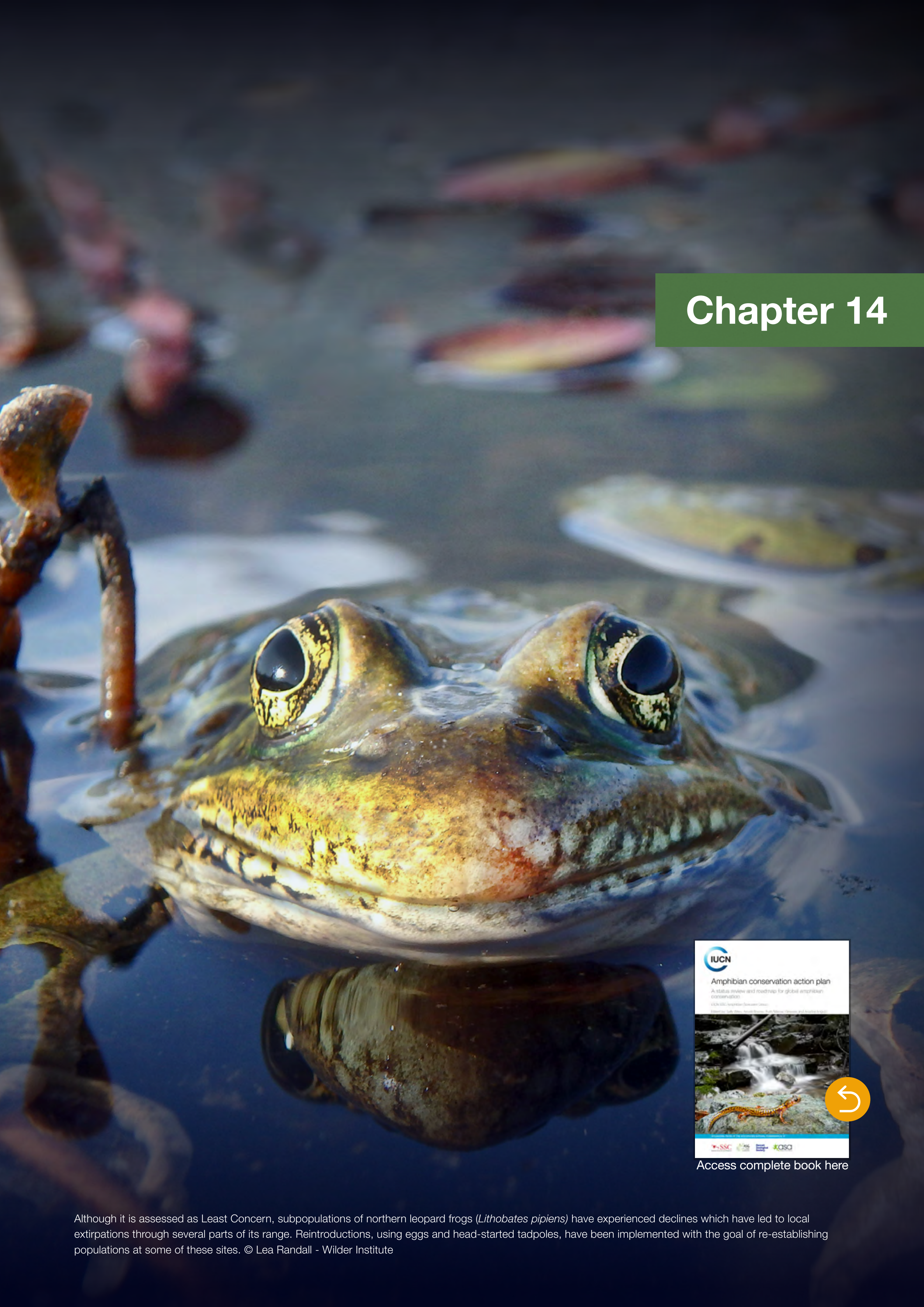

Chapter 14

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Although it is assessed as Least Concern, subpopulations of northern leopard frogs (*Lithobates pipiens)* have experienced declines which have led to local extirpations through several parts of its range. Reintroductions, using eggs and head-started tadpoles, have been implemented with the goal of re-establishing populations at some of these sites. © Lea Randall - Wilder Institute

Chapter 14

Translocations: challenges and recommendations

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Abstract

Species translocations are highly complex and challenging and those involving amphibians are no exception to this. While outcomes have improved over the decades, the last review of published herpetofauna translocations found a success rate of 41%. This is likely due to the interplay of numerous factors that need to be addressed to give releases the greatest opportunity to succeed. Some of these factors include source population, animal behaviour, habitat quality, disease risks, genetics, welfare, and ensuring that the root cause of decline has been addressed. Where questions exist around key factors, trial releases and experimental research can help to address uncertainties. Additionally, it is critical that sufficient time and resources are put into planning and monitoring, with a contingency or exit strategy in place if the project does not go as planned. Future challenges that need to be addressed by the amphibian reintroduction community include the use of translocations in the mitigation space to deal with habitat destruction and human development, as well as the application of assisted colonisation in the face of the global climate change crisis.

Introduction

Amphibian translocations, and in fact translocations of any taxonomic group, are complex undertakings. Success is not guaranteed, as project-specific uncertainties are inevitable and translocations require consideration of animal behaviour, disease, genetics, population ecology, political, socioeconomic, and stakeholder contexts (Ewen et al., 2012; IUCN/SSC, 2013; Linhoff et al., 2021). They are long-term commitments that do not end when animals are released. Often, they require years of adaptive management and years, if not decades, of monitoring to establish the level of success. Furthermore, if the initial threats to the species are not mitigated and if long-term security of the release site is not ensured, then these newly translocated populations will fail.

Historically, translocations have been used for a range of reasons. For amphibians, most past releases have been for conservation. Additionally, many releases have been carried out inadvertently (e.g. the American bullfrog, *Lithobates catesbeianus*) or for pest control (e.g. cane toads, *Rhinella marina*), and while there are many lessons that can be learned from the study of invasive species, these are outside the scope of this chapter. In the past two decades, as the science of reintroduction biology has developed and gained international recognition, there has been a substantial increase in the use of translocations for the mitigation of habitat destruction for human development (Bradley et al., 2021; Germano & Bishop, 2009; Germano et al., 2015; Miller, Bell & Germano, 2014; Romijn & Hartley, 2016; Sullivan, Nowak & Kwiatkowski, 2015). These mitigation translocations have much lower success rates than conservation translocations (Germano & Bishop, 2009) and may not meet the animal welfare or species goals that they set out to achieve (Bradley et al., 2021; Germano & Bishop, 2009). The motivations driving future amphibian translocations are likely to continue to evolve. Perhaps one of the most probable developments over the coming years will be the use of assisted colonisation in an attempt to guarantee the survival of species facing dire circumstances in the face of climate change.

Progress in reintroductions and conservation translocations

The use of translocations for the conservation of amphibians and wildlife in general has been growing worldwide (Bubac & Johnson, 2019; Dodd & Seigel, 1991; Germano & Bishop, 2009). A comparison of data collected from 1966 to 2006 (Griffiths & Pavajeau, 2008) to data collected between the first ACAPs release in 2007 and 2014 showed the number of amphibian species involved in both captive breeding and translocation projects to have increased by 57% (Harding, Griffiths & Pavajeau, 2016). Alongside this growth, a comparison of reviews of published herpetofauna releases have shown an increase in positive outcomes from a 19% success rate of reviewed cases in 1991 (Dodd & Seigel, 1991) to 41% in 2008 (Germano & Bishop, 2009). These successes are likely due to the development of reintroduction biology as a whole and a push towards adaptive management and the use of scientific approaches to address *a priori* goals. The trend after the 2007 ACAP also showed a shift towards research and a focus on captive assurance populations with very few new reintroductions (Harding, Griffiths & Pavajeau, 2016). With many more releases targeting specific research questions this continues to add to our knowledge, refine our management practices and increase the chances of future successes. Detailed information and best practice can be found in the *IUCN Guidelines for Amphibian Reintroductions and Other Conservation Translocations* (Linhoff et al., 2021).

Planning and feasibility

Planning and feasibility studies are vital steps before a reintroduction is undertaken. Each programme will require consideration of different elements depending on the threats to the species and potential impacts to habitat, ecosystems and communities. There are numerous factors to consider and a wealth of tools available to assist with the process (Canessa et al., 2016). Although the focus of each programme will be different there are a few key considerations which apply (*see* Box 14.1).

Box 14.1: Key considerations for translocation planning

1) Is the species a suitable candidate for reintroduction?

2) Have other interventions such as habitat enhancement or threat management been considered first?

3) Are there ways to protect the species in situ?

4) Is there sufficient knowledge on the species biology, ecology, and reasons for decline?

5) Are there support and resources for a reintroduction (e.g. long-term funding, expertise, partnerships, political and community support)?

6) Have threats been considered/removed/mitigated?

7) Have release sites been identified?

8) Is there a contingency plan or exit strategy for the reintroduction if needed?

Useful tools and procedures to assist feasibility and knowledge gathering

1) Species Action Planning Workshops (IUCN/SSC, 2014; IUCN – SSC Species Conservation Planning Sub-Committee, 2017)

2) Population modelling (*see* Linhoff et al., 2021)

3) Habitat Suitability Analysis (Jarchow et al., 2016; Romero, Olivero & Real, 2013)

4) Genetic studies (Wilson et al., 2008) and analysis (Weiser, Grueber & Jamieson, 2012)

5) Strategic planning tools - Using decision analysis framework (Ewen, Soorae & Canessa, 2014)

6) Collaborations with zoos, government, researchers, non-profit, traditional owners/indigenous people (Cisternas et al., 2019; Miller et al., 1994)

Detailed information on the considerations is listed in the IUCN Guidelines (IUCN/SSC, 2013) and the *IUCN Guidelines for Amphibian Reintroductions and Other Conservation Translocations* (Linhoff et al., 2021).

Experimental research such as trial translocations with a small number of individuals or using a similar species can provide useful data and test neutralization of threats and broaden feasibility. When undertaking trials, it is important to impose the same stringent protocols and procedures as the same risks are present. There are published trial releases that can provide examples of how to test translocation feasibility (Bodinof et al., 2012; Kemp et al., 2015; McCallen et al., 2018; Mortelliti, Santulli Sanzo & Boitani, 2009; Valdez et al., 2019).

There are very few published examples of the process and decision-making elements involved in planning, particularly by programmes where translocations did not go ahead based on the outcomes of feasibility studies or research. It would therefore be useful to have examples of potential reintroductions that were not undertaken as a result of low feasibility or alternative management options. Similarly, it would be useful to have more examples of translocations that did not go to plan (*see* Box 14.2 and Borzée et al., 2018), and adaptive management that resulted in alternative interventions. Examples of amphibian reintroductions along with lessons learned can be found within the IUCN SSC Conservation Translocation Specialist Group's *Global Reintroduction Perspectives* publications (Soorae, 2008; 2010; 2011; 2013; 2016; 2018; 2021) and via Conservation Evidence, particularly the Amphibian Synopses (Smith & Sutherland, 2014; Sutherland et al., 2021). Though not amphibian specific, the New Zealand Department of Conservation does provide a good example of the translocation planning process as well as supporting information. This can be found at: https://www.doc.govt.nz/get-involved/run-a-project/translocation/

Box 14.2: Case study: The Suweon treefrog

Background

The Suweon treefrog *Dryophytes suweonensis* was described in the city of Suwon, in the Republic of Korea, in 1980, before becoming functionally extinct in the early 2010s. The local government decided to bring the frogs back a few years later and terraformed an island in a reservoir with all the habitat and vegetation types known to be needed for by the species at the time of the project. Researchers from local universities were tasked with the translocation part of the project, and selected a few localities based on genetic information and population dynamics at the site to be the origin of the translocated individuals.

Methods

To ensure a higher chance of success, amplexed pairs were caught and kept in clear plastic tanks filled with water from the rice paddy where they had been caught. Eggs were collected in the morning, and transferred to a laboratory to head-start the froglets before release. The tadpoles and metamorphs, were kept isolated by clutch, and as only 150 froglets were released at the translocation site, all others were released at the point of capture to reinforce the population at the site of capture (Amaël Borzée, unpublished data), after screening for pathogens.

Results and outcomes

The frogs at the translocation site were surveyed until the beginning of hibernation, and a few young males were found calling the following spring (showing a shorter generation time than expected). No amplexus or female were observed, a commonality in the species, but tadpoles were found, and their identity confirmed through molecular tools. More males were found calling the subsequent spring, highlighting the adequacy of protocols used. This was however the last year of the project, and management changed the following fall, with all hibernation sites removed and the vegetation cut as they did not look clean for the public. No observation of the Suweon treefrogs at the site could be confirmed at a later date, and the site was transformed into a water purification plant and car park shortly afterwards.

Current status and threats

The Suweon treefrog is listed as Endangered; it is present at other locations, but the probability of extinction through a PVA for the Republic of Korea is 1 within 50 years.

See Borzée et al., 2018 for further details

Source populations for translocations

Captive populations

Amphibians exhibit a variety of characteristics that make them suitable for captive breeding and head-starting for translocation such as their high fecundity, applicability of reproductive technologies, short generation time, small body size, lack of parental care, hard-wired behaviour, and low maintenance requirements (Balmford, Mace & Leader-Williams, 1996; Bloxam & Tonge, 1995). However, not all amphibians are suitable for such programmes, and many species have husbandry requirements that are poorly understood or difficult to implement (Tapley et al., 2015). Captive breeding over many generations can have unintended genetic consequences, possibly leading to inbreeding or loss of genetic diversity; additionally, populations may undergo selection to captive conditions unless they are carefully managed (Gilligan & Frankham, 2003; Groombridge et al., 2012; McDougall et al., 2006; Witzenberger & Hochkirch, 2011). For an overview of conservation breeding, *see* Chapter 11.

Head-starting, the process by which early life stages (eggs, larvae, or juveniles) are temporarily raised in captivity and released at a later stage to avoid the heavy mortality associated with younger age classes in the wild, has also been used extensively in translocation efforts (Smith, Meredith & Sutherland, 2020). Both captive bred and head-started animals may become behaviourally adapted to captive conditions and may not be suitable for release to the wild if they do not demonstrate appropriate anti-predator responses or foraging behaviour (Griffin, Blumstein & Evans, 2000; McDougall et al., 2006). Behavioural adaptation may be partially mitigated by maintaining animals in conditions that closely resemble the wild; individuals may also benefit from pre-release and anti-predator training (Crane & Mathis, 2011; Griffiths & Pavajeau, 2008; Mendelson & Altig, 2016; Tapley et al., 2015; Teixeira & Young, 2014; Teixeira et al., 2007).

Captive breeding and reintroduction programmes have increased for threatened amphibian species. In the seven years following the first ACAP an estimated 83% of releases involved a captive breeding component (Harding, Griffiths & Pavajeau, 2016). Although the number of captive breeding and reintroduction programmes are on the rise, this is primarily occurring in countries in South America, the Caribbean and Central America as programmes are shifted to within-country efforts where amphibian diversity and declines are greatest, meanwhile, the number of programmes in more developed, industrialised countries have decreased over the same time frame (Harding, Griffiths & Pavajeau, 2016).

There is a lack of understanding about genetics, animal husbandry, and basic life history traits (such as breeding cues) for many species, and this has hampered the success of captive breeding programmes. Furthermore, captive bred animals often suffer from poor nutrition and health that can impact breeding behaviour and physiology, leading to poor production of offspring for translocation efforts. However, recent advancements have been made in the field of amphibian reproductive technologies (*see* Chapter 12) such as hormone therapies, artificial fertilisation and cryobanking of sperm and eggs, all of which can improve reproductive capacity (e.g. Kouba, Vance & Willis, 2009; Silla & Byrne, 2019). However, further research on amphibian reproductive biology, as well as on-going development and application of these tools, is needed (Della Togna et al., 2020).

Wild source populations

Wild-wild translocations avoid the costs and logistics involved with establishing and maintaining a captive facility. Equally, it circumvents the risk of adaptation to captivity through multiple generations of captive breeding. However, genetic management needs consideration, and it may be important to ensure individuals are from multiple clutches to avoid a founder effect at the release site. Although

Box 14.3: Case study: Hamilton's frog (*Leiopelma hamiltoni*)

Background

The Hamilton's frog was once more widely spread, however the introduction of mammalian predators to New Zealand resulted in this species becoming extirpated from all but two small offshore islands near the top of the South Island. One of these islands, Takapourewa/Stephens Island, had an estimated population of 169–318 frogs limited to a small 300 m^2 rock jumble near the island's summit. In the early 1990s–2000s, the Takapourewa frog was considered a separate species from the other population on Maud Island, and was classified as Critically Endangered due to the small number of individuals found at a single location. It was decided to create a backup population on a separate island to ensure the species' survival and to grow numbers. It was imperative than any translocations did not crash the source, and at the time, only population of this species.

Methods

Nukuwaiata was identified as an appropriate island release site. Stage-structured population models were developed to predict the best outcomes for the translocation based on nine potential scenarios (Tocher, Fletcher & Bishop, 2006). This allowed managers to weigh up the potential for population growth and extinction probability for both the new and donor populations. A long-term investment in intensive mark-recapture monitoring at both the source and translocated population was incorporated into the translocation plan. In 2004–2006, 71 frogs were translocated to the new island site.

Results and outcomes

The removal of 71 frogs (approximately 27% of the donor population) did not impact the sustainability of the source population and this population was able to recover over the following 10–15 years. This translocation has met the short-term goals of survival of translocatees and reproduction with new recruits found over numerous survey periods. Continued monitoring of the source population has shown that the original population was able to sustain the harvest of 71 individuals. The long-term status of the translocated Nukuwaiata population is unknown; as these frogs live for 40+ years and are K-selected, it will take decades to determine long term success.

Current status and threats

The extinction risk for *Leiopelma hamiltoni* from Takapourewa/Stephens Island has been reduced due to the establishment of a second back up population on Nukuwaiata. Continued monitoring will be required to determine the long-term sustainability of this translocated population. Knowledge about the biology and homing ability of this species is an important factor to consider for translocations of other leiopelmatid frogs.

See Tocher et al., 2006 for further details

biosecurity may be less of an issue than in a zoo setting, care needs to be taken to avoid the transfer of invasive plants or pathogens between sites during the action. Wild-wild translocations are best carried out using eggs or tadpoles, as these can develop and disperse naturally at the release site (Denton et al., 1997; Ward et al, 2016). Translocation of post-metamorphic stages needs careful consideration given that such stages can have a strong homing ability (Pašukonis et al., 2013), and may become disoriented if moved to a new site. Consideration also needs to be given to the potential impact of removing stock from the donor site. Given the relatively high natural mortality of eggs and larval stages, combining head-starting of larvae – either in situ in protective enclosures or ex situ at a nearby facility – may be the optimal solution for amphibians whose life cycle suits such an approach.

Habitat

Habitat loss and degradation is the greatest single driver of amphibian population declines and species loss (Bishop et al., 2012). As such reintroductions and conservation translocations can be a valuable action to address these threats and safeguard amphibian populations by translocating amphibians into areas of restored habitat or areas of habitat suffering minimal degradation (Foster et al., 2018; Saumure et al., 2021). Additionally, habitat quality is a key predictor of translocation outcomes (Bubac et al., 2019; Germano & Bishop, 2009; Griffith et al., 1989).

Amphibians depend on the quality and quantity of microhabitats that provide adequate conditions for shelter, feeding, reproduction, stimulation, and escape from predators. Many amphibian species, particularly those that are threatened, have narrow or specific habitat requirements making them less adaptable to modified environments. It is therefore important to assess the habitat at a proposed translocation site to ensure it is suitable for the focal species. Whilst broad habitat requirements are generally known (e.g. if a species is forest dependent), specific habitat needs and therefore sensitivity to habitat modification is lacking (Nowakowski et al., 2017). Equally, as many poorly known threatened species may be hanging on in degraded habitats that are far from optimal, caution is needed in trying to use such habitats as a template for restoration elsewhere in order to expand the species range. Further research into this area is required, both to understand the reasons for population declines and to help inform conservation translocations.

Obtaining this information prior to a translocation may be difficult, but we suggest some options. First, understanding the broad macro- and micro-habitat features at a known species site and proposed translocation site will help inform site suitability. Second, when there is no or very little information about the species of conservation concern, evaluate available information on natural history known for a closely-related species – or a species thought to occupy a similar niche — to help inform the translocation.

Receptor site and habitat protection is crucial to ensure long-term success of the translocation. Protected areas are a cornerstone of global conservation of biodiversity, including amphibians, and operate under a diverse range of management models (Dudley, 2008). Effectiveness of protected areas is dependent on various factors including socio-economic and governance conditions (Barnes et al., 2016; Schleicher et al., 2017) as well as management and resource capacity (Geldmann et al., 2018). Successful translocations will therefore need to ensure appropriate measures are in place to safeguard receptor site integrity.

Some final considerations concerning habitat:

- Assess the impact of climate change on habitat suitability when selecting a site, as what is suitable now may not be in 20- or 50-years' time. Assisted colonisation is likely to become a more frequently used conservation tool in the future in light of climate change, increasing habitat loss, invasive species and the additional challenges these threats pose (Brodie et al., 2021).

- Habitat restoration at the site may be required to provide the necessary range of microhabitats or to connect habitat fragments within and between sites. Habitat restoration and/or creation should be part of any mitigation translocations undertaken.

- When undertaking translocations for mitigation or reinforcement, the quantity and quality of habitat needs to be assessed to ensure long-term-viability and to ensure conservation gains are made.

Disease

All translocations must assess the risk of infectious diseases. For example, diseases present at the release site may imperil translocated animals, or translocated animals may become a vector to spread a pathogen to new localities, which may impact existing populations or other species already present at the release site (Walker et al., 2008).

The spread of novel infectious diseases, including fungal, bacterial, and viral pathogens, has recently caused declines and even extinctions of numerous amphibian species (Bienentreu & Lesbarrères, 2020; Scheele et al., 2019). A more complete discussion of specific diseases and their impacts on amphibian conservation is available in Chapter 6. While it is virtually impossible to eliminate all risk associated with disease in a translocation, by implementing a variety of best practice measures and performing a thorough disease risk assessment it is possible to greatly reduce any negative impacts that may occur (Hartley & Sainsbury, 2017). Refining and adapting protocols via adaptive management experiments can also have the potential to assist translocations where disease threats are present (Scheele et al., 2021).

Best practice guidelines for reducing disease risks relating to amphibian translocation are available (e.g. Linhoff et al., 2021; Murray et al., 2011; Pessier & Mendelson, 2017), but several core principles should be followed. First, animals that are kept in captivity that will be reintroduced should be isolated from other species outside their native range that may be vectors for novel pathogens. Basic biosecurity measures when working with captive amphibians such as using dedicated footwear, hand washing, and sterilising equipment can help prevent the spread of diseases in captivity and the field (Pessier & Mendelson, 2017). Second, a formal disease risk assessment should be performed (Hartley & Sainsbury, 2017; Sainsbury, Armstrong & Ewen, 2012). Deciding on a translocation programme's goals and the acceptable risk thresholds are critical and can help make informed and calculated decisions. Disease risk analysis has been done for many amphibian translocations and some helpful herpetofauna examples exist (e.g. Bobadilla Suarez et al., 2017; Sainsbury et al., 2017). Third, prior to any translocation a pre-release disease screening should be performed. Animals can be screened for general health and specific pathogens using methods such as faecal parasite examinations or using polymerase chain reaction (PCR)-based screening for the common fungal pathogens Bd and Bsal (Pessier & Mendelson 2017). Translocations of sick and unhealthy animals should also be avoided.

Genetics

Our understanding of conservation genetics and their application to reintroductions has developed considerably since the original ACAP (Jamieson & Lacy, 2012). Even though rigorous habitat assessment of the release site may maximise the chances of animals establishing a viable population, there is a risk that the released stock may be maladapted to some degree. This is particularly the case when the animals for release stem from multiple generations of captive breeding (see above), particularly if the habitat in the receptor site may have changed in subtle ways (*see* Chapter 11). Likewise, animals that have been rescued from a small, remnant population that is threatened or non-viable, may represent a bottle-necked founder population with low genetic diversity and low capacity to survive at the release site. In deciding the optimal genetic constitution of a founder population for a reintroduction, a balance may need to be struck between ensuring sufficient genetic diversity to allow the establishment of a viable population and adaptation to the new conditions and minimising the risk of outbreeding depression.

Rigorous pre-release and post-release genetic screening of a population is desirable, albeit costly in terms of the overall reintroduction budget. Equally, as many rare and cryptic amphibian species have unresolved taxonomy and phylogeography, establishing genetic baselines for informing the reintroduction may involve timescales and funds that are difficult. Nevertheless, informed decisions based on existing knowledge of distribution and habitat requirements can be made concerning the number of individuals, stage structure and sources of donor populations. Integration of genetic and demographic modelling may be important in reintroduction decision models (Converse, Moore & Armstrong, 2013), but in practice reliable data may be difficult to obtain for many amphibian species requiring conservation interventions.

Monitoring

Determining whether reintroduction goals have been met requires post-release monitoring at an appropriate scale, appropriate level, and appropriate timeframe. 'Scale' will vary geographically from a single site to a whole geographical region. 'Level' ranges from basic presence/absence, through simple population counts and population densities, through to estimates of population size. There may well be a trade-off between 'scale' and 'level,' in that obtaining population estimates at a large geographical scale may be logistically difficult (as well as unnecessary), whereas establishing just presence or absence at a single release site may be convenient but uninformative. An appropriate timeframe for monitoring will reflect both 'scale' and 'level,' as well as the milestones that have been set by the project to measure 'success.' Different success milestones can be established at different places within the timeframe. These are usually related to **1)** establishing that released animals survive; **2)** establishing that released animals are breeding; and **3)** establishing that released animals have founded a self-sustaining, viable population or metapopulation (Griffiths & Pavajeau, 2008; Miller et al., 2014; Seddon, 1999). Milestone 3) will clearly take much longer to establish than either 1) or 2). Regardless, the timeframe set needs to be measured in terms of generation times rather than months or years, as different amphibians have different life histories that run at different speeds (Linhoff et al., 2021). Although there is no set timeframe for monitoring, a study of amphibian translocations found that on average, programmes showed higher levels of success after 15 years (Harding, 2014).

Whatever scale, level and timeframe are used, amphibians present some challenges for population assessment because many species are cryptic, with highly seasonal reproductive cycles. This means that any monitoring programme must account for issues associated with imperfect detection of populations or individuals (Schmidt, 2003). Fortunately, statistical models are now available that can account for such imperfect detection and are recommended to be incorporated into the design of monitoring programmes at an early stage (Griffiths et al., 2015). Monitoring may comprise direct observations of all stages of amphibians or the calls that they produce. Additionally, indirect observations may be informative. Environmental DNA (eDNA) is proving to be an increasingly powerful tool for detecting species that are otherwise difficult to observe directly. Although extrapolating eDNA concentrations in the field to levels of abundance is currently difficult, metabarcoding approaches have the advantage of assessing a range of other taxa that may be relevant to conservation status (e.g. presence of disease, competitors, or predators). Environmental DNA methods are advancing rapidly and are likely to become a valuable part of the toolkit for assessing the status of cryptic species at large geographical scales (Harper et al., 2019).

Release methodology

The incredible diversity of amphibian species means that a programme's release methodology will likely be highly species-specific. Without previous experience with a species, a period of experimentation or adaptive management may occur during releases. It is important to continually re-assess translocation release methodologies, learn from prior mistakes, maintain flexibility, and not be afraid to apply creative solutions to solve difficult problems. There are a variety of release techniques that are worth testing, which have successfully been used for amphibians or other taxonomic groups (Tetzlaff, Sperry & DeGregorio, 2019). There are generally two types of releases: hard-releases are where the animals are simply released into the wild with no further species management, and soft-releases where animals are provided some type of support at the release site. For example, soft-released animals may receive supplemental feeding, become acclimated to the release site in predator-proof enclosures (known as a delayed-release), or receive a combination of multiple supports (Parker et al., 2012).

Integrating experimental research into a translocation's release method can also be used to test explicit hypotheses (Kemp et al., 2015). For example, splitting release animals into separate treatments and releasing them under different conditions can provide direct comparisons of protocols if combined with post-release monitoring. Variations in release treatment location, season, life-stage, age, or tests of hard- and soft-release methods can be done. For example, in a study of Wyoming toads (*Anaxyrus baxteri*) a treatment of soft-released toads held in enclosures, designed to acclimate animals to the release site, reduced dispersal movements away from the release site compared to a treatment of hard-released toads. The behaviour of soft-released animals was also more like that of wild-conspecifics (Linhoff & Donnelly, 2022). Experimental releases may help inform management decisions and answer foundational questions for any translocation. While some of these release methods have been trialled in amphibians, techniques to improve release success have been implemented in other taxonomic groups and may be useful for amphibians. Techniques such as delayed-releases (Linhoff & Donnelly, 2022; Salehi, Akmali & Sharifi, 2019), acoustic anchoring (Bradley et al., 2011), supplemental feeding (Chauvenet et al., 2012), release with familiar individuals (Goldenberg et al., 2019), and predator control at the release site (Calvete & Estrada, 2004) may all be useful for some amphibian species.

Animal welfare

Every effort should be made to reduce stress or suffering during conservation translocations and programmes should adhere to internationally accepted standards for animal welfare (IUCN/SSC, 2013), such as the OIE Terrestrial and Aquatic Animal Health Codes. However, Harrington et al. (2013) determined that despite efforts to reduce stress and suffering, 67% of reintroduction projects reported animal welfare concerns for a variety of taxa. To address these concerns, they developed a useful decision tree for all stages of release (Harrington et al., 2013). There are many aspects of translocations that can negatively affect animal welfare for example improper capture and handling, lengthy travel to release sites, and exposure to disease. Animal welfare can also be compromised if a release site lacks suitable quality, quantity, or connectivity of habitat to meet the needs of all life stages (Germano & Bishop, 2009).

Stress experienced during translocation or captivity can reduce the fitness of translocated individuals by interfering with reproduction and increasing disease susceptibility, predation risk, and likelihood of dispersing from the release site to unsuitable habitat (Dickens, Delehanty & Romero, 2010; Griffin et al., 2000; Teixeira et al., 2007). Non-invasive methods of detecting stress have been developed by quantifying levels of corticosterone from skin or buccal swabs, urine, or water-borne hormone monitoring methods (reviewed in Narayan et al., 2019). However, stressors may not be equal for captive and wild translocated animals. Soft-releases may be beneficial for captive bred animals but may actually increase stress for wild-caught animals by prolonging their captivity (IUCN/SSC, 2013). Furthermore, because many amphibian translocations include a captive breeding component, animal welfare should be an important consideration for these programmes. Recent advancements in captive care techniques have the potential to improve the welfare of captive individuals (*See* Chapter 11). Additionally, a better understanding of the sensory ecology of the species as it pertains to animal welfare can help improve management strategies for reintroduction (Swaisgood, 2010).

Discussion

Challenges for reintroductions

Translocations are not a risk-free management tool. It is often more cost-effective and biologically productive to protect a species in situ. In some circumstances, however, translocations have become a useful and/or necessary tool for the conservation management of amphibian species. There have been increases in success rates of herpetofaunal translocations in the past (Dodd & Seigel, 1991; Germano & Bishop, 2009), but success rates of roughly 40% leave significant room for the translocation community to strive for further improvements. One of the greatest challenges therefore is to ensure that translocations

Box 14.4: Case Study: Northern pool frog (*Pelophylax lessonae*)

Background

The pool frog is native to central and northern continental Europe, but populations in the far north of its range are genetically distinct. In the UK, the species was initially considered an introduction but was later recognised as native after its extinction. The species was listed as a national biodiversity priority, and a reintroduction plan was developed to establish a population using northern clade stock from Sweden. The northern pool frog had no legal protection at the time of reintroduction, but is now fully protected under UK law.

Methods

Extensive research was conducted to confirm the native status of the northern pool frog in the UK and to assess the feasibility and desirability of reintroduction. A reintroduction strategy was formulated in consultation with amphibian and reintroduction experts. Habitat restoration efforts were undertaken at a confidential receptor site in Norfolk, England, based on characteristics of historic pool frog sites in the UK and existing sites in Sweden. Wild-to-wild translocation was chosen as the reintroduction method, with a mixture of adult frogs, juveniles, spawn and larvae captured in Sweden and flown to the UK for release. Disease risk assessments, management, and post-release health surveillance were implemented in collaboration with veterinary experts. Both head-starting and hard releases were used, with releases occurring from 2005-2008.

Results and outcomes

Post-release monitoring consisted of three main components: monitoring of released pool frogs; monitoring of co-existing amphibians, reptiles, and habitat condition; and monitoring of health status. The reintroduced population successfully established a breeding population, with a stable adult population size estimated at 67 (at the end of 2016). Regular breeding was observed, although some years showed low counts of metamorphs or juveniles. The pool frogs colonised multiple ponds, and habitat conditions supported a range of other wildlife species. Common frogs exhibited substantial population growth, while the status of newts remained unchanged. Health monitoring indicated that the pool frogs and other amphibians were in good health, with no evidence of serious infectious diseases. The reintroduction of the northern pool frog contributed to national biodiversity and represented a significant gain for the species' European status. The case study demonstrated the successful implementation of a reintroduction strategy, highlighting the importance of thorough research, stakeholder collaboration, habitat restoration, and ongoing monitoring for the success of such conservation efforts.

Current status and threats

Populations at the reintroduction site have continued to increase alongside continued reintroductions of late-stage tadpoles from head-started captive stock. Management continues at the reintroduction site to maintain the openness of the ponds and an additional reintroduction site has been established.

See Foster et al., 2018 and https://www.arc-trust.org/recovering-the-pool-frog-englands-rarest-amphibian for further details are done well, and in a way that knowledge is gained and improvements (both species-specific and general) can continue to be made and shared.

Perhaps one of the greatest threats to the use of translocations for amphibian conservation comes in the development space where they are being used as a tool to mitigate the impact of habitat destruction and human development. Thorough IUCN guidance on translocations has been available for many years (IUCN, 1998; IUCN/SSC, 2013) but this guidance is rarely utilised or followed in these types of releases. More recently amphibian specific translocation guidance has been produced, (Linhoff et al., 2021) and it is hoped this may be better utilised. Additionally, the initial threat to a species must be mitigated for a translocation to succeed and to have a net gain for conservation (e.g. destruction of habitat and translocation of animals to a small portion of remaining habitat equates to a net loss overall). Furthermore, the release of animals salvaged from a construction site and released on top of an existing population that may already be at carrying capacity, puts both resident and translocated individuals at risk and further reduces the chance to mitigate for the human mediated destruction of habitat and populations. For releases that cannot meet these standards, government agencies that regulate such releases, and the practitioners and managers who perform them, need to assess and use other tools that may deliver the desired conservation outcomes. The dilemma of reconciling the needs of burgeoning human populations with habitat destruction worldwide is one of the greatest threats facing amphibians. This is also an area where compensation and management dollars spent on translocations may not be delivering intended benefits to the species or mitigating damage to species and their habitat. Practitioners working in this space should be following the mitigation hierarchy (avoid, minimise, restore and offset) outlined by best practice guidelines such as the Business and Biodiversity Offsets Programme (BBOP 2103).

In addition, another challenge on the translocation horizon is how the reintroduction biology community can use this tool in the face of climate change. Whilst translocations linked to assisted colonisation are rare there is little doubt that they can play a role in this work, but it comes with other complexities that will need to be dealt with (Butt et al., 2021; Chauvenet et al., 2013).

Recommendations

Both the amphibian conservation and reintroduction biology communities need to continue to build the capacity for practitioners and managers to work successfully in the translocation space. This includes education around the complexities and planning for translocations as outlined in some of the main detailed guideline documents (*see* Box 14.5). Government agencies and consultants also need to be educated about the success rates and dangers of using translocations and how they fit into the greater mitigation hierarchy, which should be the benchmark for addressing issues surrounding clashes between wildlife and human development.

To continue to improve techniques, the results, and challenges of releases, including failures, must be shared amongst the amphibian and translocation communities. While scientific publications may be the gold standard of analysis and communication, publications such as the *Global Reintroduction Perspectives* publications (Soorae, 2008; 2010; 2011; 2013; 2016; 2018; 2021) and databases of translocations are also key particularly in addressing potential publication bias towards successful translocations (Miller et al., 2014). Translocation databases are maintained by some government agencies and for some species (e.g. Lincoln Park Zoo maintained an avian translocation database), there is great potential for this to be developed on a wider scale as an accessible and evolving resource for practitioners worldwide.

Conclusions

Translocations are a tool that has grown in use throughout the world and across numerous taxonomic groups. Amphibian translocations have been

Box 14.5: Useful guidelines and reference documents for amphibian reintroductions

IUCN guidelines for amphibian reintroductions and other conservation translocations: first edition (https://portals.iucn.org/library/node/49485)

IUCN guidelines for reintroductions and other conservation translocations (https://portals.iucn.org/library/node/10386)

Department for Environment Food & Rural Affairs, 2021. Reintroductions and other conservation translocations: code and guidance for England https://www.gov.uk/government/publications/reintroductions-and-conservation-translocations-in-england-code-guidance-and-forms

Guidelines for conservation-related translocations of New Zealand lizards https://www.doc.govt.nz/globalassets/documents/getting-involved/translocation/translocation-best-practice-lizards-1.pdf

Great crested newt mitigation guidelines http://mokrady.wbs.cz/literatura_ke_stazeni/great_crested_newt_mitigation_guidelines.pdf -

Best management practices for amphibian and reptile salvages in British Columbia http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=10351

Guidelines for mitigation translocations of amphibians: Applications for Canada's Prairie Provinces https://www.researchgate.net/publication/323783710

Kihansi spray toad re-introduction guidelines. http://www.amphibians.org/wp-content/uploads/2013/07/kihansi-spray-toad-re-introductionguidelines.pdf

The Scottish code for conservation translocations. Scottish Natural Heritage. http://www.snh.gov.uk/docs/A1327922.pdf

Kleiman, D. G., Stanley Price, M. R. & Beck, B. B. (1994). Criteria for reintroductions. In P. Olney, G. Mace, & A. Feistner (eds.), *Creative conservation: Interactive management of wild and captive animals* (pp.287–303). London, UK: Chapman & Hall.

Amphibian population management guidelines. http://www.amphibianark.org/pdf/Aark%20material/AArk%20Amphibian%20Population%20Management%20Guidelines.pdf

a part of this growth. With a concerted effort for practitioners and managers to follow and share best practice guidelines and the continued research into improving methodology, it is hoped that the success rates of these releases will continue to improve.

Priority actions and knowledge gaps

- Priority actions

  » Focus on threat mitigation prior to conservation translocation.

  » All translocations, whether driven by conservation or mitigation needs, should follow established best-practice guidelines.

  » Knowledge sharing of best practice around translocations within the wider conservation sector including greater publication of reasons for failure.

  » Stricter regulation and assessment of development mitigation translocations and following the mitigation hierarchy rather than jumping straight to the use of translocations.

- A focus on alternatives to mitigation translocations.

- Receptor site and habitat protection is crucial to ensure long-term success of the translocation. Protected areas are a cornerstone of global conservation of biodiversity, including for amphibians, but operate under a diverse range of management models (Dudley, 2008). Effectiveness of protected areas is dependent on various factors including socio-economic and governance conditions (Barnes et al., 2016; Schleicher et al., 2017) as well as management and resource capacity (Geldmann et al., 2018). Successful translocations will therefore need to ensure appropriate measures are in place to safeguard receptor site integrity.

- **Knowledge gaps**

  - Examples of potential reintroductions that were not undertaken as a result of low feasibility or alternative management options.

  - Examples of translocations that did not go to plan (*see* Box 14.2 and Borzée et al., 2018), and adaptive management that resulted in alternative interventions or failures to improve our understanding of translocations as a tool and the methodologies being used.

  - Whilst broad habitat requirements are generally known, specific habitat needs and therefore sensitivity to habitat modification is lacking (Nowakowski et al., 2017). Furthermore, where species exist in relict populations in degraded habitats that are far from optimal, caution is needed in trying to use such habitats as a template for restoration elsewhere. Further research into this area is required, both to understand the reasons for population declines and to help inform conservation translocations.

  - Likewise, in the face of climate change, a better understanding of the potential climate regimes that species could successfully inhabit is needed. How assisted migration can be carried out successfully to help species adapt to changing climates is an area of research need.

  - Research is required into more appropriate tools that can be used instead of and alongside mitigation translocations to deal with habitat and population loss caused by human development.

Box 14.6: Glossary

Translocation: the movement of an organism by human agency that is then released in a different area; the most general and highest order term referring to human mediated movement of a species/subspecies/taxon.

Conservation translocation: intentional movement and release of living organisms where the primary objective is for conservation purposes.

Assisted colonisation: is the intentional movement and release of an organism outside its indigenous range to avoid extirpation of populations or extinction of the focal species. Assisted colonisation is primarily carried out where protection from current or likely future threats in the current range is deemed less feasible than at alternative sites outside its indigenous range.

Reintroduction: is the intentional movement and release of an organism(s) inside the species' indigenous range to a site from which the species has disappeared.

Reinforcement/Supplementation: is the intentional movement and release of an organism(s) into an existing population of conspecifics, and is synonymous with the terms augmentation, supplementation, and restocking. Reinforcement may be done for several reasons, including to enhance population viability, increase genetic diversity, or increase the representation of specific demographic groups or stages.

Mitigation translocation: the intentional removal of organisms from habitat that will be lost through anthropogenic land-use change or threat, and release at an alternative site.

Definitions are based on the 2013 *IUCN Guidelines for Reintroductions and Other Conservation Translocations* (IUCN, 2013)

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Northern leopard frog eggs (*Lithobates pipiens*) © Lea Randall - Wilder Institute

A translocation of *Leiopelma hamiltoni* from Takapourewa/Stephens Island to Nukuwaiata, a nearby island, was a key step in improving the conservation status of the Takapourewa ESU (*see* Box 14.3). This species was downlisted on the Red List, from Endangered in 2004 to Vulnerable in 2015. © Samuel Purdie

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