to help prioritise management strategies; (L-R) enigma hakea, southern emu-wren (photo: Tom Hunt); micro-trapdoor spider (photo: Jess Marsh).



CASE STUDY 12: Improved park management planning

The Department for Environment and Water has commenced development of a new park management plan for the Kangaroo Island parks affected by the 2019–20 fires.

The management plan will establish a long-term vision and consolidate management directions for each park. It will also focus future management efforts on the key conservation values, the most critical threats and the most important strategies to manage those threats. Importantly, the process will also provide opportunities for the local community to have input to the plan.

Park management plans are required by legislation, guided by public consultation and approved by the Minister for Environment and Water. They explain how a park will be managed and set strategic direction, and are the primary public accountability document for each of South Australia's parks and wilderness protection areas.

The park management plan will not address detailed operational matters, such as resourcing and equipment for fire management. However, it will provide an overview of fire management principles and practices, consistent with the key findings and recommendations from the Independent Review into South Australia's 2019–20 Bushfire Season[11].

Image: Wide angle landscape view over Flinders Chase.

[11] Keelty *et al.* (2020) Independent Review into South Australia's 2019–20 fires Bushfire Season. Government of South Australia. https://www.safecom.sa.gov.au/site/independent_review_sa_201920_bushfires.jsp.

Phase 4: Longer-term actions (3 years and beyond)

Outcome	Priority threatened species and habitats have long-term resilience	
Objectives	4.1	To secure outcomes achieved in first three years
	4.2	To develop dynamic tools to guide fire management actions
	4.3	To build resilience into social, economic and ecological systems by learning from the recovery process and building capacity to respond positively to future events
Possible actions	4.1	Maintain gains achieved from all previous actions (e.g. physical maintenance of nest boxes and revegetation, maintenance of weed and feral animal control programs)
	4.2	Adapt plans and recovery actions based on lessons learned from new research and monitoring from phases 1, 2 and 3
	4.3	Implement monitoring to inform adaptive management
	4.4	Review research plan and continue longer-term research programs
	4.5	Protect unburnt habitat based on dynamic fire management planning tools, supported by data collected during phases 1, 2 and 3
	4.6	Incorporate new knowledge to improve park management planning
	4.7	Share lessons learned from initial recovery with relevant stakeholders/partners to improve practices and outcomes
	4.8	Pursue nature-based tourism linked to recovery ('voluntourism')
	4.9	Engage with community and industry to inform, involve and collaborate
	4.10	Develop long-term dynamic fire planning tools to guide next practice hazard reduction, prescribed burning and ecological burning to better protect all assets
	4.11	Work with stakeholders, especially communities, industry, businesses and government, to adapt and transform approaches to landscape management, including fire management, to build resilience for future natural disasters

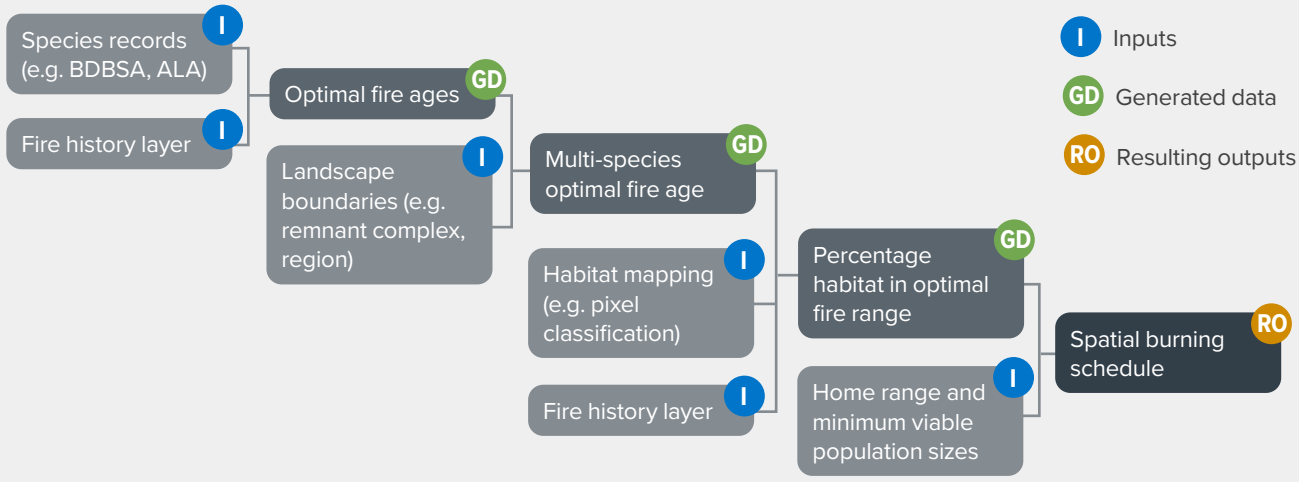
CASE STUDY 13: Fire by design – improving conservation outcomes while reducing risk to life and property

Fire has been a persistent force in the ecology of Australia for tens of millions of years. Many native species and ecosystems are reliant on fire for recruitment and/or maintenance of habitat quality. However, fire events in recent decades have highlighted the role that climate change is playing in modifying the nature of fire dynamics. It is becoming increasingly likely that fire events will be large, intense and homogeneous, and these events will become more frequent. This has very serious implications for the maintenance of biodiversity and its future evolutionary potential, as well as for lives and property.

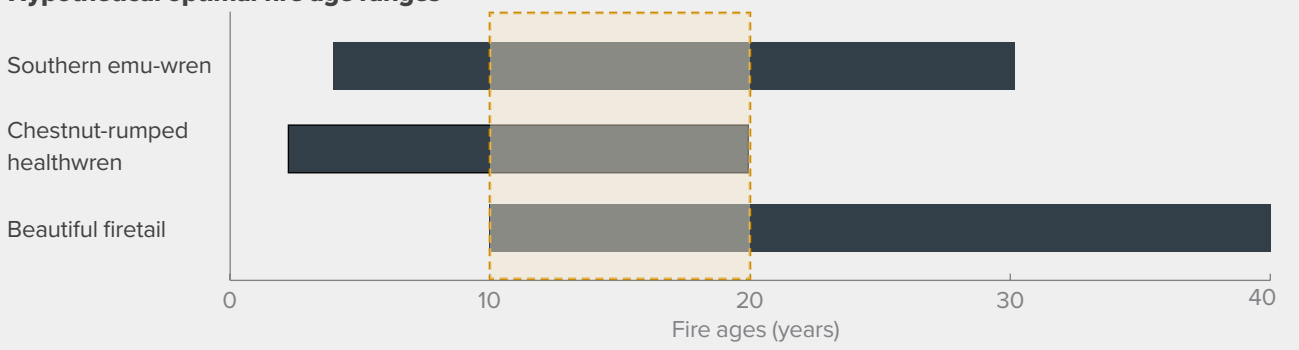
Prescribed burning is already extensively used in South Australia to reduce the risk of fire to lives and property, and is likely to be an increasingly important strategy to mitigate the impacts of forecast changes in fire dynamics. However, native species and ecosystems show substantial variability in their fire responses and requirements. Consequently, there is a critical need to be able to forecast the implications of different fire regimes on biodiversity and to identify those prescribed burning options that will ensure the maintenance of biodiversity and its evolutionary potential while successfully achieving fire risk reduction for life and property. Such forecasting needs to be dynamic and spatially explicit, so that the future implications and delivery needs can be continuously updated as prescribed burns are implemented or as wildfires occur.

A dynamic fire planning tool is currently being built for the Mount Lofty Ranges to fulfil this critical need. This tool will provide real-time, optimal prescribed burning priorities that achieve the best conservation outcomes while also reducing risks to life and property. This tool could subsequently be expanded to the remaining fire-prone areas of the state.

Analysis process and associated inputs and outputs



Hypothetical optimal fire age ranges



The figure above presents a summary of the proposed analysis process and associated inputs and outputs. The chart at the bottom shows hypothetical optimal fire age ranges for a number of individual species of conservation concern, along with the multi-species optimum highlighted by the grey-shaded age range.

CASE STUDY 14: Future-proofing biodiversity and environmental benefits – adaptation strategies for South Australia's ecosystems

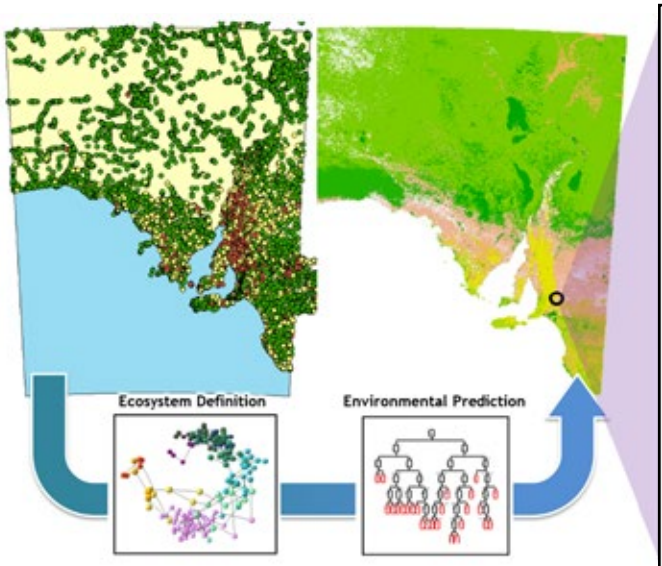
Changing fire regimes is only one of many ways in which climate change will impact the state's biodiversity. There will also be changes in hydrological regimes, temperature gradients, seasonality, and the severity and frequency of droughts and storm events. The nature and magnitude of these changes will depend upon the decisions we make now around greenhouse gas emissions.

The South Australian government is currently investing in new, high-resolution statewide climate predictions. However, to understand the likely impacts of these predictions for biodiversity, this work needs to be complemented by an assessment of several factors, especially the nature and timing of change at the scale of individual ecosystems; the arising environmental, economic and social implications; and feasible adaptation strategies to mitigate undesirable impacts.

The Ecosystems of SA project is already defining and delineating the ecosystems of the state through a data-driven analytical approach. An advantage of this approach is that the climatic factors in the analyses can be varied to reflect future climate scenarios, enabling changes in the composition and distribution of ecosystems to be forecast. The implications of these changes and potential adaptation opportunities can then be identified.

A project has been scoped to consider potential ecological impacts and adaptation opportunities to ensure that South Australia's ecosystems retain their biological diversity and evolutionary potential, support sustainable production, and provide a healthy and liveable environment for the state's residents.

Likely adaptation opportunities would include changes to existing planning, policy and delivery mechanisms across South Australia, and the identification of new on-ground actions to be delivered in collaboration with the community and industry.



RCP 2.6	Falls within Historic Range of Variability	Habitat Composition ✔ Habitat Structure ✔ Habitat Function ✔
RCP4.5 to RCP 6.0	Some environmental filtering will change species abundances	Habitat Composition ✖ Habitat Structure ✔ Habitat Function ✔
RCP 8.5	Re-assembly will change species presences and abundance	Habitat Composition ✖ Habitat Structure ✔ Habitat Function ✔

Delivery Actions for Biodiversity

[in this Landscape delivery actions would be the same under current and all future scenarios, but this is not always the case]

1. Maintain low input grazing production systems that are critical to supporting habitat structure for biodiversity values in these modified landscapes.
2. Immediate delivery measures: replace key structural habitat features lost through historic grazing production systems (particularly paddock trees and coarse woody debris)
3. Short-term delivery measures: grazing management changes to enable scattered tree replacement through time (rather than mass dense regeneration events that actually destroy habitat)

[Potential to use stewardship mechanisms to support transition from current to new regimes]

The figure above summarises the Ecosystems of SA process and the type of future forecast outputs that can be generated. The left side shows the State's biological survey sites, which are being analysed to define the Ecosystems of SA and model their predicted occurrence. This model can then be re-run under different future climate scenarios (using different greenhouse gas Representative Concentration Pathways, RCPs) to enable the resulting ecosystem changes and their implications to be identified. An example output is presented on the right side of the figure for a low rainfall woodland ecosystem in the eastern Mount Lofty Ranges. In this specific example, addressing existing issues will be more important to maintaining habitat and associated biodiversity values into the future than focusing on additional climate-specific actions.

Implementation: improving future preparedness for bushfires and bushfire recovery

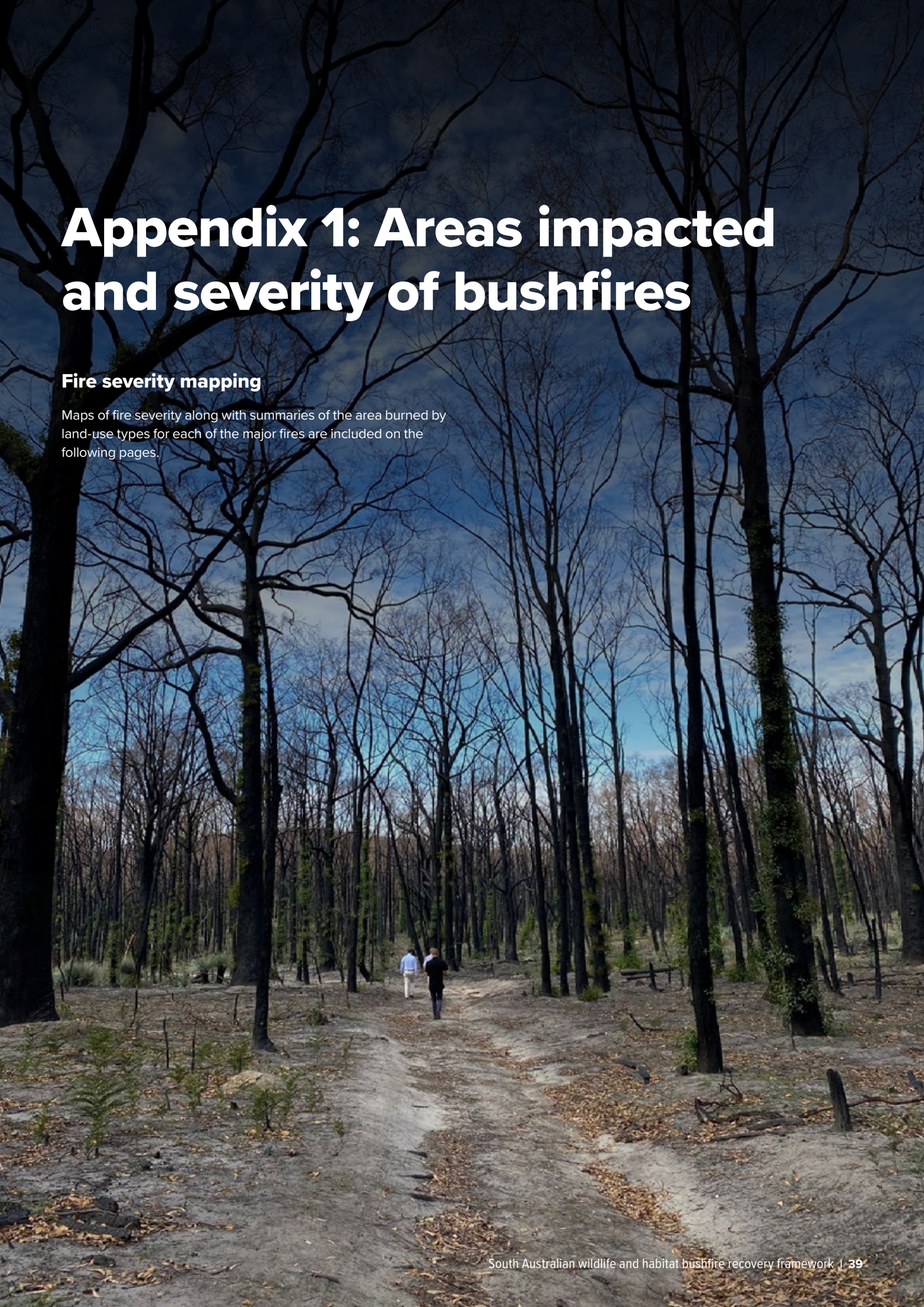
There are numerous strategic challenges and opportunities relating to ensuring the long-term resilience of habitat and wildlife and the future preparedness of government, industry and the community to bushfires. The SA Habitat and Wildlife Bushfire Recovery Taskforce has identified a number of key issues that it will continue to focus on during implementation of the recovery framework, including:

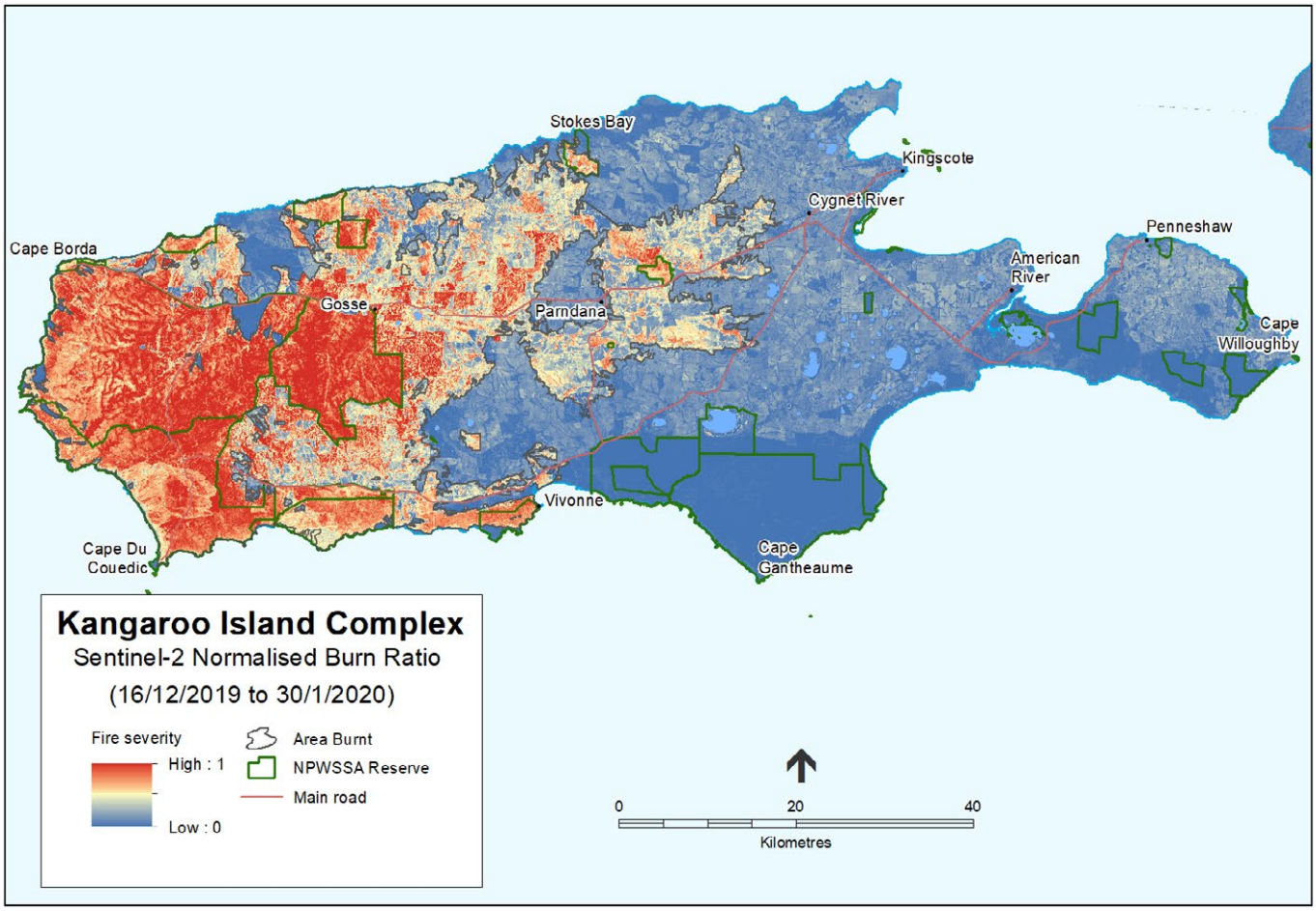
- engagement and empowerment of the community to collaborate and assist to implement the SA wildlife and habitat bushfire recovery framework
- strong partnerships with the agricultural sector, tourism, other landholders and industry associations to ensure that cross-tenure wildlife and habitat recovery can be implemented
- long-term investment in species recovery and conservation management
- clarification of the roles and responsibilities regarding wildlife and habitat recovery among organisations (including government agencies, landscape boards, the community, industry, Zoos SA, and volunteer conservation and wildlife carer organisations)
- incorporation of the impacts of climate change
- detailed examination of departmental approaches, systems and preparedness for managing future bushfires, and the impacts on conservation practice and action required to mitigate the impacts of bushfire and other natural disasters on the state's wildlife
- development of research priorities to generate the knowledge needed to underpin recovery and understand the implications for conservation of wildlife, habitat and sustainable landscapes in South Australia
- increased participation of South Australian universities in national research programs focused on recovery
- improved coordination of wildlife rescuers, their activities within firegrounds, resourcing and systems of support
- identification of opportunities to improve departmental wildlife permits and/or systems to support bushfire response
- identification of opportunities to improve departmental systems to provide up-to-date and timely information on species and ecosystems impacted, to identify recovery actions to mitigate impacts
- identification of opportunities to formalise recovery partnerships with industry sectors and community organisations
- communications and 'myth busting' activities to explain the role of fire and maintain community interest in recovery
- engagement of Aboriginal communities in recovery activities, including development of a proposal for participation of Aboriginal rangers to assist with recovery actions
- increased integration of wildlife recovery activities with economic and agricultural/landscape recovery activities
- support and advice to volunteer groups in acquitting philanthropic funds raised during bushfires
- engagement of industry (including tourism, agriculture, and environmental services) as integral partners in wildlife recovery.

Appendix 1: Areas impacted and severity of bushfires

Fire severity mapping

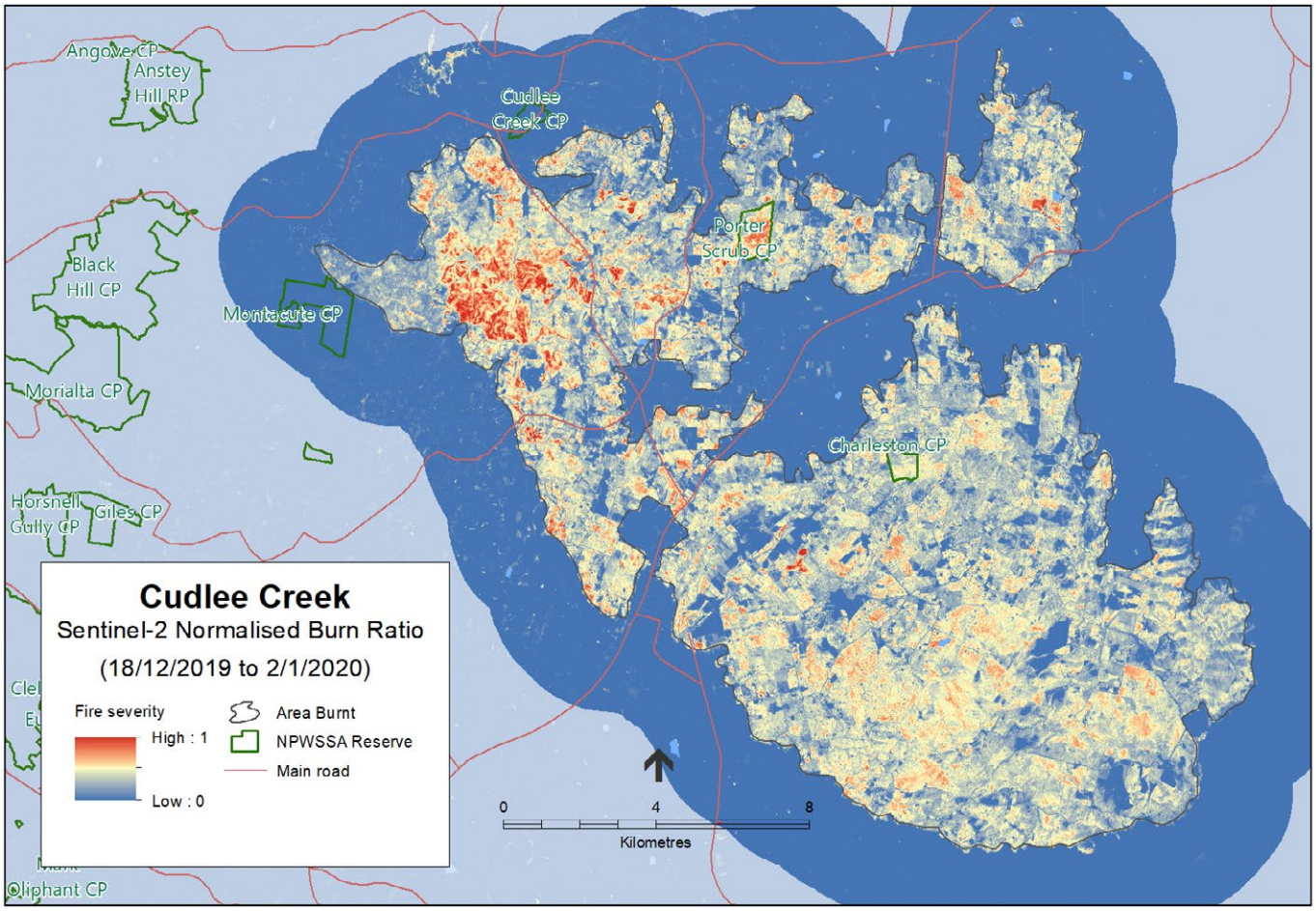
Maps of fire severity along with summaries of the area burned by land-use types for each of the major fires are included on the following pages.





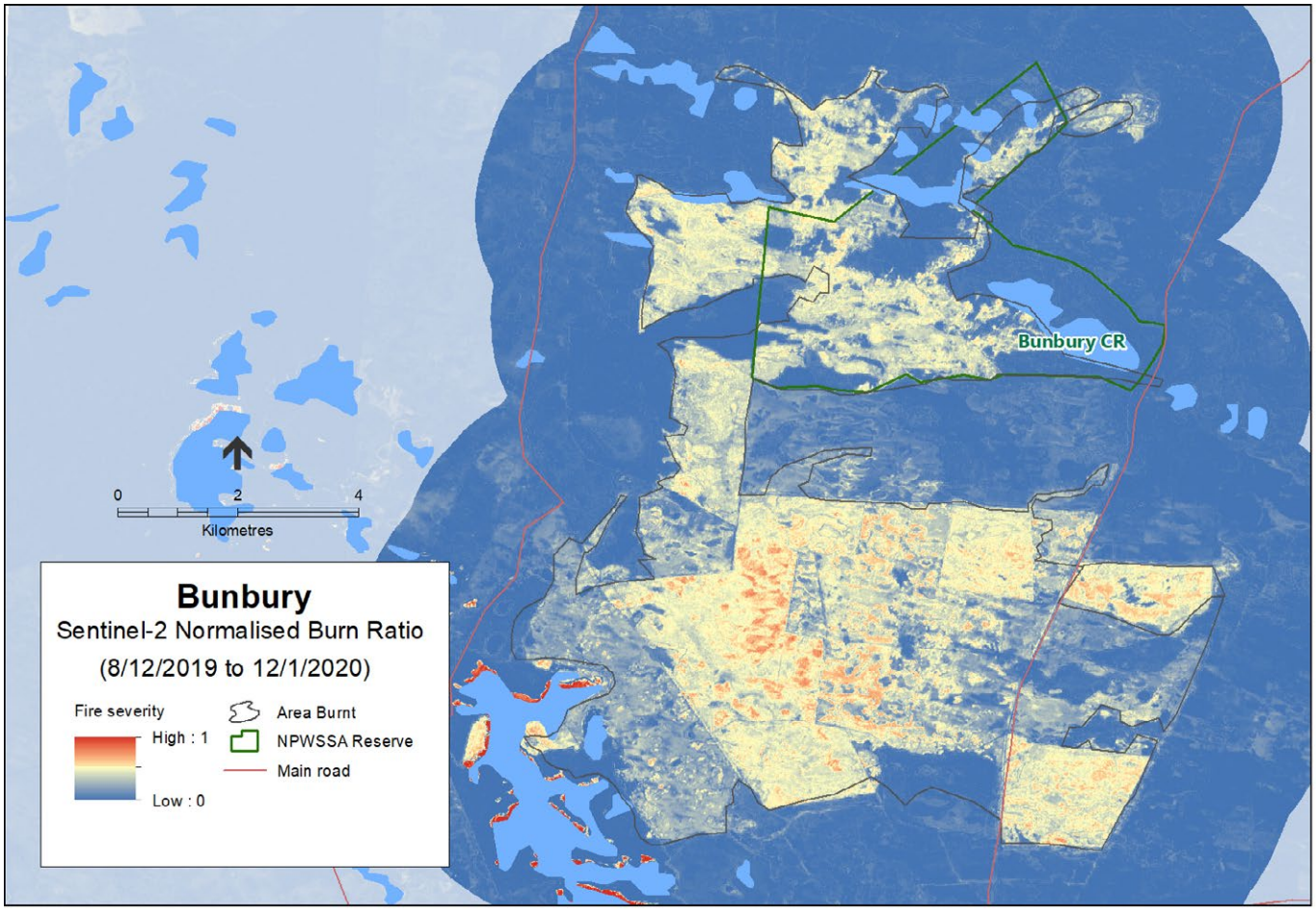
Kangaroo Island

Land-use Description	Area ha	Per cent
Nature conservation	91958	46
Managed resource protection	184	0
Other minimal use	32505	16
Plantation forests	21994	11
Grazing modified pastures	44598	22
Cropping	6159	3
Land in transition	237	0
Irrigated cropping	105	0
Irrigated perennial horticulture	60	0
Irrigated seasonal horticulture	66	0
Intensive animal production	74	0
Manufacturing and industrial	8	0
Residential and farm infrastructure	174	0
Services	40	0
Utilities	2	0
Transport and communication	2628	1
Mining	16	0
Waste treatment and disposal	1	0
Lake	159	0
Reservoir/dam	207	0
River	22	0
Marsh/wetland	617	0
	201830	100



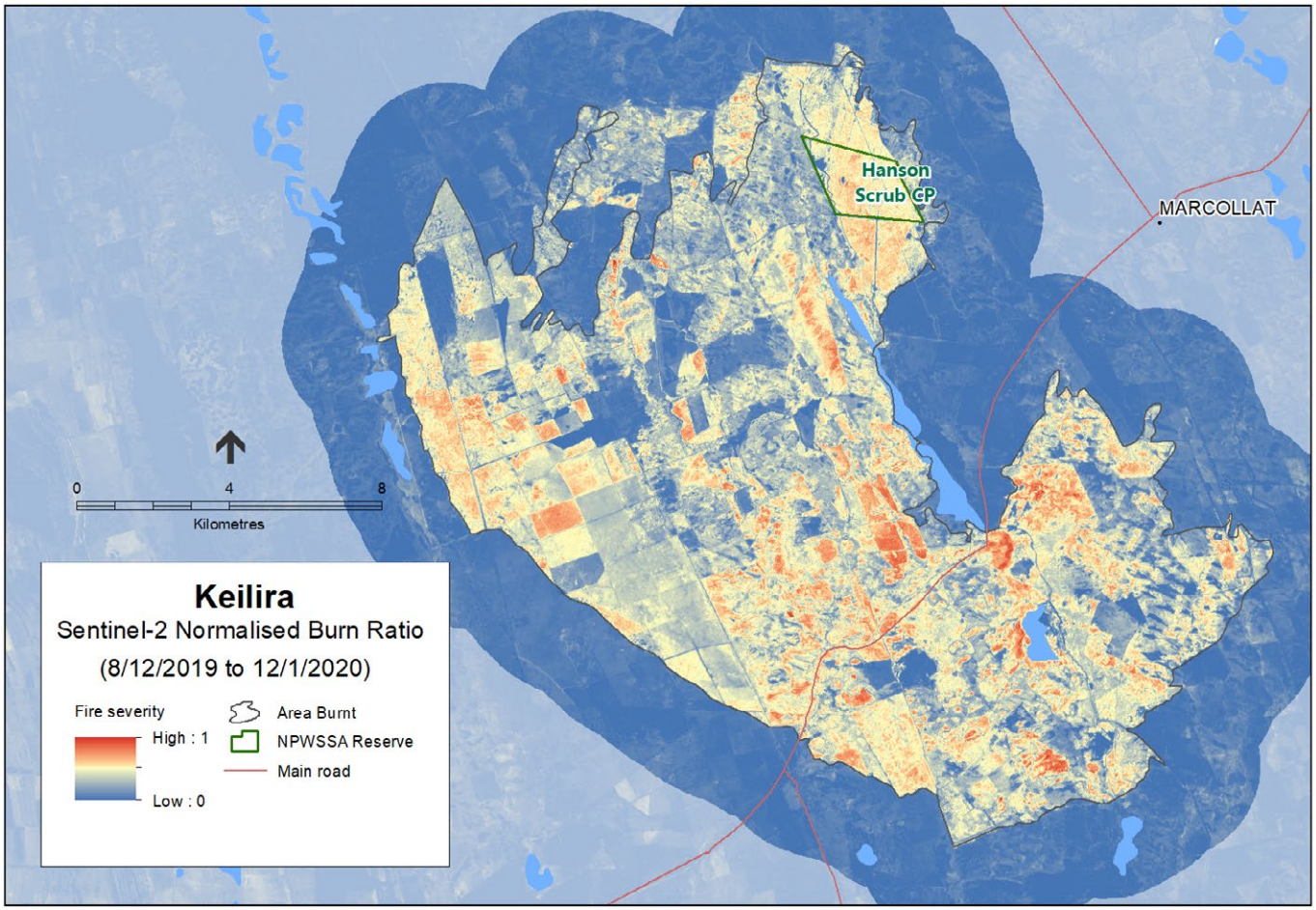
Cudlee Creek

Land-use Description	Area ha	Per cent
Nature conservation	358	2
Managed resource protection	115	1
Other minimal use	1629	7
Grazing native vegetation	152	1
Plantation forests	961	4
Grazing modified pastures	14811	65
Cropping	1033	5
Perennial horticulture	10	0
Land in transition	39	0
Grazing irrigated modified pastures	427	2
Irrigated cropping	67	0
Irrigated perennial horticulture	1032	5
Irrigated seasonal horticulture	5	0
Irrigated land in transition	54	0
Intensive horticulture	6	0
Intensive animal production	25	0
Manufacturing and industrial	3	0
Residential and farm infrastructure	1531	7
Services	120	1
Utilities	1	0
Transport and communication	522	2
Mining	39	0
Waste treatment and disposal	73	0
Reservoir/dam	157	1
Marsh/wetland	11	0
	22823	100



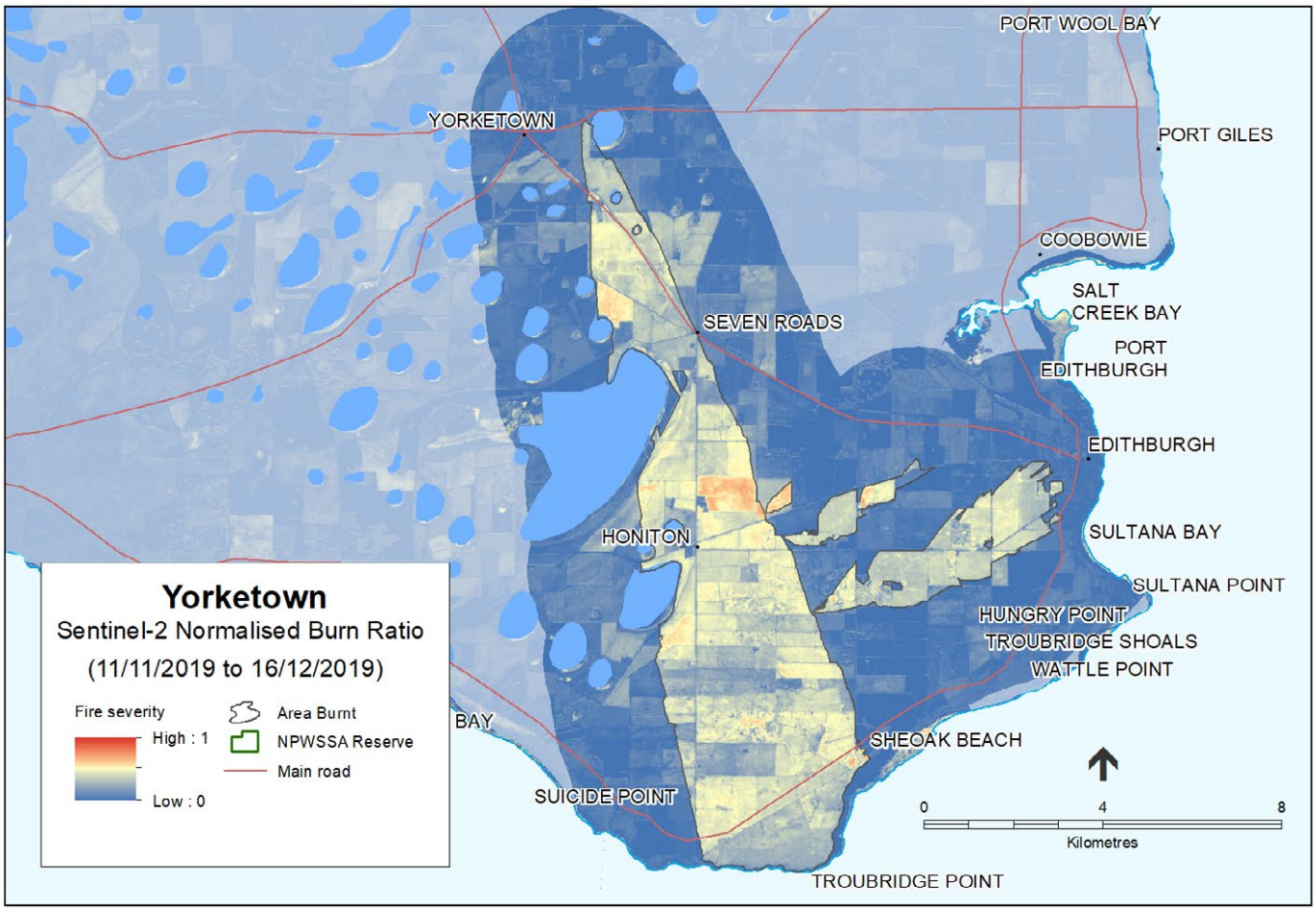
Bunbury

Land-use Description	Area ha	Per cent
Nature conservation	1750	24
Other minimal use	665	9
Grazing modified pastures	2674	37
Residential and farm infrastructure	1	0
Transport and communication	56	1
Lake	28	0
Reservoir/dam	0	0
Channel/aqueduct	2	0
Marsh/wetland	1998	28
	7174	100



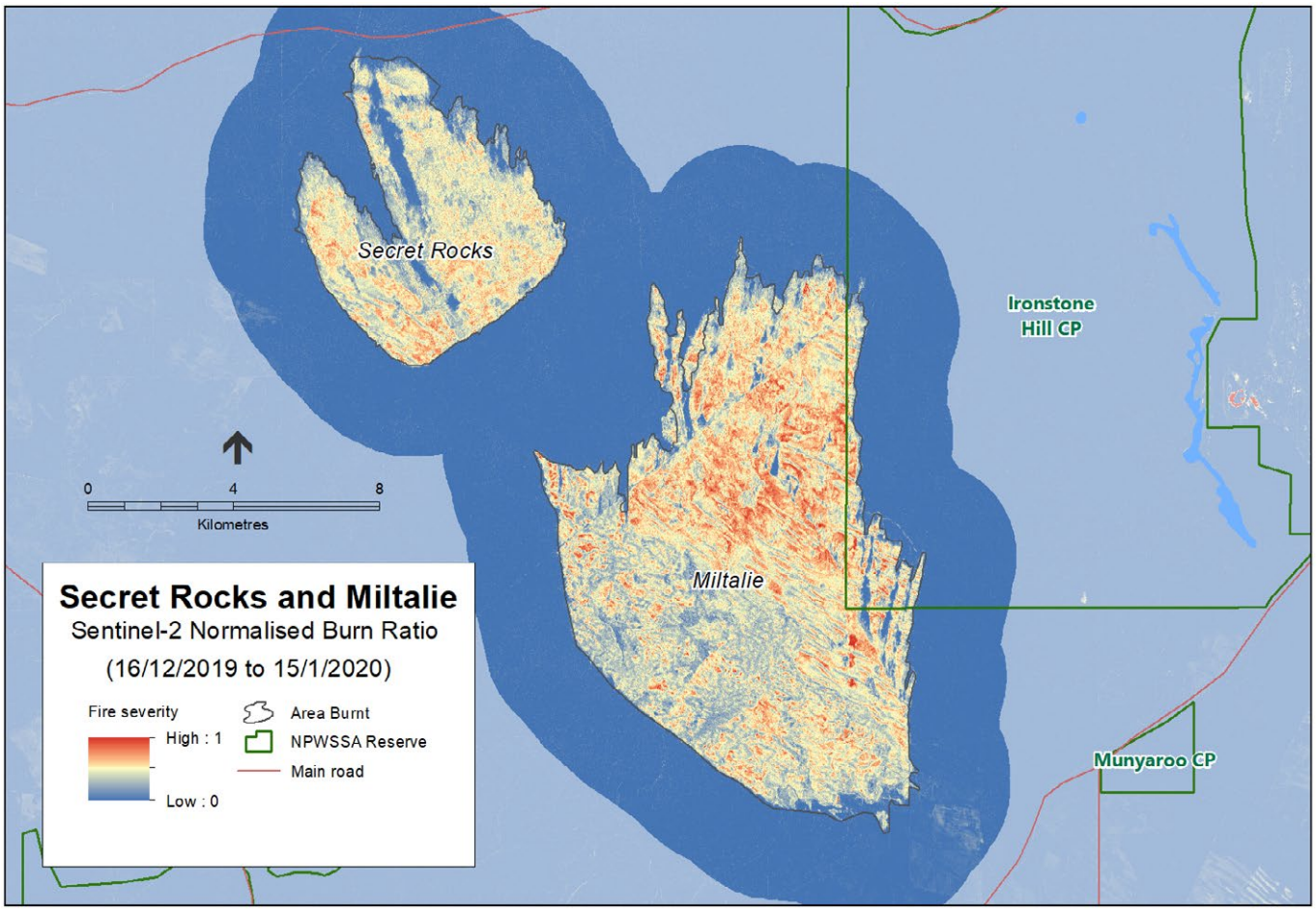
Keilira

Land-use Description	Area ha	Per cent
Nature conservation	655	3
Other minimal use	2547	11
Grazing native vegetation	659	3
Plantation forests	257	1
Grazing modified pastures	15172	66
Cropping	752	3
Land in transition	33	0
Residential and farm infrastructure	30	0
Transport and communication	229	1
Mining	3	0
Channel/aqueduct	79	0
Marsh/wetland	2477	11
	22893	100



Yorketown

Land-use Description	Area ha	Per cent
Other minimal use	62	1
Grazing modified pastures	597	12
Cropping	4124	82
Residential and farm infrastructure	36	1
Services	0	0
Utilities	9	0
Transport and communication	102	2
Lake	70	1
Marsh/wetland	0	0
	5008	100



Secret Rocks

Land-use Description	Area ha	Per cent
Nature conservation	3692	100
	3692	100

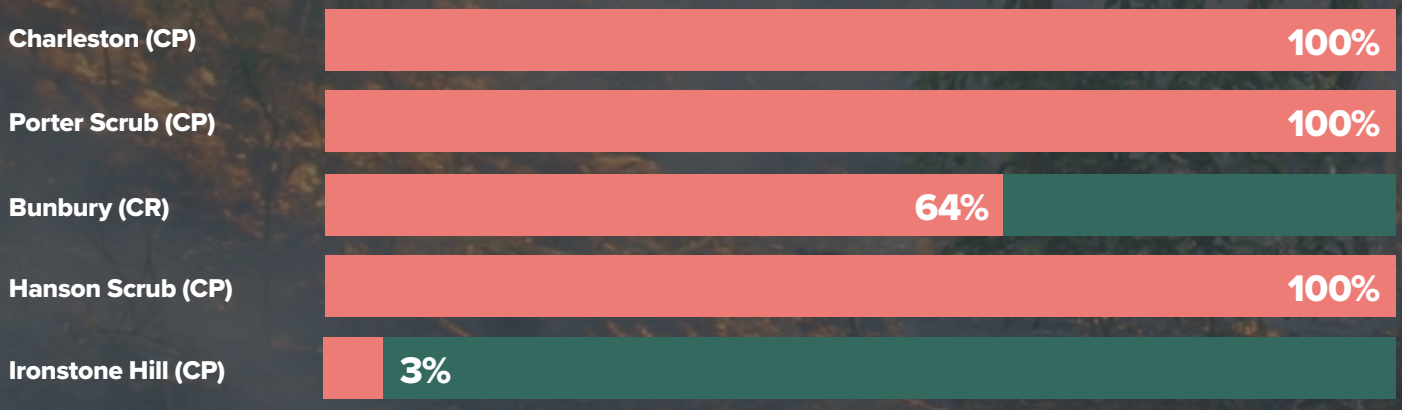
Miltalie

Land-use Description	Area ha	Per cent
Nature conservation	9355	92
Other minimal use	109	1
Grazing native vegetation	611	6
Cropping	102	1
	10178	100

Summary of area burnt for the 14 parks affected

Kangaroo Island

Cudlee Creek and others



Appendix 2: Native fauna of immediate concern

The following table lists all the fauna species of conservation concern along with their threatened status and proportion of habitat impacted (where data available).

Common name	Species name	Threatened species status		Description of impact – percentage of sites/habitat burnt where known*
		National	SA	
Kangaroo Island				
Swamp Rat	*Rattus lutreolus*	-	RARE	100% ††
Kangaroo Island Dunnart	*Sminthopsis aitkeni*	CN	EN	93% **
Little Pygmy-possum	*Cercartetus lepidus*	-	-	88%
Southern Brown Bandicoot (SA mainland and KI)	*Isoodon obesulus obesulus*	EN	VUL	53%
Short-beaked Echidna *(Kangaroo Island)*	*Tachyglossus aculeatus multiaculeatus*	EN	VUL	41%
Platypus †	*Ornithorhynchus anatinus*	-	EN	100%
Koala †	*Phascolarctos cinereus*	-	-	64%
Bassian thrush (southern FR, MLR, KI)	*Zoothera lunulata halmaturina*	VUL	RARE	95%
Southern emu-wren (Kangaroo Island)	*Stipiturus malachurus halmaturinus*	-	RARE	90%
Glossy black cockatoo (Kangaroo Island)	*Calyptorhynchus lathami halmaturinus*	EN	RARE	38% natural and artificial nesting hollows destroyed; 54% of sheoak feeding habitat burnt and unavailable until it regenerates
Western whipbird (Kangaroo Island subspecies)	*Psophodes leucogaster lashmari*	-	RARE	73%
Shy heathwren (Kangaroo Island)	*Hylacola cauta halmaturina*	-	-	72%
Beautiful firetail (MLR and KI)	*Stagonopleura bella samueli*	-	RARE	70%
Australian owlet-nightjar	*Aegotheles cristatus*	-	-	70%+
Little eattlebird	*Anthochaera chrysoptera*	-	-	65%
Yellow-tailed black cockatoo	*Zanda (Calyptorhynchus) funerea whiteae*	-	VUL	58%
Painted buttonquail	*Turnix varius*	-	RARE	unavailable

Common name	Species name	Threatened species status		Description of impact – percentage of sites/habitat burnt where known*
		National	SA	
Eastern osprey	*Pandion haliaetus cristatus*	-	EN	Impacts unknown but potential for birds and/or nests to be affected
White-bellied sea eagle	*Haliaeetus leucogaster*	-	EN	Impacts unknown but potential for birds and/or nests to be affected
Heath goanna	*Varanus rosenbergi*	-	VUL	41%
Brown toadlet	*Pseudophryne bibronii*	-	RARE	100%
Climbing galaxias	*Galaxias brevipinnis*	-	-	87%
Eastern bronze azure #	*Ogyris halmaturia*	##	##	99%; open mallee or coastal vegetation, host ant, floral resources in November; Myrmecophilous; obligate association with ant *Camponotus terebrans* (larvae develop in ant nests).##
Small brown azure #	*Ogyris otanes otanes*	##	##	80%; host ant and food plants (*Choretrum* spp.); Myrmecophilous; obligate association with ant *Camponotus terebrans* (larvae shelter in ant nests during daytime).
Raspy cricket #	*Apteronomus bordaensis*	##	##	80%; suitable oviposition sites; heath vegetation communities; likely on sand; genus endemic to KI.
Raspy cricket #	*Apteronomus tepperi*	##	##	80%; suitable oviposition sites; heath vegetation communities; likely on sand; genus endemic to KI.
KI marauding katydid #	*Metaballus mesopterus*	##	##	80%; suitable oviposition sites; dense foliage; KI endemic.
KI robust fan-winged katydid #	*Psacadonotus insulanus*	##	##	80%; suitable oviposition sites; dense foliage; Possibly associated periphery of saline or fresh wet areas; KI Endemic. **Endangered** (IUCN).
Ghost moth #	*Abantiades* sp. n. Kangaroo Island	##	##	≈80%; requires host plant (unknown); KI endemic; undescribed.
Tindale's ghost moth #	*Aenetus tindalei*	##	##	85%; requires host plant (e.g. *Dodonaea viscosa*); KI endemic.
Ghost moth #	*Oxycanus* sp. n. 'Kartus'	##	##	≈80%**;** requires host plant (unknown)**;** KI endemic; undescribed.
Kangaroo Island micro-trapdoor spider #	*Moggridgea rainbowi*	##	##	40% (100% of range of genetically distinct western population); requires steep, bare clay creek banks near low energy creek lines; KI endemic; nomination is in the process of being submitted for listing as **Endangered** (EPBC Act); molecular work required to determine phylogenetic relatedness of fire-impacted populations on KI and therefore determine species distribution, maintain genetic diversity and prevent species decline.

Common name	Species name	Threatened species status		Description of impact – percentage of sites/habitat burnt where known*
		National	SA	
Kangaroo Island assassin spider #	*Zephyrarchaea austini*	##	##	100%; open eucalypt woodland with heathland understorey; species lives in leaf litter suspended in low-lying vegetation; KI endemic. Highly restricted distribution; Nomination is in the process of being submitted for listing as **Endangered** (EPBC Act); possibly extinct.
Western KI harvestman #	*Nunciella kangarooensis*	##	##	99%; in dry/damp creek lines and wet areas and surrounds, beneath logs and rocks; KI endemic; morphologically cryptic species, molecular analyses required to assess species distribution in the burn-scar on KI and therefore extinction risk.
Cudlee Creek				
Bassian thrush	*Zoothera lunulata halmaturina*	VUL	R	Large areas of occupied habitat have been burned in the fire. Habitat patches (wet gullies) are extremely vulnerable to invasion and modification by fire-responsive weeds.
Mount Lofty Ranges chestnut-rumped heathwren	*Calamanthus pyrrhopygius parkeri*	EN	EN	
Southern brown bandicoot	*Isoodon obesulus obesulus*	EN	VUL	
Grey-headed flying-fox	*Pteropus poliocephalus*	VUL	RARE	
Secret Rocks				
Malleefowl	*Leipoa ocellata*	VUL	VUL	Species recorded within the fire scar area post fire with active nests in the region with habitat, nesting sites and food sources for malleefowl impacted by the fire.
Sandhill dunnart	*Sminthopsis psammophila*	EN	VUL	Species has been recorded within the fire scar area post fire with active burrows in the region. Habitat and food sources for sandhill dunnart have been impacted by the fire.
Bunbury				
Malleefowl	*Leipoa ocellata*	VUL	VUL	Several records of species observations in the fire scar area, all within Bunbury CP. Habitat and food sources for malleefowl have been impacted by the fire. Post-fire predator management (foxes) would assist in recovery, as will controlling feral herbivores (deer/rabbits) whilst native vegetation regenerates.

Common name	Species name	Threatened species status		Description of impact – percentage of sites/habitat burnt where known*
		National	SA	
Keilara				
Red-tailed black cockatoo	*Calyptorhynchus banksia*	EN	EN	Several records of species observations in the fire scar area, mostly in known feeding habitat (*Eucalyptus arenacea*) that has been impacted by the Keilira fire, with significant remnants present in the fire ground on private property, roadsides and paddock trees. There are limited redgum woodlands within the fire scar area (mostly along the Winpinmerit watercourse). It is unknown if any nesting hollows have been impacted.
Malleefowl	*Leipoa ocellata*	VUL	VUL	Species has been observed near Hanson Scrub CP, and observed on private land post fire. Nesting activity known on private land south of Hanson Scrub CP (within the burnt area). Habitat, nesting sites and food sources for malleefowl have been impacted by the fire.

† Introduced to Kangaroo Island.

* Percentage of KI Sites Burnt based on number of post-2000 record sites within the burnt area unless specified otherwise.

§ Field verified site assessments for GBC feeding and nesting sites.

** Based on overlaying KI dunnart distribution model from all pre-2019 records with 10% likelihood threshold overlaid on fire scar.

†† Based on <5 records.

Source *Habitat assessments for fire impacted invertebrates on Kangaroo Island Preliminary Summary*, Jessica Marsh and Richard Glatz. Unpublished.

Invertebrates are not listed in SA; assessments being planned for listed under EPBC Act.

Appendix 3: Native flora of most immediate concern

Common Name	Species Name	Threatened species Status		Description of impact – percentage of KI sites/habitat burnt*
		National	SA	
Kangaroo Island				
Downy starbush	*Asterolasia phebalioides*	VUL	VUL	~10% of known population impacted by fire. Some indication of fire responsiveness based on previous fire disturbance.
Kangaroo Island spider-orchid	*Caladenia ovata*	VUL	EN	~10% of known population impacted by fire, all of the western-most sub-population. Fire response unknown.
Twining hand flower	*Cheiranthera volubilis*	VUL	VUL	>90% of population within fire scar. Impacts/fire responsiveness poorly understood.
De Mole River correa	*Correa calycina var. halmaturorum*	VUL	EN	Unknown.
Kangaroo Island phebalium	*Leionema equestre*	EN	EN	~10% impacted by fire, including all of the only known population of western KI.
Kangaroo Island logania	*Logania insularis*	VUL	VUL	>90% of population impacted by fire. Response not well understood.
Kangaroo Island pomaderris	*Pomaderris halmaturina* ssp. *halmaturina*	VUL	VUL	<10% of population impacted by fire.
Ironestone mulla mulla	*Ptilotus beckerianus*	VUL	VUL	>80% within fire scar. Responsive to fire.
Splendid bush-pea	*Pultenaea villifera* var. *glabrescens*	VUL	VUL	50-70% of known population within fire scar. Appears to be fire responsive.
Spiral sun orchid	*Thelymitra matthewsii*	VUL	EN	90-100% within fire scar. Fire response unclear
Cudlee Creek				
Stiff white spider orchid	*Caladenia rigida*	EN	EN	Recorded within the fire scar area and impacted by the fire.
Leafy greenhood	*Pterostylis cucullata*	VUL	EN	Recorded within the fire scar area and impacted by the fire.
Clover glycine	*Glycine latrobeana*	VUL	VUL	Recorded within the fire scar area and impacted by the fire.
White beauty spider-orchid	*Caladenia argocalla*	EN	EN	Recorded within the fire scar area and impacted by the fire.
Mt Lofty speedwell	*Veronica derwentiana*	CEN	EN	Recorded within the fire scar area and impacted by the fire.
Plump swamp wallaby grass	*Amphibromus pithogastrus*	-	-	Endangered (AMLR); 1 location has been recorded within the fire scar area and in the region and impacted by the fire.
Behr's cowslip orchid	*Diuris behrii*		VUL	2 locations are recorded within the fire scar area and impacted by the fire.

Common Name	Species Name	Threatened species Status		Description of impact – percentage of KI sites/habitat burnt*
		National	SA	
Secret Rocks				
Chalky wattle	*Acacia cretacea*	EN	EN	Recorded within the fire scar area and in the region and impacted by the fire.
Yellow swainson-pea	*Swainsona pyrophila*	VUL	RARE	Recorded within the fire scar area and in the region and impacted by the fire
Bunbury				
Lowan phebalium	*Phebalium lowanense*	VUL	VUL	Uncertain.
Limestone spider orchid	*Caladenia calcicola*	VUL	E	Populations recorded just outside Bunbury CP. Potential to occur within the burn scar area. Unknown fire response of species, although *Caladenia* species often respond positively to fire events, with profuse flowering after hot summer fires (Todd 2000). Post-fire period provides opportunity for survey of fire-responsive threatened orchid populations.
Metallic sun-orchid	*Thelymitra epipactoides*	EN	E?	Populations recorded just outside Bunbury CP. Potential to occur within the burn scar area. Unknown fire response of species, although *Thelymitra* species often respond positively to fire events, with profuse flowering after hot summer fires (Todd 2000). Post-fire period provides opportunity for survey of fire-responsive threatened orchid populations.
Spiral sun-orchid	*Thelymitra mathewsii*	VUL	EN	Populations recorded just outside Bunbury CP. Potential to occur within the burn scar area. Unknown fire response of species, although *Thelymitra* species often respond positively to fire events, with profuse flowering after hot summer fires (Todd 2000). Post-fire period provides opportunity for survey of fire-responsive threatened orchid populations.
Silver daisy-bush	*Olearia pannosa spp. pannosa*	VUL	VUL	Populations in the SE are scattered/fragmented, small population numbers, with regional estimates of between 500-600 plants in total located in approximately 7 locations. The exact locations of the plants is unknown but the burn scar appears to have comprehensively burnt the known extent. Possible that intensity of the 2020 fire could result in local extinction of this species from the site – likely to only be detectable if they re-shoot or flower in spring (August-October).
Coloured spider-orchid	*Caladenia colorata*	EN	EN	The burn scar appears to have comprehensively burnt the entire known local distribution. Unknown fire response of species, although *Caladenia* species often respond positively to fire events, with profuse flowerering after hot summer fires.

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