Translocation Proposal

Securing the Future of Kosciuszko National Park's Unique Frog Fauna

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Summary

Extinctions and declines of amphibians worldwide have been occurring at an alarming rate over the past fifty years (Stuart *et al*. 2004). Australia has not been spared from this biodiversity crisis (Hero & Morrison 2004), and within Kosciuszko National Park (hereafter KNP), five frog species have suffered significant declines since the early 1980's. These species are now listed as threatened under the NSW Threatened Species Conservation Act 1995, the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, and by the International Union for Conservation of Nature (IUCN). This includes the iconic Southern Corroboree Frog (*Pseudophryne corroboree*), which is one of Australia's best known frog species, and is KNP's only endemic vertebrate. The primary cause of many recent frog declines around the world, including those in KNP, is a disease known as chytridiomycosis, which is caused by infection with the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*, hereafter Bd). Genetic studies have shown that Bd has only recently spread throughout the world (Morgan *et al*. 2007, Farrer *et al*. 2011), explaining why many frog species have limited resistance to this pathogen.

Over the past fifteen years, an active recovery program for KNP's threatened frogs has been undertaken. In general terms, this program has focused on four core objectives: (1) Determine the ongoing population trajectory of threatened species. (2) Establish captive colonies of species in an ongoing state of decline. (3) Determine effective and efficient reintroduction techniques. (4) Determine how some frog populations have achieved population level resilience to Bd. In summary, two species (Southern Corroboree Frog and Spotted Tree Frog) will become extinct in the wild within the next five years without human intervention, while a third species (Northern Corroboree Frog) also appears to be in an ongoing state of population decline. Captive colonies and successful reintroduction techniques have been established for the Southern Corroboree Frog and Spotted Tree Frog, and it has been demonstrated that the complete extinction of these species in the wild can be averted, albeit with continued management assistance. Gaining a clear understanding of why some populations of susceptible species have persisted in the face of Bd is currently the focus of two PhD research programs, and forms part of this reintroduction proposal.

This document outlines the background information, rationale, and methods for developing new management techniques for the conservation of Kosciuszko National Park's unique frog fauna. These techniques will aim to bolster the security and capacity of captive breeding programs for threatened frogs through the creation of pathogen/disease free populations in the wild. The capacity to create populations with greater resilience to disease will be trialled by establishing populations in areas with warmer thermal properties, reduced reservoir host abundance, and more reliable recruitment. In addition to this, further work will be undertaken to better understand the factors underpinning population level resistance to Bd in species that are susceptibly to Bd, and whether there is scope to selectively breed for resistance in captivity. The success of this program is critical to the survival of KNPs frog fauna, and will provide valuable knowledge that will assist in abating the ongoing decline and extinction of frogs globally.

1. Proponents

Name	Qualifications	Experience	Affiliation
David Hunter	BcS, MS, PhD	18 years implementing threatened frog recovery actions in southeastern Australia	Office of Environment and Heritage
Mike McFadden	BcS, Hon	10 years undertaking threatened frog husbandry	Taronga Conservation Society
Gerry Marantelli	BcS	25 years implementing threatened frog recovery actions	Amphibian Research Centre
Ben Scheele	BcS, Hon	5 years implementing threatened frog recovery actions and research	Australian National University
Raelene Hobbs	BcS	10 years undertaking threatened frog husbandry	Zoos Victoria
Peter Harlow	BcS, Hon, PhD	35 years implementing threatened frog and reptile recovery actions and research	Taronga Conservation Society
Chris Banks	BcS, Hon	35 years implementing threatened frog and reptile recovery actions and research	Zoos Victoria
Laura Brannelly	BcS, MS	5 years undertaking research into amphibian disease	James Cook University
Lee Skerratt	BcS, Hon, PhD	18 years researching wildlife health issues, particularly causes of global frog declines	James Cook University
Lee Berger	BcS, Hon, PhD	18 years researching causes of global frog declines	James Cook University

2. Outline of the Project

2.1 Legal status of the species:

Southern Corroboree Frog (*Pseudophryne corroboree*)
Endangered: Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) *1999*
Endangered: NSW *Threatened Species Conservation Act* (TSC Act) *1995*.
Critically Endangered: International Union for Conservation of Nature (IUCN).

Spotted Tree Frog (*Litoria spenceri*)
Endangered: Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) *1999*
Endangered: NSW *Threatened Species Conservation Act* (TSC Act) *1995*.
Critically Endangered: International Union for Conservation of Nature (IUCN).

Alpine Tree Frog (*Litoria verreauxii alpina*)
Vulnerable: Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) *1999*
Endangered: NSW *Threatened Species Conservation Act* (TSC Act) *1995*.

2.2 Overall and specific objectives of the program:

***Overall objective*:**

Establish self-sustaining populations for species currently in a state of ongoing decline towards extinction.

Establishing self-sustaining populations of the Southern Corroboree Frog and Spotted Tree Frog will require mitigating the impact of the Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis* hereafter Bd). The following interim objectives and methods are proposed as a means to ultimately achieving this broader objective. In addition to mitigating the impact of Bd, this program also focuses on increasing the security, productivity, and efficiency of maintaining these species in the wild. Owning to the current global amphibian extinction crisis, much of which is due to the spread of Bd (Skerratt *et al*. 2007), this program has broader implications, and will receive much international interest.

***Specific Objectives*:**

Southern Corroboree Frog

1. **Maintain populations of the Southern Corroboree Frog within the former known range of the species.**

Maintaining populations of the Southern Corroboree Frog within its former known range is a priority for the following reasons:

- Recovery of this species within its former known range is the most desirable outcome, and therefore efforts to achieve this will benefit from having persistent populations within this region.
- There are four areas within the species former known range that have been the focus of reintroductions over the past five years, and so continuing this work is necessary to adequately assess the merits of this program. This program will not be adequately assessed until at least 2015.

2. **Establish populations of the Southern Corroboree Frog in artificial bog environments that can be maintained Bd free.**

The capacity to maintain disease free, highly productive Southern Corroboree Frog colonies in the wild would greatly enhance many aspects of the recovery program for this species, including; security against catastrophic events, maintaining genetic variation, maintaining phenotypic fitness of colonies, and production of progeny for reintroduction elsewhere. A field enclosure with artificially established Southern Corroboree Frog breeding and non-breeding habitat is currently being constructed by the Assets, Roads, and Rehabilitation Unit in Kosciuszko National Park. This is being undertaken in conjunction with a habitat restoration program within [redacted].

3. **Establish the Southern Corroboree Frog outside the species known distribution in areas that may support self-sustaining populations.**

Due to mortality associated with Bd infection, it is currently not possible to establish self-sustaining populations of the Southern Corroboree Frog within its historic known range. To achieve this, populations would need to be established in areas where the impact of Bd is reduced. The critical factors associated with the impact of Bd at the population level are temperature, moisture, and reservoir host species. Hence, reducing the impact of Bd on the Southern Corroboree Frog would require establishing the species at lower altitude (warmer and drier), and in areas with reduced Common Eastern Froglet (*Crinia signifera*) abundance.

Spotted Tree Frog

4. **Modify the riparian environment in [redacted] to reduce the propensity for Bd impacts, and re-establish a low density population of the Spotted Tree Frog.**

Reducing the impact of Bd on the Spotted Tree Frog in [redacted] may be achieved via the following two actions: 1) Removal of dense tea-tree canopy cover over potential breeding habitat to increase sun exposure, and thus increase basking potential and the general temperature of the stream environment. 2) Reduce the capacity for Bd transmition among individuals by establishing a low-density population.

5. **Establish the Spotted Tree Frog in geographic locations that may support self-sustaining populations.**

Establishing long-term self-sustaining populations of the Spotted Tree Frog may be best achieved in areas where the impacts of Bd are predicted to be less. A sections of stream in the Tooma catchment ([redacted]) has been identified as a potential host sites with attributes less conducive to Bd impacts; warmer thermal properties (open canopy and north-westerly aspect), and no other frog species that may be a reservoir of Bd infection.

Alpine Tree Frog

6. **Examine capacity to establish the Alpine Tree Frog in habitat previously occupied by the species.**

Understanding the mechanisms by which the Alpine Tree Frog is persisting in relatively high densities at some sites, despite having declined from much of it's former range due to Bd, will assist in the development of recovery actions for species in an ongoing state of decline. A notable feature of the Alpine Tree Frog decline is that it has contracted from areas where it occupied small natural pools in sub-alpine and alpine frost hollow environments (Osborne *et al*. 1999). Reintroducing the Alpine Tree Frog into habitat where it previously occurred (sphagnum bogs with ephemeral pools) may assist our understanding of why the species no longer occurs in this habitat type, but will also allow for a test of how habitat type may influence the outcomes of reintroduction programs.

2.3 Criteria for success, targets, and timeframes:

Success	Targets	Timeframes
Objective 1. Maintain populations of the Southern Corroboree Frog within the former known range.		
Complete extinction of the Southern Corroboree Frog within its former range is prevented via the reintroduction of captive reared and/or bred individuals.	A minimum of four extant Southern Corroboree Frog populations are maintained in the wild via reintroduction of captive reared and/or bred individuals.	Ongoing (at least until 2015)
Objective 2. Establish populations of the Southern Corroboree Frog in artificial bog environments.		
Highly productive populations of the Southern Corroboree Frog are maintained in artificial bog environments that are Bd free.	A minimum of two highly productive populations of the Southern Corroboree Frog are established in artificial bogs, and maintained Bd free.	Ongoing (at least until 2015)
Objective 3. Establish the Southern Corroboree Frog outside the species known distribution.		
Self sustaining populations have been established in areas with warmer thermal properties and reduced reservoir host abundance.	A minimum of four self-sustaining populations have been established.	Ongoing (at least until 2020)
Objective 4. Modify environment and re-establish a low density Spotted Tree Frog population.		
The Spotted Tree Frog has been re-established in [redacted], and the propensity for a Bd outbreak has been reduced.	The [redacted] section of [redacted] has a more open canopy, and a low density population of the Spotted Tree Frog has been re-established.	2012 - 2018
Objective 5. Establish the Spotted Tree Frog in new geographic locations.		
Self-sustaining populations of the Spotted Tree Frog have been established.	A self-sustaining population of the Spotted Tree Frog has been established in an area predicted to have reduced potential for Bd impacts.	Ongoing (at least until 2020)
Objective 6. Examine capacity to establish the Alpine Tree Frog in habitat previously occupied.		
Assess the capacity to establish the Alpine Tree Frog in habitat previously occupied by this species.	Alpine Tree Frog has been reintroduced and post-release survivorship determined.	2013 - 2015

2.4 Is the translocation justified as part of a species recovery program.

The following recovery plan actions will be completely or partially addressed by this translocation program.

Southern Corroboree Frog:

OEH NSW (2012). *National Recovery Plan for the Southern Corroboree Frog, Pseudophryne corroboree, and the Northern Corroboree Frog, Pseudophryne pengilleyi*, Office of Environment and Heritage (NSW), Hurstville.

<u>Action 3.1</u> Assess the effectiveness of releasing SCF eggs into artificial pools.

<u>Action 3.5</u> Assess the capacity to establish chytrid free SCF populations.

<u>Action 4.3</u> Determine likely areas where SCF could be released outside their current range to reduce the impact of the amphibian chytrid fungus, and facilitate the establishment of self-sustaining populations.

Spotted Tree Frog:

Gillespie, G. R. and Clemann, N. 2011. National Recovery Plan for the Spotted Tree Frog *Litoria spenceri*. Department of Sustainability and Environment, Melbourne.

Action 4.4	Evaluate the role of disease in the decline of the Spotted Tree Frog
Action 8.1	Implement re-introduction programs in streams where the species historically occurred and where it has been assessed that key threats can be managed or mitigated.

Alpine Tree Frog:

Clemann, N. and Gillespie, G.R. 2010. National Recovery Plan for the Alpine Tree Frog *Litoria verreauxii alpina*. Department of Sustainability and Environment, Melbourne.

Action 2.1	Determine the extent and impact of chytrid fungus disease

2.5 Type of translocation:

Objective	Translocation Type
Objective 1. Maintain populations of the Southern Corroboree Frog within the former known range.	Re-introduction
Objective 2. Establish populations of the Southern Corroboree Frog in artificial bog environments.	Introduction
Objective 3. Establish the Southern Corroboree Frog outside the species known distribution.	Introduction
Objective 4. Modify environment and re-establish a low density Spotted Tree Frog population.	Re-introduction
Objective 5. Establish the Spotted Tree Frog in new geographic locations.	Introduction
Objective 6. Examine capacity to establish the Alpine Tree Frog in habitat previously occupied.	Supplementation/Re-introduction

2.6 Consequences of not proceeding:

The consequence of not proceeding with this translocation program is that the Southern Corroboree Frog and Spotted Tree Frog will become extinct in the wild. Given the iconic status of the Southern Corroboree Frog, this would represent a national tragedy. Furthermore, the husbandry institutions that have made a large investment in the Southern Corroboree Frog and Spotted Tree Frog recovery programs expect that the high priority in-situ recovery actions outlined in this proposal will be implemented. Hence, future participation and investment in these programs is reliant on pursuing the re-introductions and introductions outlined here. Given the likelihood that this program will attain knowledge and develop management approaches that will benefit other frog recovery programs around the world, there are also global consequence of not proceeding with this translocation program.

2.7 Potential risks and strategies for dealing with them:

Objective	Risk	Mitigation strategy
Objective 1. Maintain populations of the Southern Corroboree Frog within the species former known range.	Eggs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the eggs.
Objective 2. Establish populations of the Southern Corroboree Frog in artificial bog environments.	Frogs and eggs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the frogs and eggs.
	Bd infects the enclosure and kill frogs.	Despite the various measures in place to prevent this, Bd may infect the enclosure. At this stage we have no techniques beyond our current procedures to decrease the likelihood of Bd infecting the enclosure.
	The frogs perish due to factors other than Bd.	Despite every effort being made to create suitable habitat within the enclosure, the frogs or tadpoles may not prosper. A monitoring program will identify whether the animals are feeding, growing and surviving adequately. Mitigating problems associated with animals not prospering will depend on the likely causes, which cannot be identified at this stage.
Objective 3. Establish the Southern Corroboree Frog outside the species known distribution.	Eggs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the eggs.
	Frogs do not survive to sexual maturity and populations are not established.	If this occurs, introductions to these sites will cease.
Objective 4. Modify environment and re-establish a low density Spotted Tree Frog population.	Frogs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the frogs.
	A breeding population does not become established.	If this occurs, no further reintroductions to this site will be undertaken.
Objective 5. Establish the Spotted Tree Frog in new geographic locations.	Frogs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the frogs.
	A breeding population does not become established.	If this occurs, no further reintroductions to this site will be undertaken.
Objective 6. Examine capacity to establish the Alpine Tree Frog in habitat previously occupied.	Frogs start overheating during transport.	Additional ice will be purchased to cool the insulated containers transporting the frogs.

2.8 If the translocation is staged, discuss the strategy for dealing with failure at any one stage:

Objective	Type of staging	Strategy for dealing with failure.
Objective 1. Maintain populations of the Southern Corroboree Frog within the former known range.	Tadpoles are released into the field over consecutive years.	High post-release tadpole mortality was experienced in 2009, and was remedied through increasing pond size and providing more diverse silt substrates. High tadpole survivorship has been achieved ever since.
Objective 2. Establish populations of the Southern Corroboree Frog in artificial bog environments.	Tadpoles are released into the field over consecutive years.	As above.
	Frogs are released over consecutive years.	If post-release mortality results from Bd infection, no further releases will be undertaken until the source of infection has been identified, remedied and the enclosure cleared of infection. If high post-release mortality or low body condition occurs, no further releases will be undertaken until the cause of the problem has been confidently identified and remedied.
Objective 3. Establish the Southern Corroboree Frog outside the species known distribution.	Tadpoles are released into the field over consecutive years.	It is unlikely that problems will be encountered since the methods will be the same as those used for Objective 1.
Objective 4. Modify environment and re-establish a low density Spotted Tree Frog population.	Frogs will be released over two consecutive years.	If the first frog release achieves less than 10% survivorship over the first winter, consideration will be given to cancelling the second release. This seems unlikely given previous results (see Figure 7.3.4)
Objective 5. Establish the Spotted Tree Frog in new geographic locations.	Frogs will be released over two consecutive years.	If post-release survivorship over the first winter is low, despite survivorship at the control site ([redacted]) being acceptable, the second release will be cancelled.
Objective 6. Examine capacity to establish the Alpine Tree Frog in habitat previously occupied by this species.	This release is not being staged.	NA

3. Background Biology and Ecology

Southern Corroboree Frog

3.1 Taxonomy of the species

The Corroboree Frog (*Pseudophryne corroboree*) (Anura: Myobatrachidae) was described by Moore (1953) from a single specimen collected at Round Mountain (Colefax 1956). Wells and Wellington (1985) provided a brief argument for recognising the northern form as a separate species, which they named *P. pengilleyi* after Dr R. Pengilley who undertook substantial research on the species in the 1960's. Osborne *et al.* (1996) provided a detailed geographic analysis of variation in the morphology and calls of *P. corroboree* and recommended that *P. pengilleyi* be recognised.

3.2 Distribution of the species in NSW and across its range

The historic range of the Southern Corroboree Frog is entirely within Kosciuszko National Park, from Smiggin Holes in the south, and northwards to the Maragle Range. This constitutes a linear range of 51km, with the overall area being approximately 500 km^2 (Osborne 1989). The broadest part of the range (24 km) occurs near Mount Jagungal. The Southern Corroboree Frog occupies a relatively narrow altitudinal strip between about 1300 and 1760 m above sea level. The occupied range of the SCF has greatly contracted over the past 25 years, and the species now occurs in a small number of remnant populations along the north-western edge of its former range.

3.3 The relevant ecological requirements of the species

Habitat Requirements:

Habitat critical to the survival of the Southern Corroboree Frog includes both the breeding habitat, and adjacent areas where these frogs may forage. The Southern Corroboree Frog uses a variety of habitat types for breeding which includes pools and seepages in sphagnum bogs, wet tussock grasslands, fens and wet heath (Osborne 1990). They also forage and shelter in montane forest, sub-alpine woodland and tall heath adjacent to the breeding areas. During the summer, the adult frogs breed in shallow pools and seepages within the breeding area. They have a strong tendency to breed in ephemeral water bodies that dry during the summer breeding season (Osborne 1990, Hunter *et al*. 2009a). Breeding sites are usually of gently sloping topography, and typically occur on granitic and volcanic substrates (Osborne 1990). The vegetation present at breeding sites varies considerably, ranging from sphagnum bog and wet-heath at higher altitudes, to wet sod-tussock grasslands and seepage lines in montane forest. Outside the breeding season, the Southern Corroboree Frog has been found sheltering in dense litter and under logs and rocks in adjacent woodland and tall moist heath (Pengilley 1966).

Life-history and Ecology:

The Southern Corroboree Frog has a typical biphasic amphibian life-cycle with an aquatic tadpole stage and terrestrial post-metamorphic juvenile and adult frog stage. Adult males move into breeding areas in early to late summer, and call from late December through to mid February. The males call from small chambers (nests) in moss or other soft vegetation at the edges of the breeding pools (Hunter et al. 2009a). The males have three call types; an advertisement call, threat call, and courtship call (Pengilley 1971a). The advertisement call and courtship call are used to attract females to the nest site, whereas the threat call serves as a warning to other males (Pengilley 1971a). Advertisement call intensity varies depending on the weather, with more calling occurring during warmer overcast conditions, and during late afternoon (Pengilley 1971a, Osborne 1989).

Females lay their eggs in the terrestrial nests occupied by the breeding males. Males remain in their nest site through the breeding season and may accumulate multiple clutches in their nest. Clutch size is relatively low for an amphibian species; 16 to 38 eggs per female (Pengilley 1973). The eggs are amongst the largest in the genus (Tyler 1989), measuring about 3.5 mm in diameter, with the transparent capsules swelling to about 9 mm in diameter when hydrated. The eggs are laid in a terrestrial nest within or adjacent to a suitable pool, where the embryos develop to an advanced stage prior to entering diapause. Typically, the pools are dry during the breeding season when the eggs are laid. The embryos remain in diapause until flooding of the nest site in autumn or winter stimulates them to hatch. After hatching, the tadpoles move out of the nest site and into the adjacent pool where they live for the remainder of the larval period as a free swimming and feeding tadpole. The tadpoles show little growth during winter, when temperatures at the breeding sites are very low and snow often covers the ground. At the end of winter, when snow has melted from the breeding sites, the tadpoles continue growing slowly until metamorphosis in early summer (Hunter *et al*. 1999).

Information on survivorship from egg laying to metamorphosis has been obtained across several sites between 1997 and 1999. This study determined average survivorship from egg to metamorphosis to be 20 percent in the absence of early pool drying (Hunter 2000). Early pool drying (i.e. drying of the pools before tadpoles reach metamorphosis) during drought years typically caused complete failure of recruitment to metamorphosis for that year (Hunter 2000). The typically low survivorship of nest sites is consistent with the results of tadpole surveys that found that one third of small remnant breeding populations attain no recruitment to metamorphosis each year (Hunter 2000).

Very little is known about the life history of the Southern Corroboree Frog after they leave the pools as juveniles. Pengilley (1966, 1992) suggested that they remain in moist vegetation near the breeding pools for several months, where they feed on a wide variety of small invertebrates. As they grow larger, the juveniles leave the breeding area and move into the adjacent non-breeding habitat where it is thought they remain until they are adults. The diet of sub-adults and adults consists mainly of small ants and, to a lesser extent, other invertebrates (Pengilley 1971b).

Age to sexual maturity for the Southern Corroboree Frog was determined using skeletochronology (age determination based on growth rings in bone). Age to first reproduction was found to be four years from metamorphosis for the majority of individual males, with a small proportion of individuals attaining sexual maturity in three years (Hunter 2000). The oldest individuals identified using this technique were nine years old (Hunter 2000). It is likely that the majority of females take four or five years to attain sexual maturity. Based on the proportion of individuals in different age classes from one year to the next, annual survivorship for adult males was determined to be between 50 and 60 percent (Hunter 2000). There is currently no information on survivorship from metamorphosis to sexual maturity for this species.

3.4 Known and potential threats

Disease:

There is considerable evidence implicating the disease 'chytridiomycosis' as the primary cause of decline in the Southern Corroboree Frog (Hunter *et al*. 2010, see also Skerratt *et al*. 2007). This disease is caused by infection with Bd, which has spread throughout the world over the past three decades and caused mass amphibian declines and extinctions (Berger *et al*. 1998, Skerratt *et al*. 2007). The capacity for Bd to cause ongoing decline in Southern Corroboree Frogs appears to be facilitated by the Common Eastern Froglet (*Crinia signifera*) acting as a non susceptible, reservoir host for Bd in the shared environment (Hunter 2007). Mitigating the impact of Bd will require facilitating the development of population resistance to disease caused by this pathogen. Population resistance may arise through a range of processes, including; reduced virulence in the pathogen, increased resistance in individual hosts, a shift in ecological interactions, or any combination of these.

Anthropogenic Climate Change:

Climate change is expected to have a significant impact on the Southern Corroboree Frogs (Osborne and Davis 1997). Based on current climate models for the Australian Alps, winter and spring precipitation and snowfall are likely to continue to decrease (Hennessey *et al*. 2003), reducing the water table during late spring and early summer, and resulting in earlier pool drying. Given the strong tendency for corroboree frogs to breed in highly ephemeral pools (Osborne 1990, Hunter *et al*. 2009a), the most immediate and direct impact of climate change will result from increased rates of pool drying prior to metamorphosis. While pre-decline corroboree frog populations would have been robust to failed recruitment during El Niño events (Hunter 2000), an increase in the frequency of droughts will only further compromise the capacity for these species to recover from their current low population size. Moreover, the impact of *B. dendrobatidis,* through decreasing adult survival (c.f. Scherer *et al*. 2005), will increase population susceptibility to failed recruitment. This is because failed recruitment in some years is compensated by the adults being able to live longer and breed over consecutive years. Climate change may also impact on the Southern Corroboree Frog by altering the vegetation structure of breeding pools and the hydrological functioning of wetlands, which is likely to be exacerbated by increased fire frequency. This process appears to have already occurred across many sites occupied by the Northern Corroboree Frog, as many sites previously occupied by this species no longer appear to contain suitable pools (Scheele *et al*. 2012).

3.5 The success of previous translocation programs for the species or analogous species

Trial reintroductions of captive bred and reared eggs and adult frogs have been undertaken for the Southern Corroboree Frog. The results of these studies suggest that both egg and frog releases can be used to re-establish wild populations of this species (Hunter 2007, Hunter *et al*. 2009b, Hunter *et al*. 2010), however the relatively low return rates for both approaches suggests that considerable resources would be required to successfully implement these techniques. The potential for egg releases into artificial pools to be a more efficient release strategy is currently being assessed (Hunter *et al*. 2009b), however, since this program is releasing animals back into the former distribution of the species, it is unlikely to result in self-sustaining populations.

Spotted Tree Frog

3.1 Taxonomy of the species

The Spotted Tree Frog (*Litoria spenceri*) is a medium-sized species from the Family Hylidae ('tree frogs'). There are no unresolved issues associated with the taxonomy of this species.

3.2 Distribution of the species in NSW and across its range

Historically, the known distribution of the Spotted Tree Frog in New South Wales is restricted to the upper Murray and Geehi Valley regions (Hunter and Gillespie 1999). Apart from a small number individuals persisting in [redacted], as a result of previous reintroduction efforts, there are no known extant populations in New South Wales. Extant wild populations of the Spotted Tree Frog are restricted to Victoria along streams on the north-western fall of the Great Dividing Range, and one population on the southern fall of the Great Dividing Range (Gillespie and Hollis 1996).

3.3 The relevant ecological requirements of the species

Habitat Requirements:

Spotted Tree Frogs occurs in, rocky, swift-flowing streams in dissected mountainous country, between 280 and 1,110 metres elevation. The Spotted Tree Frog generally occupies sections of stream with minimal disturbance (Gillespie and Hollis 1996). A number micro habitat features along the stream appear important for the Spotted Tree Frog, including: rocky habitat where males call and female deposit eggs, and an open canopy allowing thermo-regulation by adults and tadpoles (Gillespie 2002).

Life-history and Ecology:

Spotted Tree Frogs are active between October and April. Breeding occurs from November to December. Egg clutches range from 116 to 938 eggs (Gillespie 2002). Eggs are deposited under large in-stream boulders, and tadpole development occurs within the stream between November and February (Hero *et al*. 1995, Gillespie 2002). Frogs reach sexual maturity at 2–4 years for males and 3–6 years for females post-hatching, depending upon elevation (Gillespie 2011). The maximum known longevity is 14 years in the wild (Gillespie 2011).

3.4 Known and potential threats

Disease

Bd caused the rapid decline and extinction of the [redacted] population of Spotted Tree Frog in the mid to late 1990's (Gillespie unpublished data). More recently, Bd caused the rapid decline of the re-established Spotted Tree Frog population in [redacted], and this pathogen is perceived as a major obstacle to recovering this species in NSW. Elsewhere in Victoria, Bd has been responsible for regulating Spotted Tree Frog population size, although the extent to which this pathogen caused the broader decline of this species is unknown (Graeme Gillespie personal communications).

Predation

Predation by exotic fish, especially Brown Trout *Salmo trutta* and Rainbow Trout *Oncorhynchus mykiss* has been implicated in the decline of the Spotted Tree Frog (Gillespie 2001, 2010). Gillespie (2010) estimates that predation by trout may cause up to a 6-fold reduction in adult population density in some streams (Gillespie, 2010). Other invasive fish species that have the potential to prey on tadpoles, such as European Carp *Cyprinus carpio* and European Perch *Perca fluviatilis* (Hunter *et al*. 2011), also occur in streams supporting Spotted Tree Frog populations, and so may also be impacting on this species.

3.5 The success of previous translocation programs for the species or analogous species

A reintroduction program for the Spotted Tree Frog has been undertaken in the [redacted] and Alpine Way sections of [redacted] (Kosciuszko National Park) since 2005. The reintroduction of frogs to the Alpine Way section appeared to be unsuccessful from the outset, as very few individuals were captured following release. In contrast to this, post-release survivorship for frogs in [redacted] was initially very successful, and a relatively high proportion of individuals survived through to sexual maturity (see figure 7.3.4). This resulted in the re-establishment of a breeding population of this species. However, between 2010 and 2012, this population declined to very few individuals (Figure 3.5), which seemed to be associated with an outbreak of Bd infection. It is likely that this chytrid outbreak was facilitated by the cool and wet conditions associated with the la-nina event, and possibly also the relatively high densities of frogs.

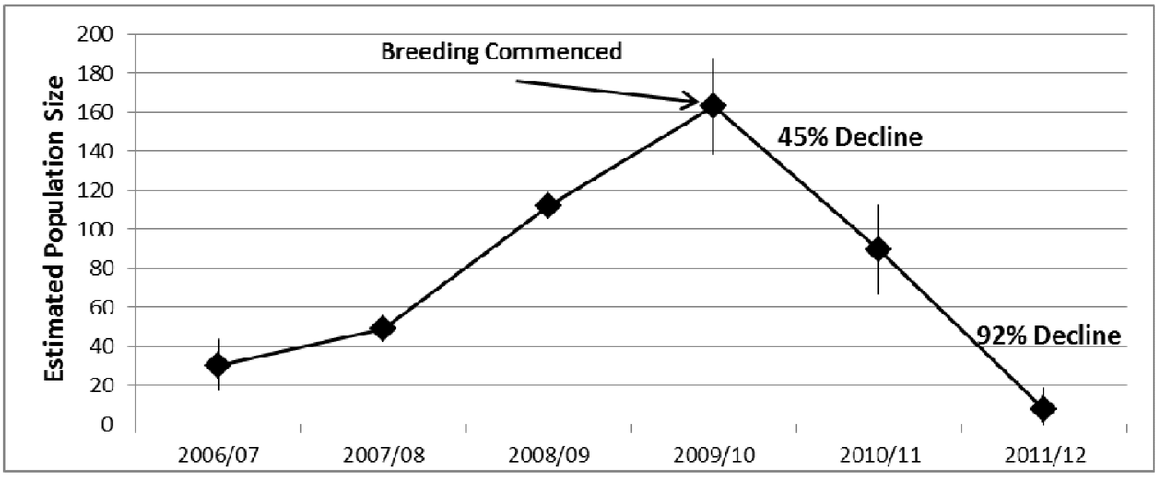

Figure 3.5. Estimated total population size of re-established Spotted Tree Frog population in [redacted].

Alpine Tree Frog

3.1 Taxonomy of the species

The Alpine Tree Frog is a high-altitude subspecies of Verreaux's Tree Frog (or Whistling Tree Frog). The clinal nature of the distribution of *L. verreauxii* in NSW and the Australian Capital Territory mean that clear delineation of the Alpine Tree Frog in this area is arbitrary (Smith *et al.* 2003). More definitive data on the systematic and geographic relationships of the subspecies of *L. verreauxii* are required to resolve the taxonomy of the Alpine Tree Frog.

3.2 Distribution of the species in NSW and across its range

Historically, the Alpine Tree Frog was distributed across most of the high country of south-eastern Australia (Osborne *et al.* 1999). Within this broader range, the frog has an inherently small and fragmented geographic distribution due to its restriction to discrete and isolated mountain peaks and plateaux within this area. Within NSW, records of the Alpine Tree Frog extend throughout Kosciuszko National Park, however, following the decline of this species during the mid 1980's, the species distribution is greatly reduced and patchy (Hunter *et al*. 1997, Osborne *et al.* 1999).

3.3 The relevant ecological requirements of the species

Habitat Requirements:

The Alpine Tree Frog is considered a habitat generalist, typical of all members of the *L. ewingii* complex. It has been found in a wide range of terrestrial habitats, including woodland, heath, grassland and herb fields at high montane, subalpine and alpine altitudes. Individuals have been found under flat rocks in streambeds or in rocky areas near streams, amongst litter and under logs. The Alpine Tree Frog breeds in natural and artificial ponds, such as bogs, fens, streamside pools, stock dams and drainage channels.

Life-history and Ecology:

During the breeding season, male Alpine Tree Frogs call while partially submerged at the edges of large pools in fen and wet grassland, and will occasionally call from the banks of waterbodies. Eggs are deposited in large jelly-like clumps around submerged vegetation (Anstis 2002). Tadpoles can be found in pools from November to January, and metamorphosis occurs in January and February (Lintermans & Osborne 2002). The Alpine Tree Frog's use of non-breeding habitat and over-wintering refuges is largely unknown, as are dispersal routes between breeding and non-breeding habitat.

3.4 Known and potential threats

Disease

The disease chytridiomycosis, caused by infection with the pathogen Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis,* has been strongly implicated in declines of amphibians in several parts of the world (Berger *et al*. 1999). Given the relatively cool and moist environment occupied by the Alpine Tree Frog, and the synchronous decline with other high altitude frog species (Osborne *et al.* 1999), it is highly likely that the Amphibian Chytrid Fungus significantly contributed to the initial decline of this species. A study involving screening Alpine Tree Frog populations for infection with the Amphibian Chytrid Fungus found that breeding populations of this species may have very high infection rates (Hunter *et al*. 2007).

3.5 The success of previous translocation programs for the species or analogous species

No translocations of the Alpine Tree Frog, or analogous species, have been undertaken previously.

4. Source environment and population

4.1 Site Tenure

Southern Corroboree Frog

Captive colonies of the Southern Corroboree Frog have been established at the Amphibian Research Centre, Taronga Zoo, Melbourne Zoo, and Healseville Sanctuary, using eggs collected from a range of declining remnant popultions of this species. All source populations were within Kosciuszko National Park.

Spotted Tree Frog

The founding individuals for the captive breeding colony at the Amphibian Research Centre where obtained from [redacted], Kosciuszko National Park (NSW) (one adult male) and Wheeler Creek (five adult females) in Victoria.

Alpine Tree Frog

The individuals collected for rearing at Taronga Zoo prior to release were collected from three sites (Grey Mare, Eucumbene, Kiandra), all of which are within Koscisuszko National Park.

4.2 Consideration of alternative source populations

Southern Corroboree Frog

Alternative source populations were not available for the Southern Corroboree Frog due to the limited distribution and rapid nature of the species ongoing decline.

Spotted Tree Frog

Given the importance of maintaining some level of genetic integrity across the range of the Spotted Tree Frog, Wheeler Creek was considered the most appropriate source population for establishing a captive breeding colony to service reintroductions back to NSW, as this population is most similar to [redacted] in terms of genetic relatedness and habitat structure (Graeme Gillespie personal communications).

Alpine Tree Frog

Alternative source populations could have been used, but there would have been limited benefits to this in terms of minimising impacts on source or host populations. Moreover, the results from the field release will be compared to the results obtained from a laboratory experiment comparing susceptibility to Bd among the different sites that were the source populations for this reintroduction.

4.3 The proposed schedule and rationale for the translocations

Component of translocation	Schedule	Rationale
Southern Corroboree Frog: release into artificial pools within former range of species		
Release of eggs	Each April from 2008 until assessment complete	This is the optimal time of hatching
Tadpole monitoring	Early November each years	Will allow an assessment of tadpole survivorship just prior to metamorphosis
Adult monitoring	Late January each year	This is when the species breeds, which allows an assessment of population size
Southern Corroboree Frog: release into artificial enclosure		
Release of adult frogs	Mid March during 2013 and 2014	Will avoid the heat of summer and allow the frogs to enter a normal winter/spring cycle which may be important for breeding
Release of eggs	Late April from 2013 onwards	This is the optimal time of hatching
Adult Frog monitoring	Each year post-release during the active months from October to May	This is when the species breeds, which allows an assessment of population size
Tadpole Monitoring	October and November 2013 onwards	Will allow an assessment of tadpole survivorship just prior to metamorphosis
Southern Corroboree Frog: release into artificial pools outside species range		
Release of eggs	Each April from 2013 until assessment complete	This is the optimal time of hatching
Tadpole monitoring	Late October each years	Will allow an assessment of tadpole survivorship just prior to metamorphosis
Adult monitoring	Late January each year	This is when the species breeds, which allows an assessment of population size
Spotted Tree Frog: Release back to [redacted]		
Release of Frogs	December 2013 and 2014	This is when stream temperature and food availability is optimal for survivorship
Post release monitoring	Censuses every three weeks from November to February	This is the active period when detecability is greatest
Spotted Tree Frog: Release to stream outside species known range ([redacted])		
Release of Frogs	December 2013 and 2014	This is when stream temperature and food availability is optimal for survivorship

Post release monitoring	Censuses every three weeks from November to February	This is the active period when detecability is greatest
Alpine Tree Frog: Release to occupied and un-occupied areas within former known range of species		
Release of Frogs	March 2013	Will avoid the heat of summer and allow the frogs to enter a normal winter/spring cycle which may be important for breeding
Post release monitoring	September to December 2013	This is when the species is breeding, which allows individuals to be captured to assess survivorship

4.4 Impact of removal upon the source population

Southern Corroboree Frog

Egg collections were undertaken to establish captive breeding colonies of this species from small declining populations just prior to their local extinction. Hence, these collection did not impact on the viability of the source populations, as they were essentially doomed to extinction.

Spotted Tree Frog

Establishing a captive breeding colony suitable for reintroductions back to NSW involved the collecting the last remaining individual from [redacted], and a small number of individuals from Wheeler Creek in Victoria. Hence, due to the fact that the [redacted] population could not recover, this collection did not impact on the viability of this population. Moreover, since the Spotted Tree Frog occurs over many kilometres of stream along Wheeler Creek, the small number of individuals collected form this site would not have impacted on the viability of this population.

Alpine Tree Frog

Two of the sites where eggs were collected (Kiandra and Eucumbene) sustain a large and extensive population of the Alpine Tree Frog. Hence, collecting five egg masses from each of these sites would not be expected to impact on the populations. This is especially the case since eggs would be expected to have naturally low survival to sexual maturity. The Grey Mare site consists of a relatively small population of the Alpine Tree Frog, however, large numbers of tadpoles were observed after the collection indicating the egg collection had minimal impact upon recruitment.

4.5 Methods of capture and transfer to the host environment

Southern Corroboree Frog

Eggs: Eggs will be transported to the field in containers packed with damp moss, with the moss filled containers being placed in large polystyrene boxes to prevent temperature increases or fluctuations. Each polystyrene box will have a small quantity of ice to maintain cool temperatures during transport. A digital thermometer will allow constant monitoring of the temperature within the polystyrene boxes.

Adult Frogs: The same procedure used to transport eggs will be used to transport the adult frogs (see above). This procedure has been used previous to transport large numbers of adult Southern Corroboree Frogs without incident.

Spotted Tree Frog

Transportation will be necessary between the captive husbandry facility in Melbourne and the release site in Kosciuszko National Park. Frogs will be packed for transport (in the morning) immediately prior to the road trip to the field release site. Frogs will be packed in sterile polyethylene food grade containers that have been moistened and had a small amount of leaf-litter placed in the enclosure with the animal. Holes around the sides of these enclosures will provide adequate ventilation. The enclosures will then be packed in polystyrene boxes to maintain a thermal buffer between the frogs and external air temperatures. Small air holes in the sides of the polystyrene boxes will allow the maintenance of oxygen levels inside the box. The polystyrene boxes will then be transported to the field in an air-conditioned car. This procedure for transporting large numbers of Spotted Tree Frog has been undertaken previously without incident.

Alpine Tree Frog

The same procedures for transporting Spotted Tree Frog will be used for the Alpine Tree Frogs (see above).

5. Host environment

5.1 Site tenure and level of conservation protection.

All areas are within Kosciuszko National Park. All Southern Corroboree Frog reintroduction sites involving infrastructure will be in areas with minimal public access.

5.2 Consideration of alternative host environments.

Southern Corroboree Frog

The areas proposed for the introduction and reintroduction of captive bred/reared Southern Corroboree Frogs are appropriate for the following reasons:

- Some sites are within the natural range of the species
- The construction of the artificial habitat within an enclosure is in an area adjacent to the species natural range, where a major rehabilitation project was being undertaken, and so the establishment of the enclosure did not require disrupting intact vegetation.
- Establishing breeding habitat in an area adjacent to the species natural range, which contains no other frogs species and a warmer microclimate, may achieve a self-sustaining populations.

Spotted Tree Frog

The current site selection for the Spotted Tree Frog reintroductions seems most appropriate for the following reasons:

- [redacted] sustained a large population of the Spotted Tree Frog until recently.
- [redacted] was the only known section of stream meeting the specific criteria used to identify an area that may support a longer term, self-sustaining population of the Spotted Tree Frog within Kosciuszko National Park (no other frog species, warmer micro-climate, ample breeding habitat).

Alpine Tree Frog

This reintroduction is experimental, and logistical factors associated with being able to undertake a mark-recapture study was critical in the site-selection process. All alternative sites are less suitable for mark-recapture because they contain more complex breeding habitat over a larger area, which would limit the capacity to capture individuals.

5.3 Whether the site is part of the historically known range of the species.

Southern Corroboree Frog

Releases associated with objective 1 are into habitat previously known to support Southern Corroboree Frog populations. The artificial enclosure (objective 2) and establishment of breeding habitat at lower altitude (objective 3) are in areas immediately adjacent to the species historic known range.

Spotted Tree Frog

The [redacted] section of [redacted] is within the natural range of the Spotted Tree Frog. [redacted] is not within the historic known range of the Spotted Tree Frog.

Alpine Tree Frog

All areas identified for the reintroduction of the Alpine Tree Frog are within the historic known range of this species.

5.4 For introductions, the conservation reasons why the species cannot be conserved satisfactorily within its historically known range.

Southern Corroboree Frog

The capacity for the Southern Corroboree Frog to maintain self-sustaining populations within its former known range is limited by two factors; the high abundance of a reservoir host (Common Eastern Froglet) for Bd (Hunter 2007), and limited capacity to evolve a robust immune response to Bd in the short term. Currently, we cannot adequately manage either factor (reservoir host abundance and frog immune system), and so achieving self-sustaining populations will require introductions into areas predicted to be less conduce to Bd infection and disease. This will involve introductions outside the species range where the abundance of reservoir host species is natural low, and micro-climates are warmer.

Spotted Tree Frog

For the same reasons outlined above (reservoir host species and limited immune response), it does not seem likely that self-sustaining populations of the Spotted Tree Frog can be established within its former known range in NSW.

5.5 How the habitat requirements of the species will be met and what rehabilitation is required prior to release.

Southern Corroboree Frog

The release of eggs associated with objective 1 is within areas known to contain suitable habitat for the Southern Corroboree Frog, based on their historic occupation of these sites. For releases associated with objective 2, the breeding and non-breeding habitats have been artificially constructed. The critical habitat requirements have been determine based on analysis (Hunter *et al*. 2009a) and observations of areas occupied by this species. For example, the grass species (*Poa costiniana*) planted around the edge of the pools is commonly used by males for nests in natural habitat (Hunter *et al*. 2009a). For releases associated with objective 3, the breeding pools will be similar to that used for objective 1 (see photo 1), however one edge will be flush with the ground and planted with *Poa costiniana*. The sites have surrounding non-breeding habitat similar to areas occupied by this species at higher altitudes.

Spotted Tree Frog

Suitable habitat at the [redacted] site is assumed for the following reasons:

- The stream is cascading with alternating rapid and pool sections consisting of bed-rock and loose cobble (see photo 4). This is considered ideal Spotted Tree Frog breeding and basking habitat.
- The open canopy will provide ample basking opportunity for the Spotted Tree Frog.
- The adjacent dry forest is consistent with the broader habitat occupied by the Spotted Tree Frog in Victoria.

5.6 How known and potential threats to the species will be managed, including the likely causes of the historical decline and/or local extinction of the species from the host environment.

Southern Corroboree Frog

The key threats to the Southern Corroboree Frog are early pool drying and diseases caused by infection with Bd. Table below outlines the strategy for managing these threats.

Objective	Disease	Drought
1	Partially Controlled: pools cannot be accessed by reservoir host (see photo 1).	Controlled: tadpoles are reared in pools that can be maintained with sufficient water (see photo 1).
2	Controlled: frogs will be within a disease free enclosure (see photo 2).	Controlled: adequate water levels can be artificially maintained through drought periods.
3	Controlled: sites will not contain reservoir species, and will be in a warmer microclimate.	Controlled: adequate water levels can be artificially maintained through drought periods.

Photo 1. Artificial pools where Southern Corroboree Frog eggs are released. These enclosures exclude the Common Eastern Froglet and provide water security during drought.

Photo 2. Field enclosure designed to maintain a Bd free population of the Southern Corroboree Frog. The construction of this enclosure is being undertaken by the Assets, Roads, and Rehabilitation Unit (Kosciuszko National Park) in conjunction with a habitat rehabilitation project within [redacted].

Spotted Tree Frog

The key threats to the Spotted Tree Frog are predation by trout and disease associated with Bd infection. The table below outlines the strategy for managing these threats.

Objective	Disease	Trout Predation
4	Partially Controlled: creating greater basking opportunities through opening the canopy (see photo 3).	Controlled: a series of waterfalls restrict trout from occupying the [redacted] section of stream.
5	Controlled: sites will not contain reservoir species, and have a warmer microclimate (see photo 4)	Controlled: a series of waterfalls restrict trout from occupying the section of [redacted] where frogs will be released.

Photo 3. Image of canopy before and after tea-tree pruning for a section of [redacted] with suitable Spotted Tree Frog breeding habitat.

Photo 4. Section of [redacted] proposed for Spotted Tree Frog introduction.

Alpine Tree Frog

The key threat for the Alpine Tree Frog is disease associated with Bd infection. The purpose of this translocation is to better understanding the host/pathogen dynamics between the Alpine Tree Frog and Bd, and how this influences the success or otherwise of translocations. Hence, no effort will be undertaken to mitigate the impact of Bd, but rather post-release monitoring will be undertaken to document the influence of this pathogen on post-release survival.

5.7 For supplementation, the likely consequences of the translocation on the genetic composition and viability of the host population.

Southern Corroboree Frog

NA

Spotted Tree Frog

NA

Alpine Tree Frog

This program is not expected to impact on the host population for the following reasons:

- The animals being reintroduced have come from at least 13 clutches, collected from across three sites. It is likely that there would have been gene flow among these sites prior to the species decline in the mid 1980's, and thus this program may be expected to enhance the genetic composition of the host sites.

- The collection sites share similar habitat (large dams with fringing sub-alpine vegetation), and occur at a similar elevation (1300 to 1500 metres) to the host sites.

5.8 An estimation of the dispersal of individuals and the carrying capacity of the habitat and whether it is considered likely to sustain a viable population of the species.

Southern Corroboree Frog

Based on recent results from the Southern Corroboree Frog reintroduction program (Hunter unpublished data), individuals can be expected to disperse at least 500 metres from the point of release.

In the absence of Bd, the host environment would be expected to support many thousands of individuals.

Due to the ongoing impact of Bd, it is unlikely that the translocations associated with objective 1 will results in self-sustaining viable populations. However, objective 2, through negating the impact of Bd, may result in a viable and productive population from which harvesting will be required to maintain numbers below the carrying capacity of the enclosure.

Since translocations associated with objective 3 are into areas predicted to have reduced impacts from Bd, it is theoretically possible that a viable and self-sustaining population will be achieved.

Spotted Tree Frog

Based on the results from the recent Spotted Tree Frog reintroduction back to [redacted], individuals of this species can be expected to disperse at least 600 metres from the point of release. After a period of time, they may be expected to be more sedentary, as examination of wild frog movement patterns suggests they typically do not move much more than 100 metres along the stream (Gillespie 1997).

Prior to the crash in 1996, the Spotted Tree Frog population density in [redacted] was in excess of 50 individuals per 100 metres (Gillespie 1997), hence, our reintroduction is unlikely to reach carrying capacity within the next ten years.

Given the recent decline of the re-established Spotted Tree Frog population in [redacted] (Figure 3.5), it is unknown whether reduced densities and increased sun exposure will prevent a Bd outbreak during cool wet years. However, based on the attributes of [redacted], it is likely that a self-sustaining population will be achieved at this site.

Alpine Tree Frog

Post-release dispersal of the Alpine Tree Frog is unknown. Based on field observations of individuals crossing roads, it seems likely that this species is capable of considerable dispersal.

Since the Alpine Tree Frog attains extremely high densities in the absence of Bd (authors personal observations), it is likely that the reintroduction sites can sustain considerably higher densities than this program will achieve, and that Bd will regulate populations of this species well below carrying capacity in subsequent years.

This program is unlikely to result in viable populations being established at the sites containing small ephemeral ponds, but may assist in maintaining viable populations at the larger dams through increased genetic diversity.

5.9 Potential environmental impacts of the species upon the host environment and surrounding ecosystems, including hybridisation and the spread of disease or parasites, and possible ameliorative measures.

There are no perceived environmental impacts on the host environment from the translocations outlined in this proposal. Moreover, hybridisation between different species is unlikely to result from this study as each species will only be released within its natural range, or in nearby areas where no closely related congeners occur.

Since the husbandry facilities involved in these translocations maintain high quarantine protocols for animals destined for translocation, the spread of disease associated with this program is unlikely. In addition to this, any unusual mortality events within captivity that cannot be confidently attribute to non-pathogen or parasite causes will result in the cancellation of the translocation.

5.10 The proposed management strategy if the translocation results in the establishment of a population that exceeds the carrying capacity of the habitat or the species spreads to areas substantially beyond the host environment.

Due to the influence of Bd on the target species, it is extremely unlikely that any of the reintroductions outlined in this program will result in populations exceeding the carrying capacity of the host environment. The exception to this may be the Southern Corroboree Frogs release into the artificial enclosure. The management of this enclosure will involve harvesting of eggs for translocation elsewhere and maintaining the number of adult frogs to approximately 150 individuals, and so it is not expected that the density of frogs will reach maximum carrying capacity.

Given the capacity for Bd to regulate populations of the target species in this proposal, and the limited available breeding habitat outside their natural range, it is unlikely that dispersal much beyond the reintroduction sites will occur.

6. Monitoring and research

Summary of number of sites, number of individuals being released at each site, and number of clutches contributing to the release at each site.

Objective	No. Sites	No. Individuals per site	No. clutches contributing
Objective 1. Maintain populations of the Southern Corroboree Frog within the species former known range.	4	250 eggs released in five separate artificial pools (50 per pools)	> 15
Objective 2. Establish populations of the Southern Corroboree Frog in artificial bog environments.	1 (enclosure is slit into two separate sections)	120 adult frogs, 80 eggs released into four separate pools (20 per pools)	> 15
Objective 3. Establish the Southern Corroboree Frog outside the species known distribution.	3	250 eggs released in five separate artificial pools (50 per pools)	> 15
Objective 4. Modify environment and re-establish a low density Spotted Tree Frog population.	1	100 one-year-old frogs released over 600 metres	5
Objective 5. Establish the Spotted Tree Frog in new geographic locations.	1	200 one-year-old frogs released over 1 kilometre	5
Objective 6. Examine capacity to establish the Alpine Tree Frog in habitat previously occupied by this species.	4 (2 sites with permanent pools, 2 sites with ephemeral pools)	Approx. 250 one-year-old frogs	13

6.1 Methods and rationale for monitoring in the first year post-release and reporting the fate of a significant proportion of the individuals translocated.

Southern Corroboree Frog

Tadpoles will be monitored using dip-net removal, with the tadpoles being housed in a 10 litre container until all the tadpoles have been captured, after which they will be returned to the pool. Given the clear water and small size of the tubs (ranging between 0.5 and 4 m^2), it is assumed that the total number of tadpoles sampled will be close to the total number of tadpoles present in the tubs. Tadpole sampling will be undertaken just prior to metamorphosis to obtain a survivorship estimate to that stage.

Adult males will be monitored by locating the position of their nest sites, using the shout-response survey technique (Hunter 2000), and then inspecting the nests at the end of the breeding season for clutches. Any males located will be temporarily removed from their nest for processing (weighing, measuring, swabbing, photographing).

Spotted Tree Frog

The monitoring program will involve censuses once every three weeks. Each census will involve night time spotlight searches for the frogs along the 800-metre release transects. Once a frog has been located it will be hand captured and processed before being released at the point of capture. Processing each frog will involve weighing to the nearest 0.01 gram, measuring for tibia and snout-vent length to the nearest 0.1 millimetre using vernier callipers, swabbing for Bd infection using a sterile medical swab, determining each individual's toe-clip mark, and recording the position along the transect. This information can then be used to estimate population size and survivorship in relation to a number of co-variates including body condition and Bd infection status.

Alpine Tree Frog

Post-release survivorship will be determined using mark-recapture methods. Because the Alpine Tree Frog can only be reliably located and caught during the breeding season, when adult males and females congregate at breeding sites, assessing survivorship in this study will occur during the first spring/early summer following release. Based on the size of the animals being released, all individuals should have attained sexual maturity by this stage.

The mark-recapture study will involve weekly censuses at each release locality from early September to December. Each census will involve systematic night-time searching of the breeding habitat by spotlight for adult frogs. Upon finding an adult, it will be hand-captured and processed. Processing will involve scanning to determine individual identification (PIT tag), measuring for snout-urostyle and tibia length using vernier callipers, and weighing on electronic balance scales. The frog will also be swabbed using a sterile swab to determine whether the individual is infected with Bd. The swabbing procedure involves holding the frog by the back legs and wiping three times each of the hands, belly, inner and outer thighs, and feet. The frog will then be released at the point of capture. This procedure should take no longer than 2 minutes.

6.2 Methods and rationale for medium-term monitoring (1-3 years) and subsequent longerterm monitoring.

The monitoring being used during the first year post-release (see section 6.1) will continue for a minimum of seven years post-release to adequately assess the stated objectives.

6.3 Methods and rationale for undertaking particular research.

This translocation is essentially a continuation of an adaptive management program aimed at securing the future of the frog fauna in Kosciuszko National Park. In essence, much of this program could be considered research, with the scientific methods being employed being the post-release monitoring to determine individual survivorship and its ramification for the conservation of these species (see section 6.1). Without taking a rigorous approach to the post-release monitoring, the necessary information to understand the mechanisms associated with the translocation outcomes will not be attained, which will impede our future progress. It will also results in these translocations providing limited value to frog conservation programs elsewhere.

6.4 How the monitoring data will be used to assess the success of the program, including impacts upon the source and host environments.

The post-release monitoring is critical for determining the extent to which these translocations have contributed to achieving the stated objectives, and hence whether this program has been successful. In addition to this, if we fail to achieve the objectives, the information from the post-release monitoring may inform future strategies to increase the likelihood of success.

6.5 How the program will inform the management of the species throughout its range.

The future of the Southern Corroboree Frog and Spotted Tree Frog in Kosciuszko National Park is completely reliant on captive breeding and translocation back to the wild. In addition to this, the Spotted Tree Frog continues to decline across its range in Victoria, and one population in this state (Buffalo Creek) is also the focus of reintroduction efforts to prevent complete extinction. Hence, this program is the highest priority recovery action for the management of these species throughout their range (Gillespie and Clemann 2011, OEH 2012).

6.6 How the program will contribute to the knowledge of best practice threatened species management.

There are numerous other conservation programs throughout the world requiring the application of translocation to prevent complete extinction of frog species, and for many of these, the key threat is Bd (Zippel *et al*. 2011). Hence, this program will provide valuable information that will be directly relevant to many other threatened frog recovery programs throughout the world.

7. Component strategies

7.1 A strategy in the event that the species fails to establish in the host environment.

The translocations outlined in this proposal are being undertaken as either targeted research or within an adaptive management framework. Hence, failure to establish the species in the host environment will not be perceived as failure, but will inform the future development of recovery actions for these threatened frog species.

7.2 For captive breeding components, discuss the need for captive breeding.

Captive breeding is required for the Southern Corroboree Frog and Spotted Tree Frog recovery programs because wild populations of both species are critically low and in an ongoing state of decline towards extinction.

7.3 For captive breeding components not covered by Department of Agriculture approval under the *Exhibited Animals Protection Act*, discuss:

The captive breeding programs associated with these translocations are covered by the *Exhibited Animals Protection Act*.

7.3.1 the proposed record keeping and genetic management techniques

NA

7.3.2 the design and standards of housing facilities, including use of display versus off-display facilities

NA

7.3.3 special requirements likely to be needed by the species (for example diet, prevention of habituation to humans, maintenance of natural behaviours)

NA

7.3.4 release strategies to optimise the chances of survival in the wild

Southern Corroboree Frog

Survivorship of eggs will be optimised by placing them directly into the water within pools that exclude the Common Eastern Froglet so that they remain Bd free until metamorphosis. The survivorship of the adult frog will be optimised by releasing them into the artificial enclosure when temperatures are relatively mild (early autumn).

Spotted Tree Frog

Post release survival will be optimised by releasing relatively large frogs, as this has been shown previously to result in greater survival (Figure 7.3.4).

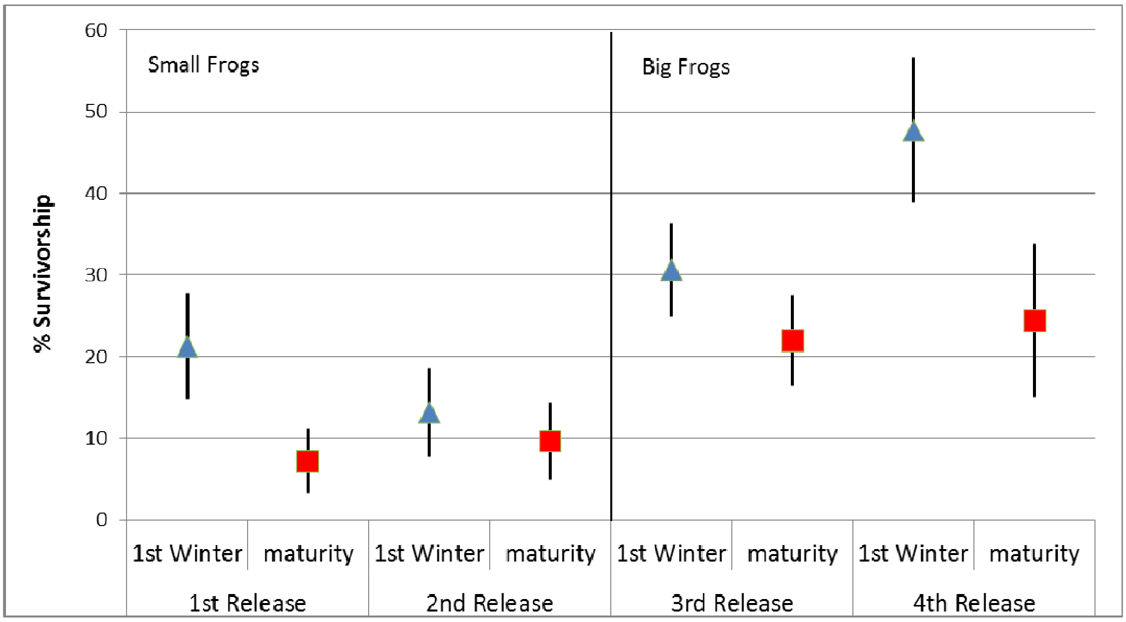

Figure 7.3.4. Estimated post-release survivorship of Spotted Tree Frogs at [redacted], and 95% CI, across the first winter (blue triangle), and to sexual maturity (red squares) for each release cohorts.

Alpine Tree Frog

Optimising survival of released frogs will involve releasing large frogs during a time of the year (early autumn) with mild temperatures, and when other frog species (i.e. Common Eastern Froglet) are not congregating at breeding sites.

7.3.5 disease risk strategies

All eggs and frogs used in these reintroductions are being maintained in high quarantine facilities specifically designed to minimise the risk of introducing disease to the wild. In particular, the husbandry institutions involved in these programs do not maintain collections of exotic frog species, the animals involved in the reintroductions are housed in separate facilities (e.g. temperature controlled shipping containers) with strict quarantine procedures.

7.4 For habitat fencing components, discuss:

7.4.1 the need for a fence

The only aspect of this program involving the fencing of habitat is the Southern Corroboree Frog introduction into a field enclosure (see photo 2). The specific purpose of this introduction is to maintain a Bd free colony of the Southern Corroboree Frog in the wild. This requires maintaining this species in an area that excludes other frog species that may carry Bd, and hence the need for a fence.

7.4.2 the proposed size of the area to be fenced and fence type in relation to the ecology of the translocated species

The area being fence is approximately 30 X 10 m. The fence is made of steel, and has shade-cloth aprons hanging approximately 40 cm either side (see photo 6). The combination of the fence height and mesh aprons will prevent the escape of any frogs, and should prevent any frogs from outside entering the enclosure. Within the enclosure, there will be a combination of breeding habitat and non-breeding habitat. Given the size of the enclosure relative to the size of tanks housing this species in captivity, there should be sufficient space to maintain a much greater number of frogs than the current plan of 150 individuals.

Photo 6. Mesh apron designed to exclude frogs from entering or leaving the field enclosure.

7.4.3 non-target impacts, particularly barrier effects

There are no non-target impacts or barrier effects anticipated in this program. The enclosure has been established in an area of highly modified/disturbed habitat (rock spoil) associated with the construction of the Snowy Hydro scheme.

7.4.4 the number of years that the fence will be maintained

The duration of the enclosure is uncertain at this stage. Since this enclosure has been established to compliment the ex-situ management of the Southern Corroboree Frog, it is likely that this enclosure will be maintained for at least 10 to 20 years. This will depend on whether the stated objectives are being achieved, in particular, whether the enclosure can be maintained Bd free.

7.5 The consequences of not utilising component strategies, particularly a threat abatement component.

The reintroductions outlined in this proposal are broadly aimed at developing methods to prevent the certain extinction of two frog species in Kosciuszko National Park (Southern Corroboree Frog and Spotted Tree Frog), and develop a greater understanding, through the use of a model species (Alpine Tree Frog), of how the key threat (disease caused by Bd infection) is impacting on susceptible species. Component strategies are being used in the various reintroductions to assist in achieving greater reintroduction success (e.g. fencing, artificial pools, release to areas perceived more climatically suitable and with fewer reservoir host species), which has been the result learning from previous reintroduction attempts and research. Failure to use these component strategies would be neglectful and compromise recovery efforts for these species.

8. Community awareness, education and involvement

Outline the strategy for community awareness, education and involvement in the translocation program, including:

8.1 Links to community components of species recovery planning, threat abatement planning and other planning mechanism.

The primary interface between the Southern Corroboree Frog and Spotted Tree Frog Recovery Programs is displays and associated signage at the major husbandry institutions involved in these programs (see photo 7). Moreover, media associated with these programs has typically focused on the reintroductions. Hence, the translocations outlined in this proposal will directly and indirectly facilitate community engagement and education associated with the plight of these species and the factors causing their decline.

Photo 7. Southern Corroboree Frog display at Taronga Zoo.

8.2 Issues related to restricting community access so that the objectives of the translocation program are not compromised.

The only site where community access is likely to compromise the objectives of the program is the [redacted] area where the Southern Corroboree Frog enclosure is being constructed. To minimise the likelihood of interference, the following procedures have been put in place:

- A locked gate has been installed at the start of the access trail. This gate can restrict cars and motorbikes.
- The door into the enclosure will be locked.
- Signage outlining the program and the need to maintain strict quarantine.

8.3 Identification of community groups, including indigenous groups, local to the source and host environments and the appropriate levels of consultation with those groups.

These translocations form the core recovery actions for threatened frog species in Kosciuszko National Park, and thus are endorsed by the plan of management for this reserve (NSW DEC 2006). A significant component of producing this plan was thorough consultation with all community and stake holder groups for this area.

9. Social and economic considerations

Summarise the social and economic factors which have been considered in relevant species recovery planning, threat abatement planning and other planning documents. Discuss all issues related to adverse social and economic effects.

Southern Corroboree Frog Recovery Plan

(taken from the '*National Recovery Plan for the Southern Corroboree Frog, Pseudophryne corroboree, and the Northern Corroboree Frog, Pseudophryne pengilleyi'*, OEH 2012)

Social and Economic Impacts

Since the majority of remaining populations occur within national parks or nature reserves, there are minimal costs associated with land reservation, protection, or foregone opportunities associated with alternative land uses. Furthermore, habitat requirements can be readily incorporated with other park management objectives and it is unlikely that significant conflict would arise. The exception to this is the state forest region of NSW, where implementation of forestry prescriptions for the NCF may reduce the amount of timber available for harvesting.

The corroboree frogs are a distinctive and striking species that have captured public attention. Their decline sends a message about the overall deterioration in the quality of our environment. If we can successfully bring these species back from the brink of extinction, there could be significant social benefits in terms of how we perceive our environment and its general health. The considerable economic benefits of saving corroboree frogs, whilst being very difficult to quantify, need to be taken into account in any assessment of the relative costs of recovery planning for these species.

Spotted Tree Frog Recovery Plan

(taken from the 'National Recovery Plan for the Spotted Tree Frog *Litoria spenceri*' Gillespie and Clemann 2011)

Social and Economic Impacts

The implementation of this Recovery Plan is unlikely to cause any significant adverse social and economic impacts. Some populations occur within parks and reserves where management for biodiversity conservation is already a high priority. Key populations on private land will be protected through negotiation and voluntary agreements with landowners, supported where possible by the provision of incentives available through regional natural resource management authorities.

There are considerable positive benefits in protecting Spotted Tree Frog habitats. The protection of these areas will augment intrinsic natural values enjoyed by visitors to such areas. These benefits complement the management aims of national parks and other reserved land where this species occurs, and visitors to these areas provide economic benefits for the local districts. Involving the community and private landholders in recovery efforts can foster a sense of pride in contributing to conservation programs.

Alpine Tree Frog

(taken from the 'National Recovery Plan for the Alpine Tree Frog *Litoria verreauxii alpina*' Clemann and Gillespie 2010)

Social and Economic Impacts

The implementation of this Recovery Plan is unlikely to cause significant adverse social and economic impacts. Most of the known range of the Alpine Tree Frog is within the Alpine and Kosciuszko National Parks, and conservation of the frog is likely to enhance the biodiversity values and conservation objectives of these reserves. However, some populations persist on freehold land, where social and economic considerations are pertinent.

There are considerable positive benefits in protecting Alpine Tree Frog habitats. The protection of these areas will augment intrinsic natural values enjoyed by recreationalists such as birdwatchers, photographers, artists and walkers. These benefits complement the management aims of the relevant national parks, and visitors pursuing these activities provide year-round economic benefits for the local districts.

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