Threatened Species Recovery Hub

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Recommendations for conservation translocations of Australian frogs

Dr Ben Scheele, Emily Hoffmann, Dr Matt West

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Australian National University

THE UNIVERSITY OF MELBOURNE

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Cover image: Spotted tree frog on burnt log. Image: Matt West

Contents

Background

Australian frog declines

Frog declines and extinctions in Australia have been reported since the 1980s. Currently, 45 of Australia's 243 frog species are identified as threatened with extinction[1]. Disease caused by an introduced pathogen, the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*), is linked to the extinction of four Australian frog species and has contributed to population declines of at least 40 other species[2]. Other major threats to Australian frogs include habitat loss and alteration, climate change, increased fire (intensity, frequency and extent) and invasive species (such as fish and pigs). When these threats to wild amphibian populations cannot be reduced or eliminated, conservation translocation could be a viable management option to prevent extirpation or extinction.

Role and types of conservation translocations

'Conservation translocation' is a broad term encompassing any deliberate movement of an organism where the goal is to yield a conservation benefit (e.g. to a population, species or ecosystem)[3]. For frogs, this usually involves the direct movement of wild animals of any life stage from one area to another (wild-wild translocations), releasing captive bred individuals (captive-wild translocations), or releasing individuals that have been wild-collected as eggs or tadpoles and captive reared (head-started) in captivity (wild-captive-wild translocations). A range of terms and associated definitions relating to conservation translocations are provided in the table below.

For frog species undergoing rapid declines, captive breeding and translocation have become increasingly important conservation management actions. Furthermore, translocations outside of species' native ranges (either wild-wild or from captive populations), are considered a potential management strategy to protect frogs from climate change impacts, particularly for species with limited distributions and dispersal abilities[4,5].

Globally, captive breeding or translocation programs have been used to help conserve over 200 amphibian species with the number of programs doubling in last decade[6]. Captive programs generally aim to both create secure ex-situ insurance populations and breed amphibians for translocation to augment or re-establish wild populations. In some cases, conservation breeding programs may only focus on one of these aims. However, despite the increasing number and success of establishing insurance captive breeding populations, the outcomes of translocations to date are highly varied[†].

A released head-started white-bellied frog. Image: Emily Hoffmann

<table>
<tr><th colspan="4">Conservation translocations
"the intentional movement and release of a living organism where the primary objective is a conservation benefit" IUCN Guidelines[3]
Includes the use of wild or captive animals</th></tr>
<tr><td colspan="2">Population restoration
Within native range</td><td>Conservation introduction
Outside native range</td><td>Other</td></tr>
<tr><td>Reinforcement (or augmentation)
Release of animals into areas supporting conspecifics to increase population viability</td><td>Reintroduction
Movement of animals into areas from which they have been extirpated with the goal of establishing a population</td><td>Assisted colonisation
Release of animals outside their indigenous range with the goal of establishing a population</td><td>Mitigation translocation*
Relocation of animals from an area where habitat is being altered or threatened</td></tr>
<tr><td colspan="4">Examples of when each translocation type may be applicable:</td></tr>
<tr><td>- to enhance population viability, for instance by increasing population size or genetic diversity</td><td>- to re-establish a viable population of the focal species within its indigenous range
- refugia have been identified within the species native range, where threats are reduced</td><td>- current threats remain within natural range (release into historical sites is not suitable)
- habitat in the native range will be unsuitable in the future due to climate change</td><td>- habitat will be lost to urban development
Depending on where animals are released, a mitigation translocation may also fall under the other categories.</td></tr>
</table>

Provided it benefits the population, species or ecosystem, and not only the translocated individuals.

Translocations of Australian frogs

In Australia, the majority of frog translocations have been for species primarily threatened by chytrid fungus[†]. Translocations have largely been population restorations (reintroductions or population reinforcement) and have included releases of a variety of life stages, most commonly tadpoles. Factors associated with translocation success in chytrid-threatened species have included releases to sites where the species persists or releases into similar habitat. In two frog species, where chytrid is not a major threat, varying success in translocation outcomes were strongly associated with key habitat attributes, particularly hydrology, highlighting the importance of assessing habitat suitability prior to translocations[5]. Overall, few published reports of translocations have been highly successful, that is, have reported successful breeding or recruitment post-release. Importantly there are few clear examples of longer-term persistence of populations following translocations. The current low success rate of many frog reintroduction programs highlights a need for further research and better guidance.

Recommendations

Below we outline recommendations for undertaking conservation translocations of Australian frogs.

These recommendations integrate findings from a review of published Australian studies, a conceptual framework for determining when conservation translocations may be both feasible and beneficial in the case of chytrid fungus, and practitioner experience (see review by Scheele *et al.* 2021 cited below for further details).

We detail steps that are broadly relevant for all frog translocations and highlight chytrid-specific considerations. 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.

These steps are discussed with a view to complement existing State, Territory and Federal Government translocation policies and aid in the planning, application and approval processes. This includes the Australian Government Threat Abatement Plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE 2016), and the development and implementation of suitable hygiene protocols to prevent the spread of chytrid fungus to naïve areas and populations

Step 1. Set clear, measurable translocation objectives

- It is essential to **develop fundamental (overall goal) and means objectives (specific goals)**.
- Means objectives need to be carefully articulated and **paired with appropriate indicators** that can be measured to assess whether the objective is achieved.
- Indicators should be context-specific and reflect the life history and ecology of the species.
- For example: a fundamental objective for a translocation could be the establishment of a self-sustaining population at a release site. An associated short-term means objective could focus on the rate of survival of released animals, with the indicator being that at least 60% of released animals survive to six months.
- **Engage all relevant stakeholders** in the initial decision-making process and defining objectives for undertaking a translocation, and whether it be a population restoration (augmentation or reintroduction) or introduction (outside their indigenous range).
- Setting clear and measurable objectives, as well as including short, medium and long-term goals, allows for ongoing assessment throughout the life of the project, and in turn can facilitate adaptive management and iterative program improvement.

Chytrid-specific considerations

- Include objectives that **focus on revealing the processes that facilitate frog coexistence with chytrid fungus**.
- **Specify indicators** associated with frog survival, chytrid fungus dynamics (including presence or abundance of host-reservoir species), as well as environmental conditions.
- For example: a means objective could be to assess the target species' capacity to persist in an environmental refuge with chytrid fungus, and the associated indicators could relate to frog survival or chytrid infection intensity.
- This information is crucial to help **understand why the translocation either failed or succeeded** (at each stage), as well as improving our understanding of species ecology and chytrid fungus dynamics.

Step 2. Develop a conceptual model of the system

- Create a species-specific conceptual model of the focal system to help **highlight areas of uncertainty** relating to the translocation:
- For example, there is often uncertainty around the number of individuals to release, the optimal life-stage to release or the optimal timing of release.
- Once key uncertainties are identified, a priori hypotheses can be stated, and the translocation designed to test the hypotheses.
- **Clearly articulating hypotheses** around relationships and processes can identify important areas of uncertainty and outline assumptions.
- While appropriate caution is needed when there are high levels of uncertainty, it is important that risks are acknowledged and minimised and that management actions do not stall. Areas of high uncertainty should be viewed as key priorities for targeted research during translocation programs.

Chytrid-specific considerations

- When chytrid is present at recipient sites, **outline processes potentially underpinning amphibian population coexistence with chytrid fungus**
- For example: What processes are hypothesized to underpin successful population establishment? Are environmental conditions hypothesized to mediate chytrid fungus prevalence and/or infection intensity?
- Does the focal species show any **resistance/tolerance to chytrid fungus?**

Case study – Corroboree frog coexistence with chytrid fungus

Species: Northern corroboree frog, *Pseudophryne pengilleyi* (critically endangered)

Main threats: Chytrid fungus, introduced species (horses), climate change

Rationale for translocations: severely declining populations, restricted distribution

Northern corroboree frogs have suffered extensive declines due to chytrid fungus and the widespread presence of the pathogen is a current barrier to success of translocations to historic sites. However, observations that a small number of populations persist despite the presence of chytrid fungus suggested that certain conditions may allow the species to coexist with the pathogen.

Research into these mechanisms revealed key processes and conditions that appear associated with persistence with chytrid fungus include: (1) favourable breeding habitat hydrology which enables some level of recruitment even in drought years[7], (2) intraspecific variation in life-history, specifically earlier age to maturation at the lower end of the species' elevational range[8], and (3) low abundance of the reservoir host species, the common eastern froglet (*Crinia signifera*)[9]. This knowledge can now be incorporated into the identification of potential refuge habitats for the species to increase the probability of translocation success.

Step 3. Identify and evaluate candidate site suitability

- **Assess** the candidate site/s **habitat suitability** for both the frog species and key threats (refer to specific guides on habitat assessment[10, 11]).

Other important elements to consider in site selection are:

- Whether the site is within (historic sites, extant or extirpated) or outside of the species' indigenous range.
- Size, trajectory and structure of **existing frog population and community** at potential candidate sites.
- The **presence of other threatening processes** and whether they can be mitigated by management (e.g. predatory invasive fish).
- Assessing the site/s **vulnerability to stochastic events** that may affect recruitment and survival (e.g. drought, flood, fire).

Chytrid-specific considerations

Additional important elements to consider in evaluating whether a site may be conducive to coexistence with chytrid fungus include:

- **Environmental suitability for chytrid fungus**.
- **Frog community composition**, with a focus on the presence/density of reservoir hosts.
- **Recruitment potential** of the site/s. For example, consider how environmental conditions affect variables such as juvenile development rates and age to maturity, which can influence a population's capacity to persist despite mortality associated with chytrid fungus.
- An exception is where there is evidence that the species has evolved increased resistance or tolerance to chytrid fungus.

Case study – Assessing site suitability for frogs and threats

Species: Spotted tree frog, *Litoria spenceri* (critically endangered)

Main threats: Introduced predators (fish), habitat degradation, chytrid fungus

Rationale for translocations: 50% reduction in species distribution, rare at all remaining sites, clear evidence of ongoing population decline.

Some initial translocation attempts of spotted tree frogs failed when threats were not adequately assessed or managed. A well-designed monitoring program allowed researchers to determine that chytrid infection was the primary cause of mortality of translocated frogs. However, identification of new translocation sites and improved survival of frogs was achieved using a two-step process to assess habitat suitability [12 (M. West, unpublished data)]. First, species distribution models were used to evaluate the habitat suitability of rivers systems for spotted tree frogs within and outside their known range. Second, two other species distribution models were used to assess and identify sites with low habitat suitability for chytrid fungus and non-native predatory fish. Importantly this approach was used as frogs may be able to coexist with chytrid fungus where environmental conditions reduce pathogen growth and survival. Furthermore, non-native fish occurrence is reduced where water temperatures are too high for fish breeding, recruitment and survival. The three distribution models were overlayed to identify sites that were highly suitable for the frogs but had low predicted suitability for key threats. Pre-translocation on-ground assessments were vital to verify the thermal properties of sites and to determine if other frogs (that may act a pathogen-reservoirs) or predatory fish were present. A translocation was conducted to a new site outside of the species known range that was identified as having high suitability based on the evaluation process. Prior to the 2019-20 bushfires, translocated frogs had survived and reproduced, and the population was thriving.

Step 4. Consider and employ translocation tactics

Translocation tactics are techniques capable of influencing post-release individual performance or population persistence[13] and may include:

Animal-focused tactics:

The number of animals released - What is the minimum number of animals needed to establish a viable population? Consider the risks associated with demographic and environmental stochasticity as well as the impact to source populations.

Demography – Evaluate the relative cost effectiveness of releasing different age animals, as well as the potential impact of removing different age animals from either wild source populations or captive breeding colonies.

Timing – Release individuals during times that favour survival (e.g. coinciding with high resources or lower environmental stress).

Genetics – Consider maximising genetic diversity. However, with population augmentations, be cautious with releasing animals that could result in undesirable outcomes such as outbreeding depression.

Environment-focused tactics:

Habitat modification to increase frog survival (e.g. manipulating hydroperiods to improve recruitment of aquatic-breeding species).

Chytrid-specific considerations

Additional tactics specific to species threatened by chytrid may include the following:

Animal-focused tactics:

Timing – Consider the timing of releases to minimise infection risk (e.g. breeding vs. non-breeding season) and whether to stagger releases to minimize temporary peaks in frog density, which may increase the transmission of chytrid fungus.

Demographic composition – Consider if different life stages vary in their susceptibility/risk of chytrid fungus infection, and differences in their dispersal ability.

Genetics – Evaluate whether to maximise genetic diversity to increase fitness and adaptive capacity, or if resistance/tolerance is hypothesised or demonstrated, use targeted selection to capture a sub-set of genetic diversity.

Environment-focused tactics:

Habitat modification can be applied to decrease suitability for chytrid fungus such as through salt application or vegetation management.

Implement suitable hygiene protocols to protect priority populations and/or prevent the spread of chytrid fungus.

Case study – Utilising animal-focused translocation tactics

Species: White- and orange-bellied frogs, *Geocrinia alba* (critically endangered) and *Geocrinia vitellina* (vulnerable)

Main threats: Habitat loss and alteration, climate change

Rationale for translocations: severely declining populations (*G. alba*), establish insurance populations (*G. vitellina*)

A variety of different animal-focused translocation tactics are employed as part of an ongoing and well-established Recovery Team program that utilises detailed research on the species' demographics, ecology and long-term monitoring[14].

Demography – Due to the limited number of adults in some populations, an initial focus was on translocating egg masses to new sites, either directly or through 'head-starting' wild-collected egg masses in captivity and releasing juvenile frogs. Captive rearing has since been developed with nearly 100% success to the juvenile stage. Likewise, rearing wild-collected egg masses in captivity to ~1 year old maximises survival of the riskiest stage, as juveniles are estimated to have very low survivorship in the wild.

Timing – Juvenile frogs are released at the start of spring during favourable conditions when the creek habitats are cool and moist, and the highest risk of flooding associated with heavy winter rain has passed. Individuals are often released to a site over multiple years to improve population persistence and reduce risks from stochastic events.

Genetics – Research has shown isolated sub-populations are highly genetically distinct. Careful accounting of where animals have been sourced from and translocated to ensures source sites are supplemented with individuals originating from that site.

Step 5. Plan and conduct monitoring

- Prior to release, **design and adequately resource a post-release monitoring plan so the mean objectives and specific goals can be assessed**.
- **Ensure indicators are linked to project objectives**, and specific monitoring methods are included, with a realistic appraisal of likely detection probabilities (e.g. lower detectability for individuals released as eggs/juveniles until they reach breeding age).
- Ensure monitoring is **fit-for-purpose**. Choosing the level of detail will be context specific and relate to the project's objectives. E.g. Is detailed information on vital rates important or are abundance counts appropriate? Translocations can be long-term commitments and monitoring programs must be designed to adequately assess short, medium and long-term objectives and goals.
- Include explicit **triggers for actions**, either in terms of post release management actions or subsequent releases.
- Typical monitoring will likely be focused on the survival of the translocated individuals or the number of offspring produced (breeding success).
- The plan should include data management and storage, as well as metadata collection.

Chytrid-specific considerations

For translocations involving chytrid-threatened frogs, also consider:

- **Parallel monitoring of chytrid fungus dynamics**. This will help distinguish mortality associated with chytrid fungus from other sources of mortality.
- **Monitoring frog community composition** to monitor changes to presence/abundance of reservoir hosts of chytrid fungus.

Step 6. Communicate results

- Clearly communicating the results from translocation projects, for example in accessible/open-access **scientific articles**, is crucial to enable ongoing learning.
- In the case of successful projects, **articulate reasons for success** to ensure other translocation projects can identify key elements.
- Develop and include **detailed accompanying appendices** to communicate greater levels of detail about the actions undertaken, as well as providing context for why certain decisions were made.
- **Report failures** to avoid repeating the same mistakes again, as well as allowing realistic evaluations of failure risk during the planning and development phases.
- 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

Conclusion

Here, we have outlined broad recommendations that cover key principles for carrying out translocations of Australian frogs. However, we stress that for each individual species, the steps involved will be unique and require system-specific knowledge.

Given the high number of chytrid-threatened frog species in Australia, we hope the application of specific chytrid-focused steps will help improve translocation outcomes and elucidate mechanisms contributing to translocation success or failure.

More broadly, with improved knowledge of species-specific systems and careful refinement and reporting, translocations may provide an essential tool for ensuring the persistence of highly threatened species in the wild.

Further information

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Relevant Australian policies and procedures

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Northern corroboree frog. Image: Damien Esquerre

Further information:

http://www.nespthreatenedspecies.edu.au

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