Global Re-introduction Perspectives: 2016

Case-studies from around the globe

Edited by Pritpal S. Soorae

IUCN/SSC Re-introduction Specialist Group (RSG)

RSG

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Cover photo: Clockwise starting from top-left:
i. Bolson's tortoise, USA @ Turner Endangered Species Fund
ii. Wetapunga, New Zealand @ Richard Gibson
iii. Morelos minnow, Mexico @ Topiltzin Contreras-MacBeath
iv. *Silene cambessedesii*, Spain @ Emilio Laguna
v. Tasmanian Devil, Maria Island, Tasmania @Simon DeSalis
vi. Agile frog, Jersey @ States of Jersey Department of the Environment

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IUCN Species Survival Commission (SSC)
The SSC is a science-based network of close to 8,000 volunteer experts from almost every country of the world, all working together towards achieving the vision of, “A world that values and conserves present levels of biodiversity.”

Environment Agency - ABU DHABI (EAD)
The EAD was established in 1996 to preserve Abu Dhabi’s natural heritage, protect our future, and raise awareness about environmental issues. EAD is Abu Dhabi’s environmental regulator and advises the government on environmental policy. It works to create sustainable communities, and protect and conserve wildlife and natural resources. EAD also works to ensure integrated and sustainable water resources management, and to ensure clean air and minimize climate change and its impacts.

Turner Endangered Species Fund (TESF)
The TESF was established in 1997 to conserve biological diversity by ensuring the persistence of imperiled species and their habitats with an emphasis on private land. Our activities range from single species conservation actions to restoration of ecological communities and functional ecosystems. We are unique in our efforts to bring the role of private lands to the forefront of ecological conservation. We aim to use the best science to effectively conserve biodiversity and disseminate reliable scientific and policy information. We are determined to establish a new level of effectiveness for private-public efforts to redress the extinction crisis.

Calgary Zoo (CZ)
The Calgary Zoo’s vision is to be Canada’s leader in wildlife conservation. In close alignment with IUCN, this vision is pursued through a mix of Canadian and global conservation initiatives regarding two strategic pillars: 1) Conservation Translocations, such as re-introductions, to avert species extinction and strengthen ecosystem function; and 2) Community Conservation to bring mutual and sustainable benefits for local livelihoods and biodiversity. The Calgary Zoo engages in collaborative partnerships around the world to develop the innovation and application of science-based solutions to achieve long-term benefits for conservation.

Denver Zoological Foundation (DZF)
The DZF is a non-profit organization whose mission is to “secure a better world for animals through human understanding.” DZF oversees Denver Zoo and conducts conservation education and biological conservation programs at the zoo, in the greater Denver area, and worldwide. Over 3,800 animals representing more than 650 species call Denver Zoo home. A member of the World Association of Zoos and Aquariums (WAZA), Denver Zoo’s accreditation from the Association of Zoos and Aquariums (AZA) assures the highest standards of animal care. A leader in environmental action, Denver Zoo was the first U.S. zoo to receive ISO 14001 sustainability certification for its entire facility and operations and in 2011 was voted the greenest zoo in the country. The ISO 14001 international certification ensures the zoo attains the highest environmental standards. Since 1994, Denver Zoo has participated in well over 550 conservation projects in 55 countries. In 2011 alone, Denver Zoo participated in 70 projects in 20 countries and spent well over US$ 1 million to support of wildlife conservation in the field.

Re-introduction Specialist Group (RSG)
The RSG is a network of specialists whose aim is to combat the ongoing and massive loss of biodiversity by using re-introductions as a responsible tool for the management and restoration of biodiversity. It does this by actively developing and promoting sound inter-disciplinary scientific information, policy, and practice to establish viable wild populations in their natural habitats.

Re-introduction of the northern corroboree frog in the Northern Brindabella Mountains, New South Wales, Australia

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Introduction

The northern corroboree frog (*Pseudophryne pengilleyi*) is a small Myobatrachid frog native to the Brindabella and Fiery Ranges of New South Wales and the Australian Capital Territory in south-eastern Australia. The species has suffered dramatic declines over the last 30 years and has disappeared from the majority of its former range. It is estimated that populations within the Northern and Southern Brindabella mountains, which are two of the three recognized distinct genetic populations or evolutionary significant units (ESUs), have less than 200 mature individuals remaining.

The decline of this species has been primarily due to the introduced fungal pathogen, amphibian chytrid fungus (*Batrachochytrium dendrobatidis*), though other factors may have contributed on a lesser scale, including climate change, exotic weeds and habitat degradation due to introduced fauna species (Hunter *et al*., 2010; Scheele *et al*., 2012). The species is listed as Critically Endangered in

Northern corroboree frog

Release of 1 year old frogs

NSW under the *Threatened Species Conservation Act 1995* and Federally under the *Environment Protection and Biodiversity Act 1999*. It is also listed as Endangered by the IUCN and in the ACT under *Nature Conservation Act 1980*.

Goals

- Goal 1: Establish a sustainable *ex-situ* colony of the *P. pengilleyi* Northern Brindabella ESU and maintain as a genetically-viable insurance colony.
- Goal 2: Ensure the persistence of *P. pengilleyi* in the Northern Brindabella mountains by supplementing wild populations with captive-bred stock.
- Goal 3: Develop efficient and reliable re-introduction protocols by assessing the effectiveness of releasing different life-stages.

Success Indicators

- Indicator 1: Have developed successful captive husbandry and reproduction techniques.
- Indicator 2: Sufficient numbers of offspring to facilitate re-introduction efforts have been produced.
- Indicator 3: Post-release survival to sexual maturity of individuals released at different life-stages has been quantified.
- Indicator 4: Breeding populations of *P. pengilleyi* in the Northern Brindabella mountains continue to persist.

Project Summary

Feasibility: The Northern Brindabella ESU of *P. pengilleyi* has been in continual decline since the arrival of chytrid fungus over three decades ago. In 2010, annual surveys indicated that the number of mature calling males had dropped to 66 calling males. By 2012, only three calling males were located throughout breeding sites within the ESU. These results suggest that population numbers at existing sites are at critically low levels and are at risk of extinction. Between 2003 and 2005, eggs were collected from a number of wild nests and taken to Tidbinbilla Nature Reserve to establish an insurance colony for this population. During 2010 and 2011, most of this captive colony was transferred to Taronga Zoo, Sydney. Successful breeding protocols have been established for this species at both institutions.

Within the Northern Brindabella mountains, the habitat of the species remains largely intact, with numerous suitable breeding sites. As far as can be discerned, chytrid fungus is present at all suitable release sites available to the species. However, despite the presence of the fungus, the species rate of decline has been relatively gradual over the past three decades. This indicates that it may be feasible to maintain wild populations of the species in the presence of the pathogen with supplementation from an *ex-situ* colony.

Ensuring the persistence of *P. pengilleyi* in the Northern Brindabella Ranges will assist the broader recovery program through maintaining the species existing genetic variation, and allowing ongoing field research into techniques to mitigate the impact of the chytrid fungus. Additionally, enabling the population to persist in the presence of the chytrid fungus may allow the possibility of continued selection for resistance to disease caused by this pathogen.

Implementation: Two release sites were selected in the Northern Brindabella Mountains that until recently maintained significant populations of *P. pengilleyi* and were reasonably resilient to pool drying during the period of tadpole development. Eggs and tadpoles were released in 2010 (179), 2011 (146), 2013 (167) and 2014 (293), evenly divided between the two sites. All releases were undertaken between July and September, coinciding with when wild tadpoles would be at a similar stage of development.

In December 2014, 160 one-year old frogs and 49 five-year old frogs were released, with numbers of each cohort also divided evenly between the two sites. Sex ratios of the adult frogs were split evenly between the two sites. The juveniles frogs could not be sexed so were randomly assigned to each site. Undertaking releases at various life stages has been conducted to assess the most effective re-introduction technique to establish populations of this species, taking into account the cost implications of rearing individuals to a later stage of development in captivity. Just prior to release, each of the frogs was weighed, measured and had photographs taken of their ventral and dorsal surfaces to permit individual identification upon recapture using pattern recognition.

Releasing tadpoles in the Northern Brindabella Mountains

Post-release monitoring: Annual monitoring has been conducted at each of the two release sites since 1999,

during the peak breeding season from late February to early March. Monitoring is conducted using a shout-response technique that has a high confidence of detecting mature calling males (Scheele *et al.*, 2012). The number of mature females is estimated based on the number of clutches within male nests. Due to their cryptic nature, there are no techniques to monitor immature individuals.

Surveys in March 2014 detected 7 males at each of the two release sites, though no eggs were laid in any of their nests. Due to the low number of adults at release sites between 2009 and 2011, and the lack of detection of frogs since 2011, it is suspected that these individuals were likely from the first tadpole releases in 2010. This is supported by length of time to maturity, with males typically maturing at 3 years in the wild, whilst females mature at 4 years. Thus in 2014, males from the 2010 tadpole release would be mature at just over 3 years of age, whilst the females may not, resulting in the perceived sexual bias.

In March 2015, seven males were detected at one site, whilst 13 were detected at the second site. At the end of the breeding season, the nests were inspected to identify and photograph males and assess their size. From the 20 nests, 12 males were still present upon inspection, of which four were identified by markings as being released 3 months earlier. At the latter release site, eggs were detected within 4 nests representing between 12 - 15 clutches of eggs.

Major difficulties faced

- The inability to detect frogs prior to maturity due to their small size and cryptic nature prevents the tracking of released young (eggs, tadpoles & juvenile frogs) animals for up to 4 years after their release.
- No practical technique to track females (because they do not call), reliance on limited data from opportunistic sightings in nests.
- Limited ability to directly link breeding adults with cohorts of released eggs. With additional funding it may be possible to do this using genetic techniques.
- The small size of the captive population and the low number of eggs produced by this species limits the number of offspring available for re-introduction.

Major lessons learned

- Survivorship to maturity can be achieved despite the persistence of chytrid fungus. Hence, it should be possible to maintain wild populations via a captive breeding and supplementation program.
- Presence of the chytrid fungus should not be a factor preventing re-introduction attempts as this will reduce the ability to gain increased knowledge of the disease dynamics in *P. pengilleyi* and prevent any possibility of selection for resistance to the disease.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Successful captive reproduction has been achieved in each year attempts were undertaken, facilitating the provision of offspring for re-introduction efforts.
- Survivorship of a small proportion of released tadpoles to maturity at the two sites has been attained from the first cohorts of eggs and tadpoles released.
- It is too early in the program to declare this project to be a success or failure, as this will require at least another 5 years of post-release monitoring.

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Head-starting, re-introduction and conservation management of the agile frog on Jersey, British Channel Isles

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Introduction

Agile frogs (*Rana dalmatina*), found throughout much of Europe and northern Turkey, are listed on Appendix II of the Bern Convention, Appendix IV of the EU Habitats Directive, and as Least Concern in the IUCN Red List. The Channel Island of Jersey (117 km^2) is towards the northern edge of the species' range, and hosts the only agile frog population in the British Isles. In Jersey, population declines occurred throughout the 1900s, with animals becoming restricted to a single 10 ha dune heathland site (L'Ouaisné Common) by 1988. Causes of decline are thought to include habitat loss and fragmentation due to development, pollution of groundwater, water shortages and the loss of breeding ponds (Racca, 2002), and an increased predation pressure due to the introduction of non-natives (States of Jersey, 2006). The agile frog is therefore regarded as locally Critically Endangered within Jersey, and is protected under the Conservation of Wildlife (Jersey) Law 2000. Furthermore, Jersey's agile frogs show lower genetic variability than other European populations (Racca, 2004). The population has been the subject of a Species Action Plan since 2001, with captive husbandry undertaken by Durrell Wildlife Conservation Trust (DWCT).

Agile frog © Jersey States Department of the Environment

Goals

- Goal 1: To ensure that there is protection of, and a conservation management program for, all existing natural sites, introduction sites or re-introduction sites.
- Goal 2: To increase the number of populations and widen the species' distribution through introductions/re-introductions.
- Goal 3: To maintain a viable breeding population of frogs through head-starting and translocation with a minimum of 20 adult animals at a minimum of three locations (a minimum of 60 adults in total).
- Goal 4: To have annual monitoring of spawning in all populations.
- Goal 5: To further investigate the threats to, and applied ecology of this species in Jersey.

Success Indicators

- Indicator 1: Protection of all sites where the species occurs, and where it will be introduced/re-introduced.
- Indicator 2: Restoration of wild, naturally spawning populations at more than one site.
- Indicator 3: Wild frog populations of at least 20 adults breed successfully at a minimum of three locations.
- Indicator 4: Populations are monitored annually allowing detection of annual variation in spawning.
- Indicator 5: Research carried out to determine ecological requirements.

Project Summary

Feasibility: This project aimed to restore the population to the point where it is self-sustaining at multiple sites. The European habitat for the agile frog comprises slow-flowing or stagnant water bodies of 30 - 80 cm depth for breeding, and woodland for their terrestrial phase. Jersey's population shows some differences in habitat use compared to its mainland counterparts, by their use of coastal habitats (States of Jersey, 2006). Survival of eggs to metamorphosis in Jersey is higher than the expected rate of 1.0% - 2.0% for wild anurans, at 2.4% - 17.1% per year when spawn is protected or head-started (Racca, 2004). The agile frog population in Jersey declined in both range and numbers from the early 1900s until the 1990s. In the 1970's frogs were known from seven localities, and by the mid-1980s this had fallen to two sites; Noirmont and L'Ouaisné. A pesticide spill in 1987 decimated the Noirmont population, prompting the first intervention for the population. Declines are attributed to poor water quality and quantity through intensive agriculture and water extraction leading to a shortened hydroperiod and earlier pond desiccation; disturbance and loss of habitat; and an increase in both native and introduced predators (States of Jersey, 2006). Frogs migrate between terrestrial and breeding habitat, requiring identification of suitable habitat and engagement with stakeholders to encourage sympathetic management. Further obstacles include road mortality during migration, water pollution from agricultural sources, and limited available habitat with poor connectivity. The partner organisations working on this project provide a strong knowledge-base for the various actions requiring implementation, increasing the likelihood of success of this project. Consideration must be made for biosecurity both *in-* and *ex-situ* as

Agile frog head-starting container © Matt Goetz

captive management carried out by Durrell Wildlife Conservation Trust (DWCT) has to ensure strict separation between its captive population of exotics and the agile frogs. Re-introduction sites can be identified through historical distribution, habitat suitability and connectivity to the existing population.

Implementation: Interventions to arrest the declines began in 1987. A collaboration between the States of Jersey Department of the Environment (DoE), DWCT, the Société Jersiaise and a number of private stakeholders created the Jersey Agile Frog Group (now the Jersey Amphibian and Reptile Group). This group has worked to implement a head-starting, re-introduction and habitat management program (Racca, 2002). This has resulted in deepening of slacks to lengthen the period that water is held, regular water quality monitoring, and localised habitat management in order to improve habitat suitability (Racca, 2004). Protection of spawn clumps *in-situ*, and removal of spawn clumps for head -starting has taken place, with tadpole rearing undertaken by the herpetology department at DWCT since 1986, and the use of a dedicated biosecure unit since 2008. Head-started individuals achieve greater mass and survival than those left *in-situ* (Jameson, 2009), and have enabled the translocation of tadpoles to new sites. In 2000 tadpoles were re-introduced back to Noirmont following work to improve water quality, and by 2012 re-introductions had taken place at a further two sites, resulting in a total of four sites receiving monitoring and management. Both principal agile frog breeding areas at L'Ouaisné and Noirmont were designated as ecological Sites of Special Interest (SSI) in 2007. Furthermore, management plans for L'Ouaisné and Noirmont SSI's have been prepared by the DoE to ensure appropriate management for amphibian populations. Further work with local stakeholders to encourage sympathetic habitat management outside of protected areas could result in improvement in the future. Press coverage, involvement of and visits to educational institutions, and printing of educational materials have all attempted to raise public awareness of the issues surrounding the conservation of Jersey's amphibians.

Post-release monitoring: Night surveys are made to each site during the breeding season to count breeding adults and spawn clumps. This monitoring has detected an increase in the number of clumps per year and the number of sites at which spawning occurs; from 12 in 1987 at a single site, to 134 spawn in 2014 at three sites, with no spawning in some years (Ward & Griffiths, 2015). Daytime

visits are also made to each site to check the condition of spawn clumps and provide spawn protection where needed. Ongoing monitoring and research has allowed identification of effective methods for maintaining a population increase, which in this case is head-starting of individuals from egg to tadpole (Ward & Griffiths, 2015). It has also enabled intervention to take place when reductions in numbers of spawn or individuals have occurred, as well as improved our knowledge of the species ecology and threats. Water quality has also been monitored at all potential wild breeding sites.

Major difficulties faced

- Determining suitable release sites due to lack of appropriate sites isolated from external threats such as agricultural runoff as well as poor connectivity in a densely populated island.
- Understanding the differences in ecology between agile frog populations in Jersey and mainland Europe, particularly the terrestrial phase.
- Unpredictable recruitment due to annual variation in water levels.
- Impacts on the population from human disturbance, including road mortality.
- Difficulties in securing staff time and funding for head-starting.

Major lessons learned

- With assistance (head-starting and spawn protection), the frog population was able to maintain a steady increase in population size, and has led to the recovery of the population at L'Ouaisné.
- Restoration to previous population levels may be difficult due to habitat availability and connectivity, and the time taken for populations to establish.
- Habitat management has probably played an important role in sustaining the population.
- Biosecurity measures put in place to reduce the threat of diseases (e.g. *B. dendrobatidis*) may have played an important role, as did monitoring of sites to mitigate unexpected threats to the habitat in the way of invasive freshwater plants (*Crassula helmsii*). This highlights the importance of being cautious, and that external factors otherwise unrecognised could play a role in the success or failure of conservation programs.
- Captive-breeding enclosures had mixed success and required a large amount of

Agile frog release into a re-introduction site

© Rob Ward

resources, whereas head-starting wild clumps proved to be more cost effective.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Intervention with spawn protection and head-starting avoided complete population loss.
- Both principal breeding sites given protection, being designated as ecological Sites of Special Interest, with habitat management programs implemented.
- Agile frog numbers are increasing at L'Ouaisné, with some wild breeding also occurring at Noirmont, Woodbine corner and Beauport, following re-introduction.
- Research into the ecology of Jersey's agile frog population has been carried out by a PhD student (Racca, 2004), as well as further research undertaken by other students to assess the success of different conservation strategies and methods applied to the population.
- There are a limited number of potential release sites, with little data on which to base their selection. Furthermore connectivity between sites further afield is likely to be poor.

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Re-introduction of the northern leopard frog in British Columbia and Alberta, Canada

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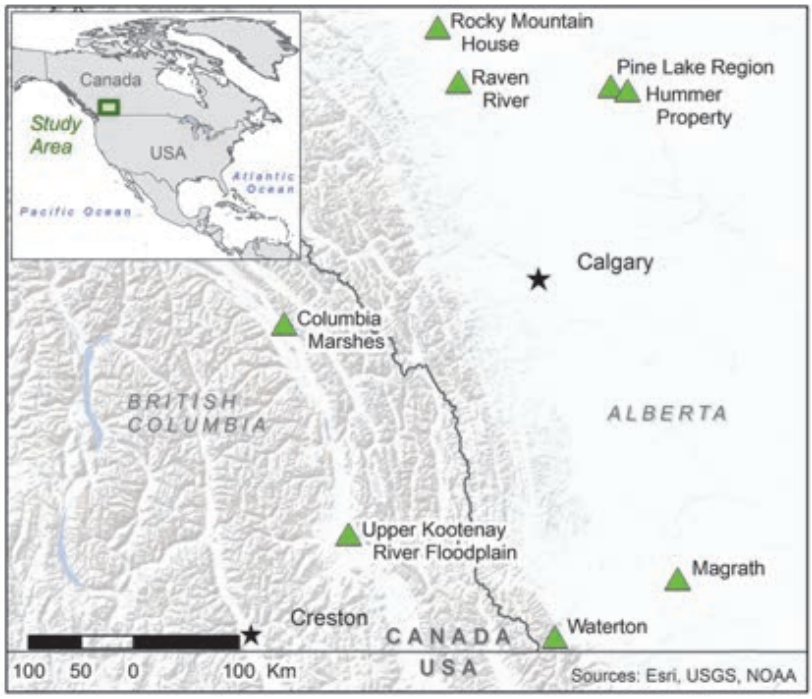
Introduction

The northern leopard frog (NLF) (*Lithobates pipiens*) was once widespread and numerous across much of North America. Reductions in range, number of populations, and abundance have led to the designation of 'Endangered' for the Rocky Mountain population in British Columbia (BC) and 'Special Concern' for the Western Boreal/Prairie populations (COSEWIC, 2009). In BC, there is a single extant population of NLFs located in the Creston Valley Wildlife Management Area (CVWMA) (BCNLFRT, 2012). The NLF is 'threatened' in Alberta (AB), and remaining populations are isolated resulting in reduced gene flow and hampering re-colonization (AESRD, 2012). Habitat loss and fragmentation, reduced water quality and quantity, introduced fish, and disease have been implicated as possible causes of declines (COSEWIC, 2009).

Chytridiomycosis is thought to have been a primary cause for population declines in BC and may have contributed to declines in AB (BCNLFRT, 2012; AESRD, 2012). Re-introduction is identified as a key strategy to recover NLFs in both provinces

Northern leopard frog in BC wetland

Figure 1. Map of select re-introduction sites covered in the document (green triangles) in BC and AB



(BCNLFRT, 2012; AESRD, 2012). Recovery efforts in BC are led by the BC NLF recovery team. Most of the AB re-introductions described were directed by the Alberta Environment and Parks (AEP) led advisory group and by Parks Canada in collaboration with AEP in Waterton Lakes National Park (WLNP). Additional re-introductions not covered in this document have occurred in AB between 2007 - 2015.

Goals

- Goal 1: Ensure well-distributed, self-sustaining populations of NLFs throughout their historical range in BC and AB.
- Goal 2: Re-introduce NLFs to at least two major river basins in both BC and AB.

Success Indicators

- Indicator 1: Re-introduced eggs hatch and some tadpoles complete their metamorphosis (includes head-starting of eggs and/or tadpoles).
- Indicator 2: Frogs overwinter successfully.
- Indicator 3: Frogs survive to sexual maturity and there is evidence of breeding activity as indicated by calling, wild-bred eggs, tadpoles, or frogs.
- Indicator 4: Some or all life-stages are detected at least 3 years post-release.
- Indicator 5: Evidence of colonization of nearby breeding habitat.

Project Summary

Feasibility: Northern leopard frogs require well-connected and proximate habitats for breeding, foraging, and overwintering. Habitat fragmentation, disease and invasive fish may hamper re-introduction efforts (BCNLFRT, 2012; AESRD, 2012). There are several wild populations that can be a source of eggs for translocation in AB; in contrast, the only sources in BC are from the CVWMA and a captive assurance population at the Vancouver Aquarium. Chytrid fungus (*Batrachochytrium dendrobatidis), or Bd*, has been detected at multiple sites in AB and BC but evidence of chytridiomycosis-caused mortality is rare (BCNLFRT, 2012; AESRD, 2012). Currently, no disease testing is done prior to release as translocations are of eggs or early-stage tadpoles which have a low probability of

harboring *Bd (*Kendell *et al.*, 2007). However, every effort is made to minimize transfer of disease, parasites and invasive species.

Researcher working in the wetlands
© Larry Halversen

Implementation: Biological and habitat connectivity assessments are required prior to selecting a re-introduction site, and consultation is required with landowners (private and governmental agencies), and any relevant First Nations aboriginal groups. In BC, there are two re-introduction sites: 1) Upper Kootenay River Floodplain (UKF) and 2) Columbia Marshes (CM) (Fig. 1). The first phase of re-introduction to UKF was between 2003 - 2005, when a total of 493 tadpoles and 3,639 head-started young-of-year (YOY) were translocated from the CVWMA (Fig. 1) (BCNLFRT, 2012).

No animals were translocated between 2005 - 2010 but between 2011 - 2015, approximately 7,500 tadpoles per year were translocated from the CVWMA for a total of approximately 34,000 (unpublished data). At CM approximately 2,000 captive bred tadpoles from the Vancouver Aquarium were released in 2013 and 2014. To increase the chance of success, these numbers were bolstered in 2015 with tadpoles from CVWMA (approximately 3,000) and Vancouver Aquarium (621) (unpublished data).

Re-introductions have occurred in AB for almost 35 years. NLFs were first re-introduced at two sites in the Pine Lake region in the 1980's *(*Kendell *et al.*, 2007). Between 1999 - 2004, eggs were collected from source sites in southern AB. Approximately 70,000 tadpoles were reared in two outdoor ponds at the Raven Brood Trout Station, near Caroline. This resulted in the survival of about 14,000 head-started YOY that were released at the Raven River (10,000+), a site near Rocky Mountain House (2,845), and Hummer Property (1,310) (a Ducks Unlimited property near Red Deer). Between 2002 - 2004, eggs were collected from source sites in southern AB and 8,500 tadpoles were released at a pond near Magrath. Between 2007 - 2010, eggs were collected from several sites in southern AB and over 75,000 tadpoles were released at three ponds in WLNP (Johnston, 2013).

Post-release monitoring: To measure success, we conducted call surveys as well as visual encounter surveys for all age classes of frogs. Success has been documented at the UKF sites both in Phase 1 and 2 (Table 1). Successful *in-situ*

breeding, as indicated by calling adult frogs and YOY, was detected post-phase 1 in 2007, 2008, & 2010 (BCNLFRT, 2012). Success of phase 2 has been confirmed by breeding call surveys and by detection of eggs in 2014. Frogs have been detected by call surveys at nearby breeding sites although breeding has not been confirmed. While the re-introduction effort at the UKF site is considered successful, populations are still too small to ensure persistence. It is too soon to expect breeding at the CM site (initiated 2013) but the first indicator of success has been met. Although YOY were detected, the small numbers released makes the detection probability of overwintered frogs extremely low.

In AB, the Pine Lake re-introduction sites reported successful metamorphosis, overwintering and reproduction for several years before one site failed due to a winter kill event and the status of the other population is currently unknown *(*Kendell *et al.*, 2007). Despite a successful head-starting program at the Raven Brood Trout Station, there were no confirmed observations of NLFs at the Rocky Mountain House or Hummer Property release sites between 2001 - 2006 *(*Kendell *et al.*, 2007). The Raven River site experienced initial success (i.e. there was evidence of successful overwintering 2001 - 2004 and evidence of breeding in 2002) but there were no observations in 2005 or 2006 *(*Kendell *et al.*, 2007). The Magrath re-introduction has been the most successful of the AB re-introductions, with evidence of successful overwintering and reproduction each year since 2005 (unpublished data).

Table 1. Measures of success at BC and AB re-introduction sites

Site	Years of re-introduction	Success Indicators				
		1	2	3	4	5
British Columbia (BC)						
UKF Phase 1	2003 - 2005	√	√	√	√	UK
UKF Phase 2	2011 - 2015	√	√	√	√	√
CM	2013 - 2018*	√	TBD	TBD	TBD	TBD
Alberta						
Pine Lake	1980s	√	√	√	-	UK
Raven River	1999 - 2004	√**	√	√	-	UK
Rocky Mountain House	2001 - 2003	√**	-	-	-	UK
Hummer Property	2002 - 2003	√**	-	-	-	UK
Magrath	2002 - 2004	√	√	√	√	UK
Waterton	2007 - 2010	√	√	-	-	UK

Key:
TBD - To be determined; UK - unknown due to lack of survey effort
***Anticipated assessment date to continue or terminate effort**
****Eggs hatched and tadpoles captive-reared (head started) to YOY, then released.**

Researcher releasing tadpoles at reintroduction site

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Many YOY were observed at two of the WLNP re-introduction sites in the years when releases occurred, indicating initial re-introduction success at these sites (Johnston, 2013). No YOYs were observed at the third site possibly because of the presence of introduced brook trout (*Salvelinus fontinalis*) (Johnston, 2013). One adult NLF was observed in the area in 2008, and another in 2009, indicating limited intermediate success (Johnston, 2013). Disease testing later revealed *Bd* in the region (Johnston, 2013). New release and egg source sites have been selected for re-introductions beginning in 2015 in the WLNP.

Major difficulties faced

- In BC, the limited number of NLFs available to serve as founder stock has resulted in low numbers of individuals released.
- In AB, sources of eggs for translocation were readily available but suitable release habitat was more difficult to find.
- *Bd* was present at some source and release sites. Other health and parasite problems have also been documented but the population level impacts remains unknown.
- It was difficult to detect NLFs post-release because of the complexity of the habitat, the extensive search areas and inaccessibility of some sites.

Major lessons learned

- In BC, annual re-introductions spanning five years may be required to ensure even modest success. Continued releases may be necessary until *in-situ* reproduction is sufficient to sustain the population. Because of the effort required and the limited founder stock available, few translocation projects can be run simultaneously.
- Long-term monitoring is required to assess the success of the re-introduction (>5 years).
- The presence of *Bd* may influence probability of success but does not guarantee failure (e.g. UKF re-introduction site in BC).
- Head-starting and release of YOY was used in the early stages of re-introduction efforts in both provinces but release of eggs or tadpoles was

speculated to encourage site fidelity, was more cost-effective, and presented a lower risk of transmitting pathogens and parasites.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- We repeated re-introductions over several years, which likely contributed to success at some sites.
- The presence of disease and introduced fish may have led to the failure of some re-introduction sites.
- We suspect that other species of amphibians (e.g., Columbia spotted frog (*Rana luteiventris*)) may have served as reservoirs and vectors for disease.
- Although every effort was made to select good release habitat, we speculate that frogs may not have been able to locate suitable habitat, or there may have been inadequate connectivity between habitats, which may have led to failure at some sites.

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