Emergency conservation interventions during times of crisis: A case study for a threatened bird species in the Australian Black Summer bushfires

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Abstract
Emergency conservation interventions will be increasingly necessary to prevent extinctions or severe population bottlenecks as extreme events become more frequent. We detail the emergency extraction of the endangered Eastern Bristlebird (Dasyornis brachypterus) during the unprecedented 2019–2020 Australian Black Summer bushfires, an intervention that led to the rapid establishment of a temporary ex situ insurance population sourced from an area under immediate threat from bushfire (Croajingolong National Park, Victoria). The intervention was triggered, coordinated, and implemented within a 4-week period, with re-release to the wild within 2 months. We present this case study within a framework for emergency conservation interventions, based on the emergency management phases of preparation, response, and recovery, with the addition of an evaluation phase. The preparation phase involved compiling existing knowledge and capacity to facilitate the operation. The response phase consisted of (a) initiation and planning of the intervention (coordination) and (b) implementation, that is, the translocation of 15 birds from an area under threat of bushfire to a captive institution (>500 km). The recovery phase saw the insurance population re-released to unburnt habitat after the bushfire had ceased. The evaluation phase incorporated lessons learnt from the other three phases as part of an adaptive management approach. We reflect on the Eastern Bristlebird emergency conservation intervention to explore how we can better prepare for, respond to, and recover from the large range of emergencies faced by biodiversity around the world.

KEYWORDS
ex situ conservation, disturbance, Eastern Bristlebird, emergency, translocation, wildfire
1 | INTRODUCTION

Extreme and emergency environmental events pose increasing risks to biodiversity worldwide. Climate change is increasing the frequency, geographical scope, and severity of extreme climatic events (pulse disturbances) in many parts of the world, including fires, floods, heat waves, hurricanes, and droughts (Field et al., 2012). Both California, North America, and Australia experienced their largest wildfires in recorded history in 2019–2020 (Collins et al., 2021; SoC, 2020, Williams et al., 2019). Pulse disturbances are most likely to threaten species with small population sizes and restricted distributions (Caughley, 1994), although the growing geographical scope and frequency of many disturbances will increasingly affect more widespread species. For example, the 2019–2020 “Black Summer” bushfires in eastern Australia affected >30% of the distributions of 26 threatened animal species, and at least 94 animal species that were not listed as threatened at the time (DAWE, 2020).

Conservation management that supports in situ resistance and resilience of species is key to preventing extinctions and population bottlenecks in intensifying disturbance regimes (Nimmo et al., 2015). This might involve protecting areas that provide refuge from disturbances (Selwood et al., 2019), or increasing the spatial extent of populations through ecological restoration and/or species translocations (Braidwood et al., 2018). However, timely and strategic emergency interventions in response to immediate threats may be necessary where populations are very restricted, where disturbances are unprecedented in scale, or where conservation management has been insufficient.

Failing to act, or acting too late, in response to environmental crises has seen poor outcomes—including extinctions—for species around the world. A resistance to take risky or controversial actions has been blamed for driving the Sumatran rhinoceros Dicerorhinus sumatrensis to the brink of extinction (Rabinowitz, 1995), and delaying ex situ intervention contributed to the extinction of the Christmas Island pipistrelle Pipistrellus murrayi (Woinarski et al., 2017). Although the extinction of the Bramble Cay melomys Melomys rubicola in Australia is reported as the first extinction caused by anthropogenic climate change (Waller et al., 2017), it has also been argued that emergency ex situ intervention would have prevented this foreseeable extinction (Woinarski, 2016).

Here, we present a case study for an “emergency conservation intervention,” which we define as an action (or set of actions) undertaken in a time-critical context that seeks to protect the viability of a population, species, or community from the impacts of a pulse disturbance. The emergency conservation intervention was undertaken for the Eastern Bristlebird (Dasyornis brachypterus) during the Australian Black Summer bushfires. The objective was to establish a temporary ex situ insurance population through the emergency extraction of individual birds from a population in Victoria, Australia, that was under immediate threat from a large, out-of-control fire in a remote area. We outline this case study within a proposed framework for emergency conservation interventions based on the emergency management principles of preparation, response, and recovery and an explicit evaluation phase (Figure 1). We reflect on the lessons from this operation, to explore how this framework might be applied to prepare for, respond to, and recover from the large range of emergencies facing biodiversity around the world as we progress through the Anthropocene.

2 | CASE STUDY: EASTERN BRISTLEBIRD EMERGENCY EXTRACTION

2.1 | Background

The endangered Eastern Bristlebird is a small (35–50 g), ground-dwelling bird endemic to southeastern Australia, confined to four isolated populations in three regions, totaling <2500 birds (OEH, 2012). It is a poor flier and of shy and cryptic nature, inhabiting low, dense vegetation in a range of vegetation communities, including grassland, sedgeland, heathland, swampland, scrubland, grassy sclerophyll forest, woodland, and rainforest (OEH, 2012). The main threat to the species is the loss and fragmentation of suitable habitat due to inappropriate fire regimes and past clearing (OEH, 2012). Key management priorities include fire prescriptions for maintaining and protecting habitat, and control of invasive predators, herbivores, and weeds (Baker, 2000; OEH, 2012). The northern population is genetically distinct and is the subject of a captive breeding program, while the central region represents the two largest and most stable populations of the species (OEH, 2012).

This case study focuses on the southernmost population at Cape Howe (~400 birds), which occurs in riparian scrub and heathland patches in the Howe Flat area, Croajingolong National Park in Victoria and the adjacent Nadgee Nature Reserve, New South Wales (Clarke & Bramwell, 1997; OEH, 2012) (Figure 2). An active fire front posed an immediate risk to the entire southern population during the Black Summer bushfires in January 2020, and at the end of the season had burned more than half of the population’s occupied area (Figure 2). An emergency conservation intervention was initiated during the bushfires to create an ex situ insurance population for the southern population.
2.2 Emergency conservation intervention framework

We present our case study within a framework consisting of “preparation,” “response,” “recovery,” and “evaluation” phases. The first three phases are based on an approach commonly applied for managing emergencies and disasters threatening human health or infrastructure around the world (e.g., AMSA, 2020; Brown & Ghilarducci, 2017; EMV, 2014). We have also included an explicit “evaluation” phase to incorporate lessons learnt from the three preceding phases as part of an adaptive management approach (Kapos et al., 2008). We adapt these concepts for the purposes of emergency conservation interventions (Figure 1).
In our framework, the “preparation” phase (predisturbance) refers to (a) conservation management that aimed to build species resistance and resilience to disturbances and (b) knowledge and capacity that enabled the emergency response. The “response” phase was triggered at the onset of the disturbance (the Black Summer bushfires – “response trigger”) and refers to the actions that led to the emergency establishment of an ex situ population (including “coordination” and “implementation” subphases, punctuated by a “response trigger”). The “recovery” phase involved ex situ management and release to the wild once the threat of bushfire to the wild population had subsided. The “evaluation” phase was focused on documenting and disseminating lessons learnt from the emergency conservation intervention to inform future management, monitoring and research.

2.3 | Preparation phase

Although we consider the following elements of “preparation” as influencing the effectiveness of the emergency conservation intervention, the intervention itself had not explicitly been prepared for or formally considered until the onset of the 2019/2020 Black Summer fires (Figure 3).

A nonemergency wild-to-wild translocation had been planned for 2020 to build resilience of the population against the threat of future stochastic events (Maute et al., 2019). All suitable habitat at this planned translocation site was burnt in the fires discussed here. Existing knowledge around the translocation and husbandry of the species was instrumental in allowing for the emergency establishment of an ex situ population. Translocation procedures (see section 2.4.2) were adopted directly from the planned translocation (Maute et al., 2019), which itself was informed by previous experiences in wild-to-wild and wild-to-captivity translocations of the species (Bain et al., 2012; Baker et al., 2012). Individuals had successfully been moved a similar distance from the central population into captivity (NSW DPIE, 2020). Ex situ management was guided by existing husbandry protocols for the species (Beutel et al., 2020) (see section 2.5.1). Recent research on the local population status at Cape Howe, including the distribution of individuals and assessments of habitat condition (Maute et al., 2019) allowed for an informed assessment of the risk that fire posed to the population, and enabled rapid, targeted intervention. This information, coupled with observed and predicted fire spread, played a significant role in preparedness for the emergency conservation intervention, triggering the response phase (Figure 1).

The species was subject to existing conservation management across its range (which spans three states), guided by a national recovery plan (OEH, 2012). As such, there was an existing network of key personnel and knowledge holders (across government agencies, NGOs, zoos, and universities) to guide and implement the emergency conservation intervention for the species, enable rapid coordination, and support sound decision making (see section 2.4.1).

2.4 | Response phase

2.4.1 | Coordination

The Eastern Bristlebird emergency conservation intervention was part of the formal Victorian state government emergency response to the Black Summer bushfires, with the delivery of biodiversity priority actions (directed by an appointed State Controller – Wildlife), alongside priorities for human safety and infrastructure protection. Identification of biodiversity priorities was facilitated by a steering committee of government agencies with responsibilities for biodiversity, informed by expert consultation and spatial analysis of impacts and risks to species as the fires were burning (DELWP, 2020). Informal updates within and between agencies were regular, and included high-level agency (CEOs, department head, Minister) notification of potential impacts and response options for the Eastern Bristlebird, among other species considered at risk (e.g., ARI, 2020).

The Eastern Bristlebird extraction was formally included as a priority intervention on January 24, 2020 by the State Controller – Wildlife, after fire forecasts predicted a high likelihood of fire affecting the population. This represented the response trigger for the implementation phase of the emergency conservation intervention (Figures 1 and 3). Final deployment of the field team was contingent on further fire observations and forecasting indicating the operation could be safely undertaken. Paired with this action was targeted fire suppression in the area (Cape Howe), to protect Eastern Bristlebird habitat and other rare and threatened taxa and vegetation communities. The aim of the intervention was to initiate a captive breeding population to re-establish the southern population of Eastern Bristlebirds should it be extirpated. The birds would be returned to the wild after the fire threat had passed if sufficient habitat in the Howe Flat area escaped fire impacts. Extracting 15–20 individuals was considered a minimum for demographic and genetic representation of the population; and feasible given the constraints of available captive housing and operational logistics. The target also took into consideration the potential impacts of the extraction to the source subpopulation in the event the site escaped fire...
but the extracted birds could not be returned (e.g., mortality during capture, transport or captivity) (i.e., 10% of 160–180 birds; Howe Flat). Given time constraints, this target was based on opinion of species and ex situ conservation experts rather than a formal assessment of extraction number.

### 2.4.2 Implementation phase

Formal roles for the implementation were assigned to three teams: (1) planning (six people), (2) captive preparation (six people), and (3) field (10 people). Both the planning and field teams included members with expertise in the species and site, bird husbandry and bird capture techniques. The captive preparations team coordinated the preparation of ex situ facilities and protocols (husbandry, diet, quarantine) to enable the rapid establishment of a new captive population (see section 3.3.1).

The planning team secured permits, developed an operational plan to determine transport and field logistics (including personnel safety), conducted an animal welfare risk assessment to determine incident triggers for halting or reviewing the operation, and assembled the field team. Members of the field team without prior fire-ground training completed existing online training prior to deployment. Expedited processes for regulatory permits were implemented to enable the rapid issue of permits before the field operation commenced. Transportation was coordinated to limit the time from field capture to captivity to <12 h and within daylight hours (actual transfer time <10 h), and included vehicle, boat and fixed-wing aircraft selected as the fastest and least stressful transport options. A subset of the planning and field teams were part of the local Incident Management Team (EMV, 2014), responsible for emergency response operations. The Incident Management Team authorized and coordinated deployment of the field team (February 3, 2020) and use of emergency transportation (including military and civilian aircraft and watercraft) and implemented targeted fire suppression before, during and after the extraction.

The extraction occurred at Howe Flat in Croajingolong National Park, Victoria (Figure 2), a location that could be safely and feasibly accessed and which had known high densities of the species (Maute et al., 2019). Three roving catching teams were deployed to aid rapid collection, with regular communication between teams to track progress against daily catch targets. Birds were captured using mist nests and call playback that was manually alternated between dual speakers to rapidly attract individual birds to the immediate area and draw them into the nets. Active and mobile mist netting approaches were more successful than passive mist netting and 73.3% of individuals were captured <2 h after daybreak. Captured birds were banded (Australian Bird and Bat Banding Scheme), weighed, measured, examined for fat and muscle condition and signs of

![Figure 3](https://example.com/fig3.png) **Figure 3** Timeline for the Eastern Bristlebird emergency conservation intervention. Panel images from left to right: Smoke plume from bushfire burning near Howe Flat at the time of the operation, February 2020 (Mark Antos); team members removing equipment from helicopter near field site, February 2020 (Tony Mitchell); Eastern Bristlebird captured at Howe Flat, Vic (Marcia Riederer); return of Eastern Bristlebirds to Howe Flat, Victoria, April 2020 (Zoos Victoria)
injury or stress, then transported in custom-made crates from the field site to captivity (>500 km), with welfare and health monitored throughout by zookeepers. Fifteen birds were captured and transported over 2 days. The Incident Management Team ordered evacuation of the field team due to increased fire threat on the afternoon of the second field day. Based on DNA-sexing, seven males and eight females were collected. The species is largely sexually monomorphic and although sexing was attempted based on size (Bain, 2007) and/or behavior, seven birds were erroneously \( n = 5 \) or equivocally sexed \( n = 2 \) in the field.

### 2.5 | Recovery phase

#### 2.5.1 | Ex situ management

Birds were housed at Melbourne Zoo, in existing enclosures that best matched the known housing requirements for the species (Beutel et al., 2020). Zookeepers with expertise in Eastern Bristlebird husbandry assisted with preparing facilities and husbandry protocols, acclimatizing the birds and training staff. Enclosures were equipped with vegetation structure to imitate the species habitat preferences for dense ground cover (planted tussocks and cut branches providing low (1–1.5 m) cover for 60% of ground, with horizontal branches 1.5–2 m high for perching). A “hands off” husbandry approach was adopted, minimizing keeper presence and veterinary intervention to maintain wild behaviors and minimize stress, and preventing associations between people and food. Disturbance was minimized by implementing a 20 m noise reduction zone around the back-of-house facility. Established diet regimes were delivered, matching the nutritional composition of wild diets, and including live invertebrates to maintain wild foraging behaviors (Beutel et al., 2020).

Six birds were paired based on sex, proximity at capture site and observations of bird behavior, while the remainder were housed individually. The population was quarantined to prevent pathogen transfer to or from other species: dedicated food supplies and equipment were used, and keepers donned personal protective equipment, used disinfection stations upon entering the facilities and did not service any other birds on site. Pathogen transfer risk was further reduced because enclosures had not previously housed any bird species. Bird behavior was regularly observed via cameras to monitor acclimatization and health. Veterinarians assessed disease risks based on the species captive history (M. Pyne, personal communication) to determine the need for specific disease screening and any prophylactic treatments. Unnecessary prophylactic treatments for low disease risks were undesirable due to the potential for deleterious side-effects of medications (Hyatt et al., 2015) and the physiological stress that can be imposed if birds require capture and restraint for administration of treatments (Teixeira et al., 2007).

Three birds died within 1 week of arrival, the first within 3 days. Laboratory tests confirmed the birds had died from aspergillosis; a noncontagious opportunistic infection of the environmental fungus, *Aspergillus fumigatus*. Aspergillosis had been considered low risk in the disease risk assessment because it had not previously been observed in the captive Eastern Bristlebird population or closely related species. Aspergillosis in birds is most often associated with immune compromise induced by stressors or by high environmental loads of the fungus (Talbot et al., 2018). Development of clinical disease takes several days in infected birds indicating the disease was likely triggered by the stress of capture, transport, and/or establishment in the aviaries given the first bird died 3 days after arrival. Aspergillosis usually results in a high mortality rate in birds meaning treatment is critically important but often unsuccessful when birds are already showing disease signs (Krautwald-Junghanns et al., 2015). Treatment was commenced in both symptomatic \( n = 5 \) and asymptomatic \( n = 7 \) birds after the disease was first detected, but three further birds died in later weeks. Given the high mortality rate normally associated with aspergillosis, the treatment regimen resulted in a better-than-expected outcome. Nevertheless, a key learning from this intervention, is that prophylactic antifungal treatment should be given to Eastern Bristlebirds during the initial phase of captivity. Six birds had low-moderate infection with intestinal protozoal parasites (coccidia) but this was judged to be of little clinical significance.

#### 2.5.2 | Reintroduction

Over 50% of the area occupied by the southern population of the Eastern Bristlebird was burnt by wildfire during the 2019–2020 fire season, mostly in the 2 weeks following the extraction (Figure 2). However, the extraction site (Howe Flat) largely escaped fire impacts (Figure 2) and so, as per the extraction plan (section 2.4.1), most surviving birds were returned to the wild. Seven birds were reintroduced to the site of capture on April 1, 2020, having passed health checks from veterinary staff. The eighth bird was released after aspergillosis symptoms had resolved (October 2020, delayed due to COVID-19 restrictions). The ninth bird was deemed unfit to be released to the wild and was retained in captivity, due to a leg-injury received during field-capture. Transport arrangements for the reintroduction mirrored those for the extraction, with birds monitored by zookeepers throughout the transfer and released within 8 h of
removal from aviaries. Protocols for radio-tracking to monitor reestablishment of reintroduced birds were developed, but COVID-19 restrictions prevented implementation. Instead, each bird was fitted with a uniquely colored, alloy band to assist with identification during future routine species monitoring of the area. At least one reintroduced bird was resighted during routine monitoring in October 2020, demonstrating both post-release survival and reestablishment of territory near the capture/release site. The impacts of the fires on the southern population have yet to be fully assessed, but initial surveys of burnt areas in New South Wales (Figure 2) indicated at least short-term survival of Eastern Bristlebirds in areas where fire severity was low, but not in areas of high fire severity (D. Oliver, personal communication, 2020).

2.6 Evaluation phase

Immediately following the extraction operation, a debriefing was conducted with members of the planning, captive and field teams to document perspectives on the successes and potential improvements of each stage of the intervention. This informed the current paper and a case study presented to the 2020 Royal Commission into National Natural Disaster Arrangements (RCNNDA, 2020). The intervention also prompted a review of the national recovery plan for the species, and a structured decision-making process to identify priority conservation actions for the species in the coming years (DELWP, unpublished data).

3 DISCUSSION

Threatened species management that fails to consider the need for emergency response can contribute to species extinctions (Woinarski et al., 2017). Despite the increasing need, there has been limited development of conceptual frameworks to guide emergency conservation interventions. Although some frameworks exist to guide response to emergencies threatening wildlife, these tend to be case specific and focus on welfare rather than conservation objectives, for example, whale strandings and entanglements (e.g., DSEWPaC, 2013); injuries to wildlife during bushfires (e.g., DJPR, 2019); and wildlife response plans for oil spills (e.g., NOPSEMA, 2018). We have presented a case study for an emergency conservation intervention, within a framework that we developed, based on a globally common approach to disaster management: preparation, response and recovery, and evaluation (Figure 1). Here we discuss each phase of the framework reflecting on the insights gained in our case study, and more broadly explore which elements are likely to be most critical to successful emergency conservation interventions.

3.1 Preparation phase

Preparation (or “preparedness”) involves developing the capacity to respond to and recover from an emergency, and often occurs alongside “prevention”, which involves avoiding or intervening to stop an incident from occurring (Brown & Ghilarducci, 2017). In our framework for emergency conservation interventions, this phase focuses on (a) preventing the need for emergency interventions, and where necessary, (b) preparing for effective response. Ideally, conservation management would enable species to withstand and recover from extreme events in situ, without the need for emergency conservation interventions. For example, management activities may include mitigating threats that extenuate the impacts of extreme events (e.g., predation, Morris et al., 2011), augmenting species distributions through translocation to spread risks (Zimmer et al., 2020), or providing opportunities for individuals to escape the impacts of disturbances by protecting or restoring landscape connectivity and access to refuges (Selwood & Zimmer, 2020). Nevertheless, our case study highlights the difficulty in predicting the likelihood and severity of extreme events: population augmentation was planned (Maute et al., 2019); however, as both the proposed source population and the translocation site were affected by the same bushfire, this action would have provided no insurance against this large-scale event.

Explicit consideration of emergency response in recovery planning can be critical to preventing species extinctions (Woinarski et al., 2017). Predefined triggers for emergency conservation interventions (i.e., developed in the preparation phase, Figure 1) are likely to be highly beneficial for facilitating good decision making for analogous scenarios (Cook et al., 2016), because interventions need to be rapid and are of high consequence. Triggers should consist of four key elements, (1) when (the requisite level of threat/s), (2) where (e.g., the location of critical populations), (3) what (the actions to be implemented, e.g., targeted threat mitigation and translocation), and (4) how (the scope of such actions). Decisions to intervene (“when”) should explicitly consider the risks of intervening (e.g., impacts of collection on source population) compared to the risks of not intervening (e.g., population extinction). In our case, although a response trigger for implementation was identified during the coordination phase, emergency intervention had not been considered prior to the emergency occurring. Nevertheless, knowledge of the species status and conservation...
importance of the population (Maute et al., 2019; OEH, 2012), coupled with a good understanding of the fire threat, facilitated rapid decision-making to trigger the emergency conservation intervention, because the risks for not intervening were clear. Knowledge of the population size meant that the risks of intervening (extraction of individuals) could also be directly assessed. The existence of procedures for capture, transportation, translocation and captive husbandry of the Eastern Bristlebird (Beutel et al., 2020; Maute et al., 2019) were critical for guiding the methods of intervention and securing necessary permits, highlighting the importance of the development of such procedures in the preparation phase. Information on population distribution enabled identification of target locations for efficient animal capture.

An important aspect of preparation for any emergency is the capacity of responders to enact an effective response when required, including the availability of skilled personnel, equipment, and resources (e.g., AMSA, 2020; DSEWPaC, 2013). Preparatory emergency training/accreditation of personnel likely to be involved in emergency conservation interventions is expected to be highly beneficial. Where emergency responses are to involve translocation (to captivity, or wild-to-wild), capacity to enact effective emergency responses will include the skills, techniques and equipment to safely collect animals or plants, and where relevant, skills and resources to breed ex situ. A pressure point for emergency conservation interventions is likely to be a limited surge capacity in ex situ institutions (Zoos Victoria, unpublished data), including the availability of ample, suitable enclosures, and so the preparation phase needs to include strategic planning for suitable ex situ housing, and expert husbandry personnel.

The preparation phase (or lack thereof) is a key determining step for whether the process progresses to the response phase. For instance, the preparation phase may reveal a lack of knowledge, techniques or resources to undertake an emergency conservation intervention with acceptable risk.

3.2 Response phase

Incident command (or control) systems are a standardized approach to the implementation of emergency responses, used around the world for disasters and emergency management, particularly for human-focused emergencies (Bigley & Roberts, 2001). Key elements of incident command systems include a focus on clear objectives, clearly defined roles and line of authority, expertise, safety, and communication. For acute disturbances like bushfires, we suggest that embedding emergency conservation interventions into such existing systems is vital to ensure human safety, site access, access to logistical resources (including transport) and expertise. Where not part of a broader human-focused emergency response, aspects of the incident command systems may provide focus for structuring emergency conservation interventions, and these structures are increasingly being applied in wildlife welfare emergency responses (e.g., DJPR, 2019; DSEWPaC, 2013).

3.2.1 Coordination

Our case study highlights the importance of biodiversity representatives playing an effective role in emergency response efforts, from high level decision-making to on-ground emergency response. Ultimately, the presence of an authorized biodiversity representative in the highest level of emergency response decision-making allowed biodiversity priorities to be actively considered alongside human priorities, thereby facilitating the response, including allocation of necessary resources, and authority to carry out the operation under the local incident command team. Explicit inclusion of biodiversity objectives in the coordination phase of emergency responses such as bushfires will be key for allowing emergency conservation interventions to be effectively implemented.

Coordination should focus on timely and clear decision-making, supported by well-informed risk assessment and prioritization of actions, and where available, predefined response triggers (section 3.1). In our case, there was a critical window of safe fire conditions that allowed the emergency conservation intervention to be implemented, as demonstrated by the evacuation of the field team after just 2 days. Any delays to decisions, and thus, implementation would have likely compromised the goals of the operation. Although an emergency response had not previously been explicitly considered for the Eastern Bristlebird, a high level of cooperation between agencies involved in biodiversity bushfire responses (wildlife authority, national parks, and zoo), an existing translocation plan, and real-time analysis of fire risk and potential impacts, and response options (DELWP, 2020) facilitated fast and effective decision-making on the need for the emergency conservation intervention. Effective advocacy also played a role in progressing decision-making. Such circumstances cannot be expected for all species, in all emergency situations, which is why an adequate preparation phase is vital for facilitating necessary emergency conservation interventions. Clear and effective institutional decision-making and prioritization frameworks will be vital for ensuring that interventions can be coordinated efficiently.
3.2.2 | Implementation

Timely and authoritative decision-making (including expedited permits) in the coordination subphase allowed our operation to proceed with certainty and with clear objectives, and to be rapidly implemented to meet goals. The embedding of our emergency conservation intervention within an operating incident command system enabled the authorized and safe deployment of the field team onto the fire ground, and successful extraction of the insurance population. Other factors we consider crucial to the successful implementation of our response (i.e., capture of the target number of animals) within a short time frame were a highly focused and skilled field team, with ample equipment, a field effort targeting known high-density areas, and nimble and responsive field methods.

Affording high priority to animal welfare (e.g., minimizing stress) is key to the success of translocation programs because it directly affects survival rates (Dickens et al., 2010). This component becomes even more critical in an emergency conservation intervention, where collected individuals might represent the sole remaining cohort of a population or species. Key personnel may themselves be under stress during emergencies, so it is important to have clear protocols and objectives in place that are understood by all. An explicit animal welfare assessment identified key mitigations, including defined conditions for capture (including weather), minimizing handling and transport time by utilizing least stressful transport options, monitoring of bird welfare and appropriate provision of care by husbandry experts throughout the capture and transport process, and the preparation of appropriate captive facilities. Although strong welfare mitigations were in place, there was still an acceptance of risk in our operation, with triggers (incidence of animal deaths/injuries) for halting the operation being higher than in an analogous nonemergency situation where the source population was not otherwise at risk (i.e., planned, nonemergency conservation translocation; Maute et al., 2019). This is an important consideration during crises, because risks to the survival of animals posed by the intervention must be balanced against the risk of not intervening (e.g., total loss of population) (e.g., Callen et al., 2020). The potential for mortality during or after translocation (captive or wild) should also be considered in deriving the target size of translocations, particularly where transportation is long-distance, the target species is known to be highly stress-prone, or husbandry/translocation knowledge for the species is lacking.

3.3 | Recovery phase

3.3.1 | Ex situ management

Where emergency interventions involve ex situ management, the capacity and knowledge to optimally maintain, and where relevant, breed, a species in captivity is crucial to success (section 3.1). The general principles on the management of ex situ populations for conservation and reintroduction will apply to emergency extracted insurance populations, including quarantine and disease monitoring, appropriate demographic and genetic management, welfare and health management, and conservation of wild behaviors and fitness (IUCN, 2002; IUCN/SSC, 2013). In our case, existing species knowledge (including housing, diet, and husbandry) and institutional capacity (enclosures and skilled staff) contributed significantly to the feasibility of the operation. Where existing husbandry and/or veterinary knowledge for a species is lacking, information for closely related or analogous species might inform husbandry practices and veterinary interventions, including disease risk assessments (IUCN, 2002). An unforeseen challenge in our case was the management of aspergillosis, which had not previously been detected in the species ex situ population. Interinstitutional cooperation and access to highly skilled zoo veterinary and husbandry teams enabled early detection of the disease and development of an effective treatment regime, which can now be applied to future captive management of the Eastern Bristlebird, and potentially other species.

3.3.2 | In situ recovery, reintroduction

Just as important as goals and triggers for emergency response, are goals and triggers for in situ recovery, including reintroduction from ex situ populations. Where disturbances have affected habitat suitability, management interventions may be required to support recovery of habitat to predisturbance condition, for example, weed control, pest control, limits on harvesting and/or active revegetation (Boyd & Davies, 2012; García-Orenes et al., 2017; Scherrer & Pickering, 2005). Where ex situ populations have been established, triggers should be identified to prompt captive breeding programs and/or reintroduce rescued or captive-bred individuals based on (a) cessation of the pulse disturbance, (b) level of impact, and where relevant, (c) adequate habitat recovery (Canessa et al., 2016). A rapid return to the wild is likely to preserve wild behaviors and improve individual postrelease survival (Grueber et al., 2017). Where disturbances have caused sufficiently low levels of impact, rescued individuals might be released at the location of capture, as occurred in our case study.
Where source habitat has been significantly affected, rescued individuals are likely to form the basis of a captive breeding program to rebuild populations for reintroduction, although in some cases it may be appropriate to release rescued individuals to seed or supplement populations in other suitable habitat. Reintroductions following emergency interventions should follow the well-established principles of conservation translocations (IUCN/SSC, 2013; Taylor et al., 2017).

3.4 | Evaluation phase

Our framework aligns with the adaptive management framework of planning, doing and evaluating (e.g., Schwartz et al., 2012). Evaluation ensures that the effectiveness of future interventions can be improved (Ferraro & Pattanayak, 2006), and we suggest that this is especially crucial for emergency conservation interventions, as a novel and evolving area of conservation management. The short timeframes over which emergency interventions will generally be coordinated and implemented (in our case, <2 weeks) may impede the development of comprehensive monitoring and evaluation frameworks. As such, we suggest that formal goals and indicators for evaluation are best considered as part of the preparation phase when options and triggers for future emergencies are being planned. Our framework distinguishes three phases and six subphases to which objectives and indicators can be attached to guide monitoring and evaluation (Margoluis et al., 2013). As yet, there has been no formal assessment of the overall costs involved with our emergency conservation intervention, but assessments of cost effectiveness are likely to be valuable to inform the allocation of resources to different phases of emergency interventions, for example, the preparation phase (e.g., supporting in situ species resistance and resilience) versus the response phase (e.g., emergency extraction).

We consider open communication around the learnings (including success and failures) in emergency conservation interventions—both through formal evaluation and through general communications (e.g., media)—important for gaining future support and trust for such interventions, particularly where they require consideration in human-focused emergency response efforts.

4 | CONCLUSION

The emergency extraction of the Eastern Bristlebird from an area under immediate threat from fire provides a tangible example of what can be achieved within critical timeframes when adequate planning and resourcing is available within an emergency management framework. It has potential to pave the way for future interventions (which have traditionally been viewed as high risk and not desirable) in a time of increasing frequency, scope and intensity of pulse disturbances. The social and institutional learnings from this case study (e.g., RCNNDDA, 2020) have been as critical as the conservation outcomes. It highlights that species that do not display the attributes of classic flagship species (a cryptic brown bird in this case) (Johnstone et al., 2015) can still play important roles in conservation messaging during periods of crisis. The framework we have presented highlights the critical importance of preparation, response, recovery and evaluation for preventing species extinctions in times of crisis, presenting a pathway for future interventions of this nature. Finally, we suggest that when immediately faced with emergencies threatening the viability of conservation targets, as conservationists we need to be bold in advocating for emergency interventions. Hesitancy to intervene can be a particularly prevalent attitude in threatened species management, especially where ex situ intervention is proposed (Canessa et al., 2020; Woinarski et al., 2017). We suggest decisions on emergency conservation interventions be centrally guided by the precautionary principle, with direct assessment and communication of the risks of not intervening.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

AUTHOR CONTRIBUTIONS

Katherine E. Selwood, Rohan H. Clarke, and Mark Antos developed the framework for the manuscript, with input from all authors. Katherine E. Selwood led the writing of the manuscript, with substantial contributions from Rohan H. Clarke and Mark Antos, and input from all
authors. All authors were involved with the planning and/or implementation of the emergency conservation intervention described in the manuscript.

**DATA AVAILABILITY STATEMENT**

There are no data associated with this manuscript.

**ETHICS STATEMENT**

The emergency conservation intervention described here was permitted under Victorian Wildlife Act 1975 Authorisations 10009370 and 10009370A.

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**REFERENCES**

AMSA. (2020). *National plan for maritime environmental emergencies – 2020 edition*. Australian Maritime Safety Authority, Commonwealth of Australia. Retrieved from https://www.amsa.gov.au/marine-environment/national-plan-maritime-environmental-emergencies#collapseArea313

ARI. (2020). *Bushfire response 2020—Aquatic rescues*. Arthur Rylah Institute. Retrieved from https://www.ari.vic.gov.au/research/fire/bushfire-response-2020-aquatic-rescues

Bain, D. (2007). Two potential sexing techniques for the eastern bristlebird *Dasyornis brachypterus*. *Australian Zoologist*, 34(1), 92–96.

Bain, D., French, K., Baker, J., & Clarke, J. (2012). Translocation of the Eastern Bristlebird 1: Radio-tracking of post-release movements. *Ecological Management and Restoration*, 13, 153–158.

Baker, J. (2000). The eastern bristlebird: Cover-dependent and firesensitive. *Emu*, 100, 286–298.

Baker, J., Bain, D., Clarke, J., & French, K. (2012). Translocation of the Eastern Bristlebird 2: Applying principles to two case studies. *Ecological Management and Restoration*, 13, 159–165.

Beutel, A., Gubler, Z., & Booth, R. (2020). *North Eastern Bristlebird Dasyornis brachypterus moinoides husbandry guidelines*. Cur-rumbin Wildlife Sanctuary.

Bigley, G. A., & Roberts, K. H. (2001). The incident command system: High-reliability organizing for complex and volatile task environments. *Academy of Management Journal*, 44, 1281–1299.

Boyd, C. S., & Davies, K. W. (2012). Spatial variability in cost and success of revegetation in a Wyoming big sagebrush community. *Environmental Management*, 50, 441–450.

Braidwood, D. W., Taggart, M. A., Smith, M., & Andersen, R. (2018). Translocations, conservation, and climate change: Use of restoration sites as protorefuges and protorefugia. *Restoration Ecology*, 26, 20–28.

Brown, E. G., & Ghilarducci, M. S. (2017). *State of California emergency plan*. State of California. Retrieved from https://www.caloes.ca.gov/PlanningPreparednessSite/Documents/California_State_Emergency_Plan_2017.pdf

Callen, A., Hayward, M. W., Klop-Toker, K., Allen, B., Ballard, G. J., Broekhuis, F., Clarke, R. H., Clulow, J., Clulow, S., Daltry, J., Davies-Mostert, H., Dixon, V., Fleming, P., Howell, L., Kerley, G., Legge, S., Lenga, D., Major, T., Montgomery, R., & Di Blanco, Y. (2020). Envisioning the future with “compassionate conservation”: An ominous projection for native wildlife and biodiversity. *Biological Conservation*, 241, 1–12.

Canessa, S., Guillera-Arroita, G., Lahoz-Monfort, J. J., Southwell, D. M., Armstrong, D. P., Chadas, I., Lacy, R. C., & Converse, S. J. (2016). Adaptive management for improving species conservation across the captive-wild spectrum. *Biological Conservation*, 199, 123–131.

Canessa, S., Taylor, G., Clarke, R. H., Ingwersen, D., Vandersteen, J., & Ewen, J. G. (2020). Risk aversion and uncertainty create a conundrum for planning recovery of critically endangered species. *Conservation Science and Practice*, 2, e138.

Caughley, G. (1994). Directions in conservation biology. *Journal of Animal Ecology*, 63, 215–244.

Clarke, R. H., & Bramwell, M. (1997). The Eastern Bristlebird *Dasyornis brachypterus* in East Gippsland, Victoria. *Australian Bird Watcher*, 17, 245–253.

Collins, L., Bradstock, R. A., Clarke, H., Clarke, M. F., Nolan, R. H., & Penman, T. D. (2021). The 2019/2020 mega-fires exposed Australian ecosystems to an unprecedented extent of high-severity fire. *Environmental Research Letters*, 16(4), 044029.

Cook, C. N., de Bie, K., Keith, D. A., & Addison, P. F. (2016). Decision triggers are a critical part of evidence-based conservation. *Biological Conservation*, 195, 46–51.

DAWE. (2020). *Rapid analysis of the 2019–20 fires on animal species, and prioritisation of species for management response*. Department of Agriculture, Water and the Environment. Retrieved from http://www.environment.gov.au/biodiversity/bushfire-recovery

DELWP. (2020). *Victoria’s bushfire emergency: Biodiversity response and recovery: Preliminary report – Version 1*. Department of the Environment, Land, Water and Planning. Retrieved from https://www.wildlife.vic.gov.au/home/biodiversity-bushfire-recovery-and-recovery

Dickens, M. J., Delehanthy, D. J., & Romero, M. (2010). Stress: An inevitable component of animal translocation. *Biological Conservation*, 143, 1329–1341.

DJPR. (2019). *Victorian emergency animal welfare plan (revision 2)*. Department of Jobs, Precincts and Regions. Retrieved from https://www.wildlife.vic.gov.au/wildlife-emergencies/wildlife-emergencies

DSEWPaC. (2013). *National guidance on the management of whale and dolphin incidents in Australian waters*. Department of Sustainability, Environment, Water, Population and Communities. Retrieved from https://www.environment.gov.au/system/
files/resources/bb73a9b4-c014-49f3-b946-4c07f0b127df/files/cetacean-incidents.pdf

EMV. (2014). State bushfire plan. Emergency Management Victoria, Victorian Government. Retrieved from https://www.emv.vic.gov.au/plans/state-bushfire-plan/

Ferraro, P. J., & Pattanayak, S. K. (2006). Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLoS Biology, 4(4), e105.

Field, C. B., Barros, V., Stocker, T. F., & Dahe, Q. (Eds.). (2012). IUCN/SSC. (2013).

Johnstone, K., Miller, K. K., & Antos, M. J. (2015). Grassland conservation and the plains-wanderer: A small brown bird makes an effective local flagship. Conservation and Society, 13, 407. https://doi.org/10.4103/0972-4923.179882

Kapos, V., Balmford, A., Aveling, R., Bubb, P., Carey, P., Entwistle, A., Hopkins, J., Mulliken, T., Safford, R., Stattersfield, A., Walpole, M., & Manica, A. (2008). Calibrating conservation new tools for measuring success. Conservation Letters, 1(4), 155–164.

Krautwald-Junghans, M. E., Vorbrüggen, S., & Böhme, J. (2015). Aspergillosis in birds: An overview of treatment options and regimens. Journal of Exotic Pet Medicine, 24(3), 296–307.

Margoluis, R., Stem, C., Swaminathan, V., Brown, M., Johnson, A., Placci, G., Salafsky, N., & Tilders, I. (2013). Results chains: A tool for conservation action design, management, and evaluation. Ecology and Society, 18(3), 22.

Maute, K., French, K., & Bramwell, M. (2019). Eastern Bristlebird (Dasyornis brachypterus) translocation plan proposal for Far East Gippsland, Victoria. Department of Environment, Land, Water and Planning.

Morris, G., Hostetler, J. A., Oli, M. K., & Conner, L. M. (2011). Effects of predation, fire, and supplemental feeding on populations of two species of Peromyscus mice. Journal of Mammalogy, 92(5), 934–944.

Nimmo, D. G., Mac Nally, R., Cunningham, S. C., Haslem, A., & Bennett, A. F. (2015). Vive la résistance: Reviving resistance for 21st century conservation. Trends in Ecology & Evolution, 30(9), 516–523.

NPOSEMA. (2018). Oil pollution risk management: Guidance note. National Offshore Petroleum Safety and Environmental Management Authority. Retrieved from https://www.nposema.gov.au/assets/Guidance-notes/A382148.pdf

NSW DPIE. (2020). Firefighting mission saves prehistoric pines. Retrieved from https://www.environment.nsw.gov.au/news/fire-fighting-mission-saves-prehistoric-pines

OEH. (2012). National recovery plan for Eastern Bristlebird Dasyornis brachypterus. Office of Environment and Heritage, Department of Premier and Cabinet (NSW).

Pullin, A. S., & Knight, T. M. (2003). Support for decision making in conservation practice: An evidence-based approach. Journal for Nature Conservation, 11, 83–90.

Rabinowitz, A. (1995). Helping a species go extinct: The Sumatran rhino in Borneo. Conservation Biology, 9, 482–488.

Royal Commission into National Natural Disaster Arrangements. (2020). Interim observations August 31, 2020. Commonwealth of Australia. Retrieved from https://naturaldisaster.royalcommission.gov.au/system/files/2020-08/Interim%20Observations%2020%20August%202020%20_0.pdf

Scherrer, P., & Pickering, C. M. (2005). Recovery of alpine vegetation from grazing and drought: Data from long-term photo-quadrats in Kosciuszko National Park, Australia. Arctic, Antarctic, and Alpine Research, 37, 574–584.

Schwartz, M. W., Deiner, K., Forrester, T., Grof-Tisza, P., Muir, M. J., Santos, M. J., Souza, L. E., Wilkerson, M. L., & Zylberberg, M. (2012). Perspectives on the open standards for the practice of conservation. Biological Conservation, 155, 169–177.

Selwood, K. E., Cunningham, S. C., & Mac Nally, R. (2019). Beyond refuges: Identifying temporarily dynamic havens to support ecological resistance and resilience to climatic disturbances. Biological Conservation, 233, 131–138.

Selwood, K. E., & Zimmer, H. C. (2020). Refuges for biodiversity conservation: A review of the evidence. Biological Conservation, 245, 108502.

SoC. (2020). Top 20 largest California wildfires. State of California. Retrieved from https://www.fire.ca.gov/media/11416/top20_acres.pdf

Talbot, J. J., Thompson, P., Vogelnest, L., & Barrs, V. R. (2018). Identification of pathogenic Aspergillus isolates from captive birds in Australia. Medical Mycology, 56, 1038–1041.

Taylor, G., Canessa, S., Clarke, R. H., Ingwersen, D., Armstrong, D. P., Seddon, P. J., & Ewen, J. E. (2017). Is reintroduction biology an effective applied science? Trends in Ecology and Evolution, 32, 873–880.

Teixeira, C. P., De Azevedo, C. S., Mendel, M., Cipreste, C. F., & Young, R. J. (2007). Revisiting translocation and reintroduction programmes: The importance of considering stress. Animal Behaviour, 73, 1–13.

Waller, N. L., Gynter, I. C., Freeman, A. B., Lavery, T. H., & Leung, L. K. P. (2017). The Bramble Cay melomys Melomys rubicola (Rodentia: Muridae): A first mammalian extinction caused by human-induced climate change? Wildlife Research, 44, 9–21.

Williams, A. P., Abatzoglou, J. T., Gershunov, A., Guzman-Morales, J., Bishop, D. A., Balch, J. K., & Lettenmaier, D. P.
(2019). Observed impacts of anthropogenic climate change on wildfire in California. Earth’s Future, 7, 892–910.

Woinarski, J. (2016). A very preventable mammal extinction. Nature, 535, 493. https://doi.org/10.1038/535493e

Woinarski, J. C., Garnett, S. T., Legge, S. M., & Lindenmayer, D. B. (2017). The contribution of policy, law, management, research, and advocacy failings to the recent extinctions of three Australian vertebrate species. Conservation Biology, 31(1), 13–23.

Zimmer, H. C., Auld, T. D., Cuneo, P., Offord, C. A., & Commander, L. E. (2020). Conservation translocation—An increasingly viable option for managing threatened plant species. Australian Journal of Botany, 67(7), 501–509.

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