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Editorial: The Role of Zoos and Aquariums in Reintroductions and Other Conservation Translocations

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The world is facing a biodiversity crisis in which hundreds of species have already been driven to extinction by anthropogenic activities and populations of surviving species have substantially declined (Pereira *et al.*, 2010; WWF, 2016). These effects have led to small and fragmented wildlife populations that are then at greater risk of extinction from intrinsic population factors and chance events (Frankham *et al.*, 2010). Conservation translocations can counter and reverse some of these effects by demographically or genetically augmenting small wild populations (reinforcement), re-establishing populations in the species' indigenous range (reintroduction) or establishing new populations in natural habitat outside the indigenous range of the species (conservation introduction, divided into assisted colonization and ecological replacement) (IUCN/SSC, 2013).

Conservation translocation is 'the intentional movement and release of a living organism where the primary objective is a conservation benefit' (IUCN/SSC, 2013), and it has a long history. One of the earliest recorded examples dates back to 1895 when Richard Henry translocated Southern brown kiwi *Apteryx australis* and Kakapo *Strigops habroptilus* from mainland New Zealand, where the flightless birds were at risk of extinction from introduced predators, onto the predator-free Resolution Island in the remote Fiordland region of the west coast of South Island (Seddon *et al.*, 2015; Seddon & Armstrong, 2016). This attempt ultimately failed (Seddon & Armstrong, 2016), but Richard Henry's pioneering effort to save threatened flightless birds was groundbreaking. Since then, innumerable conservation translocations have taken place, but it was in the 1970s and 1980s that the practice gained greater prominence with the reintroduction of high-profile species including Arabian oryx *Oryx leucoryx* and Golden lion tamarin *Leontopithecus rosalia* (Seddon *et al.*, 2007). The number of species and the diversity of taxa reintroduced, and the number of reintroduction projects have increased substantially in recent years (Seddon *et al.*, 2007; Maschinski & Haskins, 2012; Jachowski *et al.*, 2016), as has the number of publications tackling the subject. Between 2008 and 2016, the IUCN published five volumes of *Global Re-introduction Perspectives* documenting case studies from 290 projects worldwide and listing success and failure, amongst other criteria (Soorae, 2008, 2010, 2011, 2013, 2016).

THE ROLE OF ZOOS AND AQUARIUMS IN REINTRODUCTIONS

Zoological institutions are developing into conservation organizations and strengthening their commitment to the conservation of wild populations and their habitats (Barongi *et al.*, 2015). At the same time, wide-ranging anthropogenic activities increasingly result in the restriction of wildlife populations to human-dominated landscapes where wild populations are under some degree of human intervention (Mallon & Stanley Price, 2013). The traditional *in situ–ex situ* paradigm is being replaced by a spectrum of management intensity in support of species conservation. Management ranges from self-sustaining populations in natural habitats that require little support to populations within zoos and aquariums under human care (Redford *et al.*, 2011). Increasingly, species are becoming 'conservation reliant' each requiring a variety of conservation approaches for their continued survival (Scott *et al.*, 2010; Redford *et al.*, 2011).

The move away from the *in situ–ex situ* dichotomy lends itself towards integrated species-conservation management such as the One Plan approach coined by the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Conservation Breeding Specialist Group (CBSG) (CBSG, 2011; Traylor-Holzer *et al.*, in press). To better align its name with its work and with the elevated role of the One Plan approach in species conservation planning, CBSG is now known as the Conservation Planning Specialist Group (CPSG). The One Plan approach 'supports integrated species conservation planning through the joint development of management strategies and conservation actions by all responsible parties to produce one comprehensive conservation plan for the species', encompassing all populations both within and outside indigenous range of the species (Byers *et al.*, 2013). This may lead to metapopulation management of global populations where animals move between wild, semi-wild and captive populations to enhance the survival of the species. Conservation translocations have an important role to play within this context, establishing or re-establishing wild populations in the natural habitat of the species, and moving animals between wild populations to enhance genetic diversity, demographic stability or long-term sustainability (Hayward & Slowtow, 2016).

This flow of individuals between wild, semi-wild and conservation-breeding populations is exemplified by several papers in this volume. For example, the Programa Conservación Cóndor Andino's (PCCA) strategy to reinforce wild Andean condor *Vultur gryphus* populations in Argentina has a comprehensive conservation plan that combines *in situ* and *ex situ* components, including action to protect extant wild populations, the rescue, rehabilitation and release (where possible) of condors, breeding for release and a managed insurance population within zoos (Astore *et al.*, 2017). Similarly, Hogg *et al.* (2017) detail an integrated species-conservation strategy for the Tasmanian devil *Sarcophilus harrisii* that includes the management of a metapopulation across zoo-based facilities, free-ranging enclosures, an island and a fenced peninsula in the presence of a contagious lethal cancer, the devil facial tumour disease. Other papers firmly place species reintroductions and reinforcements into strategic landscape-scale conservation projects where the roles of captive breeding and conservation translocation are born out of the identified conservation needs of the species or ecosystems (Bird *et al.*, 2017; Gardiner *et al.*, 2017; Nightingale *et al.*, 2017).

In addition to providing animals or plants for release to the wild, the skills and expertise that have been acquired by zoos and aquariums readily lend themselves to conservation translocations (Stanley Price & Fa, 2007; Redford *et al.*, 2012; Jakob-Hoff *et al.*, 2015). In particular: animal handling; captive breeding of animals and propagation of plants; animal husbandry; transportation of animals; enclosure design and construction; wildlife veterinary medicine; biosecurity; animal identification and record-keeping; research; population analysis, modelling and management; public engagement; conservation education; project management; risk assessments and legislative compliance; public and media relations; field conservation including wildlife surveying. Additionally, zoos and aquariums have the resources to provide animals, funding or equipment to conservation translocations (Gilbert *et al.*, 2017).

We do not have the scope to examine all of the areas where zoos and aquariums might contribute to conservation translocations, but we think that it is important to highlight conservation education as an example. Zoos and aquariums have considerable experience and expertise in education and public engagement. Every year, more than 700 million people visit zoos and aquariums around the world (Gusset & Dick, 2011), and many of these people attend public-engagement sessions, talks and displays, and view static and interactive interpretation while they are there. Visitors also participate in formal education and 1.8 million students attended organized education sessions in British and Irish Association of Zoos and Aquariums (BIAZA) member institutions in 2016 (N. Needham, pers. comm., 2017). Further outreach sessions in the local community or at field-conservation sites also seek to connect people with nature (Thomas, 2016). This experience can be applied to conservation-translocation projects, which often include a social or education component to encourage a cultural shift in attitude towards the species of concern, its habitat or the wider environment (George & Sandhaus, 2016). This may take the form of an outreach project as per the example of Astore *et al.* (2017), who combined formal and informal education sessions and materials to inform the public and change attitudes towards Andean condors. Similarly, the innovative education campaign to address widespread negative attitudes towards snakes in Antigua has contributed to the success of the Antiguan racer *Alsophis antiguae* reintroduction programme (Daltry *et al.*, 2017). However, some conservation translocations go further and place people at the heart of the process. The project on Rotoroa Island in New Zealand aims to contribute to the conservation of wildlife through education, training and visitor-engagement activities, and consequently carried out conservation introductions of seven native species to the Island to meet this aim. The creation of a designed ecosystem primarily for education and training programmes is unique in New Zealand, and is a novel approach to wildlife conservation (Fraser *et al.*, 2017).

Zoos and aquariums have considerable experience in managing a variety of taxa resulting in them being well placed to contribute to a wide range of conservation-translocation projects. The papers in this volume exemplify how zoos and aquariums can participate in such projects for birds (Astore *et al.*, 2017; Fraser *et al.*, 2017; Fritz *et al.*, 2017; Mawson & Lambert, 2017), mammals (Hogg *et al.*, 2017; Mawson & Lambert, 2017; Parrott *et al.*, 2017), reptiles (Daltry *et al.*, 2017; Fraser *et al.*, 2017; Mawson & Lambert, 2017; Woodfine *et al.*, 2017), amphibians (Ettling *et al.*, 2017; Mawson & Lambert, 2017), terrestrial invertebrates (Gardiner *et al.*, 2017), aquatic invertebrates (Nightingale *et al.*, 2017) and plants (Bird *et al.*, 2017). This volume does not contain any case studies of conservation-translocation projects for fish, and although zoos and aquariums have certainly been involved in re-establishing fish populations in the wild (e.g. George *et al.*, 2013), they are an under-represented taxa in zoo and aquarium-related reintroduction projects in respect to their prevalence in nature and their popularity in zoos and aquariums (Gilbert *et al.*, 2017). This may be attributable to the undefined conservation needs of many fish species [e.g. less than half (48%) of the 33 400 identified species of fishes have been assessed for *The IUCN Red List of Threatened Species* (IUCN, 2016)] or conservation translocations may not be an appropriate intervention for the conservation of many fish species. The majority of conservation translocations still focus on birds and mammals (Seddon *et al.*, 2005; Soorae, 2008, 2010, 2011, 2013, 2016; Gilbert *et al.*, 2017); however, there are numerous taxa within the living collections of zoos and aquariums that have the potential to make substantial contributions to the restoration of the wide range of species that require conservation action, if they so choose.

All of the conservation-translocation papers in this volume describe projects that are the result of partnerships between zoos, governmental agencies and statutory bodies, universities, non-government organizations, charitable trusts, landowners and other stakeholders. Some of these partnerships are formalized; for example, the White-clawed crayfish *Austropotamobius pallipes* population-enhancement programmes in south-west England have taken place under the South West Crayfish Partnership, a group of UK-based conservation organizations (Nightingale *et al.*, 2017), and the 27 year captive-breeding and recovery programme for the Eastern barred bandicoot *Perameles gunnii* was instigated under a multi-agency recovery team that operates to conserve the species, manage recovery actions, and promote awareness and advocacy (Parrott *et al.*, 2017). Others may have partnerships at their core but under less formalized arrangements: most of the breed-for-release programmes for amphibians, reptiles, birds and mammals at Perth Zoo are run in collaboration with key partners (Mawson & Lambert, 2017). The development of these partnerships is crucial to the implementation and management of many conservation projects, and provides a means by which zoos and aquariums that are new to this area of conservation are able to engage with conservation-translocation projects.

FUTURE DIRECTIONS

Biodiversity faces substantial and acute challenges around the world; habitat loss, over-exploitation, the impact of invasive species and climate change all detrimentally impact biodiversity (WWF, 2016). Conservationists need to adapt to these threats by predicting forthcoming issues and conservation needs before they become critical, allowing the prioritization of limited resources. This can be achieved through a broad horizon scan of emerging issues (Sutherland & Woodroof, 2009), or a specific species evaluation of future conservation needs, such as population viability analysis modelling to inform conservation strategies (Ettling *et al.*, 2017).

Zoos and aquariums will continue to have a role as conservation programmes adapt to changing conservation needs. Concepts such as re-wilding, de-extinction, the emergence of novel ecosystems and even advances in synthetic biology will challenge our preconceptions and require us to develop new management strategies in response to an increasingly dynamic planet (Bridgewater *et al.*, 2011; Seddon & Armstrong, 2016). Assemblages of species will alter under climate-change scenarios and conservation translocations can play a role in securing populations of threatened species in the wild, as demonstrated by Gardiner *et al.* (2017) who carried out conservation introductions of two insect species that were threatened with sea-level rises in the UK.

THIS VOLUME

There is a large and extensive literature on reintroductions covering all aspects of conservation translocations and reintroduction biology. This volume of the *International Zoo Yearbook* focuses on the roles that zoos and aquariums have in re-establishing or reinforcing populations in the wild, and provides examples of reintroductions using wild (Astore *et al.*, 2017; Bird *et al.*, 2017; Daltry *et al.*, 2017; Ettling *et al.*, 2017; Nightingale *et al.*, 2017; Parrott *et al.*, 2017) or captive populations (Astore *et al.*, 2017; Bird *et al.*, 2017; Fritz *et al.*, 2017; Hogg *et al.*, 2017; Mawson & Lambert, 2017; Nightingale *et al.*, 2017; Parrott *et al.*, 2017; Woodfine *et al.*, 2017), reinforcements using captive populations (Bird *et al.*, 2017; Ettling *et al.*, 2017) and assisted colonizations (Gardiner *et al.*, 2017; Fraser *et al.*, 2017). The papers in this volume cover a range of animal and plant taxa, and present species-specific reintroduction case studies that highlight particular challenges, such as biosecurity and disease management (Hogg *et al.*, 2017; Nightingale *et al.*, 2017; Woodfine *et al.*, 2017), the impact of invasive species (Daltry *et al.*, 2017; Nightingale *et al.*, 2017) and introduced predators (Parrott *et al.*, 2017) on native biodiversity, as well as broader review articles on the role that zoos and aquariums have in reintroductions and reinforcements (Fraser *et al.*, 2017; Gilbert *et al.*, 2017), and many of the articles describe the processes associated with conservation translocations. Overall, the papers highlight many of the challenges faced by conservation-translocation practitioners, and provide a guide for zoos and aquariums seeking to participate in reintroductions and other conservation translocations.

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