Threatened Species Recovery Hub

National **Environmental Science** Programme

Adaptive reintroduction strategies for the Critically Endangered northern corroboree frog

Final report

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June 2021

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ACT Government

Figure 1. This research was conducted in sub-alpine and montane ecosystems in the ACT and southern NSW, including in Namadgi and Kosciuszko National Parks, from early 2018 to mid-2021.

Cite this publication as: Scheele, B., Lindenmayer, D., 2021. Adaptive reintroduction strategies for the Critically Endangered northern corroboree frog. NESP Threatened Sprecies Recovery Hub Project 3.3.6 report, Brisbane.

Cover image: Northern corroboree frog. Image: Adam Parsons

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Executive summary

The introduced pathogen, chytrid fungus, has caused major declines in over 40 Australian frog species. A common management response for frogs at very high risk of extinction has been the establishment of captive breeding programs, paired with translocations. The long-term objective being to release captive bred frogs to re-establish and/or supplement wild populations. However, while captive breeding has been generally successful, many translocation projects have failed, likely due to the continued severe impact of chytrid fungus. The limited success of previous projects highlights the clear need for research to help develop new strategies for the translocation of frog species impacted by chytrid fungus.

Project 3.3.6 "Adaptive reintroduction strategies for the Critically Endangered northern corroboree frog" aimed to improve and develop new strategies for translocations of frog species impacted by chytrid fungus, with a focus on the Critically Endangered northern corroboree frog (*Pseudophryne pengilleyi*). The northern corroboree frog has experienced severe declines due to chytrid fungus and has become locally extinct over the last two decades across large areas of its range. Along with a range of conservation actions for the species, a successful captive breeding program has been developed. However, attempts to reintroduce the species have had limited success, due to the ongoing impact of chytrid fungus.

The project encompassed two main components: 1) to conduct a broad-scale assessment of frog translocation projects for Australian frogs threatened by chytrid fungus, and 2) conduct research to improve the long-term conservation status of the northern corroboree frog. The second component focused on characterising refuges that are associated with the persistence of populations with chytrid fungus and developing approaches to identify and evaluate suitable candidate sites for re-establishing wild populations from the captive breeding program.

Northern corroboree frog. Image: Ben Scheele

1. Conservation translocations for amphibian species threatened by chytrid fungus

We conducted a review of two decades of translocation efforts for Australian frogs, identifying key factors associated with translocation success or failures, including the role of chytrid fungus. We also investigated the environmental context of frog declines associated with chytrid fungus in order to improve our understanding of the characteristics of refuge habitats and develop a conceptual framework for when and where translocations may be both feasible and beneficial for amphibian species threatened by chytrid fungus, by considering mechanisms that favour host persistence. Building on insights from the review and the conceptual model, we then developed a set of recommendations to guide practitioners and improve future translocation efforts for amphibians threatened by chytrid fungus.

Key findings:

- Chytrid fungus has been a key factor limiting frog translocation success in Australia
- Our conceptual model identifies two main contexts within which species or populations that have declined at least partly due to chytridiomycosis are able to persist longer-term and highlights when conservation translocations may be a beneficial management strategy in both these contexts under certain circumstances.
- We provide recommendations for undertaking amphibian translocations for species threatened by chytrid fungus including:
    - Setting project objectives and indicators that focus on revealing the processes that facilitate frog coexistence with chytrid fungus.
    - Evaluating whether a site may be conducive to coexistence with chytrid fungus, including environmental suitability for chytrid fungus, frog community composition (with a focus on the presence of reservoir hosts) and recruitment potential.
    - Employing animal-focused tactics, such as timing the release to minimise infection risk, or environment-focused tactics such as the modification of habitat, in order to increase frog survival or to decrease suitability for chytrid fungus.

2. Identifying and evaluating translocation sites for the northern corroboree frog

In order to identify potential suitable translocation sites for northern corroboree frogs, we investigated the mechanisms associated with the persistence of frog populations with chytrid fungus. We then used a combination of desktop and field surveys to identify and assess sites with a focus on habitat suitability, capacity to allow coexistence with chytrid fungus, and hydrological resilience. Candidate sites were further evaluated by comparing environmental conditions to historical and persisting sites.

Key findings:

- We found environmental conditions and frog age to maturation can strongly mediate the impact of chytrid fungus, and the ability of northern corroboree frog populations to coexist with the pathogen.
- We identified candidate sites for northern corroboree frog translocations immediately adjacent to the species' historical range that had similar environmental attributes to persisting sites and suitable hydroperiods.
- Chytrid fungus was present at all sites, however candidate sites had lower environmental suitability for chytrid (lower precipitation) and may support favourable population demographics (through being at lower elevation) to facilitate frog persistence in the presence of chytrid fungus.

Given the limited information on applied management actions in response to chytrid fungus, the process developed for northern corroboree frogs has broad applicability for threatened Australian frogs, as well as other amphibian species threatened by chytrid fungus globally. We hope the application of this example, as well as the conceptual model and recommendations to specifically articulate and test potential mechanisms of amphibian-disease coexistence, will help improve translocation outcomes and elucidate mechanisms contributing to translocation success or failure. With careful development and refinement, translocations may prove a useful tool to combat the unique conservation challenges posed by emerging diseases.

Introduction

The introduced pathogen, chytrid fungus (*Batrachochytrium dendrobatidis*), is a key threat to Australia's unique frog biodiversity. Chytrid fungus is thought to have originated in East Asia and been spread by humans, particularly through wildlife trade (Martel *et al.* 2014; O'Hanlon *et al.* 2018). Since the late 1970s, it has been implicated in major declines for over 40 Australian frog species (Scheele *et al.* 2017a). As a result, some species have become extinct, while others, like the Critically Endangered northern corroboree frog (*Pseudophryne pengilleyi*), are at risk of extinction without conservation interventions.

An increasingly common management response for frogs at very high risk of extinction has been the establishment of captive breeding programs, paired with reintroductions and translocations (Harding *et al.*2016). The long-term objective being to release captive bred frogs to re-establish wild populations (Zippel *et al.* 2011). However, while captive breeding has been quite successful, many reintroduction and translocation projects have had limited success or failed (Linhoff *et al.* 2021). The limited success of previous projects highlights the clear need for a detailed synthesis of past and current frog translocation and reintroduction projects in Australia to identify barriers to success and develop best practice guidelines to improve conservation outcomes. In parallel, there is a need for research to develop and examine new translocation strategies for endangered species.

The Critically Endangered northern corroboree frog (*Pseudophryne pengilleyi*) is a key focal species that urgently requires research to develop and trial new translocation strategies. The species has experienced severe declines due to the emergence of chytrid fungus and has become extinct over the last two decades across large areas of its range (Hunter *et al.* 2010; Scheele *et al.*, 2017b). While the species is suffering continued population declines, two sites maintain large populations, and while the long-term viability of these populations remains unclear, their persistence indicates that the species has some capacity to co-exist with chytrid fungus. Along with a range of conservation actions for the species, a comprehensive, multi-institutional captive breeding program has been developed (McFadden *et al.*, 2018). Successful captive breeding has been achieved, securing the species in captivity, and now provides an opportunity for experimental translocations, with the objective of creating self-sustaining wild populations.

While past reintroductions of captive bred northern corroboree frogs have focused on returning species to areas where they have become locally extinct, this approach has met limited success, with severe impacts from chytrid fungus appearing to be associated with low survival. Hence, there is an urgent need to develop, trial and evaluate new reintroduction and translocation strategies if we are to establish self-sustaining wild populations of the northern corroboree frog and many other chytrid sensitive species.

This project endeavoured to improve and develop new strategies for translocations of frog species, and in particular those impacted by chytrid fungus, and encompassed two main components. The first was to conduct a broad-scale assessment of frog translocation projects for Australian frogs threatened by chytridiomycosis. This synthesis component aimed to identify key attributes of successful programs, as well as barriers to success. It also aimed to provide key recommendations as to how to best monitor and undertake translocation actions in an adaptive management framework.

The second component was to improve the long-term conservation status of the Critically Endangered northern corroboree frog. More specifically, this component aimed to 1) improve understanding of the characteristics of refuges that are associated with the persistence of northern corroboree frog populations with chytrid fungus, and 2) develop new approaches to re-establishing wild populations from the captive breeding program, including identifying and evaluating suitable candidate sites for translocations of northern corroboree frogs.

Context

This project builds on long-term monitoring of northern corroboree frog populations and reintroductions in the ACT by the Environment, Planning and Sustainable Development Directorate. In NSW, the Department of Planning, Industry and Environment and the Taronga Conservation Society have conducted long-term monitoring of northern corroboree frog populations. In both cases, monitoring has informed project development and was used to guide research to identify mechanisms underpinning population trajectories. .

Methodology

Assessment of frog translocation projects for Australian frogs

We conducted a review of two decades of translocation efforts for Australian frogs, identifying key factors associated with translocation success or failures, including the role of chytrid fungus. This component involved reviewing scientific publications and government reports, as well as connecting directly with managers involved in previous or current frog reintroduction or translocation projects.

We also investigated the environmental context of frog declines associated with chytrid fungus in order to improve our understanding of the characteristics of refuge habitats and identify the mechanisms that allow the persistence of species despite the presence of chytrid fungus. We then used this information to develop a conceptual framework for when and where translocations may be both feasible and beneficial for amphibian species threatened by chytridiomycosis, by considering mechanisms that favour host persistence.

Lastly, building on insights from the Australian review and the conceptual model, we then developed a set of recommendations to guide practitioners and improve future translocation efforts for amphibians threatened by chytrid fungus. We highlighted steps that are relevant for frog translocations in general as well as steps that are specifically applicable for species threatened by chytrid fungus.

Identifying and evaluating translocation sites for the northern corroboree frog

Based on our understanding of the environmental context of frog declines associated with chytrid fungus and the characteristics of refuge habitats, we examined the mechanisms that may facilitate the coexistence of the northern corroboree frog with chytrid fungus. We conducted field research to investigate the causes of variation in relative decline severity in northern corroboree frog populations and the relationship between persistence and site elevation.

Building on this knowledge, we then evaluated potential candidate translocations sites, within or immediately adjacent to the historical range of the northern corroboree frog, which encompass cool, temperate, upland areas. The initial candidate site assessment process was conducted remotely using satellite imagery and considered a range of parameters, including site elevation. We then conducted on ground surveys at potential candidate sites identified from the satellite imagery assessment. Field surveys focused on evaluating site habitat suitability and quality, and in particular, identifying characteristics that were comparable with sites where northern corroboree frogs persist. Frog surveys were also conducted, with a focus on determining the presence of a key surrogate species, Bibron's toadlet (*Pseudophryne bibronii*), which shares similar habitat requirements and is sympatric with corroboree frogs.

At sites where habitat extent and quality appeared suitable, and Bibron's toadlet was present, we further evaluated suitability by comparing the species' niche across sites. Specifically, we examined environmental variables between the shortlist of candidate sites and both historically occupied sites and sites where the species persists. The final step in evaluating candidate sites involved detailed hydrological monitoring at shortlisted candidate sites. At both persistent sites and candidate sites, pond photos were taken daily throughout the breeding season in 2019 to track pond duration.

Findings

Conservation translocations for amphibian species threatened by chytrid fungus

Review of Australian frog translocations

We found that in Australia, the majority of frog translocations to date have been of species primarily threatened by chytrid fungus. Factors associated with success in chytrid-threatened species included releases to sites where the species persists, release into similar habitat, and the release of adults. However, overall, few of the published reports of translocations have been highly successful, that is, showed evidence of reproduction occurring several years post-release. In many cases, failure to specifically address chytrid fungus, and mechanisms by which susceptible amphibians may coexist with chytrid fungus, is likely to have contributed to translocation failures or only partially successful outcomes.

Conceptual framework for mechanisms of persistence and the role of translocations

Although our review revealed that many previous translocations had met with limited success, with improved knowledge of chytrid fungus, we argue that removal of the pathogen is not the only way to ensure host persistence and that under certain conditions, increased translocation success is possible. We present a conceptual framework identifying two main contexts within which species or populations that have declined at least partly due to chytridiomycosis are able to persist longer-term (Figure 2). Conservation translocations may be a beneficial management strategy in both these contexts under certain circumstances.

The first context for host persistence involves inducement of a fundamental change in the underlying host-pathogen-environment interaction in favour of the host (Figure 2A). This systemic change includes changes in: 1) the host species or host community composition, 2) the pathogen, or 3) the environment. For example, in the case of increased host resistance/tolerance, populations of hosts with increased resistance/tolerance may act as suitable source populations for conservation reintroductions into areas from which they had been extirpated. Reintroductions of resistant/tolerant animals may then be used to increase the frequency of such phenotypes in wild populations.

The second context involves cases whereby population persistence may be possible in the absence of systemic change (Figure 2B). In this instance, host persistence may be possible through several mechanisms including: 1) metapopulation dynamics and increasing population connectivity, 2) spatiotemporal heterogeneities and persistence in or translocation to refuges, and 3) demographic compensation and the active reduction of other, non-disease, threats. In these scenarios, conservation translocations may assist the goal of host persistence by offsetting the risk of extinctions associated with small populations and stochastic dynamics. For example, biotic threats such as chytrid fungus can have highly variable impacts across environmental gradients, thus opening the opportunity to identify areas with conditions conducive to species persistence/co-existence, which can then be evaluated as possible translocation candidate sites.

Recommendations for translocations involving chytrid fungus-threatened species

Building on our review of published Australian studies, and our conceptual framework (Figure 2), we provide recommendations for undertaking amphibian translocations for species threatened by chytridiomycosis (Figure 3). We feature steps that are relevant for frog translocations in general as well as steps that are specifically applicable for species threatened by chytrid fungus. In the context of these recommendations, it is assumed that a decision to undertake a translocation, including its justification, feasibility and risk assessment, has been made.

In brief, the recommendations for translocations for Australian frogs involve:

1. **Setting clear, measurable translocation objectives**. It is essential to develop fundamental (overall goals) and means objectives (specific goals), with means objectives carefully specified and paired with appropriate indicators to assess whether the objective is achieved. Furthermore, indicators should be context-specific and reflect the life history and ecology of the species. Setting clear and measurable objectives allows for ongoing assessment throughout the life of the project, and in turn can facilitate adaptive management and iterative program improvement. For species threatened by chytrid fungus, objectives and indicators should focus on revealing the processes that facilitate frog coexistence with chytrid fungus. This will provide valuable information that will improve understanding of why the translocation either failed or succeeded, as well as improving our understanding of species ecology and chytrid fungus dynamics.
2. **Developing a species-specific conceptual model of the focal system**. In general, this can identify areas of high uncertainty relating to the translocation and once key uncertainties are identified, a priori hypotheses can be stated, and the translocation designed to test the hypotheses. Chytrid fungus-specific considerations include outlining processes underpinning coexistence with chytrid fungus. For example, if chytrid fungus is present at the recipient site, what processes are hypothesized to underpin successful population establishment?
3. **Identifying candidate sites** by considering habitat suitability, the presence of other threatening processes and whether they can be mitigated by management (e.g. predatory invasive fish), and the sites vulnerability to stochastic events. Additional important elements to consider in evaluating whether a site may be conducive to coexistence with chytrid fungus include sites environmental suitability for chytrid fungus, frog community composition (with a focus on the presence/density of reservoir hosts) and recruitment potential of the sites. For example, consider how environmental conditions affect demographics such as juvenile development rates and age to maturity, which can influence a population's capacity to persist despite mortality associated with chytrid fungus.
4. **Considering and employing translocation tactics** – techniques capable of influencing post-release individual performance or population persistence. These may include animal-focused tactics such as the number of animals released, demographics and/or genetic composition of released animals, as well as the timing of releases. Tactics can be specific to species threatened by chytrid fungus, such as timing the releases to minimise infection risk or considering if different life stages vary in their susceptibility/risk of chytrid fungus infection. Environment-focused tactics may include the modification of habitat, in order to increase frog survival or to decrease suitability for chytrid fungus (such as through salt application or vegetation management).
5. **Planning and conducting monitoring**. A monitoring plan with associated funding should be developed at the commencement of the project. Monitoring should be fit-for-purpose and incorporate indicators linked to project objectives as well as explicit triggers for actions. Specific monitoring methods should be outlined, with parallel monitoring of chytrid fungus dynamics for chytrid fungus susceptible species. This will help distinguish mortality associated with chytrid fungus from other sources of mortality. Typical monitoring will likely be focused on the survival of the released individuals or subsequent offspring.
6. **Clearly communicating the results from translocation projects**. Communicating results in accessible/open-access scientific articles, is a crucial step to enable ongoing learning. In the case of successful projects, reports should articulate reasons for success to ensure other translocation projects can identify key elements. Conversely, reporting failures is also important to avoid repeating the same mistakes again. Developing and including detailed accompanying appendices can communicate greater levels of detail about the actions undertaken, as well as providing context for why certain decisions were made. It is also valuable to communicate the results to the broader public, particularly for successful programs that can build support for, and highlight the benefits of, conservation actions.

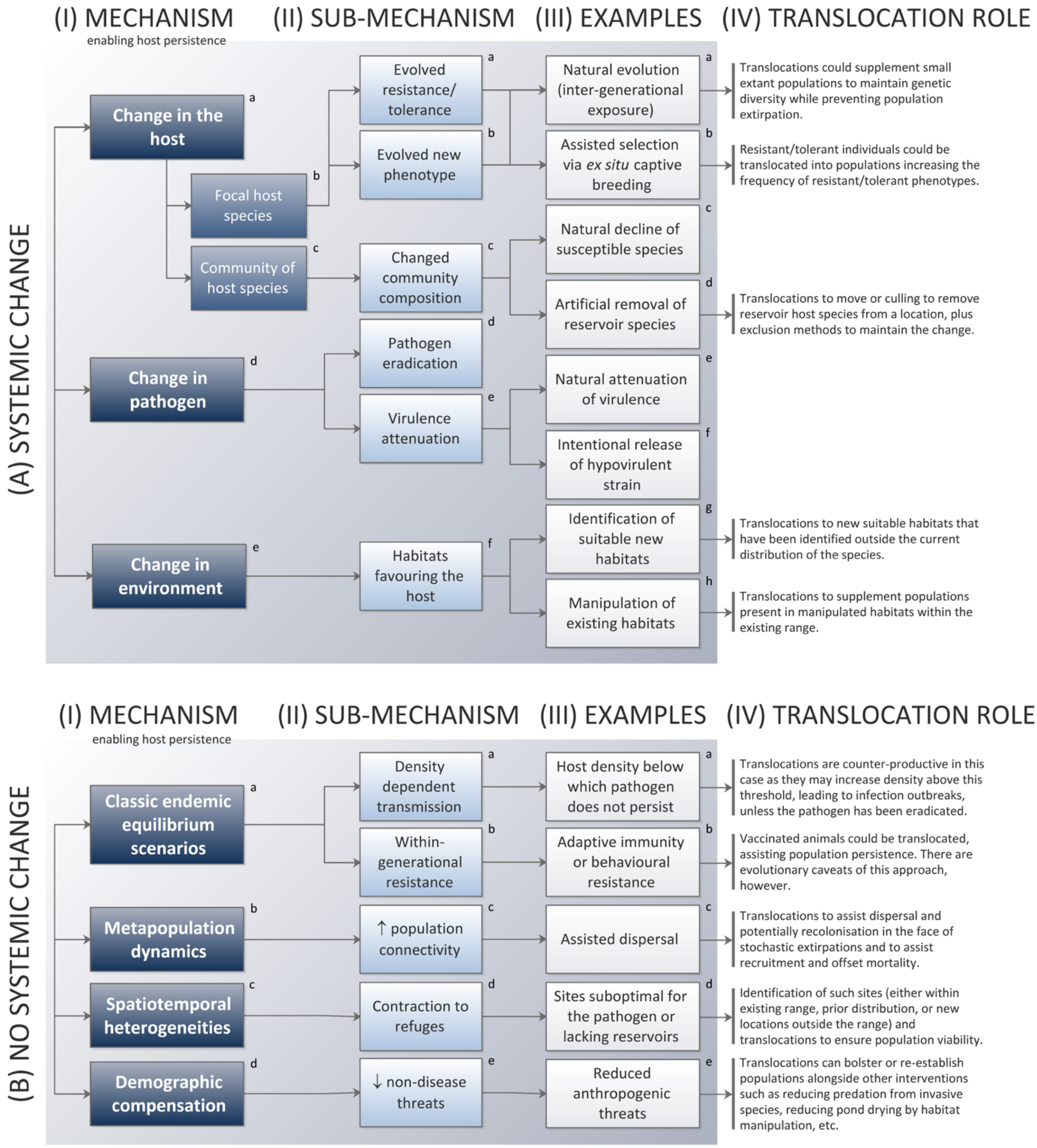

Figure 2. Conceptual model illustrating the different mechanisms by which susceptible amphibian species may be able to co-exist with Batrachochytrium dendrobatidis*, with examples of how conservation translocations might assist host persistence.*

	Generic	Chytridiomycosis
1. Objectives	☐ Develop fundamental and means objectives ☐ Population establishment ☐ Population augmentation	☐ Improve understanding of *Bd* dynamics
2. System model	☐ Develop contextual model of the system ☐ Identify areas of uncertainty	☐ Outline processes underpinning coexistence with *Bd* ☐ Resistance/tolerance to *Bd*?
3. Site	☐ Assess habitat suitability ☐ Presence of other threats ☐ Risk of environmental stochasticity	☐ Assess suitability for *Bd* ☐ Environmental suitability ☐ Amphibian community composition ☐ Recruitment potential
4. Tactics	☐ Number of animals released ☐ Timing of releases ☐ Staggered releases ☐ Demographic composition	☐ Habitat modification to reduce suitability for *Bd* ☐ Hydroperiod manipulation to increase recruitment ☐ Genetics: maximise or targeted selection?
5. Monitoring	☐ Monitoring plan ☐ Fit-for-purpose? ☐ Post-release monitoring ☐ Indicators linked to objectives ☐ Trigger points for action	☐ *Bd* dynamics ☐ Amphibian community composition
6. Communication	☐ Scientific articles ☐ Detailed appendices ☐ Report failures ☐ General public communication	

Figure 3. Checklist for translocations of amphibian species threatened by chytridiomycosis, highlighting key steps relevant for frog translocations in general as well as steps specifically applicable for translocations in the context of chytrid fungus.

Identifying and evaluating translocation sites for the northern corroboree frog

Refugia from chytrid fungus

For northern corroboree frogs, we found that environmental conditions and frog age to maturation can strongly mediate the impact of chytrid fungus, and the ability of frog populations to coexist with the pathogen. For example, site elevation was found to influence rates of growth and maturation. As northern corroboree frogs no longer persist at high elevation sites (greater than 1500 m), this may be a result of faster maturation and earlier breeding at lower elevations that allows frogs to persist in the presence of chytrid fungus.

Identification and evaluation of translocation sites

We identified candidate sites for northern corroboree frog translocations immediately adjacent to the species' historical range. Field surveys confirmed that these sites had suitable habitat and Bibron's toadlet was present. Chytrid fungus was detected at all sites. Comparing environmental attributes at sites found that candidate sites are nested within the historically occupied niche and overlap with persistent northern corroboree frog sites (Figure 4). Candidate sites have similar temperature and elevation characteristics to the persistent sites, but receive lower precipitation. Hydrological monitoring identified sites with suitable pond durations during the 2019 breeding season, despite that monitoring coincided during a time of severe drought. The continued presence of water suggested that these sites are fed by groundwater and may have sufficient resilience to drought and climate change.

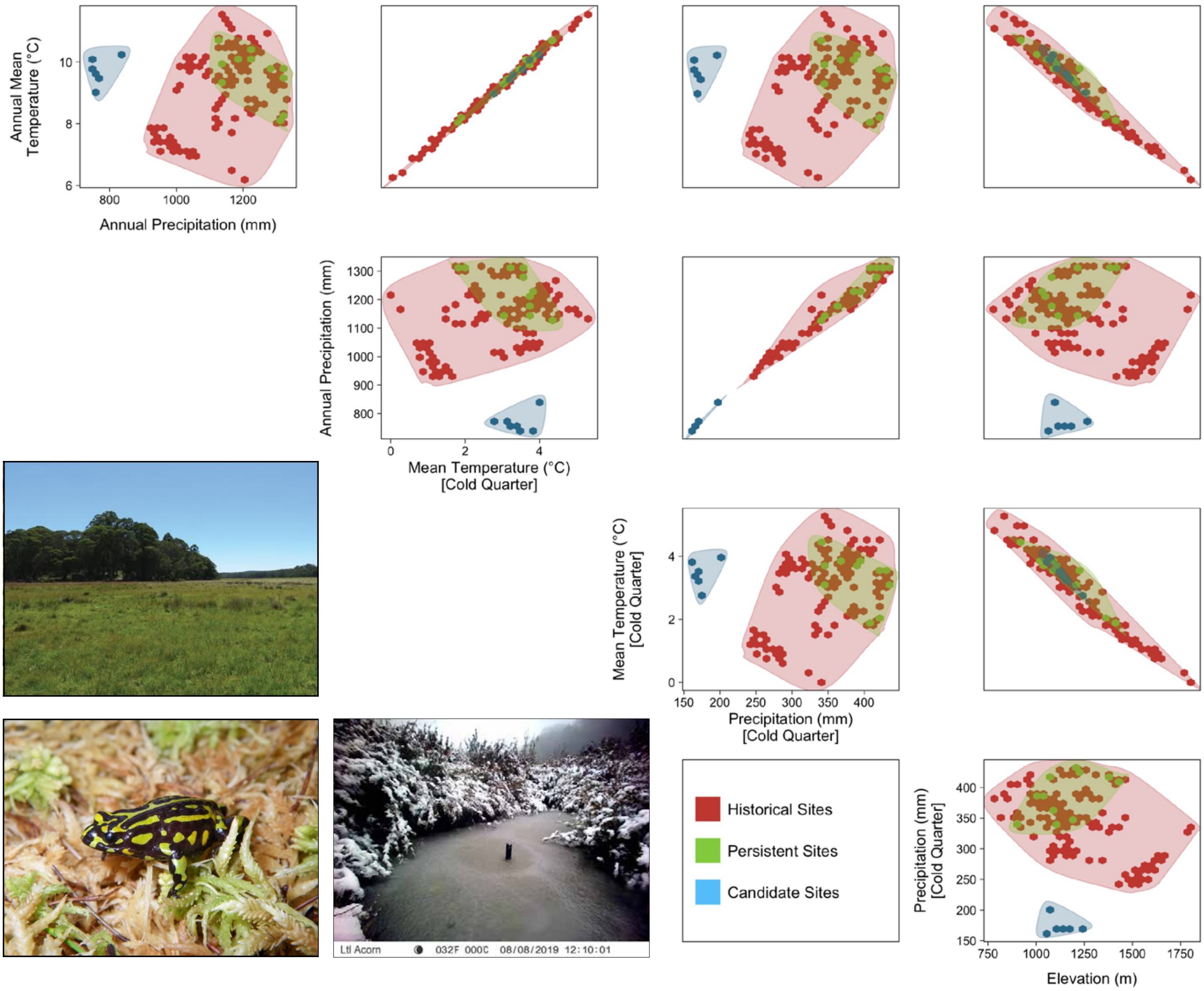

Figure 4. Comparison of environmental attributes at historically occupied sites for northern corroboree frogs, persistent northern corroboree frog sites, and candidate translocation sites. Inserts show breeding habitat at the largest remaining northern corroboree frog population, an adult male northern corroboree frog, and an example of the photographs obtained from the pond hydroperiod monitoring.

Discussion

Conservation translocations for amphibian species threatened by chytrid fungus

Our review indicated that in many cases, failure to specifically address chytrid fungus, and mechanisms by which susceptible amphibians may coexist with chytrid fungus, is likely to have contributed to translocation failures or only partially successful outcomes. Translocations of highly susceptible species occurred within the species former range and did not involve habitat modifications to promote the hosts. Furthermore, virulence of local chytrid fungus strains and the degree of evolved resistance/tolerance of translocated hosts was not assessed. Therefore, this highlighted a pressing need to consider the mechanisms that may allow threatened amphibians to persist with chytrid fungus and how this can be used to identify circumstances where translocations could be beneficial in the context of chytrid fungus.

While we found chytrid fungus has been a key factor limiting frog translocation success in Australia, improved knowledge has also created new opportunities. Moving forward, we hope application of our conceptual model (Figure 1) to specifically articulate and test potential mechanisms of amphibian-chytrid fungus coexistence, alongside our recommendations (Figure 2), will help improve translocation outcomes and elucidate mechanisms contributing to translocation success or failure. With careful development and refinement, translocations may prove a useful tool to combat the unique conservation challenges posed by emerging diseases.

Identifying and evaluating translocation sites for the northern corroboree frog

Our screening process identified a highly suitable candidate site in an area slightly outside the known historical range of the northern corroboree frog. This site supports a large population of Bibron's toadlet, across an extensive area of breeding habitat. Extent of habitat is important to enable the establishment of a large population, as well as providing a hydrological gradient from wetter to drier breeding sites to provide suitable breeding habitat in years with both high and low rainfall. Although the site has lower precipitation than persistent sites, our on-site hydrological monitoring indicates that this site maintains adequate pond hydroperiods, even during severe droughts. Indeed, the lower precipitation of the candidate site could reduce environmental suitability for chytrid fungus, potentially benefiting corroboree frogs.

Application of research (to-date and anticipated)

The findings from this research directly inform the ACT government's management plan for the Critically Endangered northern corroboree frog, providing guidance for on-ground management actions. Following our identification and evaluation process for potential northern corroboree frog sites, the next step is to design and undertake an experimental translocation to the top ranked candidate site. With consideration of our highlighted recommendations for frog translocations, such as utilizing translocation tactics and conducting appropriate monitoring, this should increase the likelihood of achieving additional self-sustaining, wild populations of the northern corroboree frog and improve the species long-term persistence.

Impact of the research (to-date and potential in future)

This research project has addressed key actions specified in the National Recovery Plan for the Southern Corroboree Frog and Northern Corroboree Frog and implemented and evaluated several key research actions identified in the Threat Abatement Plan: 'Infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016)' (Actions 3.1: Develop assisted colonisation strategies to aid recovery of amphibian populations impacted by chytrid fungus, 3.2: Understand mechanisms for resistance, including the effects of environmental factors, 3.7: Understanding chytrid fungus in the environment and the effects of environment/habitat modification).

Broader implications – for other places or species

Conservation management via the re-establishment of wild populations of frogs threatened by chytrid fungus is a global challenge. The process and factors explored here are common to other frog species for which chytrid fungus is the primary cause of decline. The new knowledge generated by this project is particularly applicable to the conservation programs for the Critically Endangered southern corroboree frog (*P. corroboree*), Baw Baw frog (*Philoria frosti*), and spotted tree frog (*Litoria spenceri*); species all primarily threatened by chytrid fungus and that have captive breeding programs and planned reintroductions. There are also ongoing efforts to establish captive breeding programs for the Critically Endangered yellow-spotted bell frog (*Litoria castanea*) and the Kroombit tinker frog (*Taudactylus pleione*). Once captive breeding programs are established for these species, the knowledge generated by this project can be used to help inform methods to re-establish wild populations.

More specifically, the process outlined here for the Critically Endangered northern corroboree frog provides a template to guide research to understand potential mechanisms of coexistence for other threatened species, and subsequently identify and evaluate candidate translocation sites. Incorporating research on understanding refugia, including habitat suitability and the suitability for pathogens, and/or species resilience to pathogens, can be used to strategically search for and evaluate potential translocations sites for threatened frogs.

Future research priorities

The role of translocations in amphibian conservation is increasing, yet there is considerable room for learning and improvement in practices, which are still relatively new and experimental (Linhoff *et al.* 2021). The development and use of guidelines, such as those produced in this project, are important for establishing and refining best practices for frog translocations. Detailed studies and reporting of individual species translocation projects will further inform and improve management techniques and ultimately the success of translocation programs. Importantly, research into understanding the processes that may allow threatened amphibians to coexist with chytrid fungus shows promise as an area that could greatly improve re-establishing populations of threatened frogs in the wild. Furthermore, assisted colonisations – translocations to sites outside of species native ranges – are suggested as a potential conservation management action for mitigating impacts from a changing climate (Gallagher *et al.* 2015; Hoffmann *et al.* 2021). More research is needed to evaluate this as a viable conservation strategy for threatened amphibians, particularly for species with limited dispersal abilities and restricted ranges.

Data sets

No datasets were created as part of this project.

Recommendations

Translocations of Australian frogs threatened by chytrid fungus

Translocations have the potential for an important role in the long-term conservation of Australian frogs threatened by disease. While we found chytrid fungus has been a key factor limiting frog translocation success in Australia, recent improved knowledge has created new opportunities. For example, research into understanding the contexts by which susceptible amphibian species may be able to co-exist with chytrid fungus, can be integrated into conservation translocation decisions. We recommend the application of our conceptual model (Figure 2) to specifically articulate and test potential mechanisms of amphibian-chytrid fungus coexistence, alongside our translocation recommendations (Figure 3), in order to improve translocation outcomes and elucidate mechanisms contributing to translocation success or failure.

Northern corroboree frog translocation site-selection

Research into environmental and demographic associations with population persistence has highlighted the following site-level considerations to increase translocation success of northern corroboree frogs:

1. Habitat suitability, including:
   - Suitable habitat requirements, including appropriate habitat extent and presence of surrogate/sympatric species (Bibron's toadlet).
   - Absence or mitigation of threats, such as the impact of feral-horses which can degrade northern corroboree frog breeding-habitat through grazing and trampling.
   - Resilience to drought and climate change, such as maintenance of suitable pond duration during drought conditions, and preferably a range of hydroperiods to provide suitable breeding in years with both high and low rainfall.
2. Suitability for pathogens, and/or species resilience, including:
   - Environmental conditions that facilitate co-existence of northern corroboree frogs with chytrid fungus.
   - Favourable population dynamics for co-existence, specifically recruitment potential (e.g. lower elevation sites where frogs can reach maturity earlier and recruit faster).

Conclusion

Attempted population restorations or conservation introductions of frogs threatened by chytrid fungus to date have had limited success. However, consideration of the potential contexts within which species or populations that have declined due to chytrid fungus are able to persist longer-term, can highlight circumstances where conservation translocations may be a valuable management strategy. We advocate that with careful and well-informed adaptive management experiments to refine translocation efforts and improved knowledge of species-specific systems, translocations may provide an essential tool for ensuring the persistence of highly threatened frog species in the wild, despite the widespread presence of introduced disease.

Acknowledgements

We acknowledge the Ngarigo, Ngunnawal, Walgalu and Wiradjuri people as Traditional Owners who maintain a long and lasting relationship with the lands on which this study was conducted. We pay our respects to the Communities and Elders past, present and emerging.

This project was funded by the Australian Government's National Environmental Science Programme through the Threatened Species Recovery Hub.

Ethics statement:

This research was approved by the Australian National University Animal Experimentation Ethics Committee (A2018/04) and authorized by the New South Wales National Parks and Wildlife Service Office of Environment and Heritage (SL102049) and the Australian Capital Territory Government (LT20198).

Further information

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Northern corroboree frog. Image: Damien Esquerre

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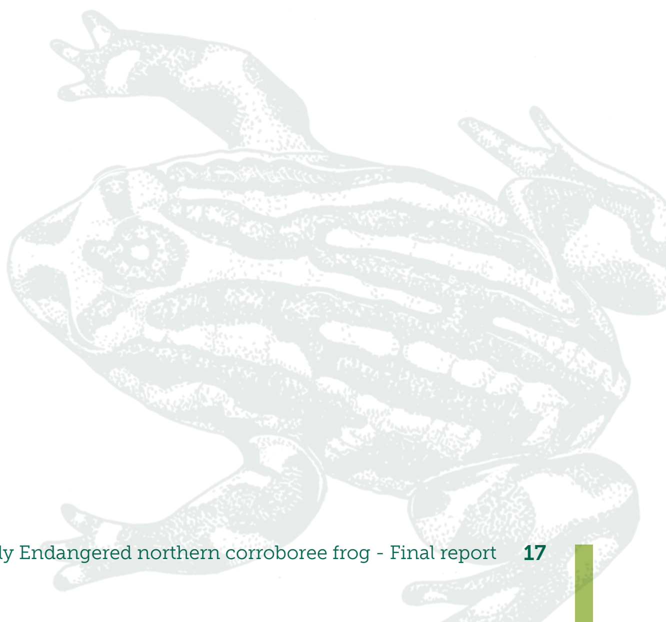

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This project is supported through funding from the
Australian Government's National Environmental Science Program.

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