From Re-introduction to Assisted Colonization:
Moving along the Conservation Translocation Spectrum

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Philip J. Seddon

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Send correspondence to Philip Seddon
Department of Zoology
University of Otago
P O Box 56
Dunedin
New Zealand

Email: philip.seddon@otago.ac.nz

Abstract

Translocation, the intentional movement of living organisms from one area to another is increasingly being used as a conservation tool to overcome barriers to dispersal. A dichotomy exists for conservation-oriented translocations: on one hand there are those that release plants or animals into known historic ranges, on the other hand there are releases outside historic distributions. Misuse of or attempts to redefine established terms, and a proliferation of variants of new terms such as assisted colonization, confuse and hamper communication. The aim of this opinion paper is to describe and define a conservation translocation spectrum, from species re-introductions through to assisted colonization, and beyond, and in so doing provide a standard framework and terminology for discussing translocation options. I suggest that we are moving along this spectrum, away from the dictates of historical species distribution records, towards the inclusion of more risky interventions that will be required to respond to habitat shifts due to anthropogenic impacts. To some extent rapid climate change changes everything, including how we should view introductions versus reintroductions. We need seriously to consider adding other approaches to our conservation toolbox. Assisted colonization will start us along this path, acknowledging as it does the accelerated rate of habitat change and the problems of attempting to preserve dynamic systems. The next step along the conservation translocation spectrum may be for reintroduction biology and restoration ecology to more comprehensively join forces on carefully selected projects to use species introductions to create novel ecosystems through active ecological community construction.

Introduction

The extent of habitat loss, fragmentation and change, coupled with the decline and loss of species from parts of their range due to over-exploitation and other human-induced pressures, means that restoration of viable free-ranging populations can seldom be achieved by reliance on natural recruitment and dispersal alone. Increasingly translocation, the intentional movement of living organisms from one area to another (IUCN 1987), is used to overcome barriers to dispersal. Humans have moved wild species around for millennia, for a wide variety of reasons. Here I'm concerned only with translocations that have the principal objective of population conservation, thus excluding other, often common types of translocations that have other primary motivations, such as the release of rehabilitated or problem animals, or for recreational or commercial purposes.

An apparently simple dichotomy exists for conservation-oriented translocations: on one hand there are those that release plants or animals into their known historic ranges, on the other hand there are releases outside historic distributions. At one end of a translocation spectrum (Table 1) there are re-introductions, at the other end are forms of conservation introduction (IUCN 1998), including assisted colonization (Hoegh-Guldberg et al. 2008).

Misuse of or attempts to redefine established terms and a proliferation of new terms have the potential to confuse and hamper communication. The aim of this essay is to define a conservation translocation spectrum, from species re-introductions, through to assisted colonization, and beyond, and in so doing provide a standard framework and terminology for discussing translocation options.

I will make the case that we are moving along this spectrum, away from the almost sole reliance on the rigid and often flawed dictates of historical species distribution records, towards the inclusion, where appropriate, of more aggressive and risky interventions that will be required to respond to habitat shifts due to anthropogenic impacts. To some extent rapid climate change changes everything, including how we should view introductions versus reintroductions.

Population Restorations

I use the overarching term **population restoration** to encompass translocations that seek to re-establish viable populations within the known distribution range of a species, i.e. to restore a self-sustaining population, either through **re-introduction**, or **re-stocking**.

Re-introduction involves the release of an organism into an area that was once part of its range but from which it has been extirpated (IUCN 1987; Table 1). The World Conservation Union (IUCN) Guidelines for Re-introductions (IUCN 1998) place emphasis on the identification of release sites within the historic range of the species and acknowledge a need to ensure that previous causes of decline have been addressed. The implicit assumption is that because extirpation has taken place within historic times, then re-introduction will focus on sites within the range of a species, known or inferred within relatively recent timeframes. To some extent the requirement of recent (here taken to be within the last few hundreds of years) range occupation is a safeguard against habitat change. However, information from even pre-historic reference points is increasingly of interest for the identification and characterization of restoration targets (Jackson & Hobbs 2009).

Three things weaken the deceptively simple premise that historical range is a reliable guide to future habitat suitability: unreliable historical records, arbitrary reference points, and accelerating habitat change. Historical records of species presence have inherent shortcomings (Ponder et al. 2001). Records may be absent for a given location because that species may have been there but never seen, or even seen but never recorded. Species distribution maps are based on occurrence records, despite all their problems (summary in Frey 2006). Uncertainty may arise where there are errors of species identifications, and where specific locations of confirmed sightings have not been adequately recorded, or with specimen mislabelling or even fraudulent records (Boessenkool et al. 2010; Dalton 2005). Sampling is often uneven (Maddock & Du Plessis 1999) and distribution maps may be more reflective of which areas are most visited by observers, rather than which areas are preferred species habitat.

The use of documented species distributions to determine release sites in reintroductions necessitates the acceptance of arbitrary reference points and implicitly assumes static distributions and stable environmental conditions. Reintroduction biologists must ask the question: restore to what? The answer to which will vary regionally. In New World countries of Oceania, and the Americas, historical restoration targets are often related to some state that existed immediately prior to major Western human influence (Jackson & Hobbs 2009). In Europe however, with a much longer history of human occupation, restoration goals may be tied to pre-industrial eras and to address relatively recent species declines. Setting targets is a challenge that is being debated also by restoration ecologists who recognise the inherent problems in trying to replicate some arbitrary condition in the past (Temperton 2007), including a lack of accurate historical records (Hobbs 2007), the dynamic nature of ecological systems (Choi et al. 2008), and the occurrence of irreversible losses or change (Hobbs & Harris 2001, Jackson & Hobbs 2009).

Whereas the IUCN guidelines emphasise the need to address the causes of previous declines (IUCN 1998), it is a harder task to ensure that other changes have not occurred to once suitable habitat. For example, although reintroduction is increasingly being recommended as a conservation a strategy for endangered plants (Maunder 1992), few attempts have resulted in the establishment of viable populations (Allen 1994), in part due to the challenges of matching source and recovery sites (Lawrence & Kaye 2009), particularly where there has been loss of target communities within a species historic range (Possley et al. 2009). The Arabian ostrich (*Struthio camelus syriacus*), which was hunted to extinction by the 1950s, but was probably doomed to disappear from south central Arabia because of long-term climate change – hunting may have just hastened the end (Seddon and Soorae 1999). Thus the former presence of ostriches in the southern Arabian desert, the Rub Al Khali, and the creation of large no-hunting protected areas there (Seddon 2000), are unable to ensure the successful establishment of new ostrich (*S. c. camelus*) populations in now hyper-arid dune lands.

Re-stocking (IUCN 1987), also termed **re-enforcement** and **supplementation** (IUCN 1998), **augmentation** (Maguire & Servheen 1992), or, in reference to plant translocations, **enhancement** (Allen 1994), entails the release of individuals into an existing population of conspecifics (Table 1). Animal re-stocking aims to boost total and effective population size, and avoid critically low population size thresholds with their attendant risks of genetic or demographic collapse due to stochastic effects. Translocation of plants for re-stocking is similarly used to overcome barriers to natural dispersal from other free-ranging populations, to speed up population growth, or to enhance genetic diversity and avoid inbreeding depression (Allen 1994; Falk et al. 1996).

Unlike re-introductions, in re-stocking some of the uncertainty over habitat suitability is removed, but not all. The existence of conspecifics does not guarantee habitat suitability (Schlaepfer et al. 2002). Changes in habitat may reduce population viability by increasing mortality and/or reducing fecundity. Reintroductions should not attempt to re-establish populations in areas where local extinctions were due to local declines in habitat quality (Armstrong & Seddon 2008). In contrast however, there may be situations where re-stocking can be used to supplement existing but temporarily non-viable populations in poor quality habitat where reproduction cannot currently compensate for local mortality (e.g. van Heezik et al. 2009). Without a clear long-term strategy for mitigating limiting factors and/or sustaining intensive management, this would literally be pouring new animals down the sink (sensu Pulliam 1988).

Conservation Introductions

Any mediated movement of organisms outside their native range is a species introduction (IUCN 1987). If the intent for such releases is the establishment of a new population explicitly for conservation, then it is termed a **benign** or **conservation introduction** (IUCN 1998), and the usual concerns over habitat suitability will apply.

Existing guidelines recognise only one justification for conservation introductions: “when there is no remaining area left within a species’ historic range” (IUCN 1998: 3). This focus sought to counter a proliferation of ill-conceived translocations that were effectively species introductions under the guise of conservation management (Stanley Price & Soorae 2003). There are two further rationales for conservation introductions: **ecological replacement**, and **assisted colonization**

Ecological replacement is the release of a species outside its historic range in order to fill an ecological niche left vacant by the extinction of a native species. Extinction removes the option of reintroduction and may mean the loss of critical ecological functions. One option is therefore to restore lost function through the establishment of an ecologically similar species (Atkinson 2001). The most parsimonious approach is the release of a closely related taxon, ideally a subspecific substitution (Seddon and Soorae 1999), but other functionally equivalent forms may be possible replacements. For example, Aldabran giant tortoises (*Aldabrachelys* sp.) have been used to restore selective grazing and seed dispersal functions once performed by the now extinct giant *Cylindraspis* tortoises on islands in the Indian Ocean (Griffiths et al. 2010).

The concept of **assisted colonization** has stimulated recent debate, and has also spawned some confusing terminology, e.g. assisted migration (McLachlan et al. 2007), and managed relocation (Richardson et al. 2009). The term migration more commonly refers to seasonal round trip movements (Hunter 2007) and does not capture the critical feature of moving organisms outside their range, while relocation is simply a synonym for translocation. I prefer the term assisted colonization, as it captures the key feature that species are deliberately being moved to areas outside their known historic ranges in order to establish new population for conservation targets. Recent interest in this form of conservation introduction has been driven by the predicted impacts on species distributions due to rapid climate change. The relative newness of this specific threat has given the impression that this type of translocation is something new – this is not the case. The best definition of assisted colonization is that of Ricciardi & Simberlof (2009 a): "translocation of a species to favourable habitat beyond their native range to protect them from human induced threats, such as climate change" (Table 1). So while climate change may loom as perhaps the most significant future threat (King 2004), assisted colonization could be and has been used to mitigate a variety of threats, including agricultural expansion and urbanization (Ricketts & Imhoff 2003), and the threats posed by (other) deliberately introduced species (Vitousek et al. 1997).

The current debate around assisted colonization focuses on uncertainty and the risk posed by introduced species (Mueller & Hellmann 2008; Ricciardi & Simberlof 2009 a, b; Sax et al. 2009; Seddon et al. 2009; Vitt et al. 2009). Some commentators confuse the concept of assisted colonization with translocations in general, claiming that the "idea of manually relocating species is decidedly controversial" (Marris 2008), and "notions of deliberately moving species are regarded with suspicion" (Hoegh-Guldberg et al. 2008), or that the detractors of assisted colonization are attempting to "prohibit intentional translocation of species for conservation purposes" (Schlaepfer et al. 2009). Clearly however, the deliberate moving of species is neither new nor controversial, and even releases outside known species distribution ranges are already positioned on the translocation spectrum. Far from being a "strategy that flies in the face of conventional conservation approaches" (Hoegh-Guldberg 2008) assisted colonization is a well-established (if recently named) conservation tool in some parts of the world. In New Zealand, extinction threats to endemic birds, herptiles and invertebrates posed by introduced mammalian predators have been addressed through translocations to predator-free offshore islands (Saunders & Norton 2001) that may not be historically documented parts of the species range. These translocations are effectively assisted colonizations, resulting in viable new populations in new areas (Atkinson 2001). The urgency of having to save critically endangered endemics has meant that New Zealand conservation managers have had fewer qualms about the dictates of historical distributions. Similarly for plant release sites, there may be a choice between known versus potential (suitable but previously unoccupied) habitat and, in the face of global climate change, selection of potential habitat may be necessary to ensure population persistence (Fiedler & Laven 1996).

Beyond Assisted Colonization

Traditionally ecological restoration has sought to return an ecosystem to some pre-disturbance state (Hobbs and Cramer 2008), but restoration ecologists have attempted to chart new directions to overcome perceived problems due to the setting of restoration goals that are subjective, arbitrary, unsustainable and impractical (Davis 2000; Digglelen et al. 2001; Holl et al. 2003; Halle 2007; Montalvo et al. 1997). Commentators have proposed new directions that do not seek to create exact replicas of the past (Temperton 2007), but rather acknowledge the dynamic nature of ecosystems subject to both natural spatial and temporal variation and human-induced change (Hobbs 2007; Hobbs & Cramer 2008; Jackson & Hobbs 2009). There is recognition that global climate change in particular, reduces the usefulness of historical ecosystem conditions as restoration reference points (Harris et al. 2006). Instead of using historical reference points, restoration ecologists are being urged to manage for ecosystem function and to focus on establishing the desired characteristics for a resilient system (Harris et al. 2006) to enable persistence in future environments (Choi 2007).

Restoration ecologists have recognised that anthropogenic drivers of environmental change may result in the development of emerging ecosystems; defined as “an ecosystem whose species composition and relative abundance have not previously occurred within a given biome” (Milton 2003). Also termed “novel ecosystems” (Chapin & Starfield 1997), or “no-analog communities” (Jackson & Hobbs 2009), these new assemblages of species have challenged the prevailing paradigm that by managing human impacts it is possible to return nature to some stable, pristine state (Hobbs & Cramer 2008). Rather than attempting to force changed ecosystems back to some, likely unsustainable or unattainable, pre-existing conditions, the development of novel ecosystems could be guided to maximise benefits (Hobbs et al. 2006) and to promote ecosystems that are feasible and resilient (Seastedt et al. 2008). Radically, this may include the active creation of “novel systems using species not native to the region” (Hobbs & Harris 2001), to maximise genetic, species and functional diversity (Seastedt et al. 2008), thus shifting from “historic” to “futuristic restoration” (Choi 2004), and the creation of “designer” (Temperton 2007) or “engineered” ecosystems (Jackson & Hobbs 2009), in which ecosystem function has been rehabilitated for future environments (Choi et al. 2008). The application of engineering principles to ecosystem management was first mooted in the 1960s by Howard Odem (Mitsch & Jorgensen 2003), entailing the use of engineering processes in natural or constructed natural systems to solve environmental problems, even to the extent of community engineering involving the design of new sets of species for specific purposes (Kangas 2004). Ecological engineering, defined as the “design, construction, operation and management of landscape and aquatic structures and associated plant and animal communities to benefit humanity and nature” (Barrett 1999), has grown into a discipline of its own, with restoration ecology considered by some to be a sub-discipline (Kangas 2004). Of relevance for reintroduction biologists is the controversial notion of introducing species as part of the development of new types of sustainable ecosystem that have both human and ecological values (Mitsch & Jorgensen 2004). I suggest that reintroduction biologists need to consider the possibility of adopting an ecological engineering perspective to use conservation translocations as a means to introduce species into suitable habitat outside their historic distribution range in order to contribute to the construction of new ecological communities. This **community construction** (Table 1) would serve both species conservation objectives and ecosystem restoration goals in the face of climate-driven habitat change. This need not require the translocation of entire ecological communities, rather the focus could be on relatively few keystone species and ecosystem engineers, acknowledging the self-design capability of ecosystems. Mitsch & Jorgensen (2004) suggested that because a natural system “manipulates its physical and chemical environment” and is “ultimately designing a system that is ideally suited to the environment that is superimposed on it”, then the self-design capability of an ecosystem “allows nature to do some of the engineering”. Perhaps the most provocative recent proposal for ecological engineering to create a novel ecosystem is that of “Pleistocene re-wilding” (Donlan et al. 2006), whereby the multitude of ecological functions once performed by now-extinct North American megafauna, could be replaced through the translocation of a suite of ecological replacements, some of which may be threatened by habitat loss or change. Although considered extreme (Rubenstein et al. 2006; Caro 2007)), the notion of Pleistocene re-wilding has stimulated a re-think of the future of restoration strategies.

In parallel with restoration ecology, the emerging discipline of reintroduction biology has been grappling with similar issues (Seddon et al. 2007 a), including developing its scientific underpinnings (Seddon et al. 2007 b) and seeking unifying research directions (Armstrong & Seddon 2008). To some extent a focus on the rigid requirements of reintroduction that insists on historically documented species distributions to serve as a target has created more angst than it should. IUCN re-introduction guidelines attempt to prevent ill-conceived releases, but have been interpreted as rules that may limit the ability of conservation managers to undertake innovative interventions (e.g. Shah 2003).

With increasing human-induced ecosystem change, we now need seriously to consider adding other approaches to our conservation toolbox. Assisted colonization will start us along this path, acknowledging as it does the accelerated rate of habitat change and the problems of attempting to preserve dynamic systems. The next step along the translocation spectrum will be for reintroduction biology and restoration ecology to more comprehensively join forces on carefully selected community construction projects to create novel resilient ecosystems.

Implications for Practice

- Historic distribution records will always provide a good starting point for identifying translocation release sites, but global climate change and the dynamic nature of ecosystems means that historical species ranges have only limited use. Other, even prehistoric reference points, and species-specific habitat suitability assessments should be considered.
- Single-species conservation actions in the core of historic range will remain the backbone of many conservation efforts, but increasingly we need to adopt an

ecosystem focus and consider the translocation of suites of species to restore key ecological functions. Ecological functions once performed by now extinct taxa can be restored through the introduction of ecological replacements, which may themselves be threatened in their native range.

- Reintroduction biologists and restoration ecologists should join forces in selected projects to create novel ecosystems, including, where appropriate, ecological community construction via conservation introductions, to serve both single-species conservation and ecosystem management objectives.

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