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Ex situ responses to the 2019–20 wildfires

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Summary

Context and challenges

- The International Union for the Conservation of Nature (IUCN) recognises the critically important role of *ex situ* conservation interventions and recommends that all threatened species should have *ex situ* options included in their recovery plans to allow for strategic and timely responses in times of increased risk.
- In Australia, many organisations are active in *ex situ* conservation, including botanic gardens, seed banks, zoos, aquariums, universities, research facilities and government agencies.
- With catastrophic events, *ex situ* options can be useful in securing species, by removing individuals from direct and secondary impacts or assisting species to recover *in situ*.
- Investment in *ex situ* facilities, programs and research prior to catastrophic events is a key indicator of likely success.
- Decisions to undertake *ex situ* efforts must be made strategically before, during and after catastrophic environmental events. However, if no previous effort has been made to secure *ex situ* populations or collections, the post-disaster period is the worst time to activate an *ex situ* rescue response. The numbers of individuals will be low and costs will be significantly higher.
- *Ex situ* response is not as simple as collecting and propagating. Significant time is needed to learn the species biology, care of animals and the science/art of consistently reproducing animals, as well as to unravel the science/art of germinating, propagating and/or storing plant species.

Main findings

- Many *ex situ* options were utilised for animal and plant species affected by the 2019–20 wildfires: existing *ex situ* recovery programs were boosted, new *ex situ* recovery programs were established and additional facilities created.

- Expert elicitation identified fire-affected species that would benefit most from *ex situ* support, and these were the primary focus of the *ex situ* response.
- Early indications reflect that the increased support for *ex situ* management options allowed for the protection of many fire-affected animal and plant species and is buying time for many more. In coming years, the impact of this work will bear witness to the contribution of *ex situ* options to conservation of many species.
- Partnerships and collaborations should be pursued and nurtured as an ongoing concern so that rapid, coordinated and collegiate responses to emergencies can be implemented without the need to form new relationships during times of crisis. These networks should include complementary expertise from both the *in situ* and *ex situ* community.
- Limitations on the ability to mobilise sufficient skills and facilities in the 2019–20 wildfires demonstrate the need for a more significant and strategic investment in *ex situ* capacity and skills.

Introduction

The 2019–20 Australian wildfires were unique in their scale and intensity. The long-term impact of the fires on species survival is still unknown; however, for many animal species over 80% of known habitat was affected by fire (see Chapter 11), and more than 800 or 3.5% of Australia's vascular plant species had more than 50% of their populations or ranges burnt, in vegetation communities ranging from rainforests, eucalypt forests and woodlands to heathlands (Godfree *et al*. 2021).

Effective conservation requires that a diversity of management actions is considered and tested using a cross-disciplinary and multi-institutional approach. As habitats continue to be impacted by a complexity of unabated threats, there is an increasing need for a 'one plan approach' (Byers *et al*. 2013) that integrates *in situ* and *ex situ* management processes (Schwartz *et al*. 2017; IUCN 2020; UNEP 2021).

Increasing rates of extinction, exacerbated by climate change, challenge the dependence on *in situ* strategies and necessitate increased development in *ex situ* approaches (Bowkett 2014). In some instances, *ex situ* management will be a primary strategy, while in others it will be of secondary importance, supporting other interventions (IUCN/SSC 2014).

Ex situ facilities deliver many strategies and tools that cannot be replicated solely in *in situ* settings. These include frozen zoos; seed banks and botanic gardens specialising in research geared towards maintaining germplasm and germline samples in perpetuity; hospitals and emergency response facilities for treatment and ongoing care and rehabilitation of animals; traditional zoos and botanic gardens providing education and advocacy for species and intensive genetic management; as well as larger fenced sites like sanctuaries and landscape isolation projects supporting demographic management of populations.

IUCN/SSC (2014) states that *ex situ* conservation has the potential to:

- *Address primary threats*. '*Ex situ* activities can help reduce primary threats … when specifically designed conservation research, conservation training or conservation education activities directly and effectively impact the causes of these threats.'
- *Offset the effects of threats*. 'Small populations … may require some form of intensive management of individuals and populations to improve demographic and genetic

viability and avoid extinction. Challenges faced by small populations can be counteracted by ... population management options, such as head start programmes to address high juvenile mortality, or population reinforcement to balance age and sex distribution.'

- *Buy time.* 'Establishment of a diverse and sustainable *ex situ* rescue or insurance population may be critical in preventing species extinction when wild population decline is steep and the chance of sufficiently rapid reduction of primary threats is slim or uncertain ...'
- *Restore wild populations.* 'Once the primary threats have been sufficiently addressed, *ex situ* populations can be used for population restoration … or conservation introduction ...' (see Boxes 27.1 to 27.4 for examples)

Box 27.1. Protecting the mountain pygmy-possum and preparing for future emergencies

The total population of the Critically Endangered mountain pygmy-possum (*Burramys parvus*) (MPP) is fewer than 2000 individuals, in three remote alpine regions, plus one captive breeding and research program at Zoos Victoria's Healesville Sanctuary (DELWP 2020). While key threats to the MPP, such as historic destruction of boulder-field habitat, introduced predators and climate change, are well known (DELWP 2020), a new threat was realised in 2017. The MPP's main food source is the migratory Bogong moth (*Agrotis infusa*), which usually arrives in the alpine zone each spring in billions. However, in spring 2017 and 2018, the moths largely failed to arrive (Green *et al.* 2021). In all monitored Victorian populations, 50–95% of MPP females lost their litters of pouch young by the end of December 2018 (DELWP 2019), with starvation of young the most likely cause of mortality.

In response, Zoos Victoria, working with experts in veterinary nutrition, successfully developed a new shelf-stable nutritionally suitable supplementary food, called 'Bogong Bikkies'. The bikkies and feeders were trialled for safety and efficacy with

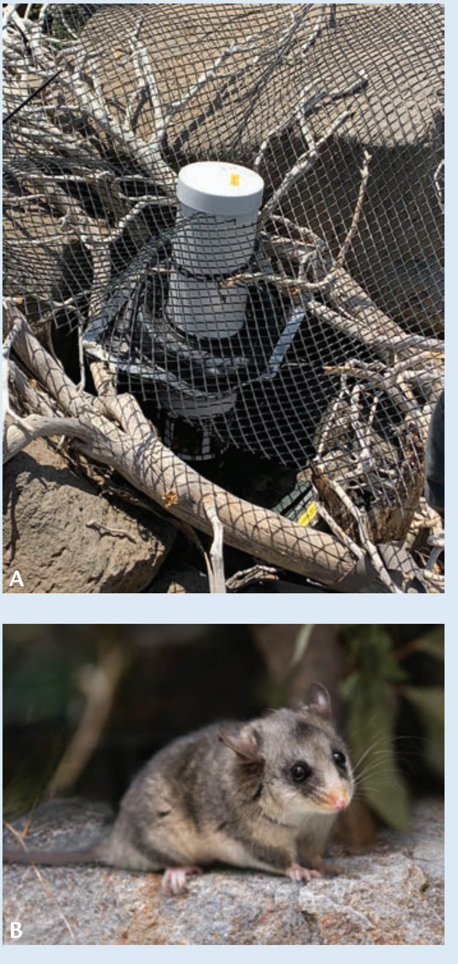

Fig. 27.1. Feeder station (A) established *in situ* for mountain pygmy-possums (B). (Photos: Zoos Victoria)

MPPs in the captive program and with a wild MPP population (Fig. 27.1), with work continuing under emergency services approval throughout the 2019–20 wildfire season (Parrott *et al.* 2021). The bikkies were commercially developed to human grade food safety standards through Zoos Victoria's partners, Wombaroo (Wombaroo Passwell, Australia), to be readily available in an emergency.

While the food was developed in response to low moth numbers, this preparedness proved crucial following the fires. Populations of MPPs in Mt Kosciuszko National Park were left without food following a firestorm in early 2020. Zoos Victoria sent Bogong Bikkies and feeder prototypes to staff in the NSW Department of Planning, Industry and Environment's Saving our Species team, to feed MPPs after the fires (Parrott *et al.* 2020). Due to this supplementation, MPPs in fire-affected areas were able to gain weight enough to successfully hibernate and raise their young in the following years.

Ex situ facilities exist as an extensive, cooperative network across Australia, with a reach extending globally through memberships with the World Association of Zoos and Aquariums and Botanic Gardens Conservation International.

Successful *ex situ* facilities have extensive experience in consistently and predictably breeding, propagating and caring for or storing living and frozen collections of species from hundreds of taxonomic groups. Ongoing work aimed at shifting the scope of species that are maintained *ex situ* is now mostly guided by strategic decision-making, current and emerging conservation needs, key threatening processes and expert elicitation.

Box 27.2. Dramatic growth in Bellinger River snapping turtle hatchlings

The Bellinger River snapping turtle (*Myuchelys georgesi*) is a Critically Endangered species, endemic to the Bellinger River drainage in northern New South Wales (Fig. 27.2). The species was locally abundant in the river system, numbering from 1500 to 4000 individuals, before its sudden and rapid decline in early 2015. At this time, a novel virus (Zhang *et al.* 2018) entered the river system, causing a mass mortality event and resulting in the extirpation of the adult population, leaving only juvenile turtles behind. Today, there are fewer than 150 turtles left in the river and the species is dependent on conservation intervention for its persistence.

At the time of decline, a small insurance population was collected from the upstream stretch of the river before the arrival of the virus at this site. After a year of quarantine at Western Sydney University, a population was established at Taronga Zoo. The breeding of these turtles has been successful and since 2017 over 165 turtles successfully hatched. This has allowed for the translocation of 52 zoo-bred turtles to the wild. Radio-tracking studies undertaken by NSW Department of Planning, Industry and Environment have indicated that survival of released juvenile turtles has been very high (> 95%), demonstrating the need for ongoing translocations from the zoo population as a conservation tool to recover this species.

The synergistic pressure of the 2019 drought and wildfires exerted further stress onto the remaining wild population by causing suboptimal environmental conditions

Fig. 27.2. Bellinger River snapping turtle. (Photo: Paul Fahy)

in the stream. As a result, the need for rebuilding the remaining population with zoo-bred turtles has become much more urgent.

With the support of a Commonwealth grant, holding facilities for hatchlings and juveniles are being expanded at Taronga Zoo and Symbio Wildlife Park; these will allow the increase in the size of the zoo-based population, kept both as an insurance population and for release to the wild. The expansions will allow for a 600% increase in release capacity to at least 210 individuals per year, which exceeds the number required to ensure the persistence of the species in the wild.

While there are many commonalities in operations, objectives and constraints, the existing *ex situ* efforts for animals and plants present some important differences (Table 27.1).

Table 27.1. Commonalities and differences between *ex situ* activity for Australian animals and plants.

Adapted from Commander *et al.* (2018); APC (2021); DAWE (2021); Martyn Yenson *et al.* (2021). Note that this tabulation for animals mostly focuses on vertebrates, and we recognise that *ex situ* conservation effort for most Australian invertebrate species is under-developed.

	Animals	Plants
Diversity	~8000 Australian vertebrate species, and ~320 000 invertebrate species (Chapman 2009).	~23 000 Australian vascular plant species (Chapman 2009; APC 2021).
No. threatened spp. under national legislation (pre-fire)	399 vertebrates and 67 invertebrates. At least 24% represented in living *ex situ* ZAA-accredited member populations (ZAA 2020).	1373 plants. At least 67% represented in seed banks and botanic gardens (DAWE 2021).

continued

Table 27.1. Continued

	Animals	Plants
Ex situ activities	Temporary removal from wild to protect from imminent threat. Research into biology, ecology, husbandry, behaviour, reproduction and genetic diversity. Short and long-term care of living animals in controlled environments. Demographic manipulation – 'head-starting' or removal of individuals from the wild reducing mortality during a specific life stage and subsequently returning them to the wild. Breeding for population restoration and assisted colonisation. Controlled outbreeding to improve genetics. Public engagement, education, advocacy and campaigns to influence behaviour-change. Translocation is increasingly common; listed threatened species require relevant permits.	Living plant collections on display in botanic gardens. Research into biology, ecology, parasitism, reproduction and genetic diversity. Short- and long-term storage in nurseries, seed banks and botanic gardens. Long-term storage of orthodox species (tolerant of traditional seed banking methods – sub-zero temperatures and low relative humidity). Storage in cryopreservation facilities in seed banks for orthodox and non-orthodox species. Maternal line collecting to maximise genetic integrity of seed collections. Seed production areas increasing seed supply and bolstering *ex situ* collections. Seedling establishment and propagation for restoration and translocation. Public engagement, education, advocacy and campaigns to influence behaviour-change. Translocation is common; listed threatened species require relevant permits.
Storage	Zoos and aquariums maintain demographically stable and genetically representative populations of species requiring targeted conservation actions in exhibited and non-exhibited facilities. Frozen arks maintain biological materials at ultra-low temperatures, or as freeze-dried material securing long-term integrity and relevance for future research and conservation.	Botanic gardens maintain collections of living plants for display and conservation. Some collections maintained in controlled conditions in glasshouses or nurseries. Seed banks maintain living collections of seed and other germplasm (such as cuttings, seeds, tissue culture and embryos) in controlled conditions from ambient conditions to low humidity and ultra-low temperatures.
Reproduction and constraints	Specific breeding times and environmental triggers may be hard to replicate and are often unknown. Many mammal and frog species take several years to mature to breeding age and generation lengths can vary significantly. These timeframes can impact the ability to repopulate quickly after a crisis. Need to secure release sites for offspring to avoid bottlenecks and pausing of breeding.	Seeds can be germinated readily if physical and/or chemical dormancy cues are known and can be replicated *ex situ*. Plants can be propagated rapidly, with juveniles used in botanic gardens and restoration or translocation projects. Generation times can be short for some species or significantly longer for others. Regular propagation of plant material retains skills and knowledge to maintain living populations. Restoration or translocation sites selected for conditions and ecosystem values favourable for reproductive success, including proximity to extant populations to limit inbreeding.
Survivorship	Increased survivorship compared to *in situ* for many species.	Orthodox seeds held for decades or centuries when stored in appropriate conditions. Non-orthodox seeds often short-lived in storage. Cryopreservation can prolong survivorship in storage otherwise regular replacement of collections is required.

	Animals	Plants
Emotional connections between animals and plants	High emotional connections, particularly for mammals and birds during a crisis.	Low emotional connections, allows for strategic planning and conservation actions without risk of compromising an individual plant's mental or emotional health.
Genetic diversity	Zoos use complex pedigree management and modelling software to intensively manage the genetics and demographics of animal populations, and increasingly utilise molecular genomic technologies to inform strategies that increase founder representation, maintain high genetic diversity and decrease inbreeding.	Botanic gardens often hold limited genetic diversity in historical display collections due to limited individuals on display and/or diversity of original source material. Seed banks maximise genetic diversity for target species by collecting from multiple sites across a species range, maintaining separate collections from each maternal line. Maintaining records and depositing voucher specimens with registered herbaria provides confidence in species-specific data for *ex situ* germplasm collections.
Management	Metapopulation management, whereby movement of specific individuals between known populations is managed/augmented by humans, with a steady exchange of genes and individuals from *in situ* to *ex situ* and vice versa.	Population management through restoration or translocation of multiple individuals from different maternal lines. Introductions from multiple source populations improves genetic diversity, reduces bottlenecking and improves the adaptation potential of populations. Seed collections made from restored or translocated populations for storage and future use.

Post-fire action

Animals

Very quickly following the fires, the Wildlife and Threatened Species Bushfire Recovery (WTSBR) Expert Panel (see Chapter 22), which included one *ex situ* expert, identified 119 vertebrates as the highest priorities for urgent management intervention. Most of these species had at least 30% of their range burnt, and many had substantially more (see also Chapters 13–16).

The Zoo and Aquarium Association Australasia (ZAA) customised an expert elicitation process to identify among these fire-affected species those that would be most likely to benefit from *ex situ* support. Operational and biological factors were considered in this prioritisation process, including experience working with the species; historic success in an *ex situ* setting; diet replicability and availability; current and planned capacity of facilities; existing expertise; costs of environmental control; spatial requirements; social structures; whether or not *ex situ* action was recommended in a statutory conservation plan; and species fecundity, including the likely number of breeding events and reproductive potential.

This prioritisation process reduced the initial list of 119 priority vertebrate species to 49 species that were candidates for *ex situ* actions. Prioritisation exercises with the WTSBR Expert Panel, state representatives and *ex situ* organisations reduced the list to 11 species for which the partners had confidence and actions to deliver animals back to the wild inside a 12–18-month timeframe.

Projects supporting these 11 species were funded by the Australian Government, individual zoos and aquariums, private donors and the ZAA. While it is too early to assess the impact of this investment, all projects will be monitored and their effectiveness reported (Table 27.2). Some other important *ex situ* responses to fire are described elsewhere in this book: for example, Chapter 6 reports on the rescue, safe-keeping in custom-designed facilities, then return to the wild of some highly threatened fish and spiny crayfish species imperilled by sedimentation following the 2019–20 wildfires.

Plants

The impact of the wildfires on Australia's flora was extensive (Chapter 9). The increasing frequency and intensity of fires is of concern for the recovery and long-term survival of Australia's floral diversity (Fairman *et al.* 2016). In response, the WTSBR Expert Panel identified 486 fire-affected plant species requiring immediate interventions to enhance their prospects of recovery (Gallagher 2020). Historical records held by environment agencies, herbaria, botanic gardens and seed banks provided valuable data on the distribution and phenology of target species to inform the recovery prioritisation process.

Table 27.2. Actions and desired outcomes of post-fire response for priority animal species.

***Ex situ* management action**	**Typical actions**	**Desired outcomes**	**No. of species prioritised for *ex situ***
Expand an existing ZAA-led or ZAA member-led insurance program, to more release-to-the-wild events.	Identify stakeholders and resource requirements. Supplement genetics to bolster *ex situ* population. Continue ZAA-led intensive genetic and demographic management and rapid release to appropriate wild sites. Manage new animals to limit adaptation to *ex situ*.	Rapid reproduction of F0 and F1. Rapid release of F2+ to appropriate wild sites. Wild sites supplemented. Historic sites repopulated.	6 species
Acquire knowledge on husbandry and care, to facilitate the later (short-term) development of a new insurance population.	Identify stakeholders and resource requirement. Develop infrastructure. Salvage appropriately sized group to found *ex situ* population. Research technical methods to support consistent reproduction. Document techniques.	Optimal techniques documented. Species consistently reproduced. Advance to insurance program.	31 species
Develop a new ZAA-led insurance program, to facilitate ongoing release-to-the-wild events.	Use a genetically appropriate group to found *ex situ* population. Develop infrastructure. Analyse for disease on incoming group. Apply ZAA-led intensive genetic and demographic management. Manage to limit adaptation to *ex situ*.	Rapid reproduction of F0 and F1. Rapid release of F2+ to appropriate wild sites. Wild sites supplemented. Historic sites repopulated.	12 species

The Australian Seed Bank Partnership (the Partnership), a program of the Council of Heads of Australian Botanic Gardens, worked with herbaria, environment agencies and local experts and communities to better understand impacts and prioritise species for targeted *ex situ* interventions.

A total of 1004 conservation actions addressed many of the priority fire-affected plant species through the Partnership's projects (Table 27.3). Actions include rapid flora assessments and seed collecting; genetically diverse collections across a species range; and determining germination protocols and long-term viability of collections in seed banks (see Boxes 27.3 and 27.4). Furthermore, the use of seedlings in restoration was prioritised for local and community-led plantings where species recovery was slow and in translocation trials where recovery *in situ* was hampered by ongoing threats from pests or disease.

Table 27.3. Actions and desired outcomes of post-fire response for priority plants species (the Partnership 2021, unpublished data).

Ex situ management action	Typical actions	Desired outcomes	No. of species addressed
Rapid flora assessments (RFA)	Identify *in situ* populations of target species. Assess target species against RFA criteria. Databasing.	Improved knowledge of fire impacts and species response. Informed species prioritisation in future fire preparedness and response. Digital reference images of seedling emergence to aid future post-fire identification.	73 species assessed 2020–2021. Up to 252 species assessed 2020–23.
Seed collecting	Determine target species' phenology. Identify optimal reconnaissance and collecting opportunities. Allocate resources for field work and laboratory processing. Coordinate volunteers and land managers for access. Databasing.	Increased representation of species diversity and within-species diversity in *ex situ* collections. Increased number of species in *ex situ* collections available for research and restoration.	128 species secured 2020–21. Up to 388 species targeted 2020–23.
Germination	Schedule trials with facility priorities and research. Do plate germination trials; monitor and score progress. Databasing.	Confirmation of physical and chemical dormancy. Development and refinement of germination protocols. *Ex situ* collections available for restoration, translocation and botanic gardens living collections.	137 species trialled 2020–21. Up to 321 species trialled 2020–23.
Propagation, Restoration, Translocation, introductions to Living Collections in Botanic Gardens	Identify and secure resource requirements. Pot germinants and cuttings. Monitor and maintain propagants. Treat for pests and/or disease. Databasing.	Propagation of threatened and priority species. Restoration of fire-impacted populations. Translocation of species impacted by wildfires. Planting of threatened and priority species in botanic gardens for *ex situ* conservation, education and research.	Up to 27 species used in restoration and translocations 2020–23. Up to 10 species planted in botanic gardens' living collections for education and research 2020–23.

Box 27.3. Addressing the threats to the Wollemi pine (*Wollemia nobilis*)

Wollemi pine is a Critically Endangered species, with only 46 mature individuals remaining in the wild and a geographical distribution of < 4 km^2 (Mackenzie and Auld in press). Discovery of the Wollemi pine in 1994 drew the attention of the world and a multifaceted recovery plan was quickly developed (NSW DEC 2006). Conservation actions are both *in situ* (Mackenzie *et al.* 2021; see also Chapter 9) and *ex situ* (Fig. 27.3), through the development of a genetically representative living collection as per the Australian guidelines (Martyn Yenson *et al.* 2021).

A propagation program was established by the Royal Botanic Gardens and Domain Trust (RBG) and, by 2005, Wollemi pines had been dispersed to many botanic gardens and became available commercially with royalties contributing to ongoing conservation.

The *ex situ* conservation of this species has enabled conservation-related research that has built knowledge of its physiology, ecology and disease susceptibility. A high priority was to explore how fire affects this species. Controlled experiments on cultivated (cutting-grown) plants confirmed that Wollemi pines could resprout after fire, with higher intensity fires reducing the regrowth (Zimmer *et al.* 2015); however, there remains some uncertainty about the response of seedlings, and of the species' response to different fire regimes.

Fig. 27.3. *Ex situ* population of Wollemi pine. (Photo: Maureen Phelan, Australian Botanic Garden)

Given the threats to Wollemi pine, including fire, recovery planning for this species has focused on translocation to suitable sites (NSW DEC 2006), with the objectives of increasing population size and distribution, and reducing risks of total loss from catastrophic fire and other threats. This ongoing process has been informed by research using *ex situ* collections, and understanding how to propagate and grow this species from seeds and cuttings, with the plant material for the translocations derived from the *ex situ* germplasm collection held by RBG (Mackenzie *et al.* 2021).

Multiple seasons following a wildfire are required to properly understand the recovery of the Australian flora. To capitalise on this opportunity, the Partnership worked collaboratively on a rapid flora assessment methodology developed by the Australian PlantBank at the Australian Institute of Botanical Science. The methodology enables seed collectors to prioritise seed collecting during field work while capturing species-specific data on whether species were heavily burnt, are resprouting or reseeding, and whether herbivory or disease are cause for immediate concern. Monitoring, including the fate of individual plants, over multiple seasons will further improve our understanding of recovery.

Collecting included targeting narrow range endemics and known fire ephemerals in the first season post fire. Additional focus was made to collect from species whose range included unburnt populations. Particular attention was made to ensure collecting efforts had minimal impact on *in situ* populations, prioritising the replenishment of the soil seed bank (Auld 2020). Other priorities include undertaking germination trials of newly secured collections to ensure scientists can break physical and chemical dormancy and achieve high germination rates for the species held *ex situ*.

Box 27.4. Restoring *Glycine latrobeana* to Lobethal Bushland Park

In December 2019, the Lobethal Bushland Park (South Australia) was extensively burnt. The fires impacted more than 23 000 ha, extirpating an entire population of the Vulnerable clover glycine (*Glycine latrobeana*) (Fig. 27.4).

While fire threatened the species' long-term survival, efforts by the South Australian Seed Conservation Centre of the Botanic Gardens and State Herbarium of South Australia (SASCC), in collaboration with ecologists from the Hills and Fleurieu Landscape Board and community volunteers, helped to return more than 230 individuals of the species to two bushland reserves.

This post-wildfire restoration actually started with a small seed collection in 2007. Following release of the recovery plan for *Glycine latrobeana* and conversations with local experts, the SASCC embarked on a mission to collect seeds of the species. More than 100 individual plants within the local population were sampled. All 1200 seeds were sent for storage at the Millennium Seed Bank, Royal Botanic Gardens, Kew, UK (MSB) as an insurance against further loss.

Following the 2019–20 fires, the SASCC requested the MSB repatriate 250 seeds from the 2007 collection to support post-fire restoration. Following a short quarantine period in Sydney, the seeds were germinated with almost 90% success. More than 230 individual plants were propagated and used in restoring the Lobethal Bushland Park

Fig. 27.4. Populations of the clover glycine (A) were severely affected by the 2019–20 wildfires, but seeds collected and stored before the fire (B) allowed for successful re-establishment. (Photos: South Australian Seed Conservation Centre)

and a nearby private bushland reserve where it had been previously recorded, but had not re-emerged since the 2019 bushfire. In 2021 a total of 730 seeds were collected from the reintroduced plants for further propagation and to duplicate collections with the MSB.

Making withdrawals from conservation seed banks to support research and restoration occurs regularly throughout Australia, but repatriation from the MSB has so far been less common. The case of *Glycine latrobeana* provides a valuable proof of concept for duplicating native seed collections in comparable facilities, illustrating how long-term *ex situ* conservation through seed banking is a viable option for future restoration and recovery efforts.

Many species will take longer to recover due to the severity of the fires, their longer reproductive cycles, or the continuing drought impacting burnt areas. Species in these groups were prioritised for germination trials of collections already held *ex situ*, aiming to ensure viability of stored seeds is effectively retained over time and made available for restoration. Several years will be needed to properly understand the recovery of various species as disease, pests and competition influence long-term survivorship.

Community engagement

The *ex situ* community galvanised its significant reach to draw public attention to the emerging wildlife crisis. They activated existing networks and engaged with new collaborators to exchange information and expertise, and share resources with the aim of enhancing the post-fire conservation response.

For fire-affected animals, numerous conservation funds were established to support three phases of action: (1) the rescue and rehabilitation of animals for return to the wild; (2) assessing the impacts on animals and habitat to understand where recovery efforts were needed; and (3) funding medium and long-term recovery efforts to return healthy animals to regenerated habitats and sustain their populations in affected areas.

Similarly for plants, the business and community responses were swift with more than $3.2 million in grants and cash donations secured through the Partnership for collecting, research and restoration. Additional funding from grants and philanthropic sources went directly to individual facilities across the country. Other offers included seed from Australian native species in overseas plantations; however, these couldn't be accepted for use in restoration efforts due to biosecurity concerns and limitations in genetic provenance data. Local landholders and 'Friends of' groups working to protect private property, community bushlands and reserves provided local knowledge to support collecting, restoration, and translocation efforts. Many private landholders and volunteers suffered significant personal impacts, yet dedicated substantial time and effort to assist with monitoring species recovery, restoring populations, and granting access to collectors.

The impacts of COVID-19 on travel were significant with many species missed in the first-year post-fire. Furthermore, engagement with First Nations peoples was severely limited with on country collecting unable to proceed due to travel restrictions to remote communities.

Key findings

Key findings are varied and significant, incorporating constraints, prioritisation, cost and implications (Table 27.4).

Conclusions

The 2019–20 wildfires demonstrated what the *ex situ* community is able to contribute during a crisis and in the recovery. A strategic approach involving collaborative prioritisation and planning, including both the *in situ* and *ex situ* communities, will have most chance of developing and implementing conservation programs that can most effectively maintain or recover biodiversity in a future likely to be marked by many more environmental catastrophes.

Differences among taxonomic groups in the extent of knowledge base resulted in prioritisation for urgent response being developed later for plants and invertebrates than for vertebrates, with this probably leading to less investment in their recovery than for vertebrates. However, given interactions between invertebrates and plants, their recovery actions should be undertaken together, not separately.

There are many similarities between plant and animal *ex situ* activities and it is plausible that collaborative efforts may prove advantageous in future planning. Taking an ecosystem approach to *ex situ* planning, involving animals and plants, might be feasible, especially in cases where some key vegetation communities such as rainforests have been unpredictably burnt.

Recommendations

The importance of preparing ahead of crises

It is critical that a national preparedness plan for wildlife (animal and plant) recovery is established and deployed ahead of crises. Preparedness of all parties is critical to ensure that an appropriate response can be mounted in a time of crisis. Including *ex situ* actions in recovery plans of relevant threatened species enhances capacity for recovery. Plans should include support for boosting *ex situ* conservation capability.

Table 27.4. Key findings with respect to *ex situ* interventions following the 2019–20 fires.

	Key findings
Constraints	Scientific ventures to support threatened species should not be an abrupt or precipitous exercise. Learning requires time and coordinated action in advance of threats and impacts to allow experts to develop a strong understanding of species biology and care, and time to unravel the science of propagating and storing the species. Access to field sites and translocation sites was hampered by ongoing fires and safety concerns. Funding and permits are not synchronised, resulting in delays to commencing some *ex situ* programs. Recovery for animal species can only happen following the recovery of the ecosystem and many plant species can take years to recover. Expectations of short-term results can be misleading. COVID-19 was a compounding factor restricting field work, threatening supply chains including the availability of liquid nitrogen for cryopreservation, and limiting opportunities, access and permits, and the ability to properly engage and collaborate on country. Separate funding from multiple sources can be limiting if delivered in isolation. Funders that provide opportunities for flexibility and enable leveraging of complementary funding facilitate greater strategic investment to address conservation priorities.
Prioritisation	Assessing potential impacts and prioritising target species for multi-state and multi-partner projects is time-consuming and reliant on substantial collaborative efforts. The desire to catalogue the animal loss before acting resulted in delays to planning and agreeing *ex situ* interventions. A strong effective response requires strategy and preparedness before the event. The welfare impact of fire on animals is significant and resulted in the urgent prioritisation of welfare actions. Post-fire prioritisation activities considered numerous factors to inform the allocation of limited resources, and involved strong interaction with the *in situ* community, academics, community groups, and governments. Despite its thoroughness, the exercise pointed to communication weaknesses between and within organisations with many of the same species and activities offered funding from multiple sources.
Costs	The cost of responding to the wildfires is significant in the short and long term; this galvanised support for targeted actions. Multiple funding avenues were made available by governments, business and philanthropic communities, supported further by private donors. For animals, the cost of implementing *ex situ* interventions varies drastically between institutions and can be quite high in some instances, particularly for larger, state-run operations. Efficient long-term maintenance of populations that are genetically representative of wild counterparts and behaviourally competent for release demands significant infrastructure. Appropriate risk management dictates that populations managed long term must be housed at multiple facilities to limit the impact of possible stochastic events, further increasing infrastructure and care costs. For plants, the costs of implementing *ex situ* interventions to conserve biodiversity are relatively low per species. Costs of collection depend on the location and rarity of a species, number of populations and (for plants) the ability to predict fruiting based on species phenology. Long-term maintenance of *ex situ* seed collections is low cost. Regular germination trials to ensure viability is maintained, appropriate monitoring systems and back-up power generation capabilities all add to the cost of long-term storage but provide valuable safeguards. COVID-19 consequences imposed substantial costs, such as by limiting the numbers of staff and volunteers permitted in field vehicles. Furthermore, limitations on personnel numbers in laboratories and seed banks reduced the hours available for processing and testing collections.

	Key findings
Implications for *ex situ* management	The post-fire response indicated a need for a longer-term skilled and flexible work force, with ongoing resourcing that can manage growing collections. By focusing on centres of excellence and collaboration, the number of threatened species in care can be expanded. In an emergency staff can move to the place of greatest need, as was seen with the eastern bristlebird extraction (see Chapter 15). Care needs to be taken in applying a reductionist approach rather than the ecosystem approach. Both are needed. *Ex situ* tends to focus on species, while *in situ* focuses on ecosystems. Synergy between taxa exists in the wild and should be prioritised in *ex situ* management. Development and dedicated maintenance of a centrally managed database of stakeholders and projects would also assist in ensuring prioritisation activities are robust and consider all necessary stakeholders.
Implications for fire management	Translocation sites need to be protected in times of emergency. A register of translocation sites should be established and identified as critical assets. In the immediate aftermath of the fires, animal care facilities were inundated by injured animals. Fences pose a lethal barrier to livestock and wildlife in an emergency. It is recommended that operating protocols allow the creation of safe passages for animals.

Species emergency recovery capability: agency and funding

For human care and infrastructure recovery in times of crisis, a dedicated recovery agency delivers better long-term outcomes. We recommend a similar approach for wildlife recovery. A dedicated nature-based recovery agency would be able to:

- create capacity to support ecosystems and wildlife in emergencies;
- develop risk-based prioritisation frameworks to assist with decision-making and adapt to emerging threats;
- coordinate interventions and capability proactively and pre-emptively, to areas of greatest need;
- encourage development of a national inventory of coordinated *ex situ* activities;
- coordinate enabling actions and support, permits, facilities and funds matched to the intervention; and
- investigate establishing an ongoing funding model with government, non-government and philanthropic and corporate support – such as the example provided by the Future Drought Fund (https://www.agriculture.gov.au/agriculture-land/farm-food-drought/drought/future-drought-fund).

Ex situ is a long-term approach

A successful response after an emergency can take years to deliver. While there is a need for moving fast to collect samples, animals, seeds and other plant germplasm, recovery to the point of wild release/reintroduction may take significant time. The recovery process must provide long-term commitment and funding.

Pick winners

With so many species in need of help, recovery runs the risk of trying to do too much and failing to achieve real success. Ecological and biological knowledge and evolutionary factors should guide species selection. A national approach is needed to prioritise and align regional and local action.

Community recovery based on nature-based recovery

Success is improved when communities are able to contribute to the recovery effort. Especially important is early engagement with traditional owners and landowners to incorporate their knowledge and to develop long-term recovery programs with guidance and support.

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