IUCN

Global Re-introduction Perspectives: 2010

Additional case-studies from around the globe

Edited by Pritpal S. Soorae

IUCN/SSC Re-introduction Specialist Group (RSG)

IUCN
Founded in 1948, IUCN (International Union for the Conservation of Nature) brings together States, government agencies and a diverse range of nongovernmental organizations in a unique world partnership: over 1,000 members in all, spread across some 160 countries. As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. IUCN builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

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.

Saudi Wildlife Commission (SWC)
The SWC in accordance with its mandate, the Commission strives to protect, conserve, and develop the wildlife resources of Saudi Arabia, and the welfare of its people. SWC’s main achievements include: development and implementation of protected area system plan, establishment of 15 protected areas, development of National Biodiversity Strategy and Action Plan, establishment of two research centers specialized in captive breeding and re-introduction programs and the re-introduction of Arabian oryx, *Reem* and *Idmi* gazelles as well as Houbara bustard.

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. This international certification ensures the zoo attains the highest environmental standards. Since 1994, Denver Zoo has participated in well over 500 conservation projects in 55 countries. In 2009 alone, Denver Zoo participated in 80 projects in 22 countries and spent more than $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.

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H. E. Razan Khalifa Al Mubarak,
Assistant Secretary General,
Environment Agency - ABU DHABI

The Environment Agency – Abu Dhabi (EAD) is a governmental agency that was established in 1996. We are committed to protecting and managing biodiversity, providing a clean environment and promoting Sustainable Development in the Emirate of Abu Dhabi. The EAD has hosted the activities of the IUCN/SSC Re-introduction Specialist Group over many years and Is pleased to see the publication of this book titled Global Re-introduction Perspectives: 2010 which features case studies from all over the globe and covering major animal and plant taxa.

This book highlights the conservation efforts being made worldwide to restore animal and plant populations facing extinction due to various challenges. The effects of climate change and unsustainable use of resources Is altering the natural biodiversity of our planet. It is interesting to see the various efforts being made globally against all these odds to re-introduce species.

The EAD is committed to giving environmental protection, regulation and natural resources conservation a high priority on the national agenda. We provide direction for Government, business and the community to build environmental considerations into the way they plan and live without compromising Abu Dhabi development.

We hope the lessons provided in this publication provide re-introduction practitioners and conservationists alike useful lessons in the restoration of biodiversity in the face of so many challenges and you find this book informative and interesting as I have.

Bandar bin Saud bin Mohammad Al-Saud,
Secretary General,
Saudi Wildlife Commission - Saudi Arabia

Wildlife conservation has a long history in the Kingdom of Saudi Arabia. However it was through the establishment of the Saudi Wildlife Commission (SWC) in 1986 (formerly known as the National Commission for Wildlife Conservation and Development) that efforts in this direction were concerted and formalized. The SWC's main objective is to conserve wildlife, including all native plant and animal species and their habitats both terrestrial and marine. One of the first major projects of the SWC focused on the protection and revival of high profile animal species such as the Houbara bustard and the Arabian oryx.

Our achievements in the captive breeding and re-introduction of endangered wildlife span a period of more than 20 years. Since 1991, over 1,000 Houbara bustard have been successfully released and regularly monitored in two protected areas. We are also proud that the legendary Arabian oryx, once extinct in the wild, has been rescued through captive breeding and re-introduction and now roams again in the Uruq Bani Maarid on the edge of the Al-Rub" Al-Khali - the largest sand desert in the world, and in other arid habitats in the Kingdom. For a complex process such as captive breeding and re-introduction of endangered wildlife, one can only learn through the sharing of knowledge and experience. Therefore, this publication will prove to be an indispensible source for re-introduction programs world-wide. Our learning from the captive breeding and re-introduction of Houbara bustard and the Arabian oryx has further helped in initiating similar programs for other endangered wildlife such as the Reem & Idmi gazelles and the red-necked ostrich (of which case studies can be referred to in the first edition of this book).

I congratulate my colleagues at the Saudi Wildlife Commission, the National Wildlife Research Center and the King Khalid Wildlife Research Center for contributing to this volume and for sharing their experiences from this part of the world. The diverse articles published here provide an invaluable insight into the subject and I am certain that this publication will not only enhance the scientific knowhow on re-introduction but also further our cause in conserving wildlife across the globe.

Richard P. Reading, Ph.D.
Director of Conservation Biology
Denver Zoological Foundation

As the Denver Zoological Foundation proudly supports a wide variety of conservation initiatives throughout the world, including continued support to the IUCN Re-introduction Specialist Group (RSG) and the RSG's effort to improve re-introduction success throughout the global. As a part of that effort Pritpal Soorae provides here his second edited volume of re-introduction projects focused on an incredible diversity of taxa from throughout the world.

Together with his previous book published in 2008 (available from the RSG), these 2 volumes include 141 case studies – 13 on fish, 13 on invertebrates, 8 on amphibians, 16 on reptiles, 30 on birds, 32 on mammals, and 22 plants – from dozens of countries around the globe and provide a valuable resource to conservationists wishing to evaluate re-introductions and learn from recent efforts.

I urge re-introduction practitioners to read these volumes, learn the lessons contained within them, and work to continue improving our ability to successfully re-introduce native plants and animals into their former ranges as part of species and ecosystem restoration efforts.

We owe our thanks to the many contributors to this volume, to Fred Launay and the RSG for supporting this work, and especially to Pritpal Soorae for monumental task of drawing these contributions together in a standardized format.

An overview and analysis of the re-introduction project case studies

Pritpal S. Soorae, Editor

Introduction

This is the second issue in the *Global Re-introduction Perspectives* series and has been produced in the same standardized format as the previous one. The case-studies are arranged in the following order: Introduction, Goals, Success Indicators, Project Summary, Major Difficulties Faced, Major Lessons Learned, Success of Project with reasons for success or failure. For this second issue we received a total of 72 case-studies compared to 62 in the last issue.

These case studies cover the following taxa as follows: invertebrates (9), fish (6), amphibians (5), reptiles (7), birds (13), mammals (20) and plants (12). I would also like to take this opportunity to thank the various authors for their patience and willingness to submit information on their projects and in many cases with a tight deadline. We hope the information presented in this book will provide a broad global perspective on challenges facing re-introduction projects trying to restore biodiversity.

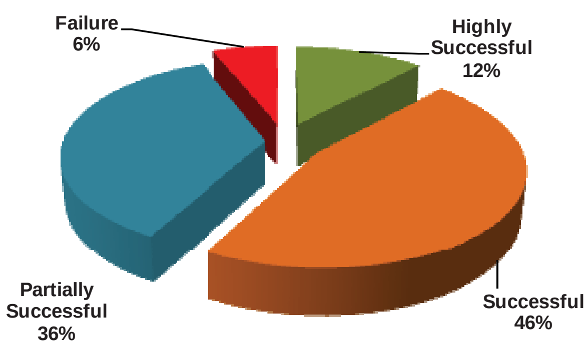
IUCN Statutory Regions

The IUCN statues have established a total of 8 global regions for the purposes of its representation in council. The IUCN's "statutory regions" are a list of States by Region, as per article 16 and 17 of the Statutes and Regulation 36 of the Regulations. All eight global regions are represented within these case studies and the regions are as follows: North America & Caribbean-7, West Europe-13, South & East Asia-7, Oceania-27, West Asia-4, Africa-9, Meso & South America-2 and East Europe, North & Central Asia-3.

Success/Failure of Projects

The projects presented here were ranked as Highly Successful, Successful, Partially Successful and Failure. Out of the 72 projects only one did not provide any ranking as the project was still in the initial stages so any deduction on its outcome could not be determined. In some cases other projects submitted multiple rankings as there was more than one release in the project at multiple

Fig. 1. Success/Failure of re-introduction projects



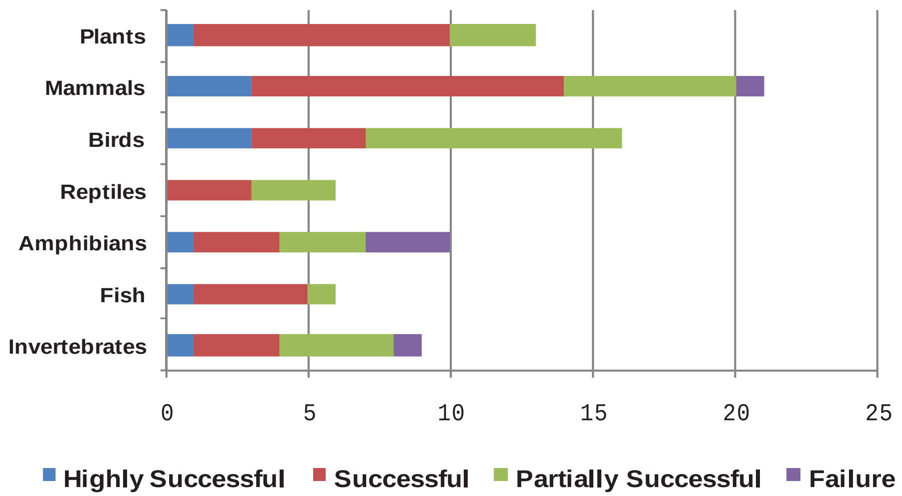
sites. As can be seen in figure 1, 12% of projects were Highly Successful, 46% were Successful, 36% were Partially Successful and 6% were Failures.

Success according to the taxa

An analysis was done to gauge the three different levels of success and failure according to the seven major taxa i.e. invertebrates, fish, amphibians, reptiles, birds, mammals and plants. Out of the seven major taxa only the reptiles did not have a Highly Successful ranked project. All the seven taxa had both Successful and Partially Successful ranked projects. Failures were only observed in invertebrates, amphibian and mammal re-introduction projects.

As can be seen in figure 2 re-introductions are not easy to conduct and a lot of trial and error is needed to get a viable population established into the wild.

Fig. 2. Success/Failure of re-introduction projects according to major taxa



Future issues of *Global Re-introduction Perspectives*

We are planning a third issue if you wish to submit a case-study or would like to fund an issue please contact me for further details. We would also appreciate any feedback you may have from this book. The Editor can be contacted at: (*pritpal.soorae@iucn.org*) and/or (*psoorae@ead.ae*).

Translocation of the giant Gippsland earthworm in Victoria, Australia

Beverley Van Praagh[1] & Alan L Yen[2]

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Introduction

The giant Gippsland earthworm (*Megascolides australis*) (hereafter GGE) is endemic to an area of approximately 40,000 ha in the Gippsland region of south-eastern Australia. Its distribution is fragmented and is determined by a combination of topographical, hydrological and soil factors. There have been dramatic changes to the original forested habitat, mostly associated with agricultural development. The vast majority of populations now occur on private land, with increased pressures from infrastructure development associated with urban expansion. GGE has a long life span, low reproductive and recruitment rates, and low dispersal ability; these render populations vulnerable. The GGE is listed as Vulnerable by the IUCN (IUCN/SSC, 2003), Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, and as Threatened under the Victorian Flora and Fauna Guarantee Act 1988. A large population of GGE's was found on a hillslope in the path of a proposed realignment of a dangerous section of the South Gippsland Highway near the small, rural township of Loch, Victoria. Options for the conservation of this population included establishing an alternative route for the highway or attempting to translocate the population. Due to the likelihood of encountering other populations with an alternate alignment, translocation was considered the most feasible option. Translocation of GGE's had not been attempted previously and it appears to be the first for any earthworm species.

Goals

- Goal 1: The overall objective is *in situ* conservation and protection of GGE populations where possible, and consideration of other conservation measures, such as translocation, if the former is not feasible.

Giant Gippsland earthworm in box

- Goal 2: Refine and test GGE translocation protocol to reduce mortality inherent in existing collecting methods and enable the transfer of as many individuals as possible across age classes to re-introduction site.
- Goal 3: Habitat recreation and management of re-introduction site.
- Goal 4: Development of monitoring protocols for translocated populations.

Success Indicators

- Indicator 1: Decision to proceed with translocation on the basis that no feasible alternatives to protect and maintain the target population were available.
- Indicator 2: Establishment of effective translocation protocols (collecting, transfer & release).
- Indicator 3: Short-term and long-term survival of translocated population.
- Indicator 4: Successful long-term breeding of GGE at translocation site.

Project Summary

Feasibility: GGE is a subterranean species with no above ground signs to indicate presence. Individuals are very fragile and easily injured. Precise information regarding suitable habitat is unavailable. Due to the species large size and complex system of horizontal and vertical burrows, individuals can only be dug out by hand, a slow process that often results in high mortality. These factors make translocation of this species technically very difficult. The decision to conduct the translocation was made at a workshop in 2003 involving relevant specialists. Permission to proceed was obtained from the Commonwealth Government through a referral under the Environment Protection and Biodiversity Conservation Act. A project team (comprising biologists, geomorphologists, geneticists, an animal health expert, and road engineers) was established to oversee the project.

The project comprised three phases: 1) development and testing of translocation techniques, selection of translocation sites; 2) translocation of population from the target to the receptor site; and 3) implementation of a monitoring program to assess the success of the translocation. During 2004, trials were conducted on collecting methods including using non-lethal chemicals, electrical currents, and physical techniques. The target population was situated on a hillslope and trials indicated that the most efficient collection method involved pumping water into a trench above the extraction site to soften the surrounding soil, making hand extraction

Source site of the giant Gippsland earthworm of individuals less likely to result in injury of the worm. A small scale translocation was attempted to assess survival. Surveys were conducted for suitable translocation receptor sites close to the source population.

Habitat of the giant Gippsland earthworm

Implementation: While several potential relocation sites were identified, the final site was chosen because 1) it was close to the original colony and supported similar conditions; and 2) it was easily accessible. To assist GGE re-establishment, a comparable soil profile of approximately 1.5 m in depth was established by transferring soil from the original population site. The surface was seeded with pasture grasses and allowed to settle for several weeks. GGE were collected using a small excavator and hand tools by a small, trained team over two months. Excavated worms and egg cocoons were placed in plastic tubs lined with wet hessian and soil. They were taken to an on-site, air-conditioned demountable shed where they were weighed, measured and their age class and reproductive status recorded. Worms were released later that same day into 60 cm x 50 cm x 30 cm holes arranged in a grid pattern with each hole 0.5 m apart. The holes were watered before releasing one to two earthworms, then gently covered with soil and watered again. A sprinkler system was used to keep the covered holes moist. A total of 901 individuals were extracted between October-December 2005; 611 were subsequently translocated, in addition to 18 egg cocoons. All age classes were represented in the translocation.

Post-release monitoring: A five year monitoring program (2006-2011) was established Attempts to develop non-destructive monitoring techniques, such as subterranean sound recorders to measure GGE movement or ground penetrating radar to monitor burrow development, were not fully explored due to budgetary constraints. Monitoring was conducted manually by 1) listening for gurgles, the sound GGE makes when moving through moist burrows; 2) digging of soil quadrats to find active burrows and fresh cast; and 3), assessing the breeding status of a small number of GGE.

Due to the inherent difficulties in monitoring, GGE it is not possible to obtain information on numbers of earthworms that survived the translocation. Monitoring during the first year after translocation (2006) found that an unknown number had survived at least 12 months after translocation and there was evidence of breeding. Monitoring in 2007 revealed a more active breeding population with gurgles and burrows located across the entire translocation site. South Gippsland


Removing giant earthworm from the soil

experienced a drought that had its most severe impacts during 2008 and early 2009. In 2008, only one earthworm was recorded in the only area that had moist soil. By May 2009, the entire site had dried, with no signs of recent earthworm activity. However, in September 2009 and in May 2010, after good rainfall, an active population was found. It is speculated that the earthworms may have been able to survive the severe drought conditions by moving deeper into the soil. The receptor site was created by building up the soil profile so that the moist soil was several meters below the soil surface. For the first 18 months after translocation, the receptor site was watered during summer with a sprinkler system. This was crucial for the initial establishment of the population and for their survival from 2005-2007, during a period of severe drought. Observations of soil moisture levels varied considerably across the site. The location of the quadrats with GGE corresponded to the areas with high visible soil moisture content. A year remains of the five year monitoring plan.

Major difficulties faced

- Subterranean habitat of GGE. Lack of information about the complex topographical, hydrological and soil factors required by GGE to assist creating and sustaining essential habitat parameters for survival.
- No effective non-destructive collecting and monitoring techniques have been developed. Although a collecting method that reduced mortality from 50% to 30% was used, it is a technique that is primarily suited to hill slopes. No non-destructive monitoring methodology has been found yet.
- Severe drought during translocation project.
- Scale & budget. Large scale of project meant high budget and only possible with major logistic support from Vic Roads (road building authority) including provision of site infrastructure, mechanical excavator (and operator), and water tanks.

Major lessons learned

- Translocation of GGE is technically feasible, but a cost-benefit analysis needs to be conducted for each case.
- While the collection methods developed for this population reduced the mortality rate, the success of this methodology may vary depending on the position of the population in the landscape (e.g. hillslope compared to creek bank).

- Effect of severe drought highlighted the importance of hydrology for GGE. The receptor site location must be able to sustain the appropriate hydrological conditions over time and be buffered to some degree from drought, otherwise supplementary watering may be required.
- Longevity of GGE makes short-term assessment of success translocations difficult. (Currently only five years).
- Team worked well but different organizational priorities of members took precedence and certain elements of program were reduced in effectiveness.
- Site management. Control of weeds a problem because effects of herbicides on GGE unknown. Adjacent tree planting has unknown effect on the hydrology of the translocation site.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason for success/failure:
- Translocation technique for GGE developed.
- GGE survived & breeding at least four years post-translocation.
- Monitoring short-term but longer term success unknown.
- Longer term effects of drought & climate change uncertain.

References

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Project Partners

Vic Roads, Department of Primary Industries, Department of Sustainability and Environment, La Trobe University (Bendigo and Bundoora), Healesville Sanctuary.

Re-introduction of the leaf-vein slug to Quail Island, Banks Peninsula, Canterbury, New Zealand

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Introduction

The leaf-vein slug (*Pseudaneitea maculata*) (Anthoracophoridae) was first described by Burton (1963) but the taxonomy of Anthoracophoridae is currently under review (Gary Barker, Landcare Research; pers. comm.). Although the species is not considered threatened, habitat loss and predation are likely to have restricted its range. The leaf-vein slugs were collected from Orton Bradley Park, Banks Peninsula, Canterbury (S 43.66575°, E 172.7079°) found in artificial refuges called weta motels and under wooden discs purposely placed there as habitat. The slugs were translocated to Quail Island (S 43.6290°, E 172.6876°) less than 5 km away in Lyttelton Harbour, Banks Peninsula, Canterbury, New Zealand. The Quail Island Ecological Restoration Trust in partnership with Department of Conservation and Te Hapu o Ngāti Wheke of Rāpaki are restoring the indigenous vegetation and fauna on the island and provide refuge for locally extinct or rare and endangered species of the Banks Peninsula region. Quail Island (85 ha) is located in Lyttelton Harbour which links the mainland via mudflats at low tide. Introduced mammalian pests, mice, rats, hedgehogs, cats and possums have been eradicated, and 90% of the mustelids (stoats, weasels and ferrets) are trapped en route to Quail Island (Bowie *et al.*, 2003). The close proximity to the mainland and the open access to public, makes this island vulnerable to reinvasion by pests, so traps and bait stations are needed to protect the island.

Leaf-vein slugs and eggs (inset)

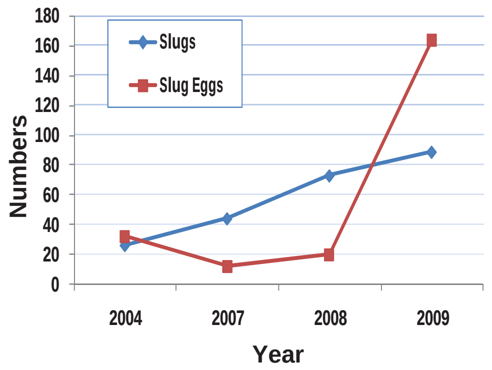
Goals

- Goal 1: Identification of potential re-introduction source close to Quail Island.
- Goal 2: Development of artificial habitat and non-destructive sampling techniques.
- Goal 3: Testing of restoration techniques.
- Goal 4: Annual monitoring of slug population at release site.
- Goal 5: Double release population in four years.

Success Indicators

- Indicator 1: Ten percent of translocated slug numbers within one year and 20% within two years.
- Indicator 2: Dispersal of slug populations to other suitable habitat on Quail Island.

Fig. 1: Leaf-vein slug and egg numbers since release on Quail Island in 2004



Project Summary

The leaf-vein slug is nocturnal and live in holes, cracks, crevices and rotten logs usually found in mature forests. The slugs eat fungi and therefore play an important ecological role or ecosystem service as a 'cleaner', feeding on fungi such as sooty mould on leaf surfaces which allows plants to photosynthesize more effectively. Quail Island is in the early stage of ecological restoration and contained few mature native trees suitable for slug habitat. Suitable refuges had to be developed using simple artificial techniques that also served as a convenient way to monitor slug numbers. Wooden discs cut out of tree trunks (Bowie & Frampton, 2004; Bowie, 2008) and placed on bare soil provided a cool dark habitat for the slugs. Weta motels (Bowie *et al.*, 2006), hollowed-out blocks of wood with a narrow entrance to exclude predators like mice were tied to tree trunks and used to provide safe, dark refuges for the slugs. Both the refuge types were also useful for monitoring, but the discs provided a good source of fungi beneath which provided a food source for slugs. Slug eggs were also laid under some discs in large numbers. Leaf-vein slugs were collected from Orton Bradley Park (5 km from Quail Island) from weta motels and under wooden discs in 2004, and were held in an incubator at 12° C with leaves infested with sooty mould (*Capnodium* sp.) prior to releasing. A total of 26 slugs (and 32 eggs laid while in captivity) were translocated to Quail Island and placed under wooden discs in a moist area containing a mixture of six year old native trees, flax (*Phormium tenax*) and exotic grasses (Burrows *et al.*, 1999). The release site discs were surrounded by a 6 x 6 grid of discs with approximate 5 m spacing creating a network of refuges they could use (see figure 1).

Major difficulties faced

- Identification of slug species was difficult so a selection of specimens were sent to an expert for verification.
- Predation by mice was a concern so we put a grid of mouse traps between the wooden discs around the release site to enhance slug establishment.

Major lessons learned

- Hermaphrodite species are advantageous for re-introductions as a male and female are not required for mating. This makes the collecting phase prior to translocation and the ability of slugs to find mates considerably easier.

- Testing restoration techniques (wooden discs and weta motels) prior to translocation also proved to be useful for sourcing of specimens.
- Sampling too often may be detrimental to the slugs as lifting the discs to inspect breaks the soil-wood seal created by worm action which protects slugs from desiccation and predators.
- Wooden discs may need to be replaced every four to six years as wood-boring insects and fungi cause natural deterioration of the wood.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Good numbers of slugs and slug eggs were found after three years even in the presence of house mouse (*Mus musculus*) on the island.
- Relatively low numbers were needed to establish a viable population of slugs.
- The simplicity of the method for creating micro-habitat and sampling slugs.

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Re-introduction of the Banks Peninsula tree weta to Quail Island, Banks Peninsula, Canterbury, New Zealand

Mike H. Bowie

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Introduction

The Banks Peninsula tree weta (*Hemideina ricta*) are only found on the eastern parts of Banks Peninsula, Canterbury, New Zealand. The weta are the rarest tree weta in New Zealand and is classified by the Department of Conservation as threatened/at risk due to a range restricted distribution (Hitchmough *et al*., 2005). The Quail Island Ecological Restoration Trust in partnership with Department of Conservation and Te Hapu o Ngāti Wheke of Rāpaki are restoring the indigenous vegetation and fauna on the island (Burrows *et al*., 1999) and provide refuge for locally extinct or rare and endangered species of the Banks Peninsula region. Quail Island (85 ha) is located in Lyttelton Harbour (S 43.62905°, E 172.6876°) which links the mainland via mudflats at low tide. Introduced mammalian pests, mice, rats, hedgehogs, cats and possums have been eradicated, and 90% of the mustelids (stoats, weasels and ferrets) are trapped en route to Quail Island (Bowie *et al*., 2003). The close proximity to the mainland and the open access to public, makes this island vulnerable to reinvasion by pests, so traps and bait stations are needed to protect the island.

Goals

- Goal 1: Identification of healthy re-introduction source close to Quail Island.
- Goal 2: Development of artificial habitat and non-destructive sampling technique.
- Goal 3: Testing of translocation/restoration technique (weta motels).
- Goal 4: Annual monitoring of weta population at release site.
- Goal 5: Double release population in four years.

Tree weta's inside a "weta motel"

Success Indicators

- Indicator 1: Ten percent of translocated weta numbers within one generation (two years) and 20% within two generations (four years).
- Indicator 2: Dispersal of populations to other suitable habitat on Quail Island.

Project Summary

Banks Peninsula tree weta (*Hemideina ricta*) are nocturnal cricket-like orthopterans and live in holes, cracks and crevices of mature trees or in rock stacks usually above 400 m in altitude (Townsend *et al*., 1997). Adult males often have harems of females that they guard against other males for the right to mate (Field & Jarman, 2001). Quail Island is in the early stage of ecological restoration (Burrows *et al*., 1999) and contained no mature native trees suitable for weta refuges, so artificial refuges were developed using a simple technique that also served as a convenient way to monitor weta numbers. Weta motels (Bowie *et al*., 2006), hollowed-out blocks of wood with a narrow entrance to exclude predators such as rodents were tied to tree trunks to provide safe, dark refuges for the weta. Weta motels are untreated wooden refuges containing an entrance hole (14 mm diameter) to exclude mice and a dark chamber for up to three adult tree weta (Bowie *et al*., 2006 & Bowie, 2008).

In November 2004 approximately 50 empty weta motels were placed on trees or fence posts at four locations on eastern Banks Peninsula where *H. ricta* were known to exist. Three days prior to the translocation, weta motels were checked for the presence of adult *H. ricta*. Weta motels with weta inside were removed and corks placed in holes to keep weta contained. Where possible weta were keep in the motels they were found in as it was thought that the presence of their own odours would reduce stress and motel abandonment that may follow. Corks were removed and motels were placed in 2 litre ice-cream containers containing some native vegetation (e.g. *Coprosma robusta*) and a small piece of carrot. On 24th January 2005 weta motels containing 14 male and 14 female Banks Peninsula tree weta were translocated to Quail Island. Motels containing weta were attached to mature kanuka trees. A male and a female weta usually in separate motels were attached to the same tree in order to pair them up to maximise mating success. As refuge for immature weta, concrete blocks with holes were stuffed with bamboo canes and placed at the base of the trees. Twelve weta and three weta were observed in the motels seven months and 18 months after the translocation respectively. Four years after the translocation, when all the original translocated weta had died from old age, five live adult weta were found in the motels.

Major difficulties faced

- Identification of the tree weta species from the common Canterbury tree weta (*Hemideina femorata*) was difficult as the most reliable method requires counting stridulatory ridges between the rear legs and the body.
- Marking the weta to be able to identify them later as sub-adults shed their exoskeleton and marks with it.
- Predation by mice was a concern so we put mouse traps around the release site to enhance weta establishment.

Major lessons learned

- Testing restoration techniques prior to translocation also proved to be useful for specimen collection.
- Quick transfer between collection and translocation is important to minimize stress in weta.
- Important to keep weta in same motel they were collected in to maximize motel fidelity for survival and monitoring.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Next generation of weta were found in motels after three years.
- Simplicity of the translocation and monitoring method.
- Snap traps were used around weta site to keep house mouse (*Mus musculus*) densities low.

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Establishing a second population of the flax snail in New Zealand

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Introduction

The flax snail *Placostylus ambagiosus* Suter, 1906 occurs at the end of the Aupouri Peninsula at the northernmost tip of New Zealand. Powell (1979) lists seventeen subspecies of *P.* ambagiosus of which ten are extant but present only in remnant populations. Some of these populations have fewer than 50 individuals. Fire and habitat destruction significantly contributed to their decline in the past, but nowadays the main threats are introduced predators - ship rats (*Rattus rattus*), Norway rats (*R. norvegicus*), mice (*Mus musculus*), pigs (*Sus scrofa*) and birds, especially song thrushes (*Turdus philomelos*). Introduced browsing mammals including feral pigs, cattle (*Bos taurus*), horses (*Equus caballus*), goats (*Capra hircus*) and brushtail possums (*Trichosurus vulpecula*) have also modified or destroyed snail habitat. Protection has included constructing fences around some colonies to protect them from browsers. However, controlling the predators of *Placostylus* snails represents the main challenge to their conservation. Protection of one population (*P. a. paraspiritus*) that survived on a small area of dry isolated vegetation surrounded by sand involved intermittent application of toxins to control rodents from 1982 onwards, supplementary plantings of some shrub species and, in 1990, an experimental translocation to two moister sites nearby.

Flax snails roosting under dry vegetation

Placostylus ambagiosus snails feed only on the yellowed leaves that fall from a variety of broadleaf shrubs and trees. They take two to 11 years to grow to the adult shell height of up to 78 mm depending on the habitat, then further increase in shell height ceases with the development of a thickened aperture lip. This lip protects the snail from predation by mice and most rats. *Placostylus a. paraspiritus* Powell, 1951 is listed as vulnerable B1+2abcde by

IUCN and as nationally endangered within New Zealand by Hitchmough *et al.* (2005). The colony is at the base of the Cape Maria van Diemen peninsula just south of Cape Reinga, Northland.

Goals

- Goal 1: To test whether new colonies of these snails can be established by wild-to-wild transfers. The aim was to test this as a potential conservation management tool in case of future need (Sherley & Parrish, 1989).
- Goal 2: To establish new populations of the snail in case of extinction of the extant colony (Sherley & Parrish, 1989).

Success Indicators

- Indicator 1: Survival of the snails that were released.
- Indicator 2: Confirmation that the snails have bred at the site.
- Indicator 3: The establishment of a self-sustaining population.

Project Summary

The existing colony is in an area of mostly introduced grasses with patches of native sedges and shrubs. It is on a small sandy headland surrounded by sand dunes on three sides with ocean on the other. The site is very vulnerable to erosion and elsewhere on the Cape Maria van Diemen peninsula there are large areas of bleached shells from former colonies. However, the colony was one of two containing hundreds and possibly thousands of snails and this allowed us to remove a small number to carry out these translocations. In 1989 bait stations for rodent control were re-activated at the parent colony and increased in number. These were restocked every three months. Bait stations were also established in the two areas selected for the releases nine months before the releases. These sites were 500 m south east of the parent colony and 100 m apart. The snails were transferred in May 1990, 25 adults and six sub-adults were released in the ‘northern experimental’ site and 25 adults and seven sub-adults in the ‘southern experimental’ site. Snails were released in groups of five or six beneath shrubs of favored food species. Each snail had a unique number engraved on the shell and the shell height was measured and recorded. The northern site consisted of shrubs surrounded by dense sedges and grasses in a moist valley whereas the southern site was drier and had more continuous and taller shrubbery.

The first monitoring occurred three months after the release. Searching was limited to areas of up to about 7 m around each release site and ten of the released adults were found alive at the northern site and nine at the southern site (see Table 1). The snails had moved away from the immediate release sites and some were found 6.5 m away. Later research conducted on translocating *P. ambagiosus* and *P. hongii* found adults would ‘home’ up to a distance of 80 m (the furthest we searched) whereas juveniles tended to remain where released. Juveniles (13 individuals) were first recorded 18 months after release and had shells 16-34 mm high. Hatchlings have shells about 6 mm high and we found that the snails grew at around 17 mm a year at the northern site, much faster than in the parent colony. The juvenile snails in the translocated colonies that had obtained a shell height of 34 mm had probably been laid soon after the transfer,

Searching for snails under shrubs at one of three sites near Cape Maria van Diemen, New Zealand

and had then grown relatively quickly. In captivity at 18°C, the eggs hatch after about 45 days, the snails take about two years to become sub-adults and the adults can also live up to 11 years (Stringer & Grant, 2007). Our data also suggest that at the parent colony, the snails took 6-11 years to develop into adults and that they may live for at least nine years as adults. It is possible that the first young occurred early at the translocation sites because gravid snails were released and because the adult snails seem to lay eggs when stressed as we have found subsequently. Adults will sometimes lay a few eggs while they are being transported.

In 1998 we began an experiment to test the effect of intensive rodent control at the two sites targeting mice, as rats were rare in that habitat. New 25 m x 25 m grids of bait stations and rodent tracking tunnels were established that covered areas of 125 m x 125 m centered on the release sites. The experiment was intended as a reciprocal one whereby toxins (bromodiolene wax baits) were laid only at the northern site for two years and then only at the southern site for two years. However, we decided to extend the period of poisoning at the northern site because large juveniles and sub-adults were present after two years of rodent

Table 1. Numbers of live *Placostylus ambagiosus paraspiritus* snails found at two sites after an experimental translocation. Numbers in brackets are recaptures of live marked snails that survived from the original release.

	1990	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004
Northern Site													
Adult	(10)	(1)	(2)	0	13 (2)	(1)	6 (1)	6	5	13	33	18	10
Juv	0	12	1	15 - 20	40	0	20	50	63	57	84	61	62
Total	10	13	3	15 - 20	53	1	26	56	68	70	117	79	72
Southern Site													
Adult	(9)	(5)	(1)	0	-	3 (1)	3 (1)	2 (1)	2	2	0	0	0
Juv	0	1	0	Eggs	-	2	5	2	3	2	5	4	1
Total	9	6	1	0	-	5	8	4	5	4	5	4	1

control and extending the period would ensure the recruitment of adult snails. The advantage of this is that the shells of adult *Placostylus* snails have a thickened aperture lip which protects the snails from being preyed on by ship rats and mice (Norway rats can bite through the thickened lips). However, managers of the area (Department of Conservation) banned the toxin between 2000 and 2002 when poisoning was due to commence at the southern site, so this was delayed until 2002. All monitoring at these two sites was done by systematically searching for the snails within large grids (100 m^2 at the northern site, 100 m^2 or 75 m^2 at the southern site) every year from 1999 until 2004. Prior to 1999 all monitoring was unsystematic.

Snails increased in the northern site during the poisoning, reaching 117 snails in 2002 when poisoning ceased. The numbers subsequently declined to similar levels as those recorded in 2001 (Table 1). In contrast, at the southern site, only 4 -5 snails were found each year between 1999 and 2002, and similar numbers were recorded after rodent control commenced there in 2002 except in the last year when only one snail was present. However, in the last three years only juveniles were found and it appears that there was insufficient time for the snails to benefit from the poisoning. Possible reasons for this were that the habitat was suboptimal and that the initial numbers of adult present (in 2002) were so low that few juveniles were produced and none matured in the time available to contribute to further population recovery.

Major difficulties faced

- The revocation of permission to use the toxin (bromodiolene) from 2000 to 2002 was while the effects of its accumulation in animals were investigated. This delayed poisoning of the southern site and subsequently reduced the period when rodents were controlled at this site.
- Changes in personnel responsible for the various poisoning regimes over the years. This affected the period before 1998 when rodent control was intermittent.
- The dispersal of the adults that were released away from release sites. This may have reduced the density of adult snails at the southern site to a level that reduced their ability to recover there

Major lessons learned

- Adult *Placostylus ambagiosus* snails can survive and reproduce after a wild-to-wild translocation into suitable habitat.
- Appropriate predator control is required during establishment and until snails reach adulthood (develop a thickened shell aperture lip which prevents predation by most rodents).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- One translocated population (northern) flourished with predator control in the better habitat.
- The other site (southern) failed possibly because the habitat was more open and probably drier, and therefore less suitable and the predator control regime was insufficient. Had predator control been more intensive before the numbers of adults present became reduced to very low levels, it too may have successfully established.

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Return of the Lord Howe Island phasmid to Lord Howe Island, Australia

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Introduction

The Lord Howe Island phasmid (*Dryococelus australis*), a giant nocturnal stick-insect, is endemic to the Lord Howe group of islands, situated approximately 600 km east of the Australian mainland. It was common on Lord Howe Island until the accidental introduction of ship rats (*Rattus rattus*) in 1918. For more than 70 years the phasmid was thought to be extinct. Although dead specimens were recovered on Balls Pyramid (a 550 m high rock stack 23 km south-east of Lord Howe Island) during the 1960s (Smithers, 1970), all subsequent attempts to locate living individuals failed (IUCN, 1983) until February 2001, when a single population of 20 or so individuals was discovered on the Pyramid (Priddel *et al.*, 2003). After its rediscovery, the phasmid was listed as critically endangered under Australian environmental legislation, a draft recovery plan was prepared (Priddel *et al.*, 2001) and a captive-breeding colony established. Now secure in captivity (>700 individuals and 14,000 eggs) (Carlile *et al.*, 2009), opportunity exists for the species to be re-introduced to Lord Howe Island. This re-introduction is only one component of a holistic ecosystem reconstruction project being planned for Lord Howe Island.

Goals

- Goal 1: Establish a captive breeding population of phasmid on the Australian mainland as security against extinction in the wild and as a source for subsequent re-introduction.
- Goal 2: Remediation of habitat on Lord Howe Island through the removal of introduced predators (rodents) and the re-establishment of natural predators (boobook owl).
- Goal 3: Re-introduction of the phasmid into the wild on Lord Howe Island.

Male Lord Howe Island stick-insect
© Dean Hiscox LHI Environmental Tours

Success Indicators

- Indicator 1: Self-sustaining captive population of the Lord Howe Island phasmid established.
- Indicator 2: Fecundity, hatch rates and survival rates of captive nymphs and adults comparable to those of other captive stick-insects.
- Indicator 3: Exotic rodents on Lord Howe Island eradicated.
- Indicator 4: Self-sustaining population of the phasmid established in the wild on Lord Howe Island.
- Indicator 5: Exotic owls on Lord Howe Island eradicated.
- Indicator 6: Self-sustaining population of boobook owl established in the wild on Lord Howe Island.

Project Summary

In 2003, two pairs of adult phasmids were removed from Balls Pyramid to establish captive populations on the Australian mainland (Priddel *et al.*, 2003). Although all four founders mated readily in captivity and eggs were laid, one pair died only a month after capture (Carlile *et al.*, 2009). The single surviving pair, at Melbourne Zoo, continued to breed successfully but the hatch rate of eggs was poor. It was not until the third generation, when much more had been learnt about the specific husbandry requirements of this particular species, that fecundity and hatch rates increased to acceptable levels. Rapid growth of the captive population then followed, and by 2008 there were sufficient animals available to establish additional captive colonies elsewhere within Australia and overseas (Carlile *et al.*, 2009). A captive population was also established on Lord Howe Island for display and public education purposes. The captive situation has advanced to such a stage that there are now sufficient phasmids for release back into the wild. However, this can only be attempted after the habitat on Lord Howe Island has been repaired through the removal of introduced predators - ship rat and house mouse (*Mus musculus*). Although technically feasible, as amply demonstrated by the successful eradication of introduced rodents from more than 270 islands worldwide (Howald *et al.*, 2007), the situation on Lord Howe Island is complicated by the presence of a large permanent human population (about 350 individuals in 150 households) along with their domestic stock and pets. Despite the complexity, planning for the eradication of exotic rodents on Lord Howe Island is well advanced. A feasibility study and a cost-benefit analysis have been completed and an operational plan has been prepared, peer-reviewed and placed on public exhibition. Although all environmental and human health issues have been addressed, some islanders are concerned that aerial baiting with rodenticide may be more hazardous than the presence of large numbers of rodents. Community consultation and education is being undertaken to address any outstanding socio-political issues. In addition, further research is being undertaken to quantify and mitigate all identified risks to the environment, non-target species and human health.

The removal of exotic rodents from Lord Howe Island will have significant broad-ranging biodiversity, human health and social benefits. However, if not appropriately managed, there may also be some undesirable consequences. One

Phasmid enclosure on the forest edge

such possible negative consequence is prey switching where, in the absence of rats and mice, predators turn to prey on threatened endemic birds. The most likely species to do so is the masked owl (*Tyto novaehollandiae*), an exotic species introduced to the island during the 1920s in a misguided and failed attempt to control rats. To eliminate this possibility, eradication of the masked owl is planned to occur concurrently with the rodent eradication. Research into the ecology of the masked owl on the island, with a view to developing eradication techniques, commenced in 2009. Once rodents have been eradicated from Lord Howe Island the phasmid, along with several other locally extinct species, can be re-introduced. Among those species lost from Lord Howe Island was an endemic subspecies of boobook owl (*Ninox novaeseelandiae albaria).* This nocturnal insectivore is likely to have been a major predator of the phasmid. Their demise undoubtedly began with the introduction of rats. Not only would rats have preyed on owl eggs and chicks, they also extirpated the phasmid, possibly one of the owl's major prey items. The fate of the boobook was probably sealed with the introduction of the much larger masked owl, a species that would have competed with the boobook for nesting hollows. The last time a boobook was heard on Lord Howe Island was during the 1950s. To prevent the phasmid from ever becoming over abundant, it is planned to restore the natural biological control for the phasmid by introducing another sub-species of boobook to Lord Howe Island. This will be undertaken only after the phasmid is well established in the wild.

Major difficulties faced

- Detailed ecological research could not be undertaken on the phasmid population living in the wild on Balls Pyramid due to poor accessibility, safety concerns and the extreme fragility of the habitat (Priddel *et al.*, 2003). Consequently, the captive-breeding component of this project was undertaken without any prior knowledge of the species' breeding ecology or habitat requirements. Had it not been for the dedication, skill and professionalism of staff at Melbourne Zoo, the captive colony would have failed soon after it began.
- The re-introduction of the phasmid to Lord Howe Island cannot be undertaken in isolation - it must be part of a more holistic approach to ecosystem reconstruction. The re-introduction of this one species, although relatively easy, is dependent on the eradication of three exotic species (rats, mice and masked owls) as well as being associated with the re-introduction of another

locally extinct species (boobook owl). These linkages add considerably to the complexity of the undertaking.

Major lessons learned

- It is possible for an invertebrate to become an effective flagship species for a major ecological restoration program.
- The presence of a resident human population adds considerably to the complexity of ecological operations that on non-inhabited islands would be relatively simple and straightforward.
- Eradication and re-introduction issues can cause deep divisions in island communities. Resolving such socio-political issues requires extensive community consultation, a strong educational emphasis and long lead times.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The operation is complex and only partially completed.
- Establishment of a captive breeding colony capable of producing a sufficient number of phasmids for re-introduction has been achieved.
- Planning for the eradication of rodents on Lord Howe Island is well advanced, but the eradication has yet to be undertaken.
- Research on the masked owl has commenced but an eradication plan has yet to be formulated.
- Planning for the re-introduction of the boobook owl has yet to commence.

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Restoring the endangered pine hoverfly in the UK

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Introduction

The endangered status of the pine hoverfly (*Blera fallax*) (Diptera, Syrphidae) was confirmed in 1999 after a 12 year investigation (Rotheray & MacGowan, 2000). The study concluded that the species had probably existed in the British Isles for several millennia, but that in the last hundred years it had declined in distribution from eight to just two known sites, both confined to the central highlands of Scotland. In 1999, the pine hoverfly was listed in the UK Red Data Book as category 1 (endangered), it is also a UK Biodiversity Action Plan priority species, and is one of 32 species listed in the Species Action Framework (2007), a Scottish Natural Heritage (SNH) initiative which focuses on improving the status of species deemed significant to overall Scottish biodiversity. Very little is known about the ecology of the pine hoverfly. In particular the elusive adults are very difficult to find; during the 12 year study no adults were observed (Rotheray & MacGowan, 2000). However breeding sites were identified where larval stages could be found and intervention is essential if we wish to safeguard UK populations of this species. In 2008 the first attempts were made to re-locate the pine hoverfly to its historic sites in Scotland.

Goals

- Goal 1: Identify at least two potential re-location sites within the species' historic range.
- Goal 2: Increase breeding resources at re-location sites.
- Goal 3: Establish populations of pine hoverflies at two re-location sites.
- Goal 4: Carry out annual monitoring to record progress and prepare additional sites to link populations.

Success Indicators

- Indicator 1: Self-sustaining populations established at re-location sites.
- Indicator 2: Distribution of the pine hoverfly extended in Scotland.

Pine hoverfly (*Blera fallax*)

Project Summary

Feasibility: In Scotland the Pine hoverfly's preferred habitat is Scots pine (*Pinus sylvestris*). It is a specialist saprophage: it develops in rotting pine stumps. Heart rot fungus (*Phaeolus schweinitzi*) attacks the centre of the tree causing it to weaken, fall and snap at the base revealing a hole that fills with rain water, and it is in this cavity that the larvae filter feed. Currently in Scotland this micro-habitat is rarely found in native pine woodlands due to a lack of veteran and senescent trees. The remaining populations survive in non-native plantations where rot-holes are formed in pine stumps left vulnerable to decay after felling. It is possible to create breeding sites by boring holes in stumps, filling them with pine chips or sawdust and allowing the rain to fill the cavity. Habitat creation in this way began in the 90's and proved successful for a closely related species, *Callicera rufa* (MacGowan, 1994). In 2003, the same methods were used at pine hoverfly sites and by the following year it was confirmed to have been similarly effective (Rotheray, 2006). Due to these simple, swift and inexpensive methods of management, re-locating this species to historic sites in Scotland is a practical option which appeals to site owners and managers alike. The pinewood sites proposed for re-location are historic sites for the pine hoverfly with a characteristic ground flora and associated shrubs. These plants, particularly rowan (*Sorbus aucuparia*) provide food for adults in the form of pollen and nectar. At these sites, the pine wood habitat has improved since the last records of the pine hoverfly due to the positive management actions under the influence of the SSSI (Sites of Special Scientific Interest) and SAC (Special Areas for Conservation) designations which cover the sites. Both sites have included provision of artificially created rot-holes as part of their agreed long term forest planning.

Implementation: The number of individuals to be released at re-location sites is under investigation and the implementation process is being developed and agreed between the BAP coordination group and the Species Action Framework management group. Rather than directly transferring individuals from one site to another, in June 2009 an attempt to captive breed the pine hoverfly was made. This species had never previously been bred in captivity and this type of re-location of a saproxylic insect has never been attempted anywhere in the world. In November 2008, fifty larvae were removed from the wild and reared in captivity in jars filled with water and pine wood chips. In June 2009, thirty eight of them emerged as adults and were split between one large on-site cage (designed to observe adult behaviour in a more natural setting) and four small indoor cages. Over a period of two months the captive adults were successfully fed on pine woodland associated flora, mated in on-site and indoor cages, and several females oviposited a total of about 460 eggs, of which roughly 300

Creating habitat by creating bore-holes


Captive rearing hoverfly larvae

larvae have survived to date. Although both cage methods were successful, the smaller indoor cages are considered more advantageous due to the greater amount of control, protection and ease of assembly. In October 2009, 85 of the captive bred larvae that had reached the final stage in development were transferred to 28 bored stumps at one of the new sites where three groups of 30 bored stumps had been created within a kilometre of each other. In June 2010, 95 adults were released at the same site and the remainder entered into a second generation of captive breeding. To avoid inbreeding and 2nd generation habituation (adaptation to captive conditions) individuals from the original site were included in captive breeding efforts during 2010. Although recent surveys show that the removal of 50 larvae from the original population has not had a measurable negative affect on the population, it is proposed that of the captive bred stock 50 adults will be released at the original site in 2011 to supplement the population.

Post-release monitoring: The relocation site is being monitored monthly and each larva that is located is photographed to follow development. Sixty percent of the released larvae were found in the cut stump holes four weeks after release. Eight weeks after release, a total of 15% were located in the holes. It is known that during winter, fully developed larvae of the pine hoverfly tend to move out of the water and into leaf litter on the ground or into deep cracks in the stumps where they are very hard to locate, while smaller larvae remain in the holes and complete their development in spring. This may explain the low numbers of larvae remaining in holes. In August 2010, 43 new pine hoverfly larvae were found in 12 stump holes we created, four of which were 1 km away from the site they were released.

Major difficulties faced

- Because of the lack of scientific research on the ecology of this species, in particular the adult requirements for feeding and breeding, much of the project involved trial and error.
- Lack of large pine stumps for habitat creation (holes cut in small stumps tend to only temporarily hold water).

Major lessons learned

- New understanding of insect husbandry, in particular the ability to rear adult flies in small indoor cages while utilising large outdoor cages to investigate pine hoverfly behaviour.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Having started in November 2008, the re-location of the pine hoverfly is in its early stages. As yet we do not know if the population at the relocation site will establish itself, however having found a new generation of larvae there, this has been taken as an indicator of success at this preliminary stage.

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Re-introduction of the Miami blue butterfly, Florida, U.S.A.

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Introduction

The Miami blue butterfly (*Cyclargus thomasi bethunebakeri*, Comstock & Huntington, 1943) is a small, brightly colored polyommatine lycaenid endemic to Florida; additional subspecies occur in the Bahamas and Hispaniola (Smith *et al.*, 1994). The taxon is listed by the state of Florida as endangered and is currently a candidate for federal listing. It was formerly distributed across much of the south Florida mainland south through the Florida Keys to the Dry Tortugas (Minno & Emmel, 1993; Calhoun *et al.*, 2002). Over the last three decades, the Miami blue has experienced a significant reduction in overall geographic distribution and numerical abundance to the point where by the early 1990s it was presumed extirpated. Today, it is restricted to a few extant populations on conservation lands in the Lower Florida Keys, namely Bahia Honda State Park and the uninhabited Marquesas Islands and Boca Grande Island in Key West National Wildlife Refuge. Because these are widely separated sites and the adults have limited dispersal ability and longevity, gene flow between the populations is unlikely. Re-introduction of captive-bred organisms began in 2004 and has concentrated on the establishment of self-sustaining populations on conservation lands on the south Florida mainland and the northern Florida Keys.

Goals

- Goal 1: Determination of appropriate protocol for the re-introduction or augmentation of captive bred butterflies into existing populations or unoccupied suitable habitat areas.
- Goal 2: Identification, evaluation and ranking of potential recipient sites for re-introduction within the taxon's historic range.
- Goal 3: Monitor the status and trends of all known populations (both natural and re-introduced) on a regular basis.

Miami blue butterfly mating pair

Male Miami blue butterfly

Success Indicators

- Indicator 1: The establishment of self-sustaining populations at re-introduction sites.
- Indicator 2: Secure and maintain stable or increasing populations over a broad geographic range at a level that does not require listing.

Project Summary

A captive propagation program was established at the McGuire Center for Lepidoptera and Biodiversity, University of Florida in February 2003. As outlined by the approved management plan, the captive population served to reduce the immediate threat of extinction while providing organisms for research and re-introduction (FWC, 2003). The initial population was founded with 100 eggs collected from all known subpopulations of the Bahia Honda State Park population, and is infused with new genetic material from the same source on a regular basis. This strategy was one of several components of a detailed genetic management plan employed to help minimize inbreeding depression in the captive population. Additionally microsatellite markers were developed, and are used in combination with non-invasive wing fragment sampling to monitor the heterozygosity of the captive and wild populations over time (Daniels, 2009). The results indicated that the wild populations retained relatively high levels of genetic diversity despite being significantly reduced in overall geographic distribution, numerical abundance and connectivity. Similarly, captive-bred organisms slated for re-introduction were genetically very similar to wild individuals and did not display any signs indicative of inbreeding depression. Some 45 generations resulting in more than 32,000 viable organisms have been produced in captivity between 2003 and 2009.

Extensive habitat assessment surveys were carried out in south Florida involving some 47 general localities and 23 islands. A detailed matrix of key variables was developed and used to help identify appropriate re-introduction sites. As mandated by the Miami blue management plan, a taxon working group (TWG) was formed to help direct recovery efforts. Under the supervision of the TWG, organism re-introduction efforts were initiated in 2004. Sites were divided into two categories (phase 1 and phase 2) that differed in their proximity to human inhabited areas due to tensions with local mosquito control operations concerning appropriate buffer distances and resulting non-target impacts. In cooperation with the Florida Department of Agriculture and Consumer Services and the Florida Coordinating Council on Mosquito Control, the TWG initiated a stakeholder driven research partnership to further investigate the potential non-target impact of mosquito control pesticides and develop appropriate recommendations to help mitigate any deleterious organism impacts before moving forward with the approval of additional re-introduction locations. As a result, only a limited number of federal and state-owned conservation lands served as approved phase 1 recipient sites, all of which were severely impacted by prolonged drought and hurricane events in the two years following. Additional re-introductions have continued in 2007, 2008, and 2009.

Bahia honda State Park showing habitat

All wild populations are monitored a regular basis, typically 5-12 times/year, to assess habitat conditions, patch occupancy, and tends in population numbers. Post-release surveys are carried out for at least three months following any organism re-introduction event and continue for an additional three months if signs of breeding were recorded. Despite the release of more than 7,000 captive-bred organisms at three recipient conservation land sites, there has been no evidence of prolonged population establishment at any location. However, the conservation program outlined by the Florida Fish and Wildlife Conservation Commission and the TWG has embraced an integrative approach to organism recovery involving more than captive breeding and organism re-introduction. Targeted program components have included basic and applied research, specifically population ecology, conservation genetics, non-target impacts of mosquito control adulticides, and ant–larval associations as well as a variety of public education and land manager training initiatives.

Major difficulties faced

- Stakeholder conflicts, most notably those surrounding the potential impacts from mosquito control and land management practices at or near re-introduction sites, remain key issues requiring final resolution.
- Limited number of recipient sites available for organism re-introduction due to the issues raised in the first point.
- Limited productivity and reduced quality of larval host and adult nectar plants at recipient sites following organism re-introduction due to prolonged multi-year drought conditions in south Florida.
- Disruptive effects of tropical cyclone impacts on the habitat and organisms at recipient sites.

Major lessons learned

- Although the formation of a taxon working group has provided significant program coordination and facilitated the open exchange of ideas and information between individuals and agencies, it has been unable to fully resolve discordant associations and conflicts in a timely manner.

- Because the Miami blue was emergency listed as endangered, management and recovery decisions were required to be made relatively quickly and before they could be better informed by scientific research.

Success of project

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Despite multiple re-introduction attempts at three recipient sites, there has been no evidence of prolonged population establishment at any location

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Re-introduction of the Southern Damselfly to Venn Ottery Common, Devon, UK

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Introduction

The southern damselfly (*Coenagrion mercuriale* (Charpentier)) is protected within Europe. It is listed on the Bonn Convention for the conservation of Migratory Species of Wild Animals, on Appendix II of the Berne Convention on the Conservation of European Wildlife and Natural Habitats (1979), which outlaws the collection or possession of listed species, on Annex II of the European Community Habitat and Species Directive (1992), which requires the designation of Special Areas of Conservation (SACs) for animal and plant species of community interest and on Schedule 5 of the UK Wildlife and Countryside Act (1981), which protects against damage and killing of individuals, and damage or destruction of habitat, and protects biotopes in localities designated as Sites of Special Scientific Interest (SSSIs). It is also listed as Rare (Category 3) in the British Red Data Book and features on the red lists of other European countries (Grand 1996). It was the only species of Odonata to appear in the first UK Biodiversity Action Plan (HMSO 1994). The UK is on the edge of its European range and its populations there are fragmented. This re-introduction project took place in south-west England where southern damselfly populations are small and genetically depauperate.

Goals

- Goal 1: Investigate sites from which the species had gone extinct within the last 30 years.
- Goal 2: Attempt to determine the reason(s) why the species had gone extinct.
- Goal 3: Restore the habitat to a condition that is favourable for the long-term persistence of the species on the site.
- Goal 4: Establish a management plan for the species on the site including the provision for long-term monitoring.

Success Indicators

- Indicator 1: Establish a self-sustaining population on the re-introduction site.
- Indicator 2: Establish a population close to existing populations so

Andromorph female of southern damselfly consuming a prey item © PC Watts that there is a possibility of gene flow from the newly established population towards the genetically depauperate neighbouring populations.

Project Summary

Following the publication of the UK's Biodiversity Action Plan in 1994 a steering group was set up to look after the interests of the southern damselfly. It contained representatives from English Nature, the Countryside Council for Wales, the Environment Agency, the Wildlife Trusts and Liverpool University, a centre of expertise in dragonfly and damselfly research. One of the aims of the plan devised by this group was to research the ecology of the species and ultimately to begin re-introductions into sites from which it had gone extinct in the UK. One of the early findings of a Studentship funded by the group was that southern damselfly sites had declined in number by more than 30% since 1960. Once the habitat requirements of the southern damselfly had been established the search began for sites from which it had gone extinct and for which habitat restoration was feasible. Venn Ottery Common, a Devon Wildlife Trust reserve lost southern damselfly in 1989, largely due to injudicious ditch digging which altered water courses to the detriment of southern damselfly, coupled with a relaxation of grazing which led to the spread of tussocks of *Molinia caerulea* which effectively covered the runnels passing down the site. It was chosen as the first re-introduction site for four reasons. First, it had lost southern damselfly relatively recently and water chemistry tests revealed that the water quality was within the range acceptable. Second, there was a strong resolve on the part of the site owners, Devon Wildlife Trust to restore southern damselfly to the site and to raise funds so to do. Third, there was enthusiastic local support from the two people most responsible for improving the status of southern damselfly on two other sites on the East Devon Pebble Beds, Aylesbeare and Colaton Raleigh Commons (Kerry, 1989). Finally there was the possibility that a meta-population structure might be established, and with it gene flow between populations (Thompson, Watts & Saccheri, 2007)

From 2002 onwards researchers at Liverpool University had estimated genetic variation in all the known sites for southern damselfly in the UK and had determined population sizes and some of them. Beaulieu Heath in the New Forest was chosen as the donor site for the re-introduction on the grounds that it had the highest population density recorded in the UK and contained the most genetically diverse population. Licences to undertake the work were obtained at the national level from Natural England, from the Forestry Commission representing the donor site and from Devon Wildlife Trust representing the recipient site. On 10th June 2007, 57 mature individuals were taken from Beaulieu Heath to Venn Ottery Common in three modified cylindrical butterfly rearing cages. The water level at Venn Ottery had dropped surprisingly in the ten days since the site had been visited previously. The decision was taken to stop the re-introduction until the water supply at Venn Ottery was more reliable, but the animals transported were released in any case. Between the summer of 2007 and spring 2009 Devon Wildlife Trust make great efforts to secure the water supply to the runnels in which southern damselfly was likely to breed. Large numbers of birch trees were removed and Devon cattle were brought in to graze the site. In addition a fast-flowing, unsuitable stream on the edge of the site was transformed by the introduction of eleven dams which produced in parts conditions for southern damselfly similar to those at the other two East Devon Pebblebed sites. Growth of *Potamogeton polygonifolius*, a favoured oviposition plant for southern damselfly, was encouraged. By summer 2009 conditions at Venn Ottery were looking much better, with a steady flow of water down the runnels into which it was hoped that southern damselflies would breed. The re-introduction program was set to proceed. It was given a timely boost by the discovery of some breeding adults on the site, which must have been descendants of the cohort introduced in 2007. Four hundred females and 100 males were transported from Beaulieu Heath to Venn Ottery Common over the course of ten days in six different batches. The car journey lasted roughly three hours but only three individuals did not survive the journey. Exclusively mated females (distinguishable by their muddy abdomen tips) were taken in the first two trips. Females store sperm and oviposit alone in the absence of males. As males were re-introduced later during the programme they would mate with females on site and by removing sperm deposited during previous matings in the New Forest (a unique feature of damselfly mating behaviour) would guarantee the highest genetic diversity per introduced female. Almost all individuals seemed unaffected by the car journey and many had begun to show reproductive behaviour within minutes of being released at Venn Ottery.

Habitat of the Damselfly at Shipton Bottom, New Forest, one of the re-introduction donor sites © PC Watts

Southern damselflies have a two-year life cycle in the UK. The first monitoring took place in 2009 in order to check whether any of the 2007 pilot introductions had bred.

Major difficulties faced

- Securing a year long water supply in the form of shallow runnels with a slow flow rate suitable for larval survival - diverting the water that was passing too quickly down one side of the site towards the runnels that were prone to drying out in the summer.
- Implementing a grazing regime that would ensure that the runnels would not be covered by encroaching vegetation.

Major lessons learned

- Habitat creation for a species with a complex life cycle such as a damselfly is multidimensional. All aspects of its habitat requirements need to be catered for from suitable plants into which the adult females can oviposit, to slow-flowing water in which the larvae are able to find food, to a structured terrestrial habitat in which the adults can find food and shelter. Often attention has been focussed into what has been perceived as the key stage of the life cycle.
- Prior to the re-introduction itself, a management plan, with details of funding for such a plan needs to be in place.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The project is only at an intermediate stage at the moment. A pilot re-introduction in 2007 led to breeding adults being recorded on site in 2009, prior to the main re-introduction effort. With time the project is likely to be classed as successful or highly successful
- The expectation of success is largely due to confidence in the stability of the water supply, the spread of suitable oviposition plants on site in the last five years and the observation that large numbers of the re-introduced animals were mating and ovipositing within hours of being released.
- What would constitute highly successful would be if there was some exchange of genes from this site with one or other of the two neighbouring sites to establish a meta-population structure for the species rather than there being three isolated sites within the region.

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Re-introduction of the San Francisco forktail damselfly into an urban park, California, USA

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Introduction

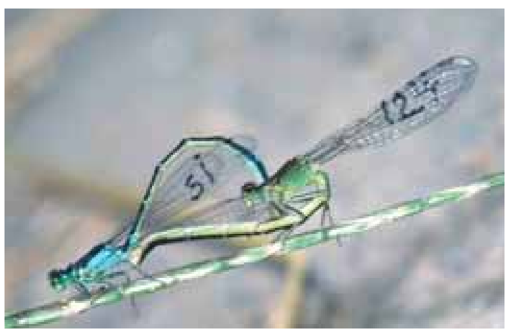
The San Francisco forktail damselfly (*Ischnura gemina*) remained largely unknown after its description (Kennedy, 1917) until rediscovered in 1978 (Garrison and Hafernik, 1981a). It is endemic to the San Francisco Bay Area of California, a region that has experienced considerable habitat loss due to urbanization. The World Conservation Union classifies *I. gemina* as vulnerable with population trends decreasing (IUCN 2009). Hybridization with a widespread relative *I. denticolis* may also threaten *I. gemina's* genetic integrity (Leong & Hafernik, 1992). Studies of *I. gemina* in Glen Canyon Park, San Francisco detailed the species' population structure and mating behavior (Garrison and Hafernik 1981b; Hafernik and Garrison 1986). In the late 1980's, habitat degradation caused extinction of *I. gemina* in the park. We re-introduced *I. gemina* into Glen Canyon after the damselfly's habitat was restored; monitored the damselfly's movements and population dynamics; and compared our data to the prior studies in the park (Hannon & Hafernik, 2007). Recapture rates were lower than in prior studies due to a larger initial decline in marked individuals. The re-introduction was initially successful and damselflies reproduced throughout the summer and into following year. However, the population failed to persist because its habitat became degraded with excess vegetation.

Goals

- Goal 1: Test whether it is possible to re-establish a population of *I. gemina* by releasing adults.
- Goal 2: Test whether the newly released population behaves like prior *I. gemina* populations in Glen Canyon as documented in Garrison and Hafernik, 1981a and Hafernik and Garrison, 1986.

Success Indicators

- Indicator 1: Observation of mating and oviposition.
- Indicator 2: Observation of newly emerged adults.



San Francisco forktail Damselfly mating pair

- Indicator 3: Observation of second-year adults and reproductive activities.
- Indicator 4: Estimation of longevity and movement patterns similar to previous studies.
- Indicator 5: Self-sustaining populations established at re-introduction site.

Project Summary

Feasibility: Most of the watershed that drains into Glen Canyon has been lost to urbanization. However, *I. gemina* persists in small, isolated wetlands similar to those in the canyon. Because adults usually move only short distances during their lifetimes, damselflies released at a site have a good chance of remaining and reproducing at that site enhancing prospects for success. The Glen Park neighborhood also is home to a group of citizens committed to maintaining native plants and animals in Glen Canyon. Their participation in active management of introduction sites could be key to future success.

Implementation: We conducted a project during 1996 and 1997 to re-introduce *I. gemina* into Glen Canyon. The receiving site for adult damselflies was a linear asphalt channel on the rim of the easternmost slope of Glen Canyon Park. The channel carries water from a permanent seep. This channel was the sole breeding area for *I. gemina* in Glen Canyon prior to its local extinction (Garrison & Hafernik, 1981b; Hafernik & Garrison, 1986). We surveyed surrounding wetlands on the San Francisco Peninsula to find a source of stock for reintroduction. Our surveys indicated that the nearest large population of *I. gemina* was in a wetland approximately 12 km south of Glen Canyon. We assessed biotic and abiotic characteristics of the receiving site and found adequate larval food for *I. gemina* in the channel and in newly created ponds in the canyon bottom. Neither habitat contained fish, although the ponds contained larval dragonflies (*Aeshna* sp.), which could prey on *I. gemina* larvae. To restore habitat for *I. gemina*, we cleared aquatic vegetation that had grown in and over the channel. This work left the site relatively free of aquatic vegetation with open and sun-exposed areas. In addition, the California Conservation Corps implemented a habitat restoration project in the bottom of the canyon. They removed riparian trees and shrubs (e.g., *Salix* spp.) from a large seep and constructed three new pond-like habitats in Islais Creek near the seep. At the source site, we collected approximately 40 mating pairs on three separate days. This number was deemed appropriate since it was not likely to negatively impact the source population, it provided an adequate sample of genetic diversity of the source population, and it allowed new releases to approximate the number of adult damselflies previously found at the channel. We carefully transferred damselflies into small plastic vials with a source of moisture. We transported them to our laboratory in a cooler containing ice to limit stress from handling, warm temperatures, and light. In the laboratory, we marked individuals on their wings with a unique number using an indelible ink pen. We released the damselflies at the channel the following morning to give them a chance to feed before their midday peak mating period.

We chose mating pairs because they provided an equal number of males and females for reintroduction. Secondly, it assured that individuals transferred were reproductively active, which increased the chance of oviposition at the receiving

Damselfly habitat before (*left*) and after restoration (*right*)

site. Thirdly, pairs are conspicuous while unpaired females are usually cryptically colored and forage and rest away from the water (Hafernik, 1989). Lastly, we chose mating adults because juvenile damselflies are more easily damaged in handling than reproductively mature ones. We re-introduced captured adults instead of lab-reared adults because re-introducing mated females maximized the likelihood of establishing a new population quickly. Alternatively, another life history stage, such as eggs or larvae, could have been used for the re-introduction. However, this procedure would have been more labor intensive and would not have allowed comparison of the behavior of newly released adults with prior research in the canyon.

Post-release monitoring: We monitored the re-introduced population daily to estimate mortality and movement patterns and to observe their behavior. After a large initial decrease in recapture rate compared to previous years, survival and movement patterns were similar to those of previous studies. As in previous studies, some damselflies dispersed from the channel to the ponds below. We observed damselflies behaving normally and mating and ovipositing into aquatic vegetation. At least two generations of new adults were observed in 1996. In 1997, damselflies emerged in the spring, but did not persist into the fall. Subsequent yearly visits to Glen Canyon have found no individuals of *I. gemina*. Future plans by the City of San Francisco call for re-introducing the damselfly again if it is not observed in the next five years. Success will require active management of wetlands in the canyon to control invasive vegetation. Additional re-introductions are being considered in restored wetlands in the Presidio of San Francisco, a U.S. National Park.

Major difficulties faced

- Habitat upkeep is needed due to loss of natural ecological processes, habitat requires vigilance and proper maintenance.
- Lack of nearby populations to provide natural reestablishment and gene flow.

Major lessons learned

- Re-introductions using adult damselflies can work.
- Because of the loss of the natural processes that maintained appropriate habitat for the damselfly, active management will be needed for it to persist in places like Glen Canyon.
- A partnership of co-operative stakeholders that includes representatives of the San Francisco Parks and Recreation Department, citizen groups and local scientists needs to be established to make management decisions quickly and review their success.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Successfully trans-located the species.
- Species behavior upon release was not impacted.
- Unable to maintain or "re-create" natural processes to keep habitat suitable through time.

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Conservation of a unique bullhead population in Flanders, Belgium

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Introduction

Bullhead is a small, bottom-dwelling freshwater cottid. Based on molecular and morphological data fifteen bullhead species can be distinguished in Europe (Freyhof *et al.*, 2005). In Belgium only two indigenous species occur: *Cottus perifretum* in the Scheldt River drainage and *Cottus rhenanus* in the Meuse River drainage (Volckaert *et al.*, 2002). Formerly bullhead was common in Flanders, the northern region of Belgium. Due to water pollution, habitat degradation and fragmentation however, it declined dramatically. Consequently bullhead is listed as IUCN susceptible in the national Red List and fully protected. It is also listed in Annex II of the Habitats Directive. Nowadays only very few small and fragmented *Cottus perifretum* populations remain in the Scheldt River drainage. To prevent further substantial losses in genetic variability within this species, management should aim to protect and conserve as many populations as possible. Until 2003, *Cottus perifretum* was thought to be extinct from the entire Demer River basin, a river basin belonging to the Scheldt River drainage. That year a unique relict population of this bullhead species was found in the Dorpbronbeek. The status of this population is extremely precarious because of the small living area and population size and the recent deterioration of the habitat.

Goals

- Goal 1: Educate authorities about the need to protect this relict population and advise them to take measures to conserve the relict population *in situ* by restoring and protecting the habitat.
- Goal 2: If feasible re-introduce cultured progeny from the relict population to other suitable locations within the same river basin in order to preserve the gene pool *ex situ*.

Recaptures one year after release

- Goal 3: Secure the gene pool in captivity for conservation purposes in the event that the wild relict population becomes extinct

Success Indicators

- Indicator 1: Develop captive breeding techniques to allow the reliable production of bullhead for re-introduction purposes.
- Indicator 2: Find suitable locations to re-introduce the bullhead.
- Indicator 3: Good survival, growth and breeding of the released animals in the wild.
- Indicator 4: Establishment of a viable, self-maintaining population.
- Indicator 5: Expansion of the species' range from the initial releasing sites.

Project Summary

Historical data show that bullhead formerly was common in the entire Demer River basin and that it declined dramatically due to pollution, habitat degradation and fragmentation. In 1957 the last bullhead was observed. For a long time it was believed to be extinct from the river basin. However, the Flemish Environment Agency (VMM) caught a bullhead in the Dorpbronbeek in 2003. Subsequent monitoring by means of electrofishing revealed that a small bullhead population still occurs in this small tributary over a short distance of about 200 m. The status of this population is extremely precarious because of the small population size and living area and the recent habitat deterioration. Immediately after the discovery of the relict population, the Research Institute for Nature and Forest (INBO) informed the authorities about the existence of the bullhead population and advised them to take measures to conserve this population *in situ*. INBO also launched together with the Agency for Nature and Forest (ANB) a re-introduction program to protect and conserve this population by re-introducing its cultured progeny to other suitable waters within the same river basin.

Feasibility: The feasibility study consisted of a genetic study, a captive breeding program and a habitat suitability study. Genetic research using microsatellites revealed that the discovered population indeed concerns a relict of the bullhead *Cottus perifretum* in the Demer River basin (Horemans, 2006). Moreover, the population has five private alleles. To prevent further genetic erosion within *Cottus perifretum*, the conservation of these unique genes is extremely important. A captive breeding program was developed at the fish culture centre of INBO to spawn and rear bullhead in captivity in order to provide enough stocking material for a possible re-introduction. The brood fish were collected from the source population in the Dorpbronbeek. The program started in 2004 and has become increasingly successful with time. In 2007, INBO assessed the macrohabitat suitability of seven waters within the Demer River basin with a sufficient to excellent chemical and biological water quality. The key habitat requirements for bullhead were obtained from the literature. The potential re-introduction sites were assessed in order to find the most suitable location for a re-introduction of bullhead. The habitat in the Dorpbronbeek was used as a reference biotope because of its similarity to the other locations within the same basin. Finally the Zevenbronnenbeek, a small tributary within the same subbasin as the

Artificial spawning substrates

Dorpbronbeek, was selected as the best re-introduction location. A qualitative electro-fishing made sure that no remnant bullhead population was present.

Implementation: In October 2008, ANB released 1220 cultured young of the year bullhead to the Zevenbronnenbeek over a distance of 1,600 m. The length of the released animals averaged 5.5 ±0.9 cm (3.1 cm - 8.0 cm) and the weight 1.9 ±1.2 g (0.2 g - 6.9 g). To enhance the habitat at the releasing site even more, 68 ceramic tiles were added to the stream as additional artificial spawning substrates and shelter (Knaepkens *et al.*, 2004).

Post-release monitoring: In 2009 the success of the re-introduction of bullhead in the Zevenbronnenbeek was assessed. During sampling by means of electro-fishing in March, August and September 2009, re-introduced bullhead were always successfully recaptured. These fish were in good visual condition and showed good growth. From January 2009 on, the ceramic tiles in the Zevenbronnenbeek were checked monthly for the presence of egg-clusters underneath them. From the end of February until the end of April, sexually active, territorial males were observed underneath the tiles. By the end of March, also bullhead egg-clusters were found. Throughout the natural breeding season about 40% of the tiles were occupied by territorial bullhead and in total 19 egg-clutches were found. Also natural substrates like hollow woody debris were used by bullheads to lay their eggs. Natural recruitment was a success since young of the year bullhead were sampled In August and September. The juveniles averaged 4.3 ±0.5 cm (3.6 cm-5.4 cm).

Major difficulties faced

- The relict population is still facing problems. It seems difficult to incite the authorities to implement protection measures, even for an Annex II species of the Habitats Directive.
- Securing adequate funding for all the phases of the re-introduction program.
- Finding suitable re-introduction sites, since the ecological quality of most of the headstreams is still insufficient.

Major lessons learned

- The ecological quality of most of the headstreams is still insufficient.
- Re-introduction of a sensitive species like bullhead is feasible.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- Successful and reliable captive breeding.
- The released fish are still present at the releasing sites.
- The re-captured fish show good growth and are in visual good condition.
- Natural recruitment was successful.
- Urgent measures should be taken to improve the habitat quality of the Dorpbronbeek in order to protect and conserve the relict population.

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Supportive breeding of the Tokyo bitterling in Tochigi Prefecture, Japan

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Introduction

The Tokyo bitterling (*Tanakia tanago*) is a threatened cyprinid species endemic to the Kanto region of central Honshu, Japan. This species primarily inhabits small brooks and swamps originating from springs scattered along hilly lowlands and alluvial fans, and its past range is thought to have extended throughout the lowlands and hilly lowlands of the Kanto Plain. In recent decades, most of its habitat has been destroyed by human activities, such as urbanization and the improvement of paddy fields. Because this species lays its eggs in the gill chambers of freshwater mussels (commonly Unionidae), declines in mussel populations also critically affect the persistence of bitterling populations. Wild populations are now found only in a few localities in Tochigi and Chiba Prefectures. Due to its drastic habitat loss, this species was designated as a natural monument of Japan in 1974 and listed as an endangered species under the Law for the Conservation of Endangered Species of Wild Fauna and Flora of Japan in 1994. This species was also catalogued as “Critically Endangered” in the Red Data Book of the Environment Agency of Japan and as “Vulnerable” in the IUCN Red List. An on-going supportive breeding program aims to reinforce a wild population in the Tone River, which inhabits a single irrigation ditch (~900 m long, 84 cm mean width) and has declined rapidly in recent years.

This project has been funded by the Environment Agency and the Fisheries Research Agency of Japan.

Tokyo bitterling (*Tanakia tanago*)

Goals

- Goal 1: To increase the number of individuals in the population.
- Goal 2: To produce genetically managed juveniles using information on the genetic relatedness of parent fish.
- Goal 3: To enable the breeding of released individuals in the wild.
- Goal 4: To avoid inbreeding in a small headwater habitat isolated by small weirs.

Success Indicators

- Indicator 1: Population size increases throughout the habitat.
- Indicator 2: The captive breeding is successful, producing juveniles that retain suitable genetic diversity.
- Indicator 3: The genetic diversity of the wild population is maintained or increased, particularly within the upper reach of weirs.

Project Summary

Feasibility: Since 2006, extensive field surveys, including estimations of population size and genetic diversity using microsatellite analyses, have examined the single remaining natural population within the Tone River system. The estimated population size was 104 (± 37 SD) individuals, and the wild population had lower genetic diversity than a captive population founded in 1994 with eight founders (four males and four females) from the natural habitat. The population was fragmented by small weirs within the ditch, and high genetic relatedness was found among individuals within fragments (mean r_{xy}=0.322; half-sibling relation in general). All the available data suggested that this population had been declining recently and that immediate reinforcement of this population was needed. Consequently, we conducted a novel supportive breeding program using wild fish as founders. We did not choose to re-introduce the existing captive population, which had been in captivity for a long period, because it might be adapted to captivity. Mussels for laying eggs are relatively abundant in the ditch, so the increase in breeding fish was believed to have helped to reinforce the population. Facilities and techniques for captive breeding had already been available at Tochigi Prefectural Fisheries Experimental Station.


Typical habitat of the Tokyo bitterling

Implementation: In the autumn of 2007, after the spawning season in the wild, 42 individuals were caught from the habitat and were re-matured using a long photoperiod and warm water temperature treatments. As


Post-release monitoring in the field

field surveys had demonstrated that pairs of fish caught some distance apart had lower genetic relatedness, mates were chosen from more distant sampling sites to avoid mating close relatives. Fifteen pairs were bred in separate aquaria from January to March 2008, and a total of 1,415 (20-150 from each pair) offspring were obtained. Twenty offspring from each family were chosen randomly for re-introduction to equalize family sizes. Ultimately, 296 (four died before release) offspring and parent fish were released throughout the natural habitat in the summer of 2008. No differences in allele frequencies or genetic diversity (heterozygosities) were observed between the re-introduced offspring and the wild population in 2006.

Post-release monitoring: The population has been monitored biannually. In the autumn of 2009, 132 under yearlings and yearlings that newly emerged in the wild (this species lives for 1-2 years) were caught, and the estimated population size was >200 individuals based on catch–mark–recapture data. The average genetic relatedness among individuals isolated above weirs had decreased to an unrelated level (mean r_{xy}=–0.002). These results suggest that natural reproduction was enhanced by the re-introduction and that short-term reinforcement of this population has been achieved. To ensure the long-term persistence of the population, habitat improvement to eliminate factors affecting the recent bottleneck is required.

Major difficulties faced

- The lack of sufficient habitat space to maintain the population: Suitable habitat for the reproduction of this population is restricted to a single 900 m long ditch. Improvement of this habitat is planned to improve the carrying capacity for long -term persistence.
- Difficulties in breeding while maintaining genetic diversity: Although breeding techniques for this species are well established, the breeding method using a large number of mates in separate aquaria was costly and required much manpower. Accordingly, it is difficult to perform this method repeatedly for reinforcing the population, especially with a limited staff.
- Illegal poaching: Poaching of the Tokyo bitterling by aquarists and traders still continues in this habitat. Surveillance of the habitat by the neighborhood association and the police has been conducted to stop poaching.

Aquaria for captive-breeding

- Anonymity of the habitat: Because this habitat has not been disclosed for conservation purposes, it is impossible to attract media interest and to raise public attention.

Major lessons learned

- Advanced scientific field data are essential for making management decisions and planning captive breeding. In particular, genetic data are important for improving the program.
- Using genetic information and advanced breeding techniques, we can provide juveniles that are genetically suitable for release.
- Re-introduction also helps to temporarily resolve the influence of habitat fragmentation on the population.
- Further ecological research should be carried out for future habitat improvement.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Reinforcement through the reproduction of released individuals was confirmed.
- Practical genetic management of the captive breeding program was planned and conducted successfully.
- Habitat has not been improved to assure the long-term persistence of the population.

Re-introduction of the "Extinct in the Wild" Yarqon bleak, Israel

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Introduction

The Yarqon bleak (*Acanthobrama telavivensis* Goren, Fishelson & Trewavas, 1973), endemic to the coastal river system in Israel, is the most notable representative of Cyprinidae in this system. Until the 1950s it was distributed throughout the coastal river network, except for Kishon River (Goren *et al.*, 1973; Goren & Ortal 1999). By 1999 only three small isolated populations survived. Following the 1999 winter drought it was on the brink of extinction. In order to save it, a breeding facility was established at Tel Aviv University and ~150 fish were captured prior to complete drying of the rivers. Initial re-introduction of the fish to nature, in 2002-2003, failed. Surveys in 2003-2004 revealed its failure to reproduce in nature. It was considered critically endangered in the Israeli Red Book (Goren, 2004) and "Extinct in the Wild" by IUCN (2006). Additional research (laboratory and artificial engineered pond fed from the Yarqon River), provided knowledge enabling proper engineering of natural and semi-natural sites. During 2006-2007, ~9,000 laboratory-born fish were introduced to 12 sites, mostly engineered. Surveys in 2007-2009 revealed juveniles at most sites. The "Extinct in the Wild" Yarqon bleak has been successfully returned to nature.

Goals

- Goal 1: To save and re-introduce the "Extinct in the Wild" Yarqon bleak to nature.
- Goal 2: To acquire the essential scientific knowledge for a successful return of the Yarqon bleak to nature and to secure its long-term survival in nature.
- Goal 3: To rehabilitate and engineer the disturbed habitat to suit the needs of the Yarqon bleak.

Success Indicators

- Indicator 1: Breeding of released individuals.
- Indicator 2: Persistence over three generations.

First generation wild fish captured in 2007

Ein Afek restored habitat - before (*left*) and after (*right*)

Project Summary

In July 1999 we realized that the last habitats of the fish were drying up as a result of the severe drought in 1999 that had followed several years of low precipitation. At this point I approached the authorities and suggested hosting several thousand fish in my laboratory for a year or two and then returning them to nature when the drought ended. Since the catastrophe was expected to continue (this area experiences frequent droughts) we had to reach a quick decision and no feasibility study was made. Fortunately, co-operation between the Yarqon River Authority, the Nature and Park Authority, the Ministry for Protection of the Environment and my own laboratory was achieved, and within three months we managed to raise the needed funds and to build the facility for maintaining the fish in the ichthyological laboratory at Tel Aviv University. Unfortunately, by then not much was left of the habitats. We were able to capture approximately only 100 fish from Nahal Yarqon and approximately 50 fish from Nahal Tut before the streams dried out. The fish, in a very bad state of health, were brought to the ichthyological laboratory and carefully treated and housed in the facility. Since only 150 had been saved, while for re-introduction of the fish thousands were needed, we set out to breed them.

Maintenance of the breeding center was complicated and included feeding the fish with a combination of manufactured and natural food, daily monitoring of the spawning substrate, transferring the spawn and their substrate to special tanks and providing each stage of the larvae and post-larvae with different conditions and diet. Within a period of three years we had managed to produce more than 10,000 fish (of both populations). Because the Yarqon bleak is a wild fish and at that time we had very little knowledge of its biology, we faced dilemmas regarding its diet, preferred spawning substrate, temperatures, velocity of the water, photoperiod, etc. Therefore, from the first day of arrival of the fish at the lab, continuous research of various biological aspects was carried out and the subsequent implementation of the findings proved to be crucial for the success of the re-introduction. We have developed a protocol for daily procedures in handling the fish, spawns, and water quality, and have developed a special menu for each stage of the larvae and post-larval development.

Parallel to our work, the Nature and Parks Authority reached an agreement with the Government to ensure a permanent, minimum supply of high quality water for the upper part of the Yarqon River. This enabled us in 2003 to return ~5,000 adult fish to the Yarqon River. This was accompanied by a public relations campaign and educational activities. Surveys carried out in the following years revealed that the re-introduced fish had survived in nature but did not reproduce. Considering the knowledge acquired in the lab, we assumed that the reason for the failure was the absence of suitable spawning substrate and insufficient shelter sites for the juveniles. To examine this hypothesis we constructed a pond of ~400 m^2 and 1 m depth, of which the bottom was covered with gravel and piles of stones. In addition various plants were planted in and around the pond (*Nymphaea coerulea, Potamogeton nodosus, Cyperus longus, Cyperus corymbosus, Lythrum salicaria, Lythrum junceum, Lycopus europaeus, Juncus fontanesii, Polygonum salicifolium, Trifolium sp, Cynodon dactylon, Phyla nodiflora*). Within a few months after stocking the pond with Yarqon bleak, thousands of juveniles were observed in the pond. Following this success and the Government's assurance regarding water, 12 sites along the Israeli coastal system were assigned for re-introduction of the fish, most of them engineered. During 2006-2007 approximately 9,000, laboratory-born fish were returned to nature. Offspring of the Yarqon River captured fish were stocked in southern Israel, in or close to the Yarqon River basin, while offspring of the Tut Stream were stocked in various rivers in the central and northern coastal system, in basins where this species had existed in the 1950s. In surveys carried out in 2007-2009, juveniles were found at most sites. The various stages of the project are described in detail in Goren (2009).

Major difficulties faced

- The almost complete lack of relevant scientific knowledge regarding the biology of the fish.
- Financial support: the budget acquired was far less than the minimum required for the project. Much of the maintenance and research was performed by volunteers.

Major lessons learned

- There are no short cuts in saving endangered species. These kinds of projects are long-term and consume a lot of time, money, good will and broad consensus of the neighboring community.
- The efforts to save a species should be directed simultaneously to several channels:

First release of bleak to Shelf River in 2002

i. Establishment of a breeding center for the species and developing a professional maintenance protocol.
ii. Research: studying the relevant aspects of the fish biology (diet, spawning habits, water quality and velocity, shelters, preferred temperatures for various stages of reproduction, preferred habitats etc.)
iii. Public relations: In order to achieve the funds needed for the project and to secure a long-term supply of water in arid countries, the good will of the public and the decision-makers is essential.
iv. Rehabilitation and engineering of the habitat.
v. Continued monitoring of the habitat after re-introduction of the fish.
vi. A devoted leader for such a project is the key to success.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The fish reproduced in nature over 2-3 consecutive years.
- The fish population has increased significantly since the re-introduction.
- A permanent supply of good quality water to the rivers was promised by the Government as part of a new approach called: “The right of nature to water”.

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Colorado pikeminnow re-introduction and population augmentation in rivers of the Western USA

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Introduction

The Colorado pikeminnow (*Ptychocheilus lucius*) attains sizes well over 1.5 m length and 35 kg weight. This species is a large river fish that migrates long distances for spawning. The Colorado pikeminnow is endemic to the Colorado River basin of the western USA and was listed as endangered in the original US Endangered Species Act of 1973. The IUCN classifies this species as vulnerable to extinction and recent population estimates indicate it remains in need of national protection. The largest population (6,000-8,000) of Colorado pikeminnow occurs in the Green River where reproduction has been repeatedly documented. The upper Colorado River is believed to support reproduction and has a population estimated to be from 600-900 adults and some subadults. The San Juan River, a tributary of the Colorado River discharging into Lake Powell (Glen Canyon Dam), had a small number of individuals (<50) with no or very limited reproduction in the 1990s. A key goal for recovery of the species is to achieve self-sustaining populations in each of these three rivers. The upper Colorado River had hatchery produced Colorado pikeminnows stocked for two years, and the San Juan has had an intensive and long-term stocking program since 2002.

Goals

- Goal 1: Establish Colorado pikeminnow in river reaches no longer producing juvenile fish.
- Goal 2: Accelerate population recovery in the unpopulated reaches upstream of the diversion dams.

Colorado Pikeminnow © US Fish and Wildlife Service

- Goal 3: Evaluate dispersal and retention of stocked juvenile Colorado pikeminnow and determine habitats needed for rearing.
- Goal 4: Add genetic diversity to the existing gene pool and establish a refuge population in suitable river reaches.

Success Indicators

- Indicator 1: Retention of stocked juvenile fish in target river reaches.
- Indicator 2: Document spawning success and recruitment of sub-adults to adults.

Project Summary

The Colorado pikeminnow is a long-lived fish (40+ years) that persists in river reaches that have been isolated by diversions and dams and no longer support the entire life cycle of the species. Augmentation of these small remnant populations with cultured fish was planned as experiments to determine the feasibility of rebuilding populations with hatchery-produced individuals. Two years of stocking juvenile fish (2,000-3,000 annually) was conducted and evaluated in the upper Colorado River basin where a small population was present and reproduction was documented. An aggressive, long-term (eight year) program of population augmentation (300,000 annual stocking objective) was implemented in the San Juan River where few fish were present and no reproduction was detected in field studies. Colorado pikeminnow stocked in the upper Colorado River failed to stay in the targeted river reaches. Most or all stocked fish dispersed downstream out of the study areas, and none were recaptured near stocking locations. Some were recorded in water diversion canals drained after the growing season. High mortality was also suspected for stocked fish, and some may have moved downstream into impounded waters not regarded as suitable habitat. Following these findings, Colorado pikeminnow population augmentation was considered unsuccessful and suspended in the upper Colorado River. Construction of fish passage facilities and screening water diversions were regarded as more effective management practices for rebuilding Colorado pikeminnow populations in the upper Colorado River. Initial evidence for success of these practices has been obtained.

In the San Juan River Colorado pikeminnow were re-introduced using all early life history stages: eggs, larvae, young of the year, and juveniles up to age five. The annual stockings were tracked to determine the extent and rate of dispersion and the fate of stocked fish. Experiences indicated that traditional fish hauling and stocking techniques might contribute to rapid downstream dispersal. Consequently a release strategy was developed to minimize immediate passive downstream dispersal. Cultured fish were acclimated in river water, and moved in live wells by rafts to multiple low-velocity, off-channel habitats for one or more days prior to release. The more intensive and long-term population augmentation in the San Juan River initially found rapid downstream dispersal out of target river reaches that suggested a poor chance of success. However, after several years of intensive stocking, evidence of survival of re-introduced fish began to emerge from field monitoring. Stocked Colorado pikeminnow have been documented to survive multiple years and the number of fish in the river has been steadily increasing from year to year. Re-introduced juveniles recently began to reach adulthood and some natural reproduction and larvae have been documented. Therefore, population augmentation by intensive stocking is now resulting in some fish completing their life cycle in the river. Thus the population augmentation by stocking is resulting in an increasingly secure population of Colorado pikeminnow in the San Juan River, and being considered an effective strategy for population recovery.

Upper Colorado River, Moab, Utah @ Mark Bain

Major difficulties faced

- Numerous dams and large reservoirs regulate river flows, alter sediment dynamics, change water temperatures, and disrupt habitat formation processes.
- Non-native fishes dominate the rivers and pose serious predation and competition in low velocity habitats that are the key nursery areas for larval and juvenile Colorado pikeminnow.
- Diversion structures and dams fragment the rivers, block migrations, and threaten dispersing young fish.
- Restoration programs must advance recovery of the Colorado pikeminnow and other endangered species and be compatible with intensive water use and further water supply development.
- The key measure of success is establishing secure, self-sustaining populations and many years will be needed to confirm this conclusion.

Major lessons learned

- Re-introduction and population augmentation can be an effective option for fish species recovery.
- Conservation strategies appear to require many years of consistent effort to judge effectiveness.
- Conservation programs should experiment with a broad range of practices and include most or all life stages.
- Monitoring the distribution and fate of re-introduced fish is essential to learn from and assess conservation programs.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Re-introduction and population augmentation appears to be succeeding in one case and failed in another case.
- Not enough time has passed to fully realize and document the establishment of a secure and self-sustaining population.
- Evidence from monitoring has documented some success criteria but not all.

References

Numerous reports, papers, and newsletters available from the Upper Colorado River Endangered Fish Recovery Program *http://www.coloradoriverrecovery.org/* were used to develop this review.

Re-introduction of Atlantic salmon to the River Rhine System: case study of the River Sieg, Germany

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Introduction

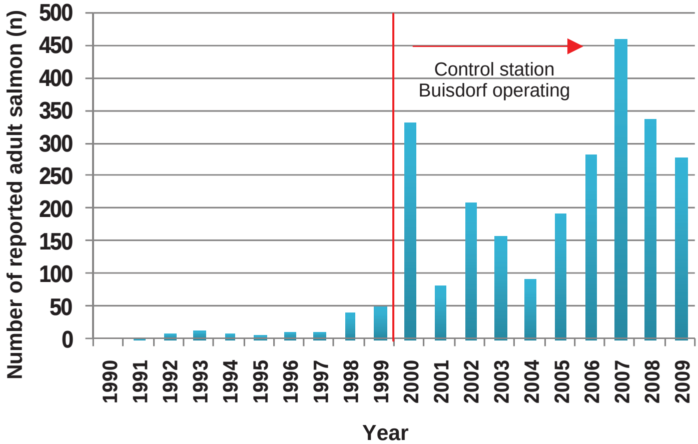
Atlantic salmon (*Salmo salar*) is an anadromous salmonid spawning in freshwater, in the headwaters of rivers. Juveniles in the range of 12 to 25 cm migrate in the springtime to the sea. After 1 to 4 years, the adults leave the sea and enter freshwater again. They grow up from 50 cm to more than 100 cm reaching a total weight of up to 30 kg. The species is widely distributed in Europe from Spain (South) to Norway and Russia (North) and formerly colonized all big German rivers draining the North Sea. The fishery of Atlantic salmon was very important in Europe and in 1885 more than 250,000 individuals were captured in the Rhine. In the beginning of the 20th century Atlantic salmon catches were strongly declining in the Rhine despite first international efforts to maintain the species. By the end of the 1950s Atlantic salmon was extinct from the Rhine System and other large German rivers (Ems, Weser and Elbe). As a consequence Atlantic salmon is listed as priority species in Annex II and V of the Habitat Directive. In the German Red List the species is listed as extreme rare (RL 1: es) and in the IUCN Red List as vulnerable (VU). The geographical area of the re-introduction project is the River Rhine System in North Rhine-Westphalia, Western Germany.

Largest salmon captured in the River Sieg since 1990 (male/113 cm) © G. Feldhaus, LANUV

Goals

- Goal 1: Rehabilitation of rivers and their habitat in order to fulfill the ecological demand of sensitive migratory fish species.
- Goal 2: Re-establishment of a genetically adapted population of Atlantic salmon by using returning adult fish in a breeding program.

Fig. 1: Number of adult salmon recorded in the River Sieg since 1990



- Goal 3: Re-introduction of the formerly extinct Atlantic salmon in best suited tributaries of the River Rhine.

Success Indicators

- Indicator 1: Increase of available juvenile habitat that can be reached again by adult spawning fish.
- Indicator 2: Increase of downstream migration of juveniles (smolts) leaving the river of their release (measured by e.g. marking experiments, rotary screw trap in the River Sieg).
- Indicator 3: Increase of the return rate of adults entering the river of their release (measured by counting adult salmon at control stations in the River Sieg and its tributaries, e.g. Buisdorf and Troisdorf).
- Indicator 4: Increase of natural reproduction of adults in several tributaries of the River Sieg (e.g. Agger, Bröl, Naafbach); counting of natural fry by electro-fishing campaigns.

Project Summary

Feasibility: The project started as early as 1988 along the River Rhine coordinated by the International Commission for the Protection of the River Rhine (ICPR). The so called Rhine Action Program (called "Salmon 2000") was initiated by the riverine countries as a reaction to a dramatic fire incident in Switzerland (Sandoz accident) where in 1986 contaminated water killed fish along a 200 km stretch of the River Rhine in Switzerland, France and Germany. The overall goal of the Rhine Action program is the ecological rehabilitation of the River System which is now integrated into the activities with regard to the Water Framework directive of the EU aiming at the good ecological status of watersheds.
In the beginning of the project, the habitat surface suitable for Atlantic salmon (juvenile and spawning habitat) was investigated in the River Sieg and its tributaries, North Rhine-Westphalia. More than 100 ha of habitats were mapped and GIS referenced. The potential salmon stocks in other European countries showing comparable environmental conditions as the former Rhine salmon were screened for the delivery of eggs and other life stages for stocking. In the beginning of the project it was decided to use a mix of several salmon origins for stocking of the River Sieg (Salmon from Norway, Scotland and Ireland). The program was run by the ministry of environment of North Rhine-Westphalia which

Release of juvenile salmon by a school class
© G. Feldhaus, LANUV

made official funds available to the state agency for ecology and fisheries of the Land Northrhine-Westfalia responsible for operating the re-introduction of salmon.

Implementation: In the beginning of the project (1988 -1994) only low numbers of salmon have been released to the River Sieg. In 1990 the first adult salmon was recorded in the Bröl, tributary of the River Sieg and in 1994 the first successful reproduction was registered after the extinction of the species in the River Rhine. From 1994 to 2000 more juveniles were released to the River Sieg but numbers of adult fish remained relatively low partly due to the lack of a systematic control at fish ladders. In 1998 the project was reorganized by the ministry and the fishery association of North Rhine-Westphalia stepped in as a cooperation partner within the new migratory fish program (1998-2010). Two permanent staff members of the fishery association went into the coordinating bureau of the program together with two project managers of the state agency for ecology and fisheries.

The key species in the migratory fish program are in addition to salmon, houting, eel and since 2007 Allis shad (see Beeck *et al.*, 2008). Since 2000, a control station is operating at the uttermost downstream dam in the River Sieg at Buisdorf as part of the monitoring which enables the counting of adult salmon ascending the river. The control station is run in close cooperation with the Land of Rhineland-Palatinate and this contribution is gratefully acknowledged. Since 2004 the use of different salmon origins in the River Sieg was abandoned and only one salmon stock from Denmark (transplanted originally from the River Ätran (Sweden) is used in accordance with the Land of Rhineland-Palatinate (responsible in middle stretch of the River Sieg). The translocation of salmon used for stocking is performed with young life stages (eyed eggs, alevins, parrs and smolts). The veterinarian control is done by Danish authorities as well as by the laboratory for fish health of the state agency for ecology and fisheries in North Rhine-Westphalia.

Post-release monitoring: One of the most important post-release monitoring techniques is electro-fishing in autumn. Selected habitats where alevins and parrs have been released in the beginning of the summer are fished every year. In the time period 1999-2003 only 1/3 of the habitats tested reached good or very good survival rates (>15, or 25 %, respectively). During this earlier period, stocking was mainly performed with unfed or shortly fed alevins. From 2004 to 2008 stocking

Salmon hatchery team of the state agency for nature and environment of Northrhine-Westfalia © G. Feldhaus, LANUV

protocol was changed to summer parrs (1 g fish, fed between 8-12 weeks) and the proportion of habitats showing good to very good survival in autumn increased to more than 70 %. Electro-fishing is also used to monitor salmon juveniles originating from natural reproduction in some accessible tributaries of River Sieg. Since 2004, the number of juveniles per 100 m^2 of tested habitats is increasing in one major tributary (River Agger), reaching a mean value of about 148 individuals per unit. The number of adult salmon returning to the River Sieg is counted at two control stations in the Sieg catchment. The maximum number was reached in 2007 with more than 400 individuals. As the efficiency for those traps is believed to reach only 50 % the number of returning salmon was probably twice as high. With a yearly estimate of the number of smolts leaving the River Sieg in spring, a return rate can be calculated in the range of 0.5% to 1.0%. This return rate is far too low to sustain the population and to stop stocking in coming years. Therefore a ranching program was started with about 100 adults captured at Buisdorf every year. The eggs of these fish are stripped at the hatchery of the state agency in Kirchhundem-Albaum and most off the offspring is used for stocking in the following spring (about 200,000 alevins). A small proportion is reared in the hatchery to feed a freshwater gene bank of offspring from returning fish. The eggs produced from those freshwater reared spawners will be used for stocking other tributaries of the River Rhine in North Rhine-Westphalia.

Major difficulties faced

- Transition of fish between freshwater and sea is hampered in the Rhine delta, the Netherlands, due to large dams constructed against sea floods.
- A large proportion of freshwater habitat is not accessible due to the presence of dams without fish passages.
- Losses of juveniles during downstream migration at hydropower plants with turbines without fish protection screens.
- Illegal fishing of protected adult salmon on their way to the spawning grounds in the Rhine (delta) and its tributaries.
- Poor habitat quality due to water pollution and erosion in the basin of spawning rivers.
- Observed decline of marine survival of Atlantic salmon in the sea in recent years.

Major lessons learned

- The re-introduction of salmon has to be coordinated not only on a national but on an international level to cope effectively with all problems faced in a large River System like the River Rhine.
- Intensive monitoring of all activities (especially stocking) in the project is necessary to evaluate the results. Control stations are mandatory in the main river (like River Sieg) to count returning adults.
- To establish a migratory fish species with a complex life cycle a long-term project funding is needed.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The long-term funding of the project and the implication of stakeholders (fishery association) is important for the success of such an ambitious re-introduction.
- The coordination of the International Commission for the Protection of the River Rhine is important in a large river system like River Rhine.
- The integration of the efforts into the water framework directive of the EU is very important to improve fish passages and habitat quality.
- The initial project goal to establish a self-sustaining salmon population is still not met and the enhancement of the new population in the River Sieg by ranching is necessary probably until 2020.

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Re-inforcement of Adriatic sturgeon in the Ticino River, Lombardy, Italy

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Introduction

The Adriatic sturgeon (*Acipenser naccarii*) is a threatened fish considered endemic to the Adriatic region (Albania, Croatia, Italy, Serbia & Montenegro and Slovenia). In Italy its historical range covers the northern part of the Adriatic Sea from which, in the first months of the year, fishes migrate upstream in the main rivers and tributaries - Po, Adige, Brenta, Piave and Tagliamento - remaining for the breeding season in freshwater until October (Bernini & Nardi, 1990). Regarding the Po river basin, in the 19th century this species migrated upstream until Turin. Since 1961 the dam of Isola Serafini at the Po confluence with Adda River prevented *Acipenser naccarii* from reaching its main spawning areas (middle-lower reach of Ticino, Agogna and Sesia rivers) from the sea. In these areas upstream the dam a small population of Adriatic sturgeon performing its entire life cycle in freshwater (Nardi, 1982; Gandolfi *et al.,* 1991). This fully protected species is classified as vulnerable (VU A1ac) in the ver 2.3 IUCN Red Data Book. It is included in Annex B of CITES, Annex II of the Bern Convention and Annex II and IV of Habitat Directive of European Union.

Goals

- Goal 1: Support the land locked population of Adriatic sturgeon present in the Ticino river in long-term.
- Goal 2: Improve the interest of this species at local level and in the Po basin area.
- Goal 3: Realize a captive breeding program for the species to support the release program.
- Goal 4: Realize two fish stairs on two dams in upper part of Ticino Rivers as stepping stone to reconstitute the ecological freshwater corridor with the Adriatic Sea.

Success Indicators

- Indicator 1: Reproduction over a medium-term period.
- Indicator 2: Occupancy of the most part of suitable area for the Adriatic sturgeon in the Ticino river.

Project Summary

The capture of some young and adult individuals of about 20 kg in the Ticino river (Bruno, 1987) confirmed the presence of a small population of Adriatic sturgeon performing its entire life cycle in freshwater. This population is protected since 1974 by the establishment of the Ticino Regional Park. A preliminary step in the conservation of this land-locked population was performed by the environmental agency of the regional government of Lombardy. Since 1988 about 250,000 young individuals of Adriatic sturgeon, originating from a stock of 70 wild specimens reared in a fish farm (Azienda Agricola VIP, Brescia, Italy), have been released. No reproductive success was recorded.

Feasibility: A monitoring survey on fish fauna of the Ticino river carried out by GRAIA in 1999, confirmed the decline of this small population and underlined the presence of limiting factors affecting its long-term survival. The aim of the Ticino project, started in 2003 within a three years Life project supported by the European Union and the environmental agency of the regional government of Lombardy was to support this population through the contrast of the main impact derived from human activities. These activities are illegal fisheries, habitat fragmentation, release of exotic species, river damming and intrinsic factors such as low density with consequent potential increase of genetic drift, slow growth rates and first reproduction from eight years of age.

Implementation: To support this population a captive breeding and release program were carried out. An initial stock of 1,152 individuals of Adriatic sturgeon (1,011 class 1^{+} with 40-80 cm size, and 41 adults of 90-120 cm) were obtained from the same fish farm (Azienda Agricola VIP) used in the previous release program. Since 2006, a captive breeding program was established In the Ticino Regional Park, using 10 adults and 50 individuals of class 1^{+} reared in a 300 m x 10 m pool with semi-natural conditions. The release program had two distinct phases: during the Life project (2004-2006) 1,061 individuals of class 1^{+} with 40-80 cm. size, and 24 adults of 90-120 cm. have been released in the Ticino river. All these specimens were marked with subcutaneous PIT tag for individual recognition. Thirty-one adults and 10 class 1+ individuals were also fitted with an implanted transmitter (CTT-82-3 or IBT-96-5; Sonotronics, USA). Following the implant of the tag seven sturgeons died: two for intestinal obstruction by the tag, three for infection caused by loosening of the stitches and two from stress. In 2007, the second phase started, and 1,300 young obtained from the captive breeding program were yearly released in the Ticino river. In 2007: 200 individuals of 10cm size; in 2008: 500 individuals of 12cm size and 100 individuals of 75cm size; in 2009: 500 individuals of 40 cm size.

Adriatic sturgeon (*Acipenser naccarii*)

Post-release monitoring: Monitoring focused mainly on distribution and habitat use of the sturgeons released in the first phase. A total of 421 “capture-recapture” survey both using electro-fishing and radio-tracking activities was established. The data indicated the majority of class 1+ sturgeons migrated downstream to the confluence of Ticino and Po rivers, and only few individuals were located in the same big pools (2 ha x 8 m deep) along the Ticino river chosen by adults. The data from this monitoring program linked to the available scientific information were used to formulate a specific Action Plan including management measures and priority recommendations needed to conserve this sturgeon population. This Plan was endorsed by the regional government of Lombardy. One of the priority conservative measures was the realization of two fish stairs for the Porto della Torre and Panperduto dams, in the northern part of Ticino river; both are under construction and will be ready at the end of 2010. This, with the programmed realization of a fish elevator for the Isola Serafini dam, will contribute to restore the ecological freshwater corridor with the Adriatic Sea. Data from a fish survey in Ticino river underlined the strong presence of the introduced sheat-fish (*Silurus glanis*) and its negative impact on all the autochthonous species. A specific study carried out on a sample of 4,293 specimens of all ages sheat-fish, confirmed that this species can occupy all the habitats suitable for the sturgeon and can prey upon different taxa (invertebrates, fishes, amphibians and also birds). An abundance control program by electro and net fishing was established since 2004, and till now 5,662 individuals (13.30 tons) were removed from the river in 195 surveys. The maintenance of theses activities during the time seems to assure good recovery possibilities to the autochthones fish species. In 2009 a small group of young Adriatic sturgeon (25 individuals of about 3 cm) was discovered in the river near Pavia city, confirming the wild reproductive success, 20 years later than the previous one.

Major difficulties faced

- The program needs a long term approach. So it is difficult to obtain the necessary funds to assure the management activities needed by this kind of program.
- The post release contact of individuals marked with a PIT tag, in a vast and complex river like Ticino.
- Complexity of the captive breeding activities for this species.
- To stop the illegal fishing; especially the underwater fishing, very effective on this species. Due to the slow growth rates and first reproduction from eight years of age, the loss of a few potential breeders in the initial project’s phase could affect the final result.

Major lessons learned

- These programs are successful only with a very long term approach and with the release of a high number of individuals. So during the time it is necessary to switch the release program in to the Park’s ordinary management activities.
- Captive breeding program on genetic basis is essential to support a re-introduction program as well as a natural rearing conditions are essential to produce captive individuals for re-introduction purposes.

- Necessity of specialized structures and high level trained staff to develop a successful captive breeding program.
- It could be more effective to release young sturgeons from class 1^{+}: 40-80 cm size minimum.
- It is necessary to implement a program for all target stakeholders especially anglers and this could also discourage illegal fishing.

Ticono river © Ticino Regional Park

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Colonization of most of the suitable areas of Ticino river, as mandated by the Action Plan.
- Wild reproduction within six years from the start of the release program.
- Establishing of a captive breeding program for reproducer stock.
- The sturgeon program is now part of the management activities carried out by the Ticino Regional Park.
- Realization of two fish stairs for the Porto della Torre and Panperduto dams, so as to establish a freshwater corridor with the Adriatic Sea.

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Re-introduction of the natterjack toad in the UK

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Introduction

The natterjack toad (*Epidalia [Bufo] calamita*) has a broad range in north central and western Europe but it is rarer - and in many places declining - towards the northern parts of its range. This is the case in the UK, where it reaches its north-western limits. Although it is listed as 'Least Concern' by IUCN, it is afforded both habitat and species protection in the UK. This level of protection is due to a substantial national decline of the species by 70-80% since the beginning of the 20th century (Beebee, 1977). Population decline in Britain has historically been attributed to habitat change through afforestation, urbanisation, agricultural practice, seral succession on neglected heathlands, acidification of breeding ponds and invasion by competitively superior species (Beebee, 1977; Beebee *et al.*, 1990; Denton & Beebee, 1994). Conservation management began in the 1970s focusing on aquatic and terrestrial habitat conditions, translocations to re-establish extirpated populations and control of competitors and predators. Natterjacks are confined to three main habitat types in the UK - lowland heathlands, coastal sand dunes and upper saltmarshes. Populations are broadly scattered across southern, eastern and north-western England, extending into south-west Scotland. There have also been recent re-introductions into north Wales.

Adult natterjack toad

Goals

- Goal 1: To re-establish the historical range of the natterjack toad in the UK.
- Goal 2: To increase the number of natterjack toads in the UK by establishing new populations.

Success Indicators

- Indicator 1: Increase the number of breeding females in the UK from 2,500 to 3,500 by 2010.

- Indicator 2: Increase the range of the species in the UK from 27 to 28 occupied 10 km grid squares by 2010.
- Indicator 3: Increase the range of the species in the UK from 17 to 21 occupied vice-counties by 2010.

Project Summary

Conservation management of the natterjack in Britain began on a significant scale in the 1970s and consisted of survey and monitoring, habitat management and translocations to re-establish populations on heathlands. As a result of the survey effort, the number of natterjack sites known increased, but no new populations have been discovered since 1993. The distribution of the species is now considered to be completely known within the country (Buckley & Beebee, 2004). By 1990, five new populations had been established using translocations (Denton *et al.*, 1997). In 1992, English Nature (now Natural England) implemented a three-year Species Recovery Program, which increased management effort at native sites and initiated a further eight populations through translocation (Denton *et al.*, 1997). Conservation efforts for the natterjack continue today led by the Amphibian and Reptile Conservation Trust, through implementation of targets set out in its Species Action Plan. This aims to maintain or improve existing populations through habitat management and restoring natterjacks to areas from where they have been lost. To this end, 10 additional translocations have taken place since 2000 in areas with authenticated historical records of natterjack toads. These efforts have seen the number of known natterjack sites in the UK increasing from about 40 in 1970 to 69 today. As a result natterjack sites in the UK consist of native sites where toads continue to persist and those that have been re-established via translocation, either pre- the Species Recovery Program or as part of it.

Re-introductions have mainly occurred through the translocation of spawn and tadpoles from existing populations, although head-starting of tadpoles and captive breeding have also played a role in some cases. Although re-introductions started in 1975, standardised monitoring protocols were not established until several years later. However, since 1985 all natterjack populations (i.e. natural and re-introductions) have been monitored on a near-annual basis and the data compiled within a national site register. The first definite successful natterjack toad translocation in Britain was one initiated in 1980 at a heathland site at Sandy (breeding to at least the second generation of animals). In 1982, Holme was the first successful translocation to a dune habitat, establishing a large population of >200 adults. The 1985 translocation at Minsmere was the first example of the successful use of artificial ponds but compared to other translocations, the population here grew more slowly and the total population size remains small (Beebee & Rowe, 2001). Translocations of spawn strings and tadpoles to Hengistbury, occurred in 1989, 1990 and 1991 and resulted in the establishment of a rapidly expanding population of >50 adults. In total, translocations have been carried out at 29 sites since 1975. Of these, 27 are at stages where the level of success can be judged. Nineteen of the 27 (70%) have been successful at least in the short- to medium-term, with adults returning to breed successfully and self-sustaining populations established at some sites. Re-establishing natterjacks on

Desiccating natterjack pond on heathland

heathland (57% success) has proved much more difficult than on dune or saltmarshes, where the overall success of translocations is much higher (85%).

All management interventions have been supported by an ongoing program of applied research, which has embraced population dynamics, identification and neutralisation of threats, genetics, reproductive biology and population modelling. Chytridiomycosis has emerged in natterjack populations in one region and is the subject of current research to determine its impacts. Conservation efforts for the natterjack to date have been encouraging, and translocations have resulted in an increase in both the number of populations and the range of the species within the UK. However, some populations are still declining despite management efforts to counter this. Ongoing research will continue to refine management methods and re-introduction techniques.

Major difficulties faced

- Understanding the scale to which habitats, particularly heathlands, have historically deteriorated in the UK and hence the level of restoration and management required.
- Limited re-introduction sites, because sites not under conservation management continue to deteriorate.
- Opportunistic - rather than planned - progress due to limits imposed by staffing and funding.

Major lessons learned

- Most sites in the UK have reduced potential for natural rejuvenation and translocation sites need to be under conservation management to maintain the key habitat features for natterjacks.
- A dedicated site manager (or a keen volunteer) is essential for the success of translocation projects, especially in the early stages.
- Population genetics research may be needed to inform the choice of donor stock.
- Captive breeding is a reliable source of animals for translocation only when biosecurity measures are in place to reduce disease risk.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Long-term monitoring of several re-introduction projects has revealed self-sustaining populations.
- A small number of re-introduction projects, mostly on heathland, have failed for reasons that are unclear (preventing the project being classified as 'Highly Successful').

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Reclaiming the lost world: Kihansi spray toad re-introduction in Tanzania

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Introduction

The Kihansi spray toad (*Nectophrynoides asperginis*) was first discovered in 1996 and listed in CITES App. I, and as critically endangered species endemic to the Kihansi river gorge in Tanzania. Its original population declined following diversion of water for hydropower production resulting in reduced flow of less than 2 m^3/s from the initial 16 m^3/s thereby causing the toad habitat to desiccate. Despite installing artificial sprinklers to generate sprays for the habitat, in late 2003 the population crashed to less than ten toads from more than 20,000 since its discovery (Lee *et al.*, 2006; Poynton *et al.*, 1999). Now, the species is extinct in the wild. The population and habitat viability assessment done in 2007 cited presence of chytridiomycosis, toxic pesticide chemicals released from dam flushing and pollution from agricultural activities as the probable causes of decline. Species conservation approach has included captive breeding in the USA since 2000 and due to commence shortly in Tanzania, ecological monitoring of the gorge habitat and Kihansi ecosystem restoration. The government of Tanzania has started plans to re-introduce the toad to Kihansi gorge using a captive population of approximately 4,000 toads presently available in the USA.

Goals

- Goal 1: A reasonable number of captive populations established at Bronx and Toledo zoos in the USA.
- Goal 2: Establish fully recovered toad habitat at all three spray wetland meadows in Kihansi gorge through management of the installed artificial spray system and the wetland vegetation.
- Goal 3: Cultivate healthy and substantial local captive population at Dar-es-Salaam and Kihansi to be used for re-introduction into the wild.
- Goal 4: Developing effective biological control for chytridiomycosis that will be used to eradicate the disease in Kihansi gorge and other infested areas.
- Goal 5: Viable and self-sustaining Kihansi toad population reinstated at the gorge and other prescribed suitable areas that are free from diseases and predators.
- Goal 6: Long-term monitoring of the re-introduced population carried out.

Success indicators

- Indicator 1: Control and treatment for chytrid fungus successfully developed.
- Indicator 2: Healthy captive population established and natural habitat restored in Tanzania.
- Indicator 3: Sustainable Kihansi spray toad population established at Kihansi gorge.

Project Summary

The diversion of Kihansi river for hydropower production left approximately 1.5-2 m^3/s water as bypass flow through the gorge. The water was insufficient to generate natural mists to maintain a healthy gorge ecosystem, consequently resulted in significant change of the gorge wetland hydrological regime. Gorge ecosystem alteration was evidenced by desiccation and rapid change in composition of the wetland vegetation and lower slope moist forests, from overgrowth of the toad's habitat herbaceous species to invasion of the wetlands by weeds, forest chameleons, lowland anurans and occasionally by safari ants (*Dorylus* sp.) (Lee *et al.*, 2006). This was followed by the toad population decline at Mhalala, Upper Spray Wetland, Lower Spray Wetland and Mid-gorge Wetland habitats. In response to these serious ecological and environmental changes in the gorge, artificial sprinklers were installed at all wetland meadows but Mhalala, to mimic the natural mists originally produced by the rapid falls. To ensure long-term perseverance of the species, about 500 toads were collected from various sites along the gorge and captive breeding was initiated at Bronx and Toledo Zoos in the USA. Captive breeding started in December 2000 by the United Republic of Tanzania (URT) and the Wildlife Conservation society (WCS) with support through the U.S. Fish and Wildlife Service, CITES and TRAFFIC. Initially, the breeding process presented unsurpassed challenges overwhelmed by sudden die-offs due to health and management issues and the population of the globally surviving Kihansi toad was soon reduced to only 37 individuals (Lee *et al.*, 2006). However, improved husbandry practices resulted in an increased population and recent reports from the Lower Kihansi Environmental Management Project (LKEMP), Tanzania which has been overseeing toad conservation show the population has reached 4,000 toads.

Mating Kihansi spray toads

Other conservation measures toward sustaining the remaining wild population included, launching various field studies such as assessing diet spectrum of insects fed on by the spray toad, amphibian inventory studies, gorge microclimate

Installed artificial sprinklers at one of the three spray wetlands toad habitat at Kihansi © Alfan A. Rija

and vegetation, working with policy makers to realize the kind of environmental flows required for the Kihansi gorge (now 2 m^3/s water) as prior to 2002, it was not legally recognized in Tanzania, toad screening for chytridiomycosis, construction of bridges and walkways within the toad habitat to reduce trampling damage and long-term ecological monitoring of the gorge by LKEMP. These measures provided invaluable data for the long-term conservation of the species, albeit were not able to sustain the Kihansi spray toad in the wild. In 2006, LKEMP launched a communication strategy to reach a wider Tanzania community to support the Kihansi toad recovery program. To gain more support for conservation by the local communities living around Kihansi catchment, LKEMP has been providing financial support for income generating projects in 21 surrounding community villages within the catchment. The projects could serve as alternative sources of cash income, thus help minimize serious negative environmental impacts emanating from human economic activities such as, valley and stream-side cultivation and use of pesticides such as endosulfan which is toxic to amphibians.

With the recovering habitat at Kihansi and the recent increase in captive population, the government of Tanzania is planning to re-introduce the toad back to the gorge. Essentially, the re-introduction program consists of four tentative stages; Pre-reintroduction phase. Main activities include, establishing possible causes of Kihansi toad crash, identifying strains and pathogenecity of chytrid fungus in Kihansi gorge, developing biological control measures for the fungus, investigating whether pesticide residues from the Kihansi dam caused population decline and determining the abundance of the toad's food habits at Kihansi. Other activities include designing pre and post release monitoring protocols as per the IUCN guidelines and selecting a task force to guide and monitor the re-introduction. Establishment of the local breeding colonies in Tanzania. Two captive breeding houses one at University of Dar-es-Salaam (already constructed) and Kihansi (not yet) will be furnished to further breed translocated Kihansi toads from the USA zoos. Capacity has been built for university technicians on husbandry practices for the toads, their feeding habits and habitat structure. Technicians have begun identifying and culturing feeder insects at the established breeding facility. Ongoing studies include, screening various amphibian species to determine chytrid fungus and other pathogens including rana viruses, survey of toad and frogs species at University of Dar-es-Salaam for histopathology studies against pathogens and testing for vegetation and diet requirements of the Kihansi spray toad.

Pre-release activities: Encompass construction of breeding house at Kihansi, translocating toads from Dar-es-Salaam to Kihansi facility for further breeding, developing monitoring indicators for soft release, site selection for soft release and final release to the wild. Long-term monitoring of the released population and the habitat. On a tentative schedule it is expected that soft releases will be done by December 2010.

Major difficulties faced

- Establishing solid re-introduction baseline data: Although there is substantial information on the habitat, food habits, and the biology of the spray toad than of any other amphibian species in Africa (D.W. Newmark, pers. comm. September 2009), important information pertinent to re-introduction is still lacking. Data are required on the suitability of potential release sites in relation to environmental variables, levels at which threats have been eliminated, nutrient dynamics in relation to habitat invasion by weeds, microclimate (temperature and relative humidity) effects on the emergence and severity of chytrid fungus, and on the best time and optimal temperature conditions to release the toads at the gorge. Such information if available would be useful for increasing chances of re-introduction success.
- Inadequate accounts of the causes of initial population decline and collapse: To date only chytrid fungus has been confirmed as the cause of population collapse. However, what caused the emergence of this disease has not been established. Ongoing studies include molecular characterization of the fungus species to determine its origin.
- Dam flushing: The impounded river dam gets flushed as part of routine maintenance work for the dam. While still investigated, this is a potential serious source of toxic substance that needs serious attention during the species re-introduction. Water and sediment samples that were collected during dam flushing in March 2009 indicated low levels of endosulfan present at the gorge. Further studies will be carried out to determine the lethal levels for amphibians, paying particular attention to the Kihansi spray toad.
- Anthropogenic issues: Despite the LKEMP investing in community development initiatives and environmental awareness, little has been appreciated by the locals. There have been serious environmental threats going on such as relentless wild fires, poaching, deforestation, stream-side and valley cultivation and use of toxic pesticides by the local communities, thereby increasing risks of damage to the gorge habitat. Although efforts have been increased to address the threats, they remain potentially critical to the survival of the re-introduced toad population.
- Healthy captive population in Tanzania: Final release of the toad to the gorge will probably depend on successfully bred colonies in Dar-es-Salaam and Kihansi. While managers are aware of the difficulty of establishing healthy colonies in Tanzania, there are also issues of longevity in captivity which may reduce species fitness to survive in the wild (McPhee, 2003). Research

(Kraaijeveld-Smith *et al.*, 2006) shows that long life in captivity up to eight generations may not reduce fitness traits. However, the recently bred colony of the Kihansi toad counts to eighth generation in captivity with perhaps more generations in Tanzania. Research is needed to test the ability of the spray toad on self defense against predators, on foraging ability and to changes in environmental conditions such as temperature and light to ascertain whether important traits are still retained by the toads in zoos.

- <u>Harmonizing with the socio and political atmosphere to support the toad recovery program</u>: Since commissioning of the Kihansi spray toad captive breeding in the USA, the toad conservation program has been ill-perceived with increasing comments from the press, some government officials, and the public being persistently negative largely due to its financial implications to a poor Tanzania nation (LKEMP, 2004). However, increased awareness raising by LKEMP to the public will probably help strengthen support for conservation of the spray toad.
- <u>Inadequate funding for re-introduction program</u>: Since its onset, toad conservation has been possible through financial support from the World Bank as part of the mitigation measures for negative environmental impacts emanating from the hydropower generation. Funding support will cease by December 2010 and all matters will be locally financed by the Tanzania government. In a poor country, the availability of internal funds is still a potential setback and a defining factor for successful implementation of the recovery program. There have been strategies to mainstream toad conservation activities into various government sectors in order to ease fund contributions from the sectors. However, the effectiveness of the mainstreaming strategy remains equivocal.

Major lessons learned

- Cultivating healthy captive colonies is a daunting undertaking that requires competent expertise as well as managerial and financial commitments. Experience acquired at Bronx and Toledo zoos will be useful for enhancing captive breeding in Tanzania.
- All threats caused initial population decline have not be completely and fully detected and addressed. Research is still required to effectively address and eliminate these threats.
- More socio-economic and political awareness at local and national level is still needed to gain support for successful recovery of the Kihansi spray toad.
- More data pertinent to re-introduction process are still needed to guide the recovery program. In the event of chytridiomycosis perseverance at the gorge, other options such as benign introduction will be explored as appropriately needed.
- A multidisciplinary team of both local and international experts is required for the Kihansi spray toad recovery program.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The Kihansi spray toad population in captivity (Bronx and Toledo zoos, USA) has increased significantly reaching 4,000 toads recently.
- The natural habitats at Upper, Lower and Mid-gorge spray wetlands at Kihansi are recovering due to the artificial spray generated by the installed artificial sprinklers.
- Discovering of chytridiomycosis as the cause for population collapse has led to the ongoing research to develop its control treatment.
- Recovery program still at its infant stage with more research data still needed to guide the whole re-introduction process.

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Assessment of re-introduction methods for the Southern Corroboree Frog in the Snowy Mountains region of Australia.

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Introduction

The southern corroboree frog (*Pseudophryne corroboree*) only occurs in the Snowy Mountains Region of Kosciuszko National Park, and is one of Australia's most iconic frog species. This species occupies the sub-alpine zone between 1300 and 1750 m (Osborne, 1989), where it typically breeds in small ephemeral pools in sphagnum bog wetlands (Hunter *et al*., 2008). The southern corroboree frog has been in a continued state of decline over the past 20 years, and is likely to be extinct in the wild within the next 10 years if recovery efforts are unsuccessful. The primary cause of decline is chytridiomycosis, a disease caused by infection with the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Hunter *et al*., in press). Given the dire predicament faced by the southern corroboree frog (monitoring of all sites in 2010 suggests there are fewer than 40 males remaining in the wild, Hunter unpublished data) preventing the

Adult male southern corroboree frog © D. Hunter extinction of this species relies on successfully establishing a captive breeding and re-introduction program. The southern corroboree frog is listed as Endangered in Australia under the *Environment Protection and Biodiversity Act* 1999, and Critically Endangered by the IUCN.

Goals

- Goal 1: Develop a successful re-introduction program to ensure the persistence of the southern corroboree frog in the wild.
- Goal 2: Develop efficient re-introduction techniques to maximize the value of available resources.
- Goal 3: Use information on post-release survivorship to identify the number of offspring required from the captive breeding program for future re-introductions.

Success Indicators

- Indicator 1: Breeding populations of the southern corroboree frog increase in size.
- Indicator 2: Accurate estimates of post-release survivorship to breeding have been attained for comparing different re-introduction strategies and setting targets for the captive breeding program.

Project Summary

Feasibility: The recovery program for the southern corroboree frog has multiple partner organizations that are committed to the long term goal of achieving self-sustaining populations of this species in the wild. It is acknowledged by all partners that this program is likely to take several decades to achieve this goal. This program has considerable public and government support, and the recovery of this species is an important objective for the biodiversity management of Kosciuszko National Park. An experimental augmentation program has previously been undertaken, which involved harvesting eggs from the wild and rearing them through to a late tadpole stage before returning them back to their natal pools (Hunter *et al*., 1999). While this program successfully increased recruitment to metamorphosis (Hunter *et al*., 1999), it failed to noticeably reduce population decline (Hunter, 2008). The current program is aimed at assessing two alternative re-introduction techniques; releasing tadpoles into artificial pools, and releasing four-year-old frogs. The potential merits of releasing tadpoles into artificial pools (400 liter plastic tubs) is that it should reduce rates of chytrid fungus infection in tadpoles, there will be no tadpole mortality associated with early pool drying, and there are negligible rearing costs prior to release. The four year old frog release is being trialed because this strategy has the greatest potential to reduce infection and mortality prior to sexual maturity. However, this technique has considerable rearing costs, and relies on frogs that have been in captivity for an extended period being capable of surviving and breeding in the wild after release. The majority of the animals used in these trials were harvested from the wild as eggs.

Implementation: *Release into artificial tubs* - Fifty eggs at hatching stage were placed in each of 20 artificial pools across four sites (five pools per site) in mid autumn (April or May) of 2008, 2009 and 2010. The artificial pools were 400 litre

Metamorph on net surface © D. Hunter

grey polypropylene tubs positioned within natural bog systems. Each tub had a constant flow from a nearby stream at a rate of approximately 20 litres per hour. A 2 cm layer of pond silt was placed on the bottom of each tub to provide a natural food source for the tadpoles. The top of the tubs were a minimum of 15 cm from the ground and positioned such that they could not be accessed by the common eastern froglet (*Crinia signifera*), which is a reservoir host for the chytrid fungus. Each pool was lined with shade cloth to provide an exit ramp for the metamorphosing frogs. Clumps of sphagnum moss were placed in two corners of each artificial pool to provide a moist refuge for the metamorphosing frogs.

Release of four year old frogs - In January 2006, 196 four-year-old frogs, and 15 five year old frogs, were released across two sites. Assuming an even sex-ratio for the released individuals, and since we only assessed male survivorship, the sample size of individuals for assessing the outcome of this study is half the number of individuals released. Prior to release, each individual frog was measured for snout-vent and tibia length, weighed, and their belly and throat photographed for individual identification using pattern recognition.

Post-release monitoring: *Release into artificial tubs* - The total number of tadpoles in each tub was assessed just prior to metamorphosis in late spring (November). Ten randomly selected tadpoles from each pool were also measured and staged. Upon reaching metamorphosis, a sample of the juvenile frogs were caught and swabbed for infection with the chytrid fungus. The mean survivorship from egg laying to metamorphosis across all pools was 35% in 2008, and 66% in 2009 (2010 has not been assessed at this stage). The results for 2008 are within the range of survivorship attained through augmenting recruitment in natural pools, while the results for 2009 are considerably greater (Hunter, 1999). The increase in survivorship during 2009 may have been due to better quality substrates provided in all pools, however this is unsubstantiated. The size of the tadpoles, and subsequent metamorphs, was typically greater than that observed in natural pools. Of the eleven artificial pools that attained survivorship through to metamorphosis in 2008, one pool was identified as infected with the chytrid fungus, which is lower than the 60% of natural pools identified as being infected in an earlier study (Hunter, 2008). Infection status of pools in 2009 and 2010 has not been analysed at this stage. While further assessment is required to determine the value of re-introducing eggs into artificial pools, the initial results are promising.

Artificial tubs © D. Hunter

Release of four year old frogs - Six surveys of calling males were undertaken at each release site during the last two weeks of January in 2007, 2008, 2009 and 2010 to identify the position of male nest sites for later inspection to determine if any of the released individuals had returned to breed. Surveys were also undertaken at all potential breeding habitats within a 2 km radius of the release sites to determine whether the released frogs had migrated to adjacent areas. Towards the end of the breeding season (first week in February), the males were removed from their nest sites to identify individuals, assess size, and swabbed for chytrid fungus infection. No re-introduced males were observed breeding in January 2007, however five breeding males were located at one of the sites in 2008. Males were observed at both breeding sites in 2009, and one site continued to have breeding adults in 2010. Chytrid fungus infection was detected in one individual in 2009. Based on the number of frogs returning to breed, estimated variation (95% conf. limits) for survivorship ranged from 1%-17%.

Major difficulties faced

- The length of time required to assess the value of the egg re-introductions (minimum seven years) has limited decision making by the recovery team in the interim.
- Severe drought immediately after the release of the four year old frogs may have greatly reduced survivorship and breeding activity, and thus produced atypical results.
- The relatively small number of four year old frogs released may have limited statistical inferences. A larger release is planned for December 2010, which will more specifically assess the role of chytridiomycosis in post-release survivorship.

Major lessons learned

- Given the relatively low post-release survivorship attained for the techniques assessed at this stage, future re-introductions will require substantial progeny from the captive breeding program.
- Post-release survivorship for the different release strategies can have substantial variation among years and sites, which should be considered in the

design of future re-introduction experiments to ensure robust results are attained.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- Re-introducing four year old frogs can be used to maintain populations in the wild, however, substantial resources will be required to produce sufficient numbers of individuals.
- The high survivorship to metamorphosis, and low chytrid fungus infection rates, for the eggs re-introduced into artificial pools suggests this technique may be an efficient re-introduction technique.

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Captive management and experimental re-introduction of the Booroolong Frog on the South Western Slopes region, New South Wales, Australia.

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Introduction

The Booroolong frog (*Litoria booroolongensis*) is a medium-sized hylid frog, mostly restricted to the western flowing streams of the Great Dividing Range in New South Wales (NSW) and north-eastern Victoria, Australia. It was formerly considered to be widespread and abundant throughout its range until the mid-1980s when it suffered dramatic declines. It has almost disappeared from the northern part of its range, with many local extinctions occurring throughout the remainder of its distribution (Gillespie & Hines, 1999). The Booroolong frog is listed as Endangered nationally under the Environment Protection and Biodiversity Act 1999 and as Endangered under Schedule 1 of the NSW Threatened Species Conservation Act 1995. It is listed as Critically Endangered by the IUCN. There are numerous threatening processes that may have contributed to the decline of this species. These include disease (chytridiomycosis), habitat

An adult Booroolong frog

loss and alteration, introduced fish, invasive weeds and stream drying. During the summer of 2006-2007, drought threatened to cause the local extinction of Booroolong frogs in the Maragle Creek catchment as a result of stream drying (Hunter & Smith, 2006). This was particularly concerning as the Booroolong frog was a flagship for riparian restoration on private properties along Maragle Creek. To prevent the local extinction of this population, a small founder population was collected to initiate a captive breeding program.

Goals

- Goal 1: Ensure the persistence of the Booroolong frog in the Maragle Creek catchment on the South Western Slopes of NSW, Australia.
- Goal 2: Establish a captive insurance population and develop successful husbandry and breeding protocols for this species.
- Goal 3: Conduct a trial release of captive-bred animals and closely monitor survival to maturity and breeding from these individuals in the wild.
- Goal 4: Increase public awareness for the Booroolong frog, its declining population status and its habitat requirements in the local community.

Success Indicators

- Indicator 1: To establish successful captive breeding protocols
- Indicator 2: That released animals survive to maturity and breed in the wild.
- Indicator 3: To increase the awareness of the Booroolong frog in the local community.

Project Summary

Feasibility: Intensive surveys were undertaken for the presence of the Booroolong frog on the South West Slopes region of NSW during 2006 (Hunter & Smith, 2006). These surveys indicated that a number of populations were under threat of local extinction due to stream drying, including those in the Maragle Creek catchment. This was largely due to the modified, agricultural land-use and prolonged drought. Due to the short lifespan of this species and its reliance on streams for breeding (Anstis *et al.*, 1998), it is especially susceptible to reduced water flows. After two years of minimal rainfall, it was determined that the risk of losing this population was sufficiently high to warrant the collection of a small insurance population and initiate a captive breeding program. This would allow the release of captive bred individuals to supplement the depleted wild population should water flows increase, and provide an opportunity to assess the capacity to utilize re-introduction as a conservation tool for this species.

Implementation: In February 2007, a founder population of 32 juvenile frogs was collected by staff of the NSW Department of Environment, Climate Change and Water (DECCW) and Taronga Zoo from three separate sites along Maragle Creek. An additional nine frogs were collected to conduct an initial disease screening to establish parasite and pathogen levels in the wild population. The frogs were transported to Taronga Zoo and held in a biosecure room and maintained under strict quarantine conditions. In late 2007, captive breeding was achieved and the majority of founder animals produced fertile spawn. For the intended release, eight spawn were obtained from 16 founder animals, to

Frogs being released at Maragle Creek

maximize genetic diversity. These spawn were obtained in cohorts of five spawn and three spawn, spaced two months apart. The tadpoles and young frogs were reared in biosecure rooms, housing only this species, under strict quarantine. At the time of release, half of the frogs were four months old, whilst the other half were two months old. Six weeks prior to release, all 610 frogs were individually marked by clipping up to three toes. Additionally, the frogs underwent an intensive pre-release pathology screening of 30 tadpoles from each clutch. Frogs were released along a 1.5 km transect of Maragle Creek in February 2008, after it had been determined the captive stock did not contain any pathogens that were absent in the wild population. This conservation program also involved an educational campaign that provided an intensive educational experience for local primary and secondary school students at Taronga Zoo followed by an “Experts” day for students in the field. It concluded in a town-wide community expo day focusing on the conservation of the species in the town Tumbarumba, NSW, which is close to the release site.

Post-release monitoring: The release transect was surveyed four times during the two month period after release in 2008, and six times between October and February during both the 2008-2009 and 2009-2010 seasons, Surveys consisted of visual searches along the release transect at night to locate active frogs. Upon capture, each frog was identified, weighed, measured and swabbed for the presence of chytrid fungus. A total of 105 individual frogs were captured after release, with 29 frogs observed surviving through to sexual maturity and engaging in breeding activity (males calling or gravid female present in the breeding area). The size and condition of the released frogs at sexual maturity were equivalent to marked, wild frogs at the site. Only four released frogs were recorded in the 2009-2010 breeding season, suggesting that mortality to this point had been high, which is consistent with the rapid life-cycle of this species. Even so, two existing threats may have contributed to the high mortality of the released cohort, as much of the stream stopped flowing and dried out soon after release in autumn and then again the following summer, and high infection with the chytrid fungus was also recorded in the population.

Major difficulties faced

- The Booroolong frog had not previously been kept and bred in captivity. Additionally, the lifespan of the Booroolong frog in the wild is quite short, which did not allow much room for error in regards to establishing captive breeding.

- Some of the existing threats to the species were still operating at the release site, including high chytrid fungus infection rates and two stream drying events.

Major lessons learned

- The species has proven relatively easy to breed in captivity. In captivity the species grew to maturity and bred much faster than in the wild, and females had a much higher reproductive output, producing multiple spawn (of 400 to 1,250 eggs in each spawn) per season.
- During the first breeding season after release, the male captive-bred animals were observed engaging in breeding activity by exhibiting advertisement calling along the stream. During the second season post-release, both male and female captive-bred animals were observed engaging in breeding activity.
- This case study highlighted the importance of conducting initial pathology screening of wild individuals to establish which parasites and pathogens are present in the wild population. During the pre-release screening, a brain parasite was identified that would have aborted the intended release had it not been previously determined that it was a natural parasite in the existing wild population of this species.
- The local community has become well informed of this species due to the interactive educational campaign in the local township of Tumbarumba. As habitat loss and alteration is a significant threat to this species, educating the local rural community is an important conservation objective.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The Booroolong frog has proven relatively easy to breed in captivity. Breeding was achieved from a large number of the collected founder animals.
- Captive-bred animals released into the wild survived to sexual maturity and engaged in breeding activity.
- Further stream drying and high levels of chytrid fungus infection may have contributed to the relatively low survivorship of released frogs.
- A successful educational campaign was undertaken in the local community of Tumbarumba.

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Lessons learned from a series of translocations of the archaic Hamilton's frog and Maud Island frog in central New Zealand

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Introduction

A series of re-introduction case-studies from which conservation management lessons have been learned are provided for two threatened terrestrial frogs that survive on islands in the Marlborough Sounds, New Zealand. Until translocation, Hamilton's frog (*Leiopelma hamiltoni*; McCulloch, 1919) were restricted to a small 300 m^2 rock bank on Stephens Island (Is.) and the Maud Island frog (*Leiopelma pakeka*; Bell, Daugherty & Hay, 1998) to a remnant 16 ha forest patch on Maud Island (Is.) These evolutionarily distinct frogs are in one of the two earliest diverging genera of modern Anura. Formerly regarded as *L. hamiltoni*, *L. pakeka* was described as a cryptic phylogenetic species based on allozymes and morphometrics. However, more recent partial 12s RNA and Cyt b sequences, showed little variation between them (<1% for Cyt b), so the taxonomic status of *L. pakeka* requires further resolution.

*** - Zealandia (formerly known as Karori Sanctuary) is a predator-proof fully fenced urban wildlife sanctuary in Wellington on the North Is. of New Zealand**

Maud Is. and Stephens Is. have remained free from introduced rats, suggesting that such mammalian predators have led to their extinction elsewhere. Sub-fossils show a species identified as *L. hamiltoni* was formerly widespread across both the North Is. and South Is. of New Zealand.

Hamilton's frog (*above*) & Maud island frog (*below*)

Transfers of *L. pakeka* began in 1984-1985, when 100 frogs were moved to a restored site at Boat Bay on Maud Is. (Bell *et al.*, 2004). Subsequent transfers beyond Maud Is. were of 300 *L. pakeka* to Motuara Is. in 2001, 101 to Long Is. in 2005, and 60 into Zealandia* Sanctuary, Wellington, in 2006-2007 (Bishop, 2005; Tocher & Pledger, 2005;

Lukis & Bell, 2007). In 1992, 12 *L. hamiltoni* were transferred to adjacent newly created habitat on Stephens Is. (Brown, 1994), then 71 frogs were transferred over 2004-2006 to Nukuwaiata Is. (Tocher *et al.*, 2006). Additional *L. hamiltoni* and *L. pakeka* have been held in captivity, where they successfully bred and young were reared, but no re-introduction of captive bred frogs into the wild has taken place. No breeding sites have been found for either species in the wild. In the 2009 IUCN Red List, *L. hamiltoni* is ranked 'Critical' and *L. pakeka* as 'Vulnerable', while under the current New Zealand Threat Classification System these two taxa are listed as 'Nationally Critical' and 'Nationally Vulnerable' respectively. No chytridiomycosis has been found in these two island populations, or in any transferred populations, and neither source population has declined under conservation management over the past 30 years.

Goals

- Goal 1: Identification of potential re-introduction sites within the species' historic range.
- Goal 2: Successful breeding of released individuals, and persistence of each translocated population.
- Goal 3: Sustainable populations established in a range of suitable habitats, free of introduced mammalian predators, and where the risk of chytridiomycosis is minimal.
- Goal 4: Through adaptive management, re-establish populations on mainland sites where the risks of mammalian predators is managed.
- Goal 5: Annual monitoring of source populations and regular monitoring of translocated populations.

Success Indicators

- Indicator 1: Self-sustaining populations established at re-introduction sites.
- Indicator 2: Overall geographical distribution of the species extended.

Project Summary

The earliest transfer of these species was a re-introduction trial of *L. pakeka* that took place in regenerating forest at Boat Bay on Maud Is. in 1984-1985 at a site that had lost its presumed former frog population as a result of habitat changes induced by farming. In 1984 the first 43 frogs were transferred, then a further 57 in 1985, all being released at the same location. Population sampling has occurred at least annually, revealing high survival of founders, increased mean body condition, most settlement close to the release site (<26 m), steady recruitment (locally-bred individuals now exceed the number released), and a rising population level (Bell *et al.*, 2004). This intra-island re-introduction represents the most successful transfer to date. Once the Boat Bay re-introduction had demonstrated that these frogs could be successfully transferred and established in a new location, a transfer of 12 *L. hamiltoni* took place on Stephens Is. in 1992, to a specially excavated 'frog pit' filled with rocks in remnant forest 50 m from the original site (Brown, 1994). A predator-proof fence was built around the new habitat to exclude tuatara (*Sphenodon punctatus*), a known predator, and the area was seeded with invertebrate prey (Brown, 1994). In 2004, a fenced tuatara-excluded corridor was created to connect the two sites, and

Left Image: Maud island the only location of *L. pakeka*, in 1984-1985, 100 frogs were translocated from remnant population "B" to forested gully "A". *Right Image*: Stephen's island the only location of *L. hamiltoni*, which survived on a rock bank near the summit prior to translocation.

while some frogs homed back to the original site, between 1996 and 2000 at least three frogs remained in the new 'frog-pit'. In 1997, in the first island-island transfer of *L. pakeka*, 300 adult frogs were translocated from Maud Is. to Motuara Is., and this new population has been regularly monitored since. In August 2002, 155 individuals were recaptured as well as 42 new recruits (Tocher & Pledger, 2005).

Given that the only population of *L. hamiltoni* amounted to c.300 individuals living in 300 m^2 on Stephens Is., there was much to be gained by establishing a population on another island but risks were greater because of the low numbers (Tocher *et al.*, 2006). A long history of monitoring the source population provided data for predicting which of nine hypothetical translocation scenarios was likely to produce the best result for the species (Tocher *et al.*, 2006). A translocation of 40 female frogs (20 adults and 20 sub-adults) along with 40 male frogs (20 adults and 20 sub-adults) was chosen as it provided a balance between risk of extinction in the donor population and probability of success in the translocated population (Tocher *et al.*, 2006).

Consequently, in 2004 the first 40 *L. hamiltoni* were moved to a new site on Nukuwaiata Is. Data-loggers had been previously installed there to confirm that a suitable microclimate existed, and boardwalks were erected so that the frogs could be monitored without disturbing the habitat. By 2006, 25 had been encountered, and sub-adults were growing at a normal rate (pers. comm. H. Cooper). With these promising results the final cohort of 31 frogs were captured on Stephens Is. and shifted to Nukuwaiata during 2006. The first new recruit to the new population was discovered in 2008 with eleven further juveniles found in 2009.

A third island population of *L. pakeka* was initiated in 2005 when 101 frogs were translocated to a prepared site on Long Is. Their initial movements and adaptation to the new site were followed showing that there was a tendency to disperse downhill and that those shifted with near neighbors were just as likely to disperse as those released with unfamiliar frogs (Germano, unpubl. M.Sc., 2006). During the four years post-release, population numbers on Long Is. appear to be in decline, possibly due to poor habitat and kiwi (*Apteryx* sp.) predation.

In Zealandia, Wellington, 30 adult *L. pakeka* that had been held in captivity were placed in a 2 x 4 m predator proof mesh enclosure in February 2006. Their sizes (most >40 mm SVL) indicated they were predominately females, so 30 more frogs in the male size range (<40 mm SVL) were transferred from Maud Is. in October 2006, initially into another 2 x 4 m enclosure (Lukis & Bell, 2007). In April 2007, 58 surviving frogs were mixed into roughly equal numbers of males and females. Using an adaptive management approach, half were retained in an enclosure, the rest were released into the wild in adjacent forest, where there were at least two potential predators, the house mouse (*Mus musculus*) and little spotted kiwi (*Apteryx owenii*).

Survival in the enclosure remained high (27/29), but the number seen in the wild declined markedly, however, suggesting poor survival in the presence of even a limited range of predators. Despite this disappointment, by February 2008 the first breeding had occurred in the protected enclosure (two brooding males). Thirteen recently hatched larvae were moved to incubators to complete metamorphosis, eleven surviving until release into nursery pens at Zealandia in March 2008. In mid-March 2009, two males were found with a total of ten nearly metamorphosed young frogs, which again completed metamorphosis in incubators, before being placed in a nursery pen in Zealandia in late March.

Major difficulties faced

- Limited size of source population, requiring a modeling approach to determine optimal number to translocate to balance risks of over-cropping the source population against risks of insufficient pioneers in the transferred population - *L. hamiltoni* Nukuwaiata Is.
- Releasing low numbers (<30) could reduce likelihood of successful establishment - *L. pakeka* Zealandia.
- Probable predation from house mice (*L. pakeka*, Zealandia) and possibly little spotted kiwi (*L. pakeka*, Zealandia and Long Is.).
- In recreating suitable rocky frog habitats in sites of release, there may be a risk of inadvertently attracting mammalian predators e.g. house mice at *L. pakeka* release site in Zealandia.
- Finding suitable habitat on appropriate predator-free islands.

Major lessons learned

- The original Boat Bay transfer was a success and provides a model for future translocations - both *L. hamiltoni* and *L. pakeka*.
- Successful translocations require sufficient numbers and a mix of ages and sexes - both *L. hamiltoni* and *L. pakeka*.
- Founders likely to be at risk to potential mammalian/avian predators at mainland and island sites, so successful transfer likely to require exclusion and/or management of suspected predators. Remedial options at Zealandia

are to intensify house mouse control, or entirely eliminate mice, to exclude potential avian ground predators like kiwi by fencing, to provide more secure retreat sites around release area, to supplement release with a larger number of frogs (100+), and to consider a large fully enclosed predator-free release environment. Future island translocations should take into consideration potential conflicts with native predators and fencing should be used to help protect an establishing population at early stages - *L. pakeka* at Zealandia and Long Is.

- Construction of artificial rocky habitat piles or pits can enhance establishment in sites where such substrate is sparse or lacking, but may run risk of attracting predators where these occur – *L. hamiltoni* Stephens Is., *L. pakeka* Zealandia.
- These are K-selected species and long-term monitoring (>20 years) is required to confirm successful establishment – both *L. hamiltoni* and *L. pakeka*.
- Despite small home range sizes, these frogs can, and do, home following short-distance translocations. As homing instincts decrease with distance, future translocation should be at a sufficient distance to discourage homing.

Success of projects

Overall success summary, all transfers, both species (1984-2007):

Highly Successful	**Successful**	Partially Successful	**Failure**
1	**2**		**3**

***L. pakeka*, Boat Bay, Maud Is., Marlborough Sounds (1984-1985):**

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- 75% of 100 founders recaptured at least 6 months post-release.
- Mean body condition index of founders increased after release.
- Mean body size growth in founding population greater than in source population.
- Increasing numbers of individuals being caught during annual sampling sessions.
- Founders now comprise a smaller proportion of captures, 34% of founders were still alive after 25-26 years.
- Immature frogs regularly observed and 136 individuals known to have been recruited into the population by 2010-more than the number of founders (100).

***L. hamiltoni*, Stephens Is., Marlborough Sounds (1992)**:

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Increased local habitat and range of existing population.
- No breeding at new site.
- The majority of translocated individuals homed to the point of capture, and very few sightings have been made of the translocated frogs that remained at the new site.

***L. pakeka*, Motuara Is., Marlborough Sounds (2001)**:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Maintained large numbers of individuals, though longer term monitoring required to confirm.
- Evidence of breeding at the site.

***L. pakeka*, Long Is., Marlborough Sounds (2005)**:

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Possibly unsuitable or suboptimal habitat, with too few rocks to provide retreat and/or breeding sites, though longer term monitoring required to confirm.
- Possible predation by little spotted kiwi. Recapture numbers have decreased substantially and one frog was caught with recent damage to one side of its face, which may be evidence of predation. Kiwi have been noted at the frog site during every monitoring session.

***L. hamiltoni*, Nukuwaiata Is., Marlborough Sounds (2004-2006)**:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Local breeding, short-term success, but still too early to confirm long-term success.

L. pakeka, Zealandia, Wellington (2006-2007):

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Decline to extinction after release, despite high survival and successful breeding over two successive years by other frogs held in predator-proof enclosure.
- Probable predation from house mice and possibly little spotted kiwi.
- Low number of frogs released (29).

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A more detailed reference list can be obtained from the first author

Re-introduction of shore skinks to offshore islands in the Auckland region, New Zealand

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Introduction

The shore skink (*Oligosoma smithi*; Gray, 1845) is one of two native lizard species that are restricted to the northern coastline of New Zealand (Hare *et al.*, 2008; Chapple *et al.*, 2009). Despite having a wide distribution on the mainland and on offshore islands in the northern part of North Island (Towns *et al.*, 2002; Hare *et al.*, 2008), this species is significantly impacted by introduced mammalian predators. In particular, several shore skink populations have shown marked increases in recruitment following pest eradications (Towns, 1991; Towns, 1996 G. Ussher, unpublished data), therefore they could be considered ideal indicator species for pest eradication projects. Shore skinks were selected as a target species for captive breeding for future translocations, as part of an ecosystem restoration approach for islands in the Auckland region. This endemic species is ideal for re-introductions due to their generalist foraging strategy, coupled with their relatively fast maturation period (M. Baling, unpublished data). Their visually active and diurnal behavior also serve as a good reptile conservation advocate to public visitors at island reserves. In 2006, the first translocation of this species was conducted to two offshore islands in the Hauraki Gulf, Auckland, and into captivity as a trial for breeding program that aims for future wild releases.

Shore skink release © D. Jenkins

Goals

- Goal 1: Promote a functional, self-sustaining ecosystem on offshore islands in the Hauraki Gulf, Auckland, by establishing new lizard species populations that are currently absent in habitats within the species historic range.

- Goal 2: Create founder populations from captive-bred shore skinks for re-introduction projects as a means of reducing pressure on wild sources.
- Goal 3: Determine at source population recovery following removal of skinks for re-introduction.

Success Indicators

- Indicator 1: *Re-introduction sites* - Short-term: The survival, establishment and breeding of founders and their offspring at islands. Long-term: Self-sustaining populations that consist of island-born breeders on islands.
- Indicator 2: *Captive population* - Short-term: The survival, establishment and breeding of the founder population. Long-term: Yearly production and survival of offspring in captivity to the point of suitable re-introduction size, condition and health.
- Indicator 3: *Source population* - The continual increase in juvenile recruitment at all cohort stages, two years following removal of skinks.

Project Summary

Feasibility: The species re-introduction was initiated through discussions between Massey University (Albany Campus) and the New Zealand Department of Conservation (DOC), for the identification of reptile research and conservation management priorities in the Auckland region. These discussions and the identification of source and release locations later expanded to involve local councils, local herpetologists, captive breeders and veterinarians to develop best practice protocols. The selection of the source population was highly dependent on a large population size that was geographically closest to re-introduction locations. The two islands selected were surveyed for best release sites based on habitat type of the source population, to increase chances of survivorship. The enclosures at the captive facility are held outdoors and have naturalistic environment settings, to promote normal intra-specific interactions and breeding. The support from Massey University, Supporters of Tiritiri Matangi Inc. (SoTM), Motuora Restoration Society Inc. (MRS), Auckland Regional Council (ARC), DOC and local iwi tribes contributed to the translocation of 120 individual shore skinks from Tawharanui Regional Park (Tawharanui) to Tiritiri Matangi Island (n=30), Motuora Island (n=30) and the Massey University Captive Reptile Breeding Facility (n=40).

Implementation: The species re-introduction underwent several stages; initial survey and disease-screening of reptiles at release sites (Tiritiri Matangi and Motuora Islands), capture and quarantine of shore skinks from source site (Tawharanui), and the release of the animals to each site. Initial reptile surveys were conducted on both islands to confirm non-presence of the shore skink, in accordance with DOC protocols. Funding for disease-screening was limited, therefore only reptile-associated parasites of health concern were targeted; i.e. *Salmonella* and *Cryptosporidia*. A sample of reptiles from the release site islands and all of the captured shore skinks were tested for true positives. In November 2006, shore skinks were sourced at a female-biased sex ratio of 1:2, with a focus on capturing gravid females to provide immediate island-born individuals (due in January/ February 2007) and to increase genetic diversity of the founder population (through non-related founder neonates). All shore skinks were quarantined at the Massey University captive facility, and wildlife veterinarian advice was sought when some individuals tested positive for *Salmonella*. The translocation as deemed fit to continue, after results showed the presence of an uncommon strain of *Salmonella* at the release sites, and that all shore skinks were tested negative (except for one). The releases at both island reserves were public events, promoting public advocacy of reptile conservation and restoration by re-introduction.

Post-release monitoring: For each founder population was conducted intensively for the first four months, and then at three-monthly intervals until the end of 2008. Live-trap grids were used to monitor survivorship and distribution of each founder population. The distributions of two other resident skink species were also recorded to investigate niche displacement. Evidence of island-born individuals from translocated gravid females was first detected in early 2007, signaling initial founder survival and successful birthing. The following New Zealand summer season (2007-2008), young or sub-adults, including several gravid females in the trapping grid were caught at Tiritiri Matangi Island (confirming successful establishment). The second release site at Motuora Island was exposed to large winter storms and the population remained undetected (with the exception of one or two adults) during the summer of 2007-2008. This was possibly due to insufficient refuges from storms and unusually high tides during the winter months at the release site. Monitoring continues bi-annually and will be conducted by the volunteers of each NGO (SoTM and MRS), with guidance from the current researcher. Volunteers are trained to set the traps, identify species and data recording for monitoring long-term trends of the populations. The possibility of supplementation (to further increase genetic diversity) is likely for founder populations that are stable or have established and is part of the original translocation proposal.

Post-removal monitoring of the source population: This was conducted as part of a postgraduate student project that was examining the effects of mouse predation on the population recovery. The source population was monitored for one year, using live-traps within pest-controlled and non-pest-controlled grids from which the skinks were sourced. The study showed that the skinks remained abundant within both grids but particularly so within the pest-controlled site. Additionally, population recovery would likely be much greater within the pest-controlled site where the population comprised of a significantly greater proportion of juvenile skinks, despite both sites having similar proportions of neonates. The study suggested that a higher predation pressure on neonate skinks by mice in non-controlled sites is likely to suppress skink recovery rates. Because ongoing pest management occurs at Tawharanui, the population is capable of recovering post-translocation. The captive founder population was established and has been successfully breeding since 2007. All animals' conditions are monitored and their morphometrics recorded monthly. There is a high survival rate for captive-born young, and they are seen to be sexually mature by two years of age. In early

2009, 30 captive sub-adult (born season 2006-2007) and 50 wild-caught shore skinks were disease-screened and released to Motuihe Island, Auckland, as part of the island's restoration plan. This marked the first translocation from the captive breeding facility. The next cohort, born 2007-2008, is planned for release to Crusoe Island, Auckland, in early 2010 as part of the Auckland Regional Council's initiative.


Ocean Dunes TRP © C. J. Wedding

Major difficulties faced

- Unpredictable weather, especially heavy storms and high tides during winter that destroyed trap grids. Therefore trap maintenance can be very high.
- The difficulty in detecting this species at low densities, especially to capture newborn individuals. This facilitated the need for multiple capture/ tracking techniques (i.e. live pitfall traps, artificial refuges, funnel traps, tracking tunnels, and hand-capture) to increase detection rates.
- Due to the high cost and limited funding for disease-screenings, a comprehensive testing of both translocated individuals and release site populations were not able to be done. Priorities for potential diseases of concern had to be selected instead.
- Developing best practice husbandry techniques and data recording, while attempting to provide for and maintain natural behaviors (e.g. intra-specific competition, foraging) in the captive population without significant detriment to the survivorship of individuals.
- Conflict of interest in shore skink experiment on pest monitoring manipulations and other wildlife management. The pest-controlled grid at source population area is also the breeding ground for the endangered New Zealand dotterel (*Charadrius obscurus*), and some volunteers of Tawharanui raised concerns about the effect of rodent bait stations and skink trap placements on the chicks.

Major lessons learned

- Selection of suitable release sites particularly within dynamic habitat types such as beaches or close to the coastline that may change according to seasonal weather should be taken into account. Sufficient stable refuges should be identified, or added if there is little choice in release sites.
- Importance in communication (before, during and after the translocation) between DOC, ARC, local councils, NGO's, iwi tribes, and researchers is very high. Good communication is needed to maintain relationships, share local knowledge and aid in funding for research and monitoring. Teaching, training and educating volunteers in monitoring techniques is advisable to maintain

reliable long-term data collection that will assist the increase in local knowledge of the species and location.
- Defining disease-screening methods and understanding of *Salmonella* prevalence in New Zealand reptiles. There was a lack of standardized protocol in disease-screening New Zealand reptiles in the Auckland region.
- Setting the standard in quarantine procedures in reptile translocation in the Auckland region. This translocation procedure preceded the next few lizard re-introductions in the Auckland region, where advice and services were sought from researcher by other NGO's organizing other lizard translocations.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- One of the two wild-release populations has fulfilled the short-term goal of the re-introduction. The long-term goal will be assessed at five and 10 years post-translocation. This first lizard re-introduction to Tiritiri Matangi Island may be used as an example for future re-introduction of more endangered New Zealand lizard species to this public scientific reserve.
- The outcome for the shore skink re-introduction to Motuora Island is currently inconclusive due to low re-capture rates and will be re-assessed in the next two years.
- The captive population has satisfied the short and long-term goals, as young are born annually and high proportions are surviving to adulthood. These young are fit to be translocated to the wild, therefore will aid in restoring the historical geographic distribution of the species, and also complete island ecosystem restorations.
- The project confirmed the capability of a high-density source population to recover after removal of 120 individuals from the site.

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Changing taxonomy and the need for supplementation in the management of re-introductions of Brothers Island tuatara in Cook Strait, New Zealand

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Introduction

Tuatara (*Sphenodon*) are medium-sized reptiles and the sole extant representatives of the order Rhynchocephalia. Once widespread in New Zealand, tuatara were extirpated from the mainland after the introduction of mammalian predators ~700 years ago. Thirty-one small natural populations are currently found on isolated off-shore islands. Although the taxonomic history of tuatara is complex, two species have been recognized since 1990: the population on North Brother Island (*S. guntheri*, Brothers Island tuatara) and all other natural populations (*S. punctatus*, Cook Strait and northern tuatara). The New Zealand Department of Conservation lists *S. guntheri* as “Nationally Endangered”, and the IUCN lists it as vulnerable (D1 + D2). However, recent genetic data indicate that the species distinction of *S. guntheri* is unwarranted, and that all tuatara are best described as

Female tuatara outside burrow

a single species (Hay *et al.*, 2010). Here we provide an update on two re-introductions of *S. guntheri* in Cook Strait, New Zealand: Titi (1995, Nelson *et al.*, 2002) and Matiu/Somes Islands (1998, Merrifield 2001). We also report a third re-introduction to Long Island (2007). North Brother Island, which is within the same ecological region, was used as the source population, and mammalian predators were eradicated prior to each re-introduction.

Goals

- Goal 1: Secure the population viability and genetic diversity of tuatara (Gaze, 2001).
- Goal 2: Ensure survival of a unique species (*Sphenodon guntheri*) through re-introductions. This goal changed in 2009 as a result of changing taxonomy (see below). The revised goal is to represent the diversity of extant populations and key geographic variants.
- Goal 3: Increase public access to tuatara and education on tuatara conservation.

Success Indicators

- Indicator 1: The release of Brothers Island tuatara onto three predator-free island sanctuaries.
- Indicator 2: Survival and growth of founders within five years of release.
- Indicator 3: Evidence of reproduction within 10 years of release.
- Indicator 4: Increased conservation advocacy.

Project Summary

Feasibility: Titi (32 ha) and Long Islands (142 ha) are protected nature and scenic reserves; Matiu/Somes (24.9 ha) is a scientific and historic reserve that is accessible by public ferry and recreational boats. Matiu/Somes Island receives about 15,000 visitors annually, posing a significant threat of reinvasion by rodents from the mainland. Upon arrival, all visitors must pass through a quarantine station administered by the Department of Conservation rangers on the island. The quarantine procedure provides an opportunity to educate visitors on the threat of introduced mammals to tuatara and other New Zealand wildlife. The mammal eradications and tuatara re-introductions required support from local Māori (indigenous peoples of New Zealand) for each island.

Implementation: The populations on Titi and Matiu/Somes Islands were founded by wild adults and captive-reared juveniles (Titi: 18 adults and 50 juveniles, Matiu/Somes: 20 adults and 35 juveniles). The Long Island population was founded entirely by captive-reared juveniles (n=53). Tuatara were sourced directly from the wild and from eggs collected from females by induction of oviposition and directly from nests on North Brother Island in 1989-1991 and 2000-2001. Eggs were hatched at Victoria University of Wellington, and juveniles were reared in semi-natural conditions in captivity at Nga Manu Nature Reserve (Titi and Matiu/Somes Islands) and the Wellington Zoo (Long Island) until release at 3-6 years of age. Tuatara were marked with unique toe-clips for identification, individually packaged in aerated poster tubes, and transported by helicopter and boat to the islands. Artificial burrows (~50cm long under vegetation) were constructed prior to re-introduction to provide a safe place to release animals. Burrows were installed on Titi and Matiu/Somes Islands by excavating soil and installing a ~1m drainage pipe; on Titi Island, this drainage pipe connected to a wooden box with a lid to facilitate monitoring. On Long Island, burrows were excavated, but the plastic drainage pipe was not used.

Post-release monitoring: The population on Long Island has not yet been formally monitored, but several individuals have been seen during informal visits. The populations on Titi and Matiu/Somes Islands were both monitored intensely in the two years following re-introduction. Titi Island was also monitored 3, 5, and 11 years after re-introduction, and Matiu/Somes was also monitored 6, 7, and 9 years after re-introduction. The most recent monitoring event was in 2007 for both populations; 185 and 195 person hours were spent searching for tuatara on these trips (Titi and Matiu/Somes Islands, respectively). On each monitoring trip, the habitat was searched thoroughly and all tuatara encountered were caught by hand. All captured tuatara were measured for body size (snout-vent length, SVL in mm) and mass (g). Over all monitoring trips, 43 of 68 founders (63%) were captured on Titi Island, and 33 of 55 founders (60%) were captured on Matiu/Somes Island. Four of the animals on Titi Island and three on Matiu/Somes Island captured in 2007 had not been captured since release, indicating that more tuatara are likely to have survived the re-introductions but have not been located. Their cryptic appearance and difficulty searching the habitat (forest, fern thickets, penguin and seabird burrows, and cliffs) make it difficult to thoroughly search all habitat. Tuatara have dispersed from release sites to other areas of the islands, but many of the juveniles were located close to their release areas.

All founders have increased in size (SVL and mass) since re-introduction. Adults which were observed to show no growth in the eight years prior to re-introduction on North Brother Island, increased in size and continued to grow for at least 9-11 years after release ($p < 0.001$ for all SVL comparisons of individuals pre- and post -translocation, repeated measures ANOVA). Tuatara are generally in very good body condition. Animals released as juveniles on Titi and Matiu/Somes Islands have shown growth comparable with captive juveniles; some have reached a comparable size to adults in the source population, although it is unclear if this reflects sexual maturity. Reproduction was confirmed in 2007 on Titi Island with the capture of an unmarked juvenile adjacent to the adult release area, and on Matiu/Somes with the discovery of a nest. The nest location was close to a public-access track, so the two viable eggs were taken off the island and incubated at Victoria University of Wellington. Hatchlings were released back onto the island within 3.5 months of hatching.

Major difficulties faced

- Monitoring was challenging, because recapturing animals (particularly small and cryptic juveniles) in dense scrub habitat limited the ability to detect survival and growth of all founders on any single monitoring trip.
- Three factors make it difficult to asses the long-term viability of the re-introduced populations. First, the extreme longevity (100+ years) and large generation interval of tuatara (~40 years) make it difficult to interpret short-term

successes and gauge long-term success. Founding populations with only juveniles creates an additional 'lag time', as it will take several years for the founders to reach sexual maturity (maturity at ~14 years). Second, we are unable to evaluate the effects of small population sizes and losses of genetic diversity (e.g. inbreeding depression) in the source and re-introduced populations because of difficulties in capturing animals (particularly juveniles) and their longevity. If populations are founded with only juveniles, higher pre-reproductive mortality rates could reduce the number of genetic founders. Third, recent data suggest that reproductive skew in tuatara is high (up to 70% of males do not mate across multiple seasons, Moore *et al.*, 2009). Models show that in these cases, at least 70 adult tuatara (or more juveniles) should be released in the founder group to ensure that genetic targets for management are met over 10 generations (Miller *et al.*, 2009). Based on this recent information, the long-term maintenance of genetic diversity (both relative to North Brother Island and other natural tuatara populations) has become an indicator of success for re-introductions.

- We have had to re-evaluate the re-introductions of Brothers Island tuatara in light of more recent data. Historically high levels of inbreeding and kinship on North Brother Island are likely exacerbated by the re-introductions. Further, recent genetic research indicated that all tuatara are best described as a single species (Hay *et al.*, 2010). This changing taxonomy, combined with small founder groups and low genetic diversity on North Brother Island, calls into question the validity of North Brother Island as a source population for re-introductions (whereas previous knowledge indicated that it was a desired source to secure a separate species).

Major lessons learned

- When re-introduced to predator-free island sanctuaries, founder survival and growth provide an indication of short-term demographic success.
- Each monitoring event results in the capture of founders that have not been seen since re-introduction. Therefore, data from multiple monitoring events are likely to provide the best indication of short-term successes.
- Changes to taxonomy may alter priorities for conserving populations and our evaluation of single populations as ideal or poor choices as source populations for re-introductions. Based on the most recent genetic information, North Brother Island is likely a poor choice of source population. Supplementation of released populations with tuatara from a wild population with high levels of genetic diversity and within the same ecological region would be desirable for long-term management.
- Goals for a re-introduction program and the indicators of success may change as new information becomes available.
- Long-term (e.g. 10 generations) goals for genetic diversity are important to consider at the time of release, based on species biology.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Three re-introduced populations were founded from North Brother Island, all of which are secure from introduced predators in protected reserves. One of these populations (Matiu/Somes Island) is readily accessible to the public without a permit. This re-introduced population is a successful tool for conservation advocacy, as thousands of visitors are educated annually on threats to tuatara annually.
- Growth and survival of individuals and reproduction were detected in the two populations that have been monitored for ~10 years.
- The survival of recruits and whether the re-introduced populations have a positive growth rate is unknown. The founder contributions cannot be evaluated until a large number of island-born animals are detected. It is possible that a high degree of reproductive skew in the founder groups will lead to rapid increases in inbreeding and losses of genetic diversity. Further, the effects of inbreeding cannot be determined, as it is not currently possible to evaluate individual reproductive success in the wild.
- The criteria for and indicators of success needed to be re-evaluated in light of the most recent taxonomic information. Whilst the re-introduced populations appear successful in the short-term, these populations now seem to be of lower conservation value. Success in the long-term is constrained, as re-introduction constitutes a demographic and genetic bottleneck in a historically small population.

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Re-introduction of the Antiguan racer to offshore islands of Antigua, West Indies

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Introduction

The Critically Endangered Antiguan racer (*Alsophis antiguae*: Colubridae) was historically distributed throughout Antigua (280 km^2) and probably Barbuda (161 km^2). Henry W. Parker first described this snake in 1933, but declared it extinct three years later, purportedly due to the introduction of Asian mongooses (*Herpestes javanicus*). In 1989, Antiguan racers were rediscovered on Great Bird Island, a mongoose-free 8 ha islet, 2.4 km from Antigua's Northeast coast. A study by the first author found only 50 individuals remaining, half of which had injuries consistent with bites by alien rats (*Rattus rattus*). This finding prompted the formation of the Antiguan Racer Conservation Project by local and international organisations, which eradicated the rats from Great Bird Island. Within two years, the racer population had more than doubled in size (Varnham *et al.*, 1998). To enable the world population to increase further, a re-introduction program was launched in 1999 (ARCP, 1999), using wild stock from Great Bird to repopulate islands cleared of rats and mongoose. By 2010, more than 500 Antiguan racers inhabited four islands totalling 63 ha. While the islands are within a marine protected area, the racer lacks adequate legal protection and remains seriously threatened by alien species and human pressures (Daltry, 2007).

Antiguan racer © Matthew Morton, DWCT

Goals

- Goal 1: Suitable re-introduction sites within the Antiguan racer's historic range identified and alien invasive predators (rats and mongooses) eradicated.
- Goal 2: The support of local stakeholders and policy-makers secured through education, awareness-raising and consultations.

- Goal 3: Breeding colonies of Antiguan racers established on predator-free islands and form a viable meta-population.
- Goal 4: All Antiguan racer colonies adequately protected from threats and routinely monitored.

Success Indicators

- Indicator 1: Individual racers translocated from Great Bird Island to re-introduction sites exhibit higher rates of growth and survival.
- Indicator 2: Antiguan racers confirmed to be reproducing on all re-introduction islands within three years of release.
- Indicator 3: All islands inhabited by Antiguan racers protected and kept free of alien invasive predators.
- Indicator 4: Local stakeholders demonstrate positive commitment to conserving Antiguan racers and their habitat.

Project Summary

Feasibility Stage: Studies of the racer's population status and behavioural ecology began in 1995, using radiotelemetry, mark-recapture and direct observations (Daltry *et al.*, 2001). This medium-sized (snout-vent length to 105 cm) diurnal colubrid was found to prey almost exclusively on lizards (*Anolis wattsi* and the endemic *A. leachi, Ameiva griswoldi,* and *Sphaerodactylus elegantulus*). Antiguan racers are capable of reproducing from two years of age, and can live more than 15 years, but population turnover is high, with an annual age-independent mortality rate of 44%. Antiguan racers can achieve densities of up to 20 individuals per ha in the absence of alien mammals. Antigua has approximately 30 low-lying offshore islands ranging from less than 1 ha to 200 ha. Most, including Great Bird Island, are naturally vegetated with xeric woodlands, with white sand beaches and extensive areas of exposed limestone pavement. The only native mammals are bats, and the most conspicuous vertebrates are lizards and birds, including globally significant seabird colonies. All but the smallest islands had been invaded by alien black rats (*Rattus rattus*), which attack small snakes and degrade their habitat. The members of the Antiguan Racer Conservation Project (Forestry Unit, Environmental Awareness Group, Durrell Wildlife Conservation Trust, Fauna & Flora International, Island Resources Foundation and Black Hills State University) therefore concluded the rats should be eliminated from all prospective racer re-introduction sites (ARCP, 1999).

Antigua's offshore islands include both crown land and private islands, some of which have been developed for luxury housing. Tens of thousands of people visit the uninhabited islands on private vessels and tourist catamarans, with Great Bird Island and Green Island being the most popular for recreation. In 2006, seven years after the re-introduction program began, every island mentioned in this article was gazetted as part of the North East Marine Management Area, a multiple-use marine protected area. At the time of writing, however, this area still lacks regulations or staff on the ground. In the mid-1990s, few Antiguans knew of the racer's existence and most expressed a negative attitude towards snakes. To give the re-introduction program a chance of success, it was important to popularise the racer, especially among the private land owners, tour operators


Donald Anthonyson, Jenny Daltry and friends releasing racers on York © Tom Aveling, FFI

and other regular users of the islands. The Environmental Awareness Group (national NGO) and the Forestry Unit (Ministry of Agriculture, Lands, Housing and Environment) led the education efforts and dialogue with the many stakeholders. In addition to organising numerous public talks and field trips to Great Bird Island, project personnel visited schools throughout Antigua to display live racers and developed several documentaries about the project, articles in newspapers and magazines, postings on the Internet, radio interviews, and tour operator training workshops. Public knowledge and opinion of the racers improved significantly, and the project team gained permission to re-introduce the species even to private islands (notably Green and York, owned by the Mill Reef Club). In 1999, the IUCN/SSC Re-introduction Specialist Group formally endorsed a plan from the Antiguan Racer Conservation Project, which presented these issues in more detail (ARCP, 1999).

Implementation Stage: Between 1995 and 2008, rats and, where present, small Asian mongooses were eradicated from 12 islands using brodifacoum bait (Varnham *et al.*, 1998). Islands were selected based on their potential suitability for snake re-introductions or to reduce the risk of re-introduction sites being reinvaded. The first re-introduction of Antiguan racers took place on Rabbit Island (2 ha) in 1999, followed by Green Island (45 ha) in 2002 and York Island (7 ha) in 2008. In all cases, young racers were observed within two or three years of the first release, confirming that the snakes had bred. To combat inbreeding, additional stock are periodically taken from Great Bird to the re-introduction sites. All source animals were translocated from Great Bird Island, where the population had attained its carrying capacity of between 100 and 160 adults and subadults. No more than 10% of the source population was removed in any one year, and the closely-monitored source population has remained consistently high. All translocated individuals were tagged and a sliver of tissue removed from the tail for genetic analysis. The snakes were transported by boat from Great Bird to the re-introduction sites, typically within less than 24 hours of capture. Only adult and subadult snakes in peak physical condition were translocated.

Post-release monitoring: This was done using radiotelemetry and direct observations which have revealed that the translocated racers adapted easily to the new islands and exhibit growth spurts when released from the competitive


Green Island - the largest re-introduction site
© Jenny Daltry, FFI

environment on Great Bird Island. Almost every year, a census lasting approximately 40 days is conducted by project staff using a standardized mark-recapture method (Daltry *et al.*, 2001). All captured racers are marked with a unique PIT tag. The total population exceeded 500 adults and subadults in 2010, a ten-fold increase since the project began. Populations of the racer's main prey species – *Anolis wattsi* and *Ameiva griswoldi* – have also been the subject of intensive field-based investigations (e.g., Smith & Colbert, 2002). As the racer populations have increased on each island, the lizard populations have appeared to dip slightly, but not significantly. Threats to the racers are being monitored, especially the presence of alien invasive species and the number and impacts of human visitors to the offshore islands. Since 2002, a network of rat-bait stations has been maintained and monitored on each re-introduction site to provide an early warning of any re-invasions by rats. Contingency supplies of rodenticide are maintained in Antigua to allow a rapid response in the event of a reinvasion. The project partners meet annually to evaluate progress and decide upon future goals.

Major difficulties faced

- Initially, most people who own or use the offshore islands regarded snakes as vermin. The project had to invest heavily in nationwide education and awareness programmes to ensure local stakeholders would not kill the snakes or oppose the re-introduction.
- The source population on Great Bird Island, which was probably isolated for hundreds of years, exhibits many signs of inbreeding. This raises questions over whether any of the re-introduced populations will be genetically viable over the long term.
- Alien invasive species - notably the black rat (*Rattus rattus*) and fire ants (tentatively identified as *Wasmannia auropunctata*) remain a significant threat to all islands occupied by racers, and are difficult to control.
- The ever-increasing numbers of visitors and vessels increase the risk of alien invasions as well as increased human-snake encounters, habitat degradation and increased fire risk. The annual number of visitors to the 8 ha Great Bird Island, for example, has increased from 17,000 (mid-1990s) to well over 40,000.
- Securing sufficient funding to maintain the project remains a perpetual challenge. There may be potential to charge fees to recreational visitors who

use the marine protected area to help support essential protection and conservation activities.

Major lessons learned

- The Antiguan racer re-introduction program was grounded in a sound scientific understanding of the behaviour and population dynamics of the target species and its prey.
- The fact the program was operated by a consortium of organisations, rather than one body, gave it resilience. Wherever a partner was unable to contribute sufficient human or financial resources, the other partners worked harder to keep the program going.
- The re-introduction program benefited from being embedded in a wider, holistic landscape conservation program (the Offshore Islands Conservation Program) that addresses the management and sustainable use of the offshore islands.
- The use of relatively small offshore islands makes the eradication of introduced predators feasible. Preventing the reinvasion of re-introduction sites by rats is a perpetual challenge, and requires dedicated personnel and continuous funding streams to be sustained.
- The use of multiple re-introduction sites (islands) to establish a meta-population has made the target species more secure from stochastic impacts on individual sites.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Breeding colonies have been successfully established on all three islands to which the Antiguan racers have been re-introduced. and there has been at least a ten-fold increase in the global Antiguan racer population.
- Introduced predators were successfully eradicated and prevented from reinvading multiple sites.
- The Antiguan racer, and the re-introduction program, has met with strong support from key stakeholders, and local capacity to sustain the program has been significantly increased.
- The current sum of four populated islands is still short of our original target of five islands, however, and there is a lack of additional islands that appear suitable for re-introduction.
- None of the four islands can by themselves support a genetically viable population (numbering in the thousands). The future survival of this meta-population is therefore dependent on concerted protection and the assisted transfer of individuals between islands.

Acknowledgments
The Antiguan Racer Conservation Project forms part of the Offshore Islands Conservation Program co-managed by the Forestry Unit (Ministry of Agriculture, Lands, Housing and Environment), Environmental Awareness Group, Durrell Wildlife Conservation Trust, Island Resources Foundation, Fauna & Flora International and Black Hills State University. The authors thank everyone who have contributed their valuable time to planning, implementing and monitoring the Antiguan racer re-introduction program over the years, including Chrissundra Abdool, Mike Appleton, Steve Ashton, Tom Aveling, Calvin Balagne, Jahmilla Baptiste, Quentin Bloxam, Sophia Browne, Kevin Buley, Mykl Clovis, Dr Brian Cooper, Gillian Cooper, Lena Dempewolf, Kim Derrick, Winston Downes, Kevin Drew, Calvin Fenton, Joanne Ford, the Fuller family, Dr. Stephen Funk, Dr Gerardo Garcia, Carole-Faye George, Collie Gardner, Richard Gibson, Algernon Grant, Jervaine Greenaway, Harmony Hall, John Hartley, Leslie Henry, McRonnie Henry, Milly Iturra, Dr Karron James, Philmore James, Victor Joseph, Florita Kentish, Ian Kisson, Dr Jason Kolbe, Ato Lewis, Kevel Lindsay, Trisha Lovell, Cortright Marshall, Carole McCauley, Sarah McIntyre, Sean Mendonca, Lucia Mings, the Mill Reef Club, Dr Reg Murphy, Aldrick Nicholas, Lia Nicholson, Anantha O'Dean, Agnieszka Ogrodowczyk, Andrea Otto, Sean Peters, Polly Phillpot, Kohylah Piper, Junior Prosper, Kumarie Ram, Toby Ross, Dr Brian Smith, Nate Stephen, Ingrid Sylvester, Adriel Thibou, Kim Walter, Everette Williams, Dr Kevin Wright and Karen Varnham. Fieldwork and the preparation of this manuscript were supported by British Airways Assisting Conservation, Balcombe Trust, Disney Worldwide Conservation Fund, Durrell Wildlife Conservation Trust, Fauna & Flora International, Curtis and Edith Munson Foundation, Organization of American States, US Fish and Wildlife Service (grant 96200-9-G292), and Whitley Award Scheme. The rat eradication work described in this paper was made possible with the kind support of Syngenta Agrochemicals.

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Trial re-introduction of the woma python in northern South Australia

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Introduction

The woma (*Aspidites ramsayi*) are large (~2m), brown terrestrial pythons that are endemic to the arid and semi-arid parts of Australia. Womas occur in a wide range of sand dune and sand plane habitats (Tyler *et al.*, 1990; Cogger, 2000). Despite their size, womas are inconspicuous and rarely seen because they are primarily nocturnal, living in mammal burrows during the day. Mammals, reptiles and birds are the main prey of womas. Womas are endangered in eastern Australia and vulnerable in South Australia. Womas are critically endangered in south-western Western Australia (Cogger *et al.*, 1993), where habitat clearance is considered their greatest threat and where they have not been seen since 1980. Introduced cats (*Felis catus*) and foxes (*Vulpes vulpes*), which have driven many Australian mammalian prey species of womas to extinction or into serious decline in southern parts of the Australian arid zone (Johnson, 2006) probably also threaten womas by direct predation, particularly of juveniles.

Goals

- Goal 1: A trial re-introduction of woma pythons using available captive-bred stock, as a preliminary to a full-scale re-introduction ensuring appropriate genetic diversity (Read *et al.*, in press).
- Goal 2: To investigate the ecology, behavior and threatening processes of an inadequately studied locally (and potentially nationally) threatened species.
- Goal 3: To introduce a native predator to assist in population regulation of re-introduced mammals within the fenced portion of the Arid Recovery Reserve.
- Goal 4: To develop protocols for possible future breed-and-release programs of other endangered Boid snakes, in particular the critically endangered south-western Australian population of the woma.
- Goal 5: To increase public awareness of conservation issues.

Success Indicators

- Indicator 1: Clarification of disease-free status of captive-bred womas particularly with regard to ophidian paramyxovirus and inclusion body disease.
- Indicator 2: Recovery and successful feeding of womas post surgical insertion of transmitters.

- Indicator 3: Release of captive bred woma pythons into the Arid Recovery Reserve under two experimental conditions of food availability.
- Indicator 4: Collection and analysis of movement, habitat use, diet and causes of mortality of radio -tracked woma pythons.
- Indicator 5: Survival of released snakes over 12 months with a decline to no less than 60% of their pre-feeding release weight.
- Indicator 6: Attention from print, radio and television media, and public attendance at pre-release community meetings and presentations.

Woma python (*Aspidites ramsayi*) © T. Morley

Project Summary

Feasibility: The Arid Recovery Reserve is a 60 km^2 fenced exclosure in northern South Australia (S 30.4844, E 136.8833) from which all introduced rabbits (*Oryctolagus cuniculus*), cats and foxes have been removed. The reserve lies within the known historical natural range of womas, but no womas have been recorded within the reserve since it was established in 1997, despite weekly monitoring. The recovery of native mammal populations at the Arid Recovery Reserve has occurred due to natural increases following removal of introduced mammals, and the successful re-introduction of four locally-extinct, herbivorous and omnivorous mammal species. In addition to developing a re-introduction protocol to improve the conservation status of womas, introduction of a native predator was an appropriate management initiative to limit bourgeoning mammal populations within the Arid Recovery Reserve (Read & Johnston, 2005). Ten womas from a single clutch were bred at Adelaide Zoo from wild-caught parents. We considered regional provenance to be important because womas show considerable geographic variation in morphology. The parents of the released womas were wild caught within 400 km of the release site. Miniature radio-transmitters were surgically implanted into the gut cavity between 3rd and 5th April 2007. All snakes fed and sloughed their skin at least once following transmitter insertion before they were released. Prior to the release, the incidence of endemic parasites and potential pathogens was investigated in reptiles from the Arid Recovery Reserve. All womas identified for release were held in isolation from all other reptiles from May 2004 until they were released in September 2007. During this time they exhibited no symptoms of disease. Particular attention was paid to the possibility of ophidian paramyxovirus or inclusion body disease. All released snakes were negative for DNA tests for paramyxovirus.

Mulga snake predating on a woma © Chris McGoldrick

Implementation: Ten womas were transported from Adelaide Zoo to Roxby Downs on 21st September 2007. One of the 10 transmitters failed prior to release, so this individual was returned to Adelaide Zoo. The remaining nine womas (7:2) were either hard-released (4 males:1 female) directly in to the Arid Recovery Reserve or soft-released (3 males:1 female) into a 0.5 ha pen within the Reserve into which weed-free oats were spread weekly for five weeks before the release to encourage high rodent densities. Womas in the hard release group were placed at separate locations (at least 150 m apart) on dunes within 2.5 km of the release pen. Each woma was released next to a disused bilby burrow on the morning of 22nd September 2007.

Post-release monitoring: Following release, the womas were radio-tracked daily to determine their location, habitat, health, and details of retreats used. We deliberately located snakes at different times of the day to maximize the temperature and diurnal range of observations, but found that we were not able to locate nocturnal fixes with precision or confidence without potentially damaging the snake refuges. Therefore most radio-tracking was conducted during daylight hours. Following an initial sedentary period, the womas moved shelters every five days, or so. Individual womas travelled up to 230 m. The womas released into the 'soft release' pen moved out of the pen within two weeks. All womas were found within or just outside underground retreats, usually burrow or warrens, during daylight hours. Successful feeding was confirmed for several of the released womas. The most noteworthy outcome of the study was that all released woma pythons were killed within four months, most likely by mulga snakes (*Pseudechis australis*).

Major difficulties faced

- Assessing disease status of captive bred woma pythons, specifically with regard to ophidian paramyxovirus and inclusion body disease. Both diseases were confirmed in captive reptile collections in Australia just prior to instigation of the re-introduction program. No testing facilities in Australia. This testing took over two years.
- Long-term captive husbandry required due to delays in assessing disease status of captive bred woma pythons.
- Unexpected predation by mulga snakes, which were not identified as an important predator during planning stages of the trial re-introduction.

Major lessons learned

- Allow sufficient time for pre-release assessment of disease status in the face of emerging diseases for which diagnostic tools are being developed.
- Womas easily and rapidly scaled the netting fence designed to contain them within the soft-release experiment
- Expect to be surprised, even in areas where you have long experience of the fauna and natural history. Predation by mulga snakes was not predicted to be a major source of mortality prior to the release.


Habitat at the Arid Recovery Reserve site trial re-introduction © Terry Morley

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Trial release achieved, snakes fed and found shelter, although all released snakes were predated within four months.
- New information obtained about the ecology, behavior and threatening processes that will inform future re-introductions of woma pythons.
- Public awareness of conservation issues increased through considerable media attention and public attendance at pre-release community meetings and presentations

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Welfare release of Babcock's leopard tortoise, KwaZulu-Natal, South Africa

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Introduction

The options available for tortoises in rehabilitation centres are a life-time in captivity, euthanasia or release. However, in South Africa, there are not enough suitable tortoise sanctuaries, and rehabilitation centres are reluctant to euthanize tortoises because this is contrary to their aims. As a result, tortoises are released into the wild without reference to a documented release protocol and with no consistent post-release monitoring. We released Babcock's leopard tortoise (*Stigmochelys pardalis babcocki*), not internationally red-listed, as this tortoise is the most frequently admitted to a large rehabilitation centre in the KwaZulu-Natal province (KZN).

Leopard tortoise with transmitter

Since only the subspecies *S. p. babcocki* can be released in KZN, various morphological indicators were used to separate it from *S. p. pardalis*, and from putative hybrids of the two subspecies. Even though many authors do not recognize the two subspecies (e.g. Boycott & Bourquin, 2000), there is genetic evidence to suggest that there is a difference (e.g. Le *et al*., 2006). Release areas had to be on private land in KZN, as releases are not permitted in state protected areas. We published results of our release study in Chelonian Conservation and Biology (Wimberger *et al*., 2009), which has been reprinted here with permission.

Goals

- Goal 1: To test the efficacy of a tortoise release protocol developed using the IUCN Re-introduction Guidelines by a

provincial conservation authority, Ezemvelo KwaZulu-Natal Wildlife (EKZNW), to increase the probability that the release of rehabilitated tortoises would be successful while minimizing risks to biodiversity.
- Goal 2: To provide the first documented post-release monitoring of rehabilitated South African tortoises.
- Goal 3: To determine whether rehabilitated *S. p. babcocki* could be successfully released into the wild (Wimberger *et al*., 2009).

Overview of tortoise habitat

Success Indicators

- Indicator 1: Survival of released tortoises.
- Indicator 2: Site fidelity.
- Indicator 3: Causes of death, whether natural or as a result of other factors (e.g. not adjusting to release) (Wimberger *et al*., 2009).

Project Summary

We chose two sites for release, the 913 ha Leopard Mountain Game Reserve (GR) and the 2,196 ha Usuthu Gorge Community Conservation Area (CCA), in north-eastern KZN. Both locations contained suitable habitats for leopard tortoises, and at least some of the leopard tortoise's preferred food plants, refuge sites and water. Both reserves had *S. p. babcocki*, and the reserves were within the historical range of the species. The number of tortoises in the reserves was unknown but likely to be below carrying capacity. This was due to a recent severe drought in the region of Leopard Mountain GR, and surrounding areas having recently been converted from cattle farms to a consolidated wildlife conservation area, while the Usuthu Gorge CCA was in the process of becoming established as a community conservation area. Previously, high tortoise mortalities were likely on the release areas and surrounding land because of the use of tortoises for food, and from being burnt during uncontrolled fires or during fires designed to promote livestock production as opposed to wildlife conservation (Boycott & Bourquin, 2000).

As tortoises are killed by vehicles while crossing roads (Boycott & Bourquin, 2000), it was important that neither release areas had tarred roads (which promote greater traffic flow and higher traffic speeds), and only Leopard Mountain GR had a district road passing through it, which was used mainly by reserve vehicles and vehicles of tourist clients entering or exiting the reserve. The release program was understood, accepted and supported by the neighbouring landowners and local communities.

Tortoises were selected for release if they had greater than 100 mm carapace length, had been at a rehabilitation center for longer than two months, and were deemed medically fit for release by a herpetologist. Besides one tortoise (confiscated from the traditional medicine trade), most of the *S. p. babcocki* were escaped pets, as they would not naturally be found in the suburbs of the city of Durban or in that region, and most had distorted carapaces (e.g. pyramiding of scutes). In January 2005, 22 *S. p. babcocki* (5 males and 5 females with radiotransmitters attached) were hard released into the Leopard Mountain GR. In December 2006 and February 2007, 7 (2 males and 5 females with radiotransmitters attached) *S. p. babcocki* were hard released into the Usuthu Gorge CCA. Post-release interventions included returning those tortoises that we detected as having moved from the fenced reserves to ensure that we could relocate the tortoises through the study and to prevent the tortoises from being exposed to greater threats than might occur on the patrolled areas during the study. We realized that some of the tortoises might disperse again later, but we hoped that by returning them they might settle down in the release areas (as this has been done in some tortoise relocation studies, e.g. Tuberville *et al.*, 2005), or else that by the end of the study the tortoises would be more familiar with the habitat of the region. Furthermore, if any of the released *S. p. babcocki* showed signs of disease, it was taken to a veterinarian to be treated.

The 10 radio-telemetered tortoises released at Leopard Mountain GR were located monthly for the first 10 months after release, and sporadically (maximum five times) up to 25 months after release. A radio-telemetered wild tortoise was located monthly (after affixing the radio-telemeter), until the telemeter was found detached on the ground. Due to malfunctioning of some of the radio-telemetry equipment, not all radio-telemetered tortoises were found at each monitoring session. Non-telemetered tortoises were located opportunistically. Tortoises released at Usuthu Gorge CCA were located monthly for up to 13 months, when the study ended. A 3-tier Yagi aerial and a wide-range receiver were used to locate the radio-telemetered tortoises. Once found, their locations were obtained using a Global Positioning System. By the end of the study, one of the tortoises was returned to captivity because of disease, four were killed intentionally or accidentally by humans, three others died due to a combination of disease, starvation and/or dehydration, and the fate of six were unknown. Due to known failure of two radio-telemeters, it was the likely cause of the disappearance of the other tortoises. Two tortoises were known to survive 13 months after release at Usutu Gorge CCA and one tortoise was known to survive 25 months after release at Leopard Mountain Game Reserve (Wimberger *et al*., 2009).

Major difficulties faced

- Lack of comprehensive disease checking protocol for implementation before release to ensure all life-threatening and transmittable diseases were detected and cured before release.

Radio-tracking released tortoises

- Large numbers of leopard tortoises, which have large spatial requirements, in rehabilitation, with no space for them at these centers.
- Diseases easily spread amongst tortoises in captive situations. Was captivity the origin of the diseases whose symptoms were displayed by some of the released tortoises?
- Identification and fate of putative hybrids. Sterilization of males is easier than in females, so does that mean we only release sterilized males and euthanize the females?
- Knowledge of the origin and history of the tortoises. A large number could be ex-pets. Post-release survival could depend on the time kept in captivity as a pet (absence of survival behavior in the wild (e.g. brummation in winter)) and perhaps on what they were fed as a pet.
- Education of the public in order to persuade them not to keep leopard tortoises illegally as pets, especially if the tortoises are found in the wild. The education programs implemented previously have not stopped the illegal keeping of tortoises in captivity.
- Human threats to released tortoises, namely poaching and collisions with vehicles.
- Dispersal from release sites, and leaving the secure areas.

Major lessons learned

- A high survival of released rehabilitated tortoises cannot be assumed.
- Thorough disease checking by a veterinarian is vital before any rehabilitated tortoises are released.
- Where possible and practical, placing rehabilitated *S. p. babcocki* in an enclosure for a period before release may help to increase site fidelity (Tuberville *et al.*, 2005), may allow susceptibility to the diseases present at the release site to be manifest and for latent diseases from captivity to reveal themselves (Dodd & Siegel, 1991), and may allow the tortoises to adapt to eating the indigenous vegetation in the area.
- Reserve fencing should be properly secured to prevent tortoises from pushing through.
- Rehabilitated *S. p. babcocki* should not be released in precipitous landscapes as rehabilitated tortoises may not be as fit as wild tortoises due to their time in captivity.
- If possible, release areas should not have public roads traversing them.

- As suggested by others, future post-release monitoring could be carried out by the local residents (e.g. game rangers), which may decrease the interest in harvesting tortoises (Wimberger *et al.,* 2009).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- 47% of the *S. p. babcocki* released in this study died,
- At least five (29%) of the released tortoises were known to have survived 13 months post-release and were in good health.
- Improvements in the rehabilitation process, particularly with respect to disease checking and cure, and in the release protocol (e.g. the use of penning at the release sites if possible and practical, and in involving local people in the monitoring) should increase the success rate of future releases of rehabilitated *S. p. babcocki*.

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Translocation of Duvaucel's geckos to Tiritiri Matangi and Motuora Islands, Hauraki Gulf, as part of island ecological restoration initiatives.

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Introduction

Duvaucel's geckos (*Hoplodactylus duvaucelii*) are New Zealand's largest extant gecko reaching total lengths of 320 mm (160 mm snout-vent length [SVL]) and weighing up to 118 g (Gill & Whitaker, 1996). They are an important component of forest ecosystems, providing ecological roles as predators, prey, pollinators, and seed dispersers (Whitaker, 1987). Sub-fossil evidence and their present discontinuous geographical distribution suggest that *H. duvaucelii* were once widespread across New Zealand, however the combined effects of habitat degradation and introduced mammalian predators have confined this species to 36 isolated island populations (Towns, 1991). *Hoplodactylus duvaucelii* are listed under Category 6 ('At Risk-Naturally Uncommon', Human Induced) by the New Zealand Department of Conservation Threat Classification System (Hitchmough *et al*., 2007). This category includes all species that occur within typically small and widely scattered populations. The IUCN Red List classifies *H. duvaucelii* as 'Lower Risk'/ 'Least Concern' with its history insufficiently known (Groombridge, 1994). Tiritiri Matangi (220 ha) and Motuora (80 ha) Islands are protected sanctuaries and are currently undergoing ecological restoration by way of re-vegetation and faunal re-introduction programs. These islands were considered ideal candidates for the introduction of *H. duvaucelii* populations.

Gecko with backpack transmitter © D. van Winkel

Goals

- Goal 1: Re-establishing a functional ecosystem on Tiritiri Matangi and Motuora Islands, which involves restoring the herpetofaunal communities to those of pre-human times; a component of which is the successful establishment of a breeding population of *H. duvaucelii* through translocation.
- Goal 2: Describing the first year post-release responses of *H. duvaucelii* to unfamiliar environments. Information will also be used for the management of future lizard translocations.
- Goal 3: Establishing long-term, volunteer-driven monitoring programs to evaluate *H. duvaucelii* establishment and breeding on Tiritiri Matangi and Motuora Islands.

Success Indicators

- Indicator 1: Recapture at least 50% of founders within three months of release.
- Indicator 2: Record evidence of island-born juveniles (offspring of released gravid founders) within one year of the release.
- Indicator 3: Provide evidence for successful recruitment by recording successive generations of offspring and survival of cohorts to adulthood.
- Indicator 4: Show the extent of dispersal and population expansion by capturing individuals outside of the release site.
- Indicator 5: Provide evidence of a self-sustaining population, with a greater proportion of new island born geckos captured compared with original founders.

Project Summary

Feasibility: Tiritiri Matangi and Motuora Islands are predator-free islands in the Hauraki Gulf, and are administered by the New Zealand Department of Conservation (DOC). These islands have had a long history of human occupation and have suffered severe habitat degradation through burning and livestock grazing. Currently, these islands are open to the public and are greatly supported by independent community restoration groups, Supporters of Tiritiri Matangi Inc. (SoTM) and Motuora Restoration Society (MRS). Both islands have large areas of established coastal vegetation, and are becoming progressively similar to the more pristine offshore islands that typically support a high density and diversity of reptile species. As part of each islands' restoration initiatives, re-introduction of native reptiles is important and *H. duvaucelii* were chosen for their ecological roles and charismatic appearance. Release sites within each island were selected on the basis of suitable habitat and food resources occurring in the immediate and surrounding areas. Korapuki Island, in the Coromandel, was selected as the source site for *H. duvaucelii*, as it supports a high density population of *H. duvaucelii*, and is therefore capable of sustaining the effects of harvesting. The island also represents the closest *H. duvaucelii* source population to the release islands. Consultation was done between DOC, local iwi tribes, SoTM, MRS and Massey University to determine research objectives, and logistics.

Implementation: Pre-translocation reptile surveys were conducted on Tiritiri Matangi and Motuora Islands to confirm local absence of *H. duvaucelii*, identify

Tiritiri Matangi Island (*left*) and Motuora Island (*right*) © A. Mitchell & MRS

other potential mutually exclusive/ competitive species, and to detect potential pathogens within the resident reptile population. Thirty-nine *H. duvaucelii* were captured from Korapuki Island, with a 50:50 sex ratio and a preference for gravid individuals amongst the females. Geckos were quarantined for two weeks to test for *Salmonella*, *Cryptosporidia*, and *Giardia*, and to provide opportunity for expulsion of unwanted material (i.e. seeds) and organisms from their bodies. No animals tested positive for the selected pathogens and all animals were deemed acceptable for translocation. All geckos were implanted with PIT tags prior to release, to allow individual identification and therefore provide detailed re-capture histories to be built following translocation. Half of the animals (i.e. 10 geckos per island) were also fitted with two-stage, externally mounted, backpack transmitters to allow detailed tracking of movement, dispersal, and habitat-use. Morphological measurements were recorded before being transported to the islands, via boat, in individually housed plastic tubes. Nineteen and 20 *H. duvaucelii* were released onto Tiritiri Matangi and Motuora Islands, respectively, in December 2006.

Post-release monitoring: Geckos were monitored using a suite of standard techniques, including radio-telemetry, spotlight searches, footprint tracking tunnels, artificial refuges and funnel traps, to increase the detection probability of *H. duvaucelii*. Monitoring took place within a defined area surrounding each release site. Radio-telemetry data collected within the post-release year indicated that initial movements by *H. duvaucelii* were low but increased considerably over time as animals dispersed further away from release sites. *H. duvaucelii* utilised a range of habitat types at release sites. Annual monitoring since 2007 has revealed that dispersal movements have varied considerably among the adult founders. Additionally there were no post-release mortalities recorded and all re-captured individuals showed marked increases in body condition over the year-long intensive monitoring period. Island-born juveniles (offspring of released gravid founders) were recorded 12 months after the release and all juveniles were in excellent condition, suggesting their capability of securing resources on the islands was adequate. Recent monitoring in 2009 also showed the recruitment of a second offspring cohort, on Tiritiri Matangi Island, indicating the first occurrence of natural matings post-translocation. This information provides baseline references on habitat size and quality requirements, dispersal behaviour and expected reproduction by *H. duvaucelii* post-release, which can be used to select optimum release sites and maximise the success in future translocations. Long-term monitoring plans for *H. duvaucelii* will involve annual surveys, with methods designed by researchers and implemented by SoTM and MRS volunteers. Lead volunteers will be trained prior to undertaking these surveys by current herpetologist associated with the project. Annual monitoring will involve spotlight searches, footprint tracking tunnels, funnel traps, and artificial refuge techniques. These methods will provide an index of abundance and allow detection of juvenile geckos via footprint tracking tunnels. Information from these efforts will be sufficient to determine breeding success and population growth on the islands.

Major difficulties faced

- Detecting nocturnal, semi-arboreal species such as *H. duvaucelii* can be difficult when they exist at low densities. Despite employing a suite of different monitoring techniques, re-capture rates of *H. duvaucelii* were low. This was due to monitoring efforts that focused intensely within the release sites, and therefore any dispersal out of these sites by *H. duvaucelii* may not have been detected.
- The original founder population sizes were low and concerns regarding the long-term genetic viability of the populations are realized. The effects of inbreeding on these populations are speculative and genetic sampling over time is being conducted. Future population augmentation for long-term viability is a valid possibility.
- Community restoration group volunteers are very useful for collecting data however they are often insufficiently trained to undertake scientific monitoring. Since this project is focused on involving volunteers, it is a priority to provide training and support during the first few monitoring periods. This support will be required until such time that volunteers are capable of confidently locating, capturing, and processing the animals.
- Problems arose with respect to radio-transmitter harnesses causing skin abrasions to some *H. duvaucelii*. Affected individuals were treated and a softer, more flexible material was used for transmitter harnesses thereafter, with no adverse effects.
- The high cost and limited funding for disease-screenings restricted the project in performing comprehensive testing of both translocated individuals and resident populations at release sites. Priorities for specific pathogens of concern and a smaller sample size from the resident populations had to be selected instead.

Major lessons learned

- Monitoring methods vary considerably in their detection rates and are influenced by both spatial and environmental conditions. When employing a suite of monitoring techniques, good positioning of each method based on species behavior (i.e. vertical and horizontal spacings, and habitat types) and ideal environmental conditions (i.e. warm, calm, moonless nights in summer) needs to be considered to maximize the efficacy in detecting *H. duvaucelii*.
- The large variation in post-release movements and habitat-use by *H. duvaucelii* in this study can be used as guidelines for conservation managers

in selecting future release sites that will fulfill the habitat and size requirements of the species.

- Long-term monitoring is essential in long-lived species, for determining their translocation success and assessing the populations' genetic viability.
- Community restoration groups and NGOs have great interest in conservation and are valuable contributors as data collectors. Their involvement should be incorporated into scientific-based translocation programs.
- Utilizing SoTM and MRS volunteers as part of a researcher's monitoring group proved to be beneficial and valuable for both parties. Not only could volunteers learn and gain skills, but they were also important for advocating reptile conservation to the public and other community groups.
- It is important to have constant communication between DOC, community restoration groups, iwi tribes, and researchers. Good communication is needed to maintain relationships, share local knowledge and aid in funding for research and monitoring.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- High number of individual founders re-captured on both islands (≥70%) within three months of release.
- Island-born juveniles with high body condition scores were captured on both islands one year post-release.
- Evidence of natural breeding occurring with a second generation of offspring detected three years post-release.
- Detailed information collected on the movements, dispersal, and habitat-use of *H. duvaucelii* post-translocation.
- Successful creation of at least one additional population of *H. duvaucelii* within their geographical range.

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Development of a re-introduction and re-enforcement program for Siamese crocodiles in Cambodia

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Introduction

The Critically Endangered Siamese crocodile (*Crocodylus siamensis*) was once abundant in rivers, lakes and swamps in Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, Thailand and Vietnam. During the 20th century, the crocodiles became highly sought after for their skins and many thousands were captured to stock >1,500 crocodile farms, where they were frequently mated with other species (*C. porosus* & *C. rhombifer*) to produce faster-growing hybrids. During the same period, human population growth and expansion of agriculture and fisheries placed severe pressure on the crocodiles' wetlands. Siamese crocodiles still remain in up to 50 scattered locations, but the total wild population is believed to number <250 adults and no more than five nests are recorded annually. Illegal trafficking continues, despite this rare crocodile being on CITES App. I (Daltry & Thorbjarnarson, 2004). This project focuses on Cambodia, which holds most of the remaining wild population and still has extensive natural habitat. In addition to the current task of protecting the few remaining breeding colonies, the Cambodian Crocodile Conservation Program plans to restock at least four sites that are devoid of crocodiles (re-introduction) or have too few individuals to reproduce (reinforcement). The full re-introduction and reinforcement plan will be published in 2011.

Sorn Piseth, FA staff with radio-tagged crocodile
© Boyd Simpson FFI-CCCP

Goals

- Goal 1: Suitable re-introduction/re-enforcement sites within the Siamese crocodile's historic range are identified and the active support of local stakeholders and policy-makers is secured.

- Goal 2: Captive pure-bred Siamese crocodiles of Cambodian origin are identified and bred for release.
- Goal 3: Fully wild breeding colonies of crocodiles are established in at least four sites by 2030, with effective measures in place to protect them.
- Goal 4: All breeding populations in Cambodia (both existing and re-introduced) are routinely monitored.
- Goal 5: Additional re-introduction projects in the species' historical range are inspired and informed by this program.

Success Indicators

- Indicator 1: Captive-bred crocodiles released in the re-introduction/re-enforcement sites do not exhibit lower rates of growth and survival than wild-born crocodiles.
- Indicator 2: Crocodiles are confirmed to be reproducing in all re-introduction sites by approximately 15 years of age.
- Indicator 3: All re-introduction and reinforcement sites are well protected by law and have an effective managers, enforcement personnel and regulations in place.
- Indicator 4: Local stakeholders demonstrate positive commitment to conserving Siamese crocodiles and their habitat.
- Indicator 5: Re-introduction programs are developed in other parts of the species range, citing lessons learned from this project.

Project Summary

Feasibility stage: This project forms part of the Cambodian Crocodile Conservation Program (CCCP) of the Forestry Administration and Fauna & Flora International which was initiated in 2001 and has included: i) Research on the ecology of and threats to Siamese crocodiles; ii) Education and training; iii) Evaluations of potential release sites; iv) Identification of captive stock suitable for breeding and release; and v) Development and testing of methods to protect wild crocodiles and their habitats. Studies of the crocodiles' distribution, status and ecology have been conducted since 2001. Methods for detecting even lone individuals were developed and disseminated to wildlife officers, rangers and other researchers in Cambodia (Simpson, 2006). More than 30 occupied sites have been discovered nationwide, but evidence of breeding has been obtained in only five sites. Wild Siamese crocodiles take approximately 15 years to mature and produce small clutches (typically <25 eggs) annually or biennially.

Radio-telemetry studies have revealed Cambodia's Siamese crocodiles have small home ranges, typically remaining within few kilometres' radius: This suggests that the scattered wild individuals are unlikely to re-colonise vacant areas without intervention. Analysis of more than 300 faecal samples has confirmed Siamese crocodiles are generalist predators that feed on wide range of mammals, birds, reptiles, fish and amphibians (e.g. Simpson & Sam, 2005). Significantly, there are no records of wild Siamese crocodiles preying upon or otherwise attacking people. Cambodians accustomed to living in crocodile areas will wash or swim in rivers without fear of injury. Conflict can arise, however, when crocodiles break fishing nets and other equipment. Illegal trade in wild individuals

Ideal Siamese crocodile habitat in Areng Crocodile Sanctuary © Chris Loades FFI-CCCP

continues to be a threat, with wild adults fetching up to US$ 1,000. Daltry & Thorbjarnarson (2004) documented at least 61 wild crocodiles illegally captured in Cambodia between January 2001 and March 2004. Largely due to the education and protection efforts of the CCCP, most Cambodians living in crocodile areas now know this species is rare and protected and the number of crocodiles caught has fallen. Only three cases were detected in 2009.

Based on nearly ten years of research, the CCCP has identified selection criteria for suitable re-introduction and re-enforcement sites. For example, it should retain ≥1.5m-depth of water all year, ideally be within an existing protected area, and not be downstream of any potential hydropower developments. A shortlist of six potential re-introduction and re-enforcement sites have been identified in Southwest Cambodia. The release stock will come from two sources: captive-bred crocodiles and, to a lesser extent, wild stock confiscated from poachers or translocated from threatened sites. There are many examples worldwide of captive-bred crocodilians being successfully returned to the wild, including the 2002-2004 re-introduction of Siamese crocodiles to Cat Tien National Park in Vietnam (Polet, 2004).

This project will use the Government's Wildlife Rescue Centre near Phnom Penh as its captive breeding facility. Genetic tests in 2009 confirmed the Centre holds 35 pure-bred Siamese crocodiles (6 adults, 1 subadult, and 28 juveniles and hatchlings), which have been separated from the cryptic *siamensis x porosus* and *siamensis x rhombifer* hybrids (Starr *et al.*, 2009). New breeding pens and rearing enclosures will be constructed in 2010 and the Centre is expected to generate at least 50 pure-bred hatchlings per year. The crocodiles will be reared for at least one year before being released to reduce the risk of natural mortality. It will be vital to ensure the crocodiles are accepted by local communities and adequately protected from poachers, fishing nets, and other threats. CCCP has gained invaluable experience from the participatory establishment of three crocodile sanctuaries in Southwest Cambodia, where villagers are employed as wardens and receive practical support to gain land tenure and improve their livelihoods. This strategy has worked well, with the first sanctuaries already demonstrating evidence the crocodile populations are stable or increasing (Daltry *et al.* 2005; Oum *et al.*, 2009).

Implementation stage: This is scheduled to begin in 2012, with the first release of up to 50 captive-bred juveniles. Further releases will be conducted annually, but not without the prior informed consent of local stakeholders or before protection measures have been established in the site. In our experience, it takes two-to-three years to establish a sanctuary and enlist the active cooperation of local people and enforcement officers.

Post-release monitoring: This should begin when the crocodiles are released and continue for at least 30 years, in view of their long generation time. All released crocodiles will be marked with microchips and by clipping up to three tail scutes. The crocodiles will be monitored using regular direct observations and a small number will be radio-tracked for at least six months to determine whether they behave naturally and remain in the intended area. In re-enforcement sites, any interactions between the indigenous and released stock will be closely observed. As in the existing sanctuaries, local wardens and rangers will regularly patrol the release sites from the start to monitor and respond to poaching or other threats, and the CCCP and affiliated organisations will conduct annual transect-based surveys of crocodile signs (tracks and dung) in every site. When the released animals mature, there will also need to be thorough surveys between April and June to detect and record any nests (Simpson, 2006). Standardized methods will also be developed by the CCCP to monitor local attitudes, which may change as the crocodiles increase in size and number.

Major difficulties faced

- The Siamese crocodile is commercially valuable animal in an impoverished country that has high levels of corruption and inadequate understanding and enforcement of the law. This species depends on wetlands, which are seriously threatened by intensive fishing, agricultural conversion, pollution and hydropower dams and other factors.
- Many of the sites currently occupied by Siamese crocodiles or suitable for re-introduction are remote and hazardous. Project staff have, for example, encountered unmarked minefields and been seriously ill with malaria multiple times.
- Wildlife management in Cambodia is constrained by the generally low capacity of most local and national agencies. The CCCP has therefore had to invest a significant proportion of time and funding to training,

Teachers distributing crocodile books and t-shirts to children © Sam Han FA-CCCP

Releasing head-started juvenile Siamese crocodiles
© Jeremy Holden, CCCP

mentoring and equipping its staff and other government officers, rangers and community wardens.

- Genetic testing of captive stock is essential to ensure no hybrids are accidentally released. All DNA samples must be sent to labs overseas for testing, which is time-consuming and necessitates both CITES import and export permits.
- Securing sufficient funding to maintain the project remains a perpetual challenge. The re-introduction and re-enforcement program will take at least three decades to complete and cost approximately US$ 150,000 per year (US$ 4.5 million total).

Major lessons learned

- The Siamese crocodile re-introduction and re-enforcement program, summarised above, has been formulated over nearly one decade, during which the project team (most of them Cambodian nationals) have honed their skills, gained an good understanding of the species, and tested protection and head-starting measures that work in the field. We believe this long preparation stage will have maximised the probability of success.
- It takes a long time to build trust with villagers in remote areas and develop a genuine consensus to conserve crocodiles and their wetlands. Project staff must commit to making frequent visits to villages, strengthen local governance and, wherever possible, seek innovative ways to ensure the people also benefit from the project.
- The CCCP partnership between a government agency and an international NGO has worked very well to date, with both partners sharing ownership. The direct involvement of a government agency with jurisdiction over most parts of Cambodia is proving especially useful for facilitating the legislative and enforcement aspects of this program.

Success of project

Highly Successful	Successful	Partially Successful	Failure
-	-	-	-

None of these options apply because no animals have been released yet.

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Re-introduction of corncrakes in the UK

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Introduction

The corncrake (*Crex crex*, Linnaeus 1758) appears as Near Threatened in the 2009 IUCN Red List, following recent surveys in eastern Europe and new enhanced population estimates for Asiatic Russia. New information suggests that the introduction of intensive agricultural technologies in some areas will be compensated for by the reduction of agricultural production in other areas. In Asiatic Russia, where the bulk of the world population breeds, future moderately rapid declines are predicted on the basis of land abandonment, with meadows becoming overgrown by bushy vegetation and trees (Information from BirdLife International website). In the United Kingdom, the corncrake population was wiped out on the mainland by the late 20th century, owing to the mechanization of agriculture, and only survived on Scottish islands in the far west and north. Through strenuous conservation efforts aimed at promoting corncrake-friendly farming practices in these areas, the population doubled in just ten years, but is currently still only a little over 1,000 singing males, and is therefore on the Red List of *Birds Of Conservation Concern* in the United Kingdom. A re-introduction program at a site in eastern England began in 2001.

Goals

- Goal 1: To establish a self-sustaining population of at least 50 calling male corncrakes at a protected and suitably managed site in eastern England
- Goal 2: This is a pilot project and, if successful, will provide the knowledge and experience to repeat the process elsewhere in the UK (subject to availability of suitable habitat), and so further the long-term objective of securing the future of the corncrake as a breeding bird throughout the UK.

Success Indicators

- Indicator 1: To establish a captive-breeding population of corncrakes
- Indicator 2: To release at least 100 captive-bred juvenile corncrakes annually for a period of at least three years (possibly up to seven years, depending on the number of chicks bred in captivity)
- Indicator 3: An increasing number of calling males recorded at the release locality each year until the target figure is reached

Project Summary

Feasibility Stage

Habitat: The RSPB and English Nature assessed the suitability of potential release sites, and concluded that the best site was the Nene Washes (Cambridgeshire). The total area of the Washes is 1,350 ha of which about 67% is grassland. Consultation with landowners and occupiers within the Nene

Washes were conducted by English Nature and RSPB wardening staff, and the response was favourable. The RSPB has control of grazing/cutting on its own landholdings. Other areas of the Washes are under EN management agreements with owners and occupiers. Late cutting is essential to prevent the destruction of nests, eggs, chicks and adults-the demise of corncrakes in much of Europe was due to earlier mowing of grasslands.

Corn crake (*Crex crex*)
© Andy Hay (*rspb-images.com*)

Aviculture: The original plan was to remove 10 chicks (5 males:5 females) from the wild in Scotland, rear them in captivity in Germany and attempt to breed from them the next spring. In the event, there was opposition in the Scottish breeding locality selected for collecting chicks, and this proposal was abandoned. Instead, EN and RSPB agreed to use 15 captive-bred juvenile corncrakes imported from the aviculturist in Germany, who had surplus stock derived from individuals collected in Germany and Poland. It was felt that these birds were sufficiently similar genetically to the extinct English population for this to be successful and justifiable. These birds were housed at Whipsnade Wild Animal Park (Zoological Society of London) and the breeding program was under the supervision of ZSL staff. It was hoped that the captive breeding program would produce a surplus of at least 100 juveniles per year for a minimum of three years. These numbers were based on the fact that corncrakes are short-lived (few two-year old corncrakes have been re-trapped in the UK). Therefore, it was essential to release the maximum number of juveniles each year, with the expectation that a wild breeding population could become established fairly quickly (This is in contrast with experience with raptors - red kites and white-tailed eagles - which are long-lived and for which populations can be built up gradually over a period of several years).

Implementation stage: The breeding stock is kept in a purpose-built facility - the birds live in a communal aviary during the winter, but are split into individual breeding pens in spring. Males are assigned to females according to their genetics and breeding condition, and the pair remain together until a clutch is part -laid, at which time the male is removed. The eggs are transferred to incubators once the clutch is complete and the female has incubated for around 15 days. The chicks are hand-reared out of sight of the keepers, then transported to holding pens at the Nene Washes in batches, ideally at around two weeks of age. At that stage they can feed themselves, and are given a mixture of live insects and proprietary pellets. The juveniles are released into suitable habitat at around

Typical corn crake habitat
© Andy Hay (*rspb-images.com*)

28 days old. Concerns over the poor return rate of released birds the following spring, in 2008-2009 a new technique was tried out. A proportion of the 2008 chicks were retained in captivity over the winter, and released as breeding-age adults in spring 2009. These birds were radio-tagged, and it was clear that some of the males established territories and females located themselves close to calling males.

Post-release monitoring: This is extremely difficult for corncrakes, which are highly secretive and leave the release site soon after release on migration to unknown wintering areas. Satellite tags are not yet available for birds as small as corncrakes. However, in the first year of release, six birds had radio-tags attached, in order to check on their use of the habitats available after release, and to detect any major predation or other mortality issues. Two radios failed, two birds left the area the same night, but the remaining two foraged on the reserve for around two weeks before disappearing. As stated above, captive-bred birds released as adults in 2009 were also radio-tagged and shown to be remaining on the reserve and behaving as breeding birds. Each spring and summer, regular night counts of singing males are made over the whole release locality and surrounding potential areas. Trapping of males is also undertaken, to find out how many of these are captive-bred and how many of wild origin. Unfortunately, almost all of the trapped birds have been found to be released individuals, but checking the records has shown that the returning birds have tended to be among the heaviest individuals at the time of release.

Major difficulties faced

- Difficulty in getting authorization to capture wild Scottish corncrakes for the captive-breeding population.
- Inbreeding among the captive-bred individuals imported from Germany to found the UK breeding population.
- Heavy losses of captive adults and chicks in the first breeding season due to predation by a weasel which entered the breeding enclosure.
- High mortality among adult males trapped in Poland for augmentation of the captive breeding population (due to abnormally hot weather).
- Low return rate of released birds each following spring (even lower return rate than for wild populations).

- Little observed recruitment of wild-bred birds into the wild breeding population (most trapped returning males found to be captive-bred individuals from the previous year).
- Disease issues at a subsidiary breeding facility.

Major lessons learned

- Captive corncrakes have the ability to produce large numbers of chicks each season.
- Captive females tend to be poor mothers, so hand-rearing is important if the maximum number of chicks is to reached fledging.
- The captive-breeding population needed to be supplemented regularly with young, healthy and not inbred individuals. Therefore a reliable source of supply needs to identified.
- Corncrake chicks easily become tame, so should be reared in isolation from humans.
- There is a considerable risk of disease among the captive birds, so thorough screening is essential to minimize losses and ensure that exotic disease organisms are not released into the wild.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The project is not yet complete and will continue until at least 2010.
- Calling males return to the release site in increasing numbers each year, but many of these are still released rather than wild-bred birds.
- Breeding in the wild has been confirmed on one occasion, but an increasing proportion of un-ringed male corncrakes each year suggests that breeding in the wild is occurring regularly

Grey partridge supplementations in Oxfordshire and east Gloucestershire, UK

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Introduction

The grey partridge (*Perdix perdix*, Linnaeus 1758) is a native farmland species and a traditional game bird in the United Kingdom. Once a common species in the English countryside, the populations of this species have decreased dramatically (e.g. -88% between 1967 and 2006 (Baillie *et al.*, 2009)) mainly as a result of habitat loss due to agricultural intensification. Consequently, the grey partridge has been included on the red list of birds in the UK with highest conservation priority. There have been many attempts in the UK to re-establish or re-stock grey partridge populations through releases of captive-bred birds onto sympathetically managed farmland (e.g. Rands & Hayward, 1987; Dowell, 1990; Parish & Sotherton, 2007). However, released birds have had far inferior survival and breeding success compared to wild grey partridges (Rands & Hayward, 1987; Dowell, 1990), possibly because of their inadequate anti-predator behaviour brought about by captive breeding (Dowell, 1990).

Goals

- Goal 1: Increasing grey partridge numbers locally on appropriately managed farms.
- Goal 2: Monitoring behaviour and survival among the released birds to improve guidelines for grey partridge re-introductions/supplementations.

Success indicators

- Indicator 1: Settlement of the released grey partridges onto the release sites.
- Indicator 2: Breeding success of the released birds.

Project summary

We established four study sites in Oxfordshire and east Gloucestershire in the UK on arable farms growing winter and spring cereals, oilseed rape and beans. These farms provided the key habitats for grey partridge, i.e. nesting and brood-rearing habitats (field margins, hedges) as well as over-wintering cover (hedges, planted game covers) and predator control. Grey partridges were not hunted on these farms, and none of the sites conducted more than eight days of shooting annually, limiting the probability of disturbance and of accidental shooting (when mistaken for other species). We applied two established release methods, pair


Tagged male grey partridge © Francis Buner

releases in the spring (April), and covey (family group) releases in the autumn (October-November), used previously by the Game and Wildlife Conservation Trust (Buner & Aebischer, 2008). The grey partridges were obtained as three-week-old chicks from a game farm where the species had been bred for at least seven generations and hand-reared in brooder houses. The birds were housed in pens outdoors with food and water continuously available from feeders and drinkers, and the birds were monitored regularly for parasites and treated where necessary. Before the releases, four to five randomly chosen juvenile birds in the autumn coveys and all females of the spring pairs were radio-tagged using 10 gram necklace radio-transmitters with mortality sensors (RI-2BM, Holohil Systems Ltd., Ontario, Canada). The 10 gram radio-tags accounted for 2.6% of the average weight of grey partridges (390 gram; Robinson, 2005). The birds were allowed to get accustomed to the tags in their home pens for at least 24 hours before they were moved to the study sites, and if a bird reacted strongly to wearing the tag, the transmitter was swapped to another bird. Parish & Sotherton (2007) had previously detected no difference in survival between radio-tagged and non-tagged released grey partridges, so it was assumed that the survival of the radio-tagged birds in this study was representative of that of all released birds.

Between mid-October and early November in 2006-2007, 20 autumn coveys were released each year on the four study sites, five coveys per site. After transport, each covey was put into its separate release pen (size 3 m x 1.5 m). The five pens on each site were scattered within 1 km^2 in suitable locations next to tall vegetation cover (e.g. game cover or field margin with tall grass). Food, water and shelter were provided in these pens where each covey was kept for an acclimatisation period of four days before release. We used soft instead of hard release with the coveys in autumn in order to facilitate settlement, as the dispersal distances of autumn coveys have been nearly three times greater than those of spring pairs (1.4 km vs. 0.5 km on average) in previous releases (Buner, 2006). In April 2007, 70 pairs were released on two study sites (30 or 40 pairs on each site), and each pair was released directly after transport to the site along field edges (approximately 100 metres apart and next to crops providing cover). The released radio-tagged birds were located two to four times daily during an intensive monitoring period of the first two weeks after release in order to determine their activity ranges and habitat use. For each radio-tracking location, or “fix”, the date, time of day and the type of habitat were recorded. The survival

Radio-tracking released partridge

status of each released radio-tagged bird was checked regularly for eight weeks after the releases (every day for the first two weeks and then twice a week). Thereafter, the release sites were checked every 1-2 weeks for radio-tagged birds still alive and present at the sites. When the pulse of a radio-signal indicated that the tag had not moved for at least 12 hours, the tag was recovered and the date, time and location as well as any remains or signs found with the tag suggesting the cause of death were recorded.

Monitoring by radio-tracking showed that released grey partridges tended to settle onto the release sites, and preferred crops and field margins in spring and game covers in autumn, as their habitats. Released grey partridges suffered from high predation rates, both by mammalian and avian predators, and mortality rates were higher in spring (80% eight weeks after release) than in autumn (40%-50% eight weeks after release). In 2007, the autumn coveys broke up by January, as would also occur in wild grey partridges, while in autumn 2006 this covey breakup happened exceptionally early, in October-November. The disintegration of the coveys was followed by pairing and dispersal from the release sites by most radio -tagged individuals, and further monitoring of these individuals was logistically very difficult. Breeding was witnessed in only one pair released in spring, and in two other pairs in which the radio-tagged birds had been released in the previous autumn and could still be found on the release sites.

Major difficulties faced

- Predation rates were high and particularly unsustainable in pairs released in spring.
- The dispersal of released grey partridges from release sites after covey disintegration made it difficult to monitor and manage the released population after December-January.
- Coveys can disband exceptionally early as was witnessed in coveys in autumn 2006, again making further monitoring and management difficult.

Major lessons learnt

- Spring releases are particularly ineffective due to high mortality and low breeding rates.

- Covey releases in autumn are more feasible, but the dispersal of newly-formed pairs after the coveys disband makes them less efficient in increasing grey partridge populations locally on particular release sites.
- Game covers serve as key habitats for autumn coveys and may help their initial settlement onto release sites.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Released grey partridges initially settled well onto the release sites, but then either suffered from very high mortality rates (spring pairs) or dispersed in great numbers from the release sites (pairs formed when the autumn coveys broke up).
- Released birds were witnessed breeding, but the sample that could be monitored at that stage was too small to draw reliable conclusion.

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Re-introduction successes of Asian houbara bustard in the Kingdom of Saudi Arabia

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Introduction

The houbara bustard inhabits in open or scrub-covered plains and occurs over a huge range from Canary Islands, Spain, across North Africa to the Middle East and Central Asia via South Asia to mainland China. The population has been estimated at 49,000-62,000 individuals, but it is likely to exceed 100,000 birds (BirdLife International, 2001). The houbara is included in App. I of CITES and in App. I & II of the Convention on Migratory Species. It was not previously listed as globally threatened by IUCN, but in 2005 it was placed on the BirdLife/IUCN Red List with the status Vulnerable (IUCN 2009). It is classified as Vulnerable because it has undergone rapid population declines estimated to be 35% over three generations, owing largely to unsustainable hunting levels (BirdLife International, 2001).


Houbara bustard © M. Z. Islam

There are three sub-species recognized 1) *Chlamydotis undulata undulata* (9,800 birds) is resident in North Africa where it has declined in Libya, Egypt and Tunisia, and probably also in Algeria, Mauritania, Morocco and Sudan; 2) *Chlamydotis undulata fuertaventurae* (700-750 birds) occurs on the Canary Islands, Spain; and 3) *Chlamydotis undulata macqueenii* is thought to occupy six sub-regions: resident and migratory birds occur in the Middle East (Turkey, Jordan, Israel, Iraq, Kuwait, Bahrain, Oman, Qatar, Saudi Arabia, United Arab Emirates, Syria, Yemen), and in Russia (including in the Asian region), Iran, Pakistan, India, Afghanistan, Uzbekistan, Tajikistan, from western Kazakhstan to Turkmenistan, and on the Mongolian plateau and in the Gobi desert of Mongolia and western China.

The population of *C. macqueenii* is estimated at 39,000-52,000 individuals, mostly breeding in Kazakhstan (30,000-40,000), although numbers in the mainland China are likely to be

Houbara were released by HRH Prince Khalid al Faisal in Mahazat as-Sayd Protected Area © M. Z. Islam

much higher than the current estimate of 500 birds (BirdLife International, 2001). Declines are reported from Bahrain, Jordan, Iran, Iraq and India. Populations from some sub-regions are thought to mix on the wintering grounds. In recognition of perceived declines in houbara numbers in Saudi Arabia, the Minister of Foreign Affairs, His Royal Highness Prince Saud Al Faisal established both a captive-breeding center called the National Wildlife Research Center (NWRC) near the city of Taif in the Emirate of Makkah, and the Saudi Wildlife Commission (SWC) in Riyadh to oversee all species conservation concerns within Saudi Arabia (Seddon *et al*., 1995).

Goals

- Goal 1: The long-term goal of houbara conservation strategy is to secure self-sustaining wild populations of houbara throughout the Kingdom of Saudi Arabia.
- Goal 2: To determine the distribution, status and trends of houbara populations in the Kingdom.
- Goal 3: To improve our understanding of the ecology of houbara bustard.
- Goal 4: To protect and improve houbara habitat in the Kingdom.
- Goal 5: To establish and maintain an houbara captive-breeding facility (further develop the technical skills necessary to breed houbara in the captivity and to further investigate aspects of houbara biology).
- Goal 6: To develop techniques for the release of captive-bred houbara to establish new wild populations.
- Goal 7: Promote public awareness and foster public support for houbara conservation.
- Goal 8: To take a lead in initiating cooperative conservation efforts between houbara range states.

Success indicators

- Indicator 1: The captive-breeding program of houbara at NWRC has achieved its expected goals (on an average 300 birds are produced per year).
- Indicator 2: The captive herd at NWRC is maintained for re-introduction programs in other protected areas.

- Indicator 3: The re-introduction of houbara bustard in Mahazat as-Sayd for more than 20 years has now significant self sustaining population is considered to be a success.
- Indicator 4: After nine years of re-introduction in Saja Umm Ar Rimth which is also considered as partially successful.
- Indicator 5: A new website will be hosted by the NWRC (www.nwrc.gov.sa) that contains houbara information.

Project Summary

Houbara captive-breeding Program in Saudi Arabia: Since 1986, an important houbara project was undertaken by the National Wildlife Research Center based in Taif, western Saudi Arabia. During the first phase attention focused on the development of a houbara captive-breeding for future release and national houbara restoration program. During the initial stages captive-breeding was partially successful and the NWRC anticipated around 100-150 houbara chicks. In 2008 more than 300 chicks were produced by the NWRC, and in the second phase, the main focus of the program shifted towards the development of suitable release techniques and houbara project development (Seddon *et al.,* 1995).

Re-introduction: Two sites selected for Houbara re-introduction were Mahazat as-Sayd and Saja Umm Ar-Rimth protected areas in 1990 and 2001 respectively. All re-introductions were done in accordance with the IUCN Guidelines for Re-introductions. These two sites have attracted winter migrant houbara and anecdotal accounts suggest breeding may have occurred here in the past.

Mahazat as-Sayd protected area (site 1): This is an area of about 219,000 ha of fairly level, sandy plain at an altitude of 900 m to 1,100 m with a few rock outcrops in Makkah province. This nature reserve was established in 1988, especially to re -introduce Arabian oryx, Gazelle and Houbara and is fenced. The vegetation is *Acacia totilis, Indigofera* and *Salsola* as dominant shrub/trees. The substrate at Mahazat may be sand, gravel, or alluvial clays, and is usually loose, but not shifting, forming an even surface.

Saja Umm Ar-Rimth Protected Area (site 2): This was established as an extension of the Mahazat as-Sayd protected area in 2003 by HRH Prince Saud Al Faisal as a possible re-introduction site for houbara. In 1998, a 6,000 km^2 area was proposed by the NWRC for the re-introduction of houbara and houbara were released into a 400 km^2 enclosure near Jibal Barah.

Re-introduction methods: The houbara re-introduction program has been a primary focus of work in the Mahazat since 1991 and the following techniques have been tested (Combreau & Smith, 1998):

- Sub-adult (3-5 month old) houbara whose feathers on one wing have been cut were released in a 400 ha enclosure predator free zone to acclimatize to natural habitat.
- A covey in which 30-50 day old chicks were released with a pinioned, surrogate mother, to teach the juveniles feeding, habitat use and predator avoidance.

- Captive-bred juveniles of 4-6 months translocated to long tunnel-shaped cages and after three to four weeks released in to the predator-proof enclosure.

Pre-release (predator-free) enclosure for houbara: The 4 km^2 enclosure was built in Mahazat in 1989, with a predator proof electric fence. Within this enclosure six tunnels were built and the houbara re transferred into these from NWRC.

Field biology of houbara bustard: Re-introduction of houbara in Mahazat and Saja reserves provide opportunities to carry out research to improve our understanding of the ecology of houbara that include trapping, tagging, habitat use, feeding and breeding. Also included in this study are land management techniques and their influence on houbara, establishing and managing a network of suitable habitats and initiate collaborative research and conservation programs within the wider Gulf Co-operation Council (GCC) States.

Breeding in the wild: Captive-bred houbara have been released in Mahazat as-Sayd protected area since 1992 by NWRC and those birds have been successfully breeding since then. Reproductive biology studies have shown that from mid-January until the end of May the males periodically make courtship displays to attract female to individual territories and the distance between territories were between one and two kilometers, displays begin before sunrise and finish at dusk. After copulating with the male, the female makes a circular nest on bare ground between 300 m to 2,000 m from the nearest male and at 450 -900 m from neighboring females. A full clutch contains three to four eggs (occasionally two or five eggs). Brooding begins after the laying of the second egg and the intensity increases and reaches a maximum at hatching. Incubation lasts for 22-24 days and after hatching the chicks remains in the nest for first two days and then moves away from the nesting site.

Causes of mortalities: It is known that released captive-bred houbara in the wild are less successful compared to wild ones. During 1990 and 1991 the releases failed in Mahazat due to houbara ontogeny was not compatible with existing habitat conditions, while experimental releases in 1992 accounted for problems resulting from adaptation of captive-bred birds to natural habitat conditions (Combreau & Smith, 1988). The key cause of mortality was predation.

Trapping of carnivores: Mammalian predators are trapped in and around the houbara pre-release enclosure in Mahazat and Saja reserves in order to temporarily decrease predator's densities and give more chance of survival to young naïve bustards after release. Key predators are the red fox (*Vulpes vulpes*), Rüppel fox (*Vulpes ruppelli*), wild cat (*Felis catus/sylvestris*) and sand cat (*Felis margarita*).

Status of houbara in Mahazat: A total of 1,005 houbara have been shifted to Mahazat as-Sayd and 970 (493 males:477 females) were released from 1991 to 2010. The remaining birds either brought back to NWRC or some died inside the tunnels. Of those 970 birds released, 62 were still located by the mid-February 2010 and rest are missing due to transmitter reliability. More than 200 birds

Mahazat as-Sayd Reserve © NWRC

cannot be located and many of these birds had faulty or weak transmitters when last located, and may still be alive. Although very little is known about the natural density of houbara populations (this may differ according to habitat and/or species social structure), it seems reasonable to assume that Mahazat probably shelters one of the densest houbara population in the world. The present population in Mahazat ranges between 250-300 and the re-introduction should be considered partially successful.

Status of houbara in Saja Umm Ar-Rimth Protected Area: In Saja, the re-introduction program was started in 2003 and a total of 256 (122 males:134 females) houbara were released until 2010. By mid-February 2010, around 50 houbara were still alive from the 2003-2009 cohorts. Mortality after release is the key issue in Saja, which is mainly due to predation by mammals (foxes and cats) and in some cases starvation and poaching.

Home-ranges of houbara in Mahazat: The annual home ranges for 442 birds with the mean (±1 SE) varied from 482.02 (±58.45) km^2 in 2002-2003 to 163.91 (±24.32) km^2 in 1999-2000, with an overall mean of 307.76 (±15.91) km^2 (Islam, 2008).

Major difficulties faced

- No suitable habitat was available during the initial stages of re-introduction due to hunting pressure, lack of fencing and protection of the re-introduction sites.
- High mortality rates of released houbara in the fenced area of Mahazat and Saja Umm ar Rimth was a serious issue.
- Species management plan was available especially in fenced re-introduction site (Mahazat) but implementation was a real difficulty.
- No study on genetic diversity of houbara in re-introduction sites in recent years.
- Lack of public support at large and awareness programs insufficient.

Major lessons learned

- Houbara were selected from populations which were identical to the same species that had been exterminated as per the IUCN Guidelines for Re-introduction (1998).

NWRC staff in Mahazat as-Sayd Reserve
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- The program for the restoration of houbara populations in Saudi Arabia is based on the provision and protection of suitable habitat under the NCWCD's PA plan, which serve as release sites for captive-bred houbara, and as refugia for migrants.
- Whether through the establishment of populations arising from released houbara, or through the attraction of migrants to stay and breed, it is intended that these areas have formed the focus of self-sustaining resident houbara populations.
- Rather than concentrating efforts in single large possibly isolated reserves containing meta-populations vulnerable to local catastrophes (droughts, locust plagues, etc.), it is planned to work towards a series of smaller reserves. This network of reserves is intended to support sub-populations of houbara in sufficiently close proximity to allow dispersal and genetic mixing.
- Prior to any translocation the range conditions in the release area have to be improved and the area protected from the onslaught of livestock exploitation. Once pasture conditions show adequate signs of improvement and the site is adequately protected, re-introduction of the birds can be contemplated.
- Release should coincide with suitable vegetation conditions to limit environmental stress on houbara.
- Keeping the birds in pre-release enclosures within the re-introduction site for acclimatization with minimal amounts of food and water as per natural conditions.
- Regulate tourism to re-introduction sites as that constitutes an additional concern related to habitat degradation.
- Strict law enforcement to minimize poaching of houbara around re-introduction sites.
- A public-awareness program to inform citizens of the biological and historic significance of the houbara in the society in order to encourage their participation in the conservation program.

Success of project

Mahazat as-Sayd Protected Area (fenced area):

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Saja Umm Ar Rimth Protected Area:

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The population of Asian Houbara bustard was seriously depleted, or decreasing due to over-exploitation or other factors, and which are at risk of becoming Endangered category of IUCN if causal factors were unchecked and now have self sustaining population in Mahazat as-Sayd Protected Area in Saudi Arabia through the captive-breeding and re-introduction programs and new areas are now proposed for protection which are At Taysiyah and Harrat al Harrah reserves, which are within the zone of historic houbara breeding.
- The NWRC is carrying out educational and awareness programs to meet these challenges for long-term survival and conservation of globally-threatened houbara in Saudi Arabia.

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Experimental release of young captive-bred black storks in Ticino Regional Park–Lombardy, Italy: as potential support to the wild population

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Introduction

Black stork (*Ciconia nigra*) breeds from Spain to Sakalin island in the Russian Far East. In the last 20 years the number of breeding pairs increased in Central Europe, Spain and in several countries from where it had disappeared. In Italy there are no historical data regarding breeding (Spina & Volponi, 2009) and the first nest was discovered in 1994 in the Piedmont region (Bordignon, 1995). In 2008 only seven pairs were distributed in Piedmont and in central South Italy (Bordignon *et al*., 2008) and the ringed individuals observed stemming from Czech Republic, Germany, Poland and Slovakia (Spina & Volponi, 2009). The wintering area depends on the origin of the birds: the few individuals present in Italy apparently spend the winter in West Africa. The species is listed as Least Concern in IUCN Red List, but it is present in App. II of the Bern Convention, Annex I of the E.U. Birds Directive, App. II of CITES, and protected by Italian law 157/92. This experimental program, co-financed by the CARIPLO Foundation and with logistic support of Colibri Association, started at Oriano in the northern part of the Ticino Park, situated not far from the nesting area in Piedmont and along a migratory route.

Young black storks with satellite tags in a pre-release aviary © A. Aebischer

Goals

- Goal 1: Test if the young captive black storks are able to survive in the wild, i.e. whether they are able to migrate to the wintering quarter in Africa, to come back to Italy in the next spring and to survive up to the age they will settle and breed.
- Goal 2: Test the effectiveness of the rear and release techniques.
- Goal 3: Identify the resting areas used by migrating black storks.
- Goal 4: Improve the knowledge about this species in the project area.

Success Indicators

- Indicator 1: Survive in the wild from release until the following summer.
- Indicator 2: Effective migration and joining the natural population in the winter quarters in Africa.

Project Summary

Feasibility: In the black stork, as in other endangered species, some birds are reared in captivity and later on released as support to the wild population. In the former projects, the released birds were marked only with leg rings and so there are few information regarding their surviving in the wild, space use and migrating routes. A complete feasibility study based on IUCN Guidelines for Re-introductions was not carried out in this experimental release, we only considered the limiting factors that could affect the release success. In our case, young birds reared at Natur-und Tierpark Goldau and Monticello Breeding Center were tracked by satellite transmitters, a method that was successfully applied on wild black storks in France and in the Czech Republic.

Implementation: The groundwork was conducted in 2005 and 2006 with the release of two individuals (male and female) in each year. The first step was to build up in Oriano a pre-release aviary of 14 m x 6 m x 5 m high with a good sized pond where live fishes are stocked to keep the storks exercised and learn wild prey catching skills. For tracking a 30 g transmitter powered by batteries was used and the signals of the transmitters were recorded by the ARGOS satellite system. The transmitters were attached as backpacks using Teflon ribbon as a harness. A pre-breaking point was prepared in order to allow the transmitters to fall off after the end of the battery life span. The life span was about 1,100 hours that were spread over 3 duty cycles with constant on-periods of 8 hours, and changing off-periods of 101 hours for 4 repeats, then 37 hours (55 repeats) and then again 101 hours for the rest of the time. In this way we assured a tracking duration of about 14 months. The accuracy of the 7 location classes (LC) given by the Argos system was: more than 1,000 m for LC0; 350-1,000 m for LC1; 150-350 m for LC2; and less than 150 m for LC3. For Z, B and A locations no precision can be given, but LCA are often as precise as LC1 and LCB are often in a range of 10 km from the real location, as observed in the field. This was enough for the project goals and we used all LCs, but not LCZ. The two birds released in 2006 were also fitted on one leg with a 6 g VHF tag with a life span of about 14 months.

Post-release monitoring: The birds released in 2005 were born in the Natur-und Tierpark Goldau and one year old when released. They were released on 26th

Typical black stork habitat © il Colibri

July after spending 14 days in the pre-release aviary of Oriano. The female was monitored for 88 days till 15th September and the male for 133 days till 8th December, when the radio signal was last received. We suppose that both storks were illegally shot. We received 133 position data from the male, and used the 100 locations to estimate movements, and 52 useful locations of the female out of 96 data sets and no migration occurred. In 2006, we decided to release two younger storks (<1 year old) from Monticello Centre, because we supposed that keeping them long in the aviary could interfere with migratory behavior. The release occurred on 22nd September after 16 days in the pre-release aviary. The signal from the female disappeared after three days, and even with the VHF-system it was impossible to locate the bird, suggesting it was illegally shot. The male was tracked for 387 days and we received 449 useful locations and could reconstruct its movements: at the beginning it was localized near Alessandria city but after few days it moved in an area near the Po river where it stayed till 28th October when it moved in a coastal area near Pisa (Migliarino-San Rossore Regional Park). The location on 5th November confirmed that the bird was in a coastal area of Algeria. On 11th November it flew further south and after another 350 km it arrived in Tunisia. Due to the duty cycle of the tags we have not received data during the flight from Italy to Africa and back and surprisingly, it came back to Italy after a week! On 16th November it was again in Northern Italy near Parma. The male made short range movements within this area where some black storks were wintering (Staffora valley-Pavia) till October 2008, when the battery was exhausted. The bird was seen in February 2009 still alive and in good health.

Major difficulties faced

- Captive bred young Black storks are notoriously difficult to find. Human disturbances (at least in zoos open to the public) and the often observed incompatibility between two mates, too often prevent successful breeding.
- The illegal hunting is the most important cause of mortality in Italy; over 80% of the individuals observed in Italy did not survive till autumn because of hunting (Spina & Volponi, 2009).

Major lessons learned

- The captive birds if properly reared (big aviaries and possibility to catch live fishes) are able to survive in the wild and moving over long distance in very few days.

- We suppose that it is better to release young birds (<1 year old) to obtain individuals that do migrate.
- The habitat use analysis showed that released individuals were positively linked with the presence of humid areas also of small size. This underlines the importance to preserve these kinds of habitats for the long terms conservation of the black stork.
- The storks are able to survive during winter as well. We would like to underline that more and more black storks and other birds (e.g. *Ardea cinereus* and *Egretta egretta)* do spend the winter in Italy instead of migrating (e.g. Tinarelli, 2005 for Emilia Romagna, and Bordignon *et al.*, 2008 for Pavia area).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The released captive birds showed the possibility to survive in the wild and easily migrate to Africa, but with no evidence to join the wild population in the wintering African areas.
- To try to obtain more information regarding the last aspect, we would implement this program with the release of two other captive couples in two years, with the same protocols as used in 2006.

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Re-introduction of the saker falcon to Bulgaria, South-East Europe

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Introduction

The breeding distribution of the saker falcon (*Falco cherrug*) extends across the Palearctic region from Central Europe in the west to the Amur Basin in the east and from approximately 55 º N to 30º S. Within this range sakers exhibit clinal variation in plumage and body size, with two 'forms' generally recognized; *cherrug* and *milvipes*. In the west the population is fragmented, with breeding centers in the Pannonian Basin (Hungary, Slovakia, Austria, Czech Republic, Romania, Serbia and Croatia), the steppes adjoining the Black and Caspian Seas (Ukraine, Moldova, Russia and Kazakhstan) and in Asia Minor. The saker falcon was listed as globally Endangered (A2bcd + 3bcd) in the IUCN Red List on the basis of a rapid population decline, particularly in Central Asia, as a result of inadequately controlled capture for the falconry trade. Recently its status was updated to Vulnerable (A2bcd+3cd+4bcd) due to a new review of the breeding population numbers in Asia. In Bulgaria the species is listed as Critically Endangered in the National Red List, with several birds reported in the breeding season annually but the last recorded nesting attempt in the country was in 1998. The European Union holds <2% of the global saker population but it has a high conservation profile and in recent years has been the focus of three EU LIFE projects.


Historical photograph of saker falcons breeding in Bulgaria in the 1980's © T. Michev

Goals

- Goal 1: Establish a self-sustaining breeding population of saker falcons in Bulgaria.
- Goal 2: To use the re-introduction to promote wider conservation awareness, in order to protect other associated wildlife and habitats.

Former saker falcon sites were surveyed to check for signs of occupation © D. Ragyov

- Goal 3: To increase the capacities of organization involved in nature conservation in Bulgaria via transfer of skills and the application of re-introduction techniques for other threatened species.

Success Indicators

- Indicator 1: To obtain the first wild-breeding pair 3-4 years after initiation and to establish a population of 4-6 breeding pairs in five years.
- Indicator 2: The production of research papers and popular articles on the important habitats, prey species and threats faced by saker falcons in the modern Bulgarian landscape.
- Indicator 3: Evidence of collaborative work in the re-introduction project between government agencies, conservation NGO's and hunting groups in Bulgaria and internationally.

Project Summary

At the end of 2009 the project to re-introduce the saker falcon to Bulgaria has reached the stage of completing a feasibility study. The purpose of the feasibility study was to i) determine the current breeding status of the saker falcon in Bulgaria, ii) undertake a review of the historical status of the species in the country, iii) assess the factors that were responsible for the population decline, iv) to review potential release areas and select a suitable site for the re-introduction, v) review potential re-introduction strategies for their appropriateness to meet the goals of the project and vi) to develop population models to determine requirements of releases.

In the 19th century the saker was a common and widespread breeding species in Bulgaria. The major decline in the Bulgarian saker population occurred in the first half of the 20th century as a result of direct persecution. From the middle of the century this decline was exacerbated by large-scale habitat changes associated with agricultural intensification and the effects of organochlorine pesticides. By the 1970s it is estimated that only 30-50 pairs remained. Subsequently, this small population was affected by continuing persecution and the theft of chicks for falconry, mainly for export to Europe and the Middle East. The socio-economic collapse following the fall of the communist regime resulted in intensified levels of wildlife exploitation, with the saker being particularly affected. Chicks were probably taken from the last known breeding attempt in the country in 1998.

Following accession to the European Union, formal structures for the conservation of habitats and species in Bulgaria have improved markedly and the threat of illegal exploitation has diminished. The feasibility study showed that suitable habitat for saker falcons still exists across Bulgaria and it identified a specific Protected Area in the Central Balkan Mountains that would serve as an ideal release area as it supports a wide range of prey (mammalian and avian), numerous nesting sites and has a high degree of environmental protection.

Saker falcons from neighboring breeding populations (e.g. Ukraine) could be used for translocation to Bulgaria © D. Ragyov

The feasibility study will be used in stakeholder consultations in 2010 in order to obtain the necessary permits for the re-introduction from the Bulgarian Ministry of Environment and Water. Consultation will take the form of meetings and workshops with stakeholders and a wider, national and international public consultation through an internet forum. In tandem, a DNA study of museum specimens from the former Bulgarian population and adjacent western populations from the Pannonian Basin and the Black-Caspian Sea steppes will be undertaken, the aim of which is to determine the genetic similarity of extant western saker populations with the extinct Bulgarian population. The timetable, depending on the outcome of consultations, is to move towards the implementation phase in 2011. Implementation will involve the annual release, by hacking, of 20 captive bred and/or translocated young falcons at a single site in the Central Balkan Mountains for a period of five years. Our population modeling (i.e. an age and sex-structured stochastic model using a range of survival and breeding parameters) indicates that this release strategy results in the establishment of a viable population and, therefore, a successful re-introduction. Survival of released birds would be carefully monitored using satellite tracking and patagial tags in order to determine if the actual levels of survival are similar to those used in the population model; this will enable us to adapt the release program as necessary during the implementation phase.

Major difficulties faced

- A major difficulty has been obtaining co-operation from certain conservation NGO’s. There are a number of reasons for this: Firstly, because the feasibility study was funded by a Middle Eastern country and the project is perceived as being biased towards the interests of falconry, when thefts for falconry has been one of the main reasons for the extinction of the saker in Bulgaria. Secondly, the socio-economic situation in former communist states in Eastern Europe has lead to a proliferation of small NGO’s that compete with one another for conservation funds. Consequently, Bulgarian NGOs are often wary of co-operation and are very defensive of their own data and their specific areas of interest.

- The information on the past status of the saker in Bulgaria was scanty and information on the current status contradictory. Consequently, we had to conduct our own surveys in order to determine the true status of the species in the country. The paucity of information has meant that it is difficult to assign specific causes to population decline.
- Identifying captive breeding stock has proved problematic as the number of European birds held in captivity is relatively small and they are scattered across several countries in Europe. In addition, captive stock with a documented pedigree still need to be genetically screened to ensure that there is no hybrid ancestry and that they are genetically similar to the former Bulgarian population. Appropriate genetic population markers still need to be developed.
- There is a degree of opposition towards re-introduction as a conservation management option. Re-introduction is not listed a conservation strategy in the European Union Single species Action Plan for the saker falcon. An EU LIFE project using artificial nests to encourage sakers from the population in the Pannonian Basin to colonize Bulgaria has been initiated. This ‘assisted’ natural recolonization is a novel and untested management technique that can run in tandem with a re-introduction program.

Major lessons learned

- The degree to which a re-introduction proposal would be regarded as controversial was something of a surprise. The roots for this controversy range from concerns for the genetic integrity of the regional saker populations, perceptions relating to the ‘naturalness’ of populations to opposition based on perceived motives behind the project. We have learned that it is necessary to be open about all aspects of the development of the project and to ensure that the rational for the re-introduction is under-pinned by sound scientific evidence.
- Despite repeated rebuttals it is worth continuing to include opposition NGO’s in discussions relating to the re-introduction as changes in circumstances and staffing can result in a complete shift of attitudes over time.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The project is still at an early stage (feasibility completed, consultation initiated).
- The saker falcon is something of an iconic species for conservationists in central and eastern Europe and re-introduction is perceived as a controversial conservation management strategy. Consequently, a robust feasibility study is required together with wide consultation before any project can be implemented.

Re-introduction of Griffon vultures and consequent return of Egyptian vultures in the Kotel Mountains, Bulgaria

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Introduction

The Griffon vulture (*Gyps fulvus*) is a large old world vulture, scavenger, feeding mostly from carcasses of dead animals which it finds by soaring over open areas, often moving in flocks. It grunts and hisses at roosts or when feeding on carrion. It breeds on crags in mountains in southern Europe, north Africa and Asia, forming colonies and laying one egg. It is included in IUCN Red List in Least Concern category and in National Red Book of endangered species. Griffon vulture population in Bulgaria and neighboring countries dramatically decreased in the last decades, as a result of persecution, habitat destruction and using of poison bites for predators. At present there is only one small breeding population in Bulgaria, located in Eastern Rhodopes Mountains.

Griffon Vulture (*Gyps fulvus*)

The Egyptian vulture (*Neophron percnopterus*) is a small old world vulture, found in Southern Europe, Northern Africa and Eastern Asia. It is declining in most of his range, totally collapsed in India, due to using of poisons used in veterinary medicine, which entered the species food chain. The species has declined fast in Bulgaria, probably as a result of complex factors, including the use of poison baits against predators, destruction of nesting habitats and a high decrease in animal farming.

Consequently this species was up-listed from Least Concern to Endangered status in the 2007 IUCN Red List. It is also included in the National Red Book or rare and endangered species. Kotel mountain is a part of Eastern Stara planina (Balkan)

Egyptian vulture
(*Neophron percnopterus*)

mountains. The area includes a variety of habitats, dominantly broad-leaved woods and pastures. The mountains holds vast species diversity and many parts of it are under protection by national laws or Natura 2000.

Goals

- Goal 1: Re-introduction of the Griffon vultures as a tool for the re-introduction of the globally threatened Egyptian vultures.
- Goal 2: Attracting and concentrating remnant non-breeding Egyptian Vultures individuals from a larger area, where facing different types of threats and reproduction limitations to a safe well managed area and establishing a nucleus of several breeding pairs.
- Goal 3: Managing and monitoring of the most favorable nesting and foraging sites in the area, in order to provide optimal conditions for breeding of Griffon and Egyptian vultures.
- Goal 4: Establishment of feeding stations for vultures and other birds of prey in order to stabilize the populations and prevent the risk of poisoning.
- Goal 5: Establishment of extensive sheep breeding farms managed in optimal conditions to benefit the vultures and the habitat.

Success Indicators

- Indicator 1: New and regular observations of the targeted species in the project area and recorded first breeding attempts.
- Indicator 2: Working system for provision of food resources for the targeted species.
- Indicator 3: Complete or partial restriction on the use of poison against predators.

Project Summary

All four European vulture species used to breed in Kotel Mountain in Bulgaria until the mid 20th century and the last pair of Egyptian vulture (*Neophron percnopterus*) survived until 1989. The extinction of the vultures came after a mass and well organized (on state level) campaign for poison baits use against wild predators. It was combined with complete changes in livestock breeding practices and hygiene improvement which led to food scarcity and frequent poisoning incidents. After 1992 the poisoning was officially forbidden, but it still continued locally and less intensively as illegal practice. At the same time the species status fast became unfavorable in almost its entire range, due to the reasons mentioned above. Once


View from Kotel Mountain

the commonest vulture in Bulgaria, the species started to disappear from many traditional breeding places. The livestock farming decrease led to massive habitat changes, especially degradation of pastures and thus to extinction of many species connected to them. Strongly involved in nature conservation activities in the region, the Fund for Wild Flora and Fauna (FWFF) decided to start actions to support the vultures in Kotel Mountain. The project was supported by specialists and volunteers from other NGO's and University of Sofia.

Main objectives of the initiative included establishment of feeding station for birds of prey, re-establishment of livestock breeding in the area and re-introduction of Griffon vultures (*Gyps fulvus*) as an instrument to attract and re-establish local breeding nucleus of Egyptian vultures. Local people were also involved in the activities, especially in the newly established extensive sheep farms and in the monitoring activities.

Following a variety of project activities, came the first success. A small nucleus of Griffon vultures, after 50 years of absence, and first observations of four sub-adult and immature Egyptian vultures on the feeding station after almost 20 years absence. Experiencing the breeding and territorial behavior of a young new pair of Egyptian vultures while the species is facing an overall rapid decline in Bulgaria and globally.

Major difficulties faced

- Modifying local people attitude to birds of prey, traditionally known as a threat for farm and game animals.
- Preventing the use of poisons against predators, as a major threat for vultures.
- Involving a solid number of educated scientists and volunteers to monitor all stages of the project.
- Convincing the conservation community that re-introduction of the non priority species as Griffon vulture is a very good tool for restoring the population of the highly endangered Egyptian vulture.

Major lessons learned

- Direct involvement of the local community in project work and connecting the re-introduction with tourist activities in the region is vital.

- A management of system for providing carcasses at the feeding station guarantees the presence of birds and protects them from poisoning risks from uncontrolled feeding.
- Griffon vultures that are easy to find for release could be used as instrument for attracting and creating a new nucleus of Egyptian vultures in safe areas.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Return of the Griffon vulture and Egyptian vulture in Kotel mountain after approximately 50 and 20 years absence respectively and the constant presence of the birds in the area.
- The attraction and permanent presence of several birds as well as the breeding and territorial behavior of the Egyptian vultures increases expectations for constant species returning and breeding in the area. The project would be considered highly successful after establishing of high reproduction success which is still not documented, but expected in the future.
- Established feeding station for birds of prey holds permanently additional rare species of raptors, including Griffon vulture, Egyptian vulture, golden eagle, black kite and globally threatened eastern imperial eagle of which only the golden eagle was previously present.

Re-introduction of captive-bred Malherbe's parakeet to Maud Island, Marlborough Sounds, New Zealand

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Introduction

The Malherbe's parakeet (*Cyanoramphus malherbi)* is a critically endangered New Zealand endemic (Juniper & Parr, 1998; Kearvell *et al.*, 2003) confined to three remnant populations in the South Island (Robertson *et al.*, 2007) and two populations on offshore islands established by the release of captive-bred individuals (Elliot & Suggate, 2007). The species has a long taxonomic history, in large part due to its morphological and phenotypic similarity to the yellow-crowned parakeet (*Cyanoramphus auriceps*) and only recently has been recognized as a distinctive species (Boon *et al.*, 2000). By the time the species was recognized as a separate evolutionary unit, the global population was thought to be around 500 individuals in the wild (Kearvell, 1997 cited in Boon *et al.*, 2000).

As with other *Cyanoramphus* species, introduced predators such as mustelids (*Mustela* spp.) and rats (*Rattus* spp.) and human-induced habitat modification are thought to be the major drivers of the species decline (Grant & Kearvell, 2000). Following the recognition of the Malherbe's parakeet as a distinctive species in urgent need of conservation action, the Department of Conservation in partnership with the Isaac Wildlife Trust, established a captive-breeding program aimed at providing individuals for later re-introduction to offshore islands free of introduced predators (Grant & Kearvell, 2000). Starting in 2005, captive-bred individuals have been released on Chalky Island, Fiordland and in 2007 on Maud Island, Marlborough Sounds. The release of captive-bred Malherbe's

Malherbe's parakeet (*Cyanoramphus malherbi*) parakeets has provided a unique opportunity to study its biology on island environments free of mammalian predators, which provide a safe environment for this critically endangered species.

Goals

- Goal 1: Establishment of a self-sustaining population of Malherbe's parakeets on Maud Island.
- Goal 2: Geographic expansion of the species.

Success Indicators

- Indicator 1: 50% survival of first founder flock three months after release.
- Indicator 2: Successful breeding on Maud Island within a year of translocation.

Project Summary

Maud Island (also known as "Te Hoiere") is a Scientific Reserve (296 ha) located in the Marlborough Sounds of the South Island, New Zealand and administered by the Department of Conservation. Maud Island was identified as an eligible release site for Malherbe's parakeets due to the presence of remnants of coastal forest (47 ha) and remnants of regenerating forest (220 ha), which contain mature trees likely to provide nesting sites. Three areas of *Pinus radiata* (former pine plantations, 17 ha) and grassland (2 ha) are also present on the island. Maud Island does not have other resident parakeet species, which was considered an important feature to prevent hybridization (Grant & Kearvell, 2000). Most significantly, Maud Island is considered mammalian-predator free except for the sporadic incursions of stoats (*Mustela erminea*) (Elliot *et al.*, 2001). Finally, Maud Island is accessible by boat and helicopter and has a track network that allows monitoring of the parakeets (Ortiz-Catedral and Brunton, 2009).

Starting in March 2007, 68 Malherbe's parakeets bred in captivity at the Isaac Wildlife Trust in Christchurch, were transferred by plane from Christchurch to Blenheim airport and by helicopter from Blenheim airport to Maud Island. Parakeets have been released onto Maud Island on eight occasions. Groups released have varied from three to 14 individuals ranging in age from two months to approximately four years. Although the proportion of males and females varied between releases, an overall even sex ratio has been achieved by the release of 34 females and 34 males. The releases were planned according to the number of fledglings available at the captive breeding facility and consequently, the releases occurred two to 11 months apart and consisted of flocks of three to 14 birds. Prior to release, all parakeets were given a unique metal numbered band and a combination of plastic coloured bands for individual identification. Also, 20 parakeets were fitted with tail mount transmitters prior to release.

Teams of four observers undertook monitoring approximately every two months. Three months after the first release (which consisted of 11 individuals), eight individuals (72%) were confirmed alive, six of them in breeding pairs. The first evidence of breeding behaviour was noticed within a month of release when courtship behaviour was observed in a pair. Subsequently, two actively incubated clutches were found within two months of the first release. The first confirmed

Parakeet habitat on Maud Island

fledged juveniles (3) were recorded three months after the first release. Sightings of unbanded Malherbe's parakeets have been made consistently across the island since. In November 2008, two breeding pairs of unbanded adults were observed nesting near ground level. A clutch of two eggs was confirmed in one nest. Since the first release, Malherbe's parakeets have been recorded foraging in all vegetation types around the island on native and exotic plant species as well as taking invertebrates (Ortiz-Catedral and Brunton, 2009) indicating that captive-bred individuals make use of all available habitats of Maud Island.

Major difficulties faced

- Hard to monitor: Limited access to areas on Maud Island where other critically endangered species occur (i.e. Maud Island frog *Leiopelma pakeka*) meant that monitoring of parakeets had to be restricted to the track network (Ortiz-Catedral & Brunton, 2009) and the shoreline of the island. This means that during the first two years after the first release only limited information was obtained in this low-density population.
- Discrepancies between management priorities by the Department of Conservation and research needs from academics originated conflict over techniques for data collection and the level of acceptable handling of individuals. Such situation developed an agreement over a minimum of research goals to study the biology of this species on an island for the first time. Consequently, the breeding biology of this species remains poorly studied.

Major lessons learned

- Long-term monitoring schemes must be implemented considering the access limitations on site.
- Discrepancies between the management and research approaches need to be negotiated further to encourage further field research for this critically endangered species. Both approaches are complementary and when combined have the potential to advance the improvement of the conservation status of Malherbe's parakeets.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The re-introduction of captive-bred Malherbe’s parakeets on Maud Island has resulted in an increase of the global population of this taxon.
- In addition, the geographic range of the species has been expanded

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Conservation translocations of red-fronted parakeet on Matiu/Somes Island and Motuihe Island, New Zealand

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Introduction

The red-fronted parakeet (*Cyanoramphus novaezelandiae*) is a vulnerable species (CITES App. I) endemic to New Zealand and its outlying islands (Juniper & Parr, 1998). Sub-fossil evidence and accounts by early ornithologists indicate the species was widely distributed throughout the archipelago (Higgins, 1999). Natural populations of the red-fronted parakeets are currently restricted to predator-free offshore islands with sporadic sightings on North and South Islands and a few locations on Stewart Island (Higgins, 1999; Robertson *et al*., 2007). This species marked population decline and reduction in geographic range has been attributed to a combination of predation by introduced mammals (mainly rats (*Rattus* spp.), stoats (*Mustela erminea*) and cats (*Felis catus*)), hunting and large-scale anthropogenic habitat modification (Higgins, 1999). Red-fronted parakeets are commonly kept in captivity under specific permits by the Department of Conservation, New Zealand. Since 1974 the species has been repeatedly translocated to islands and mainland sites undergoing community-led ecological restoration resulting in at least five successfully established island populations. Earlier releases of captive-reared red-fronted parakeets were prompted by the widespread availability of captive stock but little consideration was given to the potential of remaining natural populations to act as sources for translocation or to conservation issues such as, hybridisation, genetics, disease prevalence, meta-population dynamics and susceptibility to pathogens. Accordingly, in 2005 the Department

Red-fronted parakeet
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of Conservation made a recommendation to stop further releases of captive-bred parakeets because preliminary analyses showed that much of the captive-bred stock has been hybridised with the closely related yellow-crowned parakeet (*Cyanoramphus auriceps)* (Triggs & Daugherty, 1988). Starting in 2003, we have carried out a series of translocations of red-fronted parakeets using wild individuals caught from natural populations which has allowed the improvement of capture, housing, transport and translocation techniques for this species.

Goals

- Goal 1: The identification of potential source and predator-free release sites within the natural range of the species.
- Goal 2: The generation of baseline information on pathogen load on Little Barrier Island (LBI).
- Goal 3: The translocation of at least 30 individuals per site.

Success Indicator

- Indicator 1: 50% survival of founders six months after release (for translocations from LBI).
- Indicator 2: Successful breeding at release sites within a year of translocation.
- Indicator 3: Unassisted dispersal to adjacent conservation management sites.

Project Summary

Between 2003 and 2007 we identified two prospective island source populations of red-fronted parakeets for conservation translocation: Kapiti Island and Little Barrier Island. The species is common on both islands and the sites are easily accessible by boat and helicopter. We also identified two potential release islands following requests by community groups directly involved with the ecological restoration of such sites: Matiu/Somes and Motuihe Islands. The most important criteria for the selection of release sites was the sustained absence of introduced mammals; a factor that has been linked to the disappearance of this species across its historic range (Ortiz-Catedral *et al*., 2009b). Ship rats (*Rattus rattus*) were eradicated from Matiu/Somes in 1989 while Norway rats (*Rattus norvegicus*) were removed from Motuihe in 1997 (Clout & Russell, 2006). Matiu/Somes and Motuihe Islands have been revegetated with native plant species and numerous nesting sites were identified before the release of parakeets. These nesting sites include burrows, rock crevices, holes in trunks and vacant sacred kingfisher (*Todiramphus sanctus*) nests. One hundred artificial nest boxes were also installed on Matiu/Somes Island. Additionally, Matiu/Somes and Motuihe Island are in close vicinity to other areas undergoing restoration and/or pest control, which would allow red-fronted parakeets to naturally disperse. Suitable sites in the proximity of Matiu/Somes Island include Zealandica, Karori Wildlife Sanctuary, Eastbourne's Mainland Island Restoration Operation and Regional Council land within Wellington City. For Motuihe Island, the Rangitoto/Motutapu Island restoration project is less than 2 km away. Thus Matiu/Somes and Motuihe were considered ecologically suitable for translocation.

There are no published studies on the genetics of remnant red-fronted parakeets to assist management decisions regarding provenance of founder flocks.

Natural habitat on Little Barrier Island
© L. Ortiz-Catedral

However, due to the geographic proximity of Kapiti Island to Matiu/Somes Island and Little Barrier Island to Motuihe Island and because both source islands have large populations that have not undergone significant historic declines it was decided these would be the most appropriate source/release site associations. Finally, Kapiti and Little Barrier Islands have excellent field logistical support with existing aviaries and accommodation from ongoing fauna management practices. Kapiti, Little Barrier, Matiu/Somes and Motuihe Island are administered by the Department of Conservation, New Zealand in partnership with local indigenous communities (Te Atiawa ki Whakarongotai, Te Ati Awa, Ngati Manuhiri, Ngati Wai) and community trusts such as Matiu/Somes Island Charitable Trust and Motuihe Island Trust. Red-fronted parakeets commonly forage in grassland and coastal forest fragments allowing operation of mist nets. A total of 31 parakeets were captured on Kapiti Island between 27th and 29th of May 2003 (11 birds) and 19th to 23rd April 2004 (20 birds) and transferred by boat, car and/or helicopter to a purpose-built aviary on Matiu/Somes on 30th May 2003 and 23rd April 2004. No disease screening was undertaken. The parakeets were released directly from the aviary eight and three days later, respectively. Monitoring was undertaken by volunteers with variable bird observation skills and so reliable monitoring results were sporadic. Mating was first observed two months after the first release but the first juveniles were not confirmed until a year later, soon after the second release. No efforts were made to find or monitor nests although nest boxes were checked monthly for the first two years and were apparently not used. Subsequently juveniles have been seen on a regular basis (identified by the absence of bands and by their juvenile plumage) and a healthy population is considered to be established, although no population census has been attempted. Red-crowned parakeets are now occasionally seen in the adjacent areas of Wellington City

On Little Barrier Island, 49 red-fronted parakeets were captured in two events: 5th to 18th of May 2008 (31 individuals) and 3rd to 9th of March 2009 (18 individuals). Capture was by mist-nets placed along known foraging grounds. All birds destined for translocation were held in an aviary on site for up to eight days. Screening for *Salmonella*, *Campylobacter*, *Yersinia* and Beak and Feather Disease Virus (BFDV) were conducted (Ortiz-Catedral *et al*., 2009b, 2009c). On the day of release, parakeets were placed individually in pet-carry cardboard boxes and transferred via helicopter to Motuihe Island where they were released.

Twenty parakeets had radio-transmitters mounted on two tail feathers. Parakeets were radio-tracked once per week for three months (the total duration of the battery life). Additional monitoring consisted of observer walks across the whole track system on Motuihe Island once every two weeks for three months after release. Six months after release parakeets on Motuihe Island were monitored once per month in addition to sporadic sightings by volunteers who visit the island weekly to plant trees or remove weeds. Six months after the release of the first flock (31 birds), eight breeding pairs and their territories were identified. The first evidence of breeding on Motuihe was a female visiting a cavity in a Puriri (*Vitex lucens*) tree five months after release. Subsequently, four fledglings in two groups were seen on January 2009, eight months after initial release. Unbanded juveniles have been sighted consistently since and there have been reports of pairs of red-fronted parakeets on nearby Rangitoto Island and Motutapu Island (Graham, 2009). We successfully transferred a minimum of 31 red-fronted parakeets to target restoration islands and there is evidence of high survival of founders within the first semester after translocation. Further, successful breeding was recorded within a year of the first release and unassisted dispersal to neighboring areas has occurred. We thus consider these translocations highly successful.

Major difficulties faced

- Seasonal changes in numbers of parakeets available for capture. Time of capture is also crucial. Catching rates were high during April-May on LBI and numerous juveniles were noticed and thus these are considered ideal months for capture and transfer. One attempt to capture parakeets in September on LBI resulted in only two individuals being captured and subsequently released locally due to insufficient catching rates
- Holding aviary design and management of birds while in the aviary is important to ensure weight loss is minimised and to avoid mortality from flushing/fright in the aviary. Three birds held on Kapiti Island died from collision into the aviary and two deaths occurred on LBI.
- Red-crowned kakariki are known to die from stress associated with handling. Of the 80 birds transferred (31 Kapiti-Matiu.Somes; 49 LBI-Motuihe Island) one individual destined for release on Matiu/Somes and one released on Motuihe Island apparently died from stress related causes.
- Management of diseases: Neither *Salmonella*, *Yersinia* or *Campylobacter* were found on Little Barrier Island (Ortiz-Catedral, Ismar *et al*., 2009) however, BFDV was detected in 28% of 54 individuals screened (Ortiz-Catedral, McInnes *et al*., 2009). Only non-infected individuals and infected but sub-clinical individuals were released on Motuihe Island. Because this finding represents the first report of the virus in wild New Zealand parrots a major revision of translocation practices for New Zealand psittacines is underway.
- Hard to monitor. Need experienced people to be able to identify individuals by their colour bands and calls. The introduced and widely distributed eastern rosella (*Platycercus eximius*) is often mistaken for red-fronted parakeets by less experienced observers.

Major lessons learned

- Communication between wildlife managers, academic researchers, community groups and local indigenous communities is crucial for timely capture and transfer of parakeets.
- Once transferred, parakeets appear to quickly establish a breeding population with minimal management needed after release. The addition of nesting boxes seems to have little influence in likelihood of establishment and parakeets readily make use of any available nesting sites such as tree-holes.
- The recent finding of BFDV during a translocation of wild red-fronted parakeets has prompted a revision of translocation priorities, policies and risks associated with the management of all New Zealand parrots.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Establishment of two additional populations using wild sourced animals.
- Successful breeding shortly after release.
- Natural dispersal to neighbouring islands and mainland areas where predator control occurs has been noticed, thereby increasing the chances of new populations establishing without intervention.

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Re-introduction of yellow-crowned kakariki to Long Island (Marlborough), Mana Island (Wellington) and Motuara Island (Marlborough), New Zealand

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Introduction

Yellow-crowned kakariki (or yellow-crowned parakeet, *Cyanoramphus auriceps*) is listed as near threatened in IUCN Red list criteria, not threatened in New Zealands Threat Classification System (Miskelly, 2008) and is listed as CITES App. II. Yellow-crowned kakariki are a forest-dwelling species and were once common throughout New Zealand but introduced predators (rats, possum, mustelids and cats) have probably played the largest part in their decline. Populations now only persist in large tracts of unmodified forests where they are uncommon. Healthy populations occur on offshore islands where introduced mammalian predators have been eradicated. Mana, Long and Motuara Islands are relatively small islands (217 ha, 142 ha and 59 ha respectively) that were deforested during European colonization and are now undergoing conservation restoration.

Introduced mammalian predators have been eradicated and species re-introductions have occurred on all islands since eradication, the native falcon (*Falco novaeseelandiae*) is seen on both Motuara and Long Islands. The Mana Island restoration plan guides restoration activity (Miskelly, 1999) which includes active planting, but both Long and Motuara Islands have established forest cover naturally over the last 100 years. The closest population of yellow-crown kakariki from all three islands, which is large enough to harvest, is the predator-free Chetwode Island group in Marlborough Sounds. Te Kakaho Island in the Chetwode group was considered the most appropriate source due to the similar habitats of regenerating scrubland and young forest.

Goals

- Goal 1: To transfer up to 30 yellow-crowned kakariki from Te Kakaho Island in the Chetwode group to Long Island (2002), Mana Island (2004) and up to 45 from Long Island to Motuara Island (2007).
- Goal 2: Establish a self-sustaining populations of kakariki on all three Islands as a component of the of the original forest bird assemblage.

Success Indicators

- Indicator 1: Kakariki are transferred, released and remain on all three Islands.
- Indicator 2: Released birds utilize habitat over the entire island, including replantings, rank grass areas and wind/salt-sheared scrubland.
- Indicator 3: Released individuals are breeding the following summer.

Jason with yellow-crowned kakariki

Project Summary

At least one transfer of yellow -crowned kakariki occurred in ~1970. Little is recorded but "too few… not in good health" were transferred from Chetwode Island to Stephens Island (D. Veitch *pers. com*.). Birds did not persist on Stephens Island and disappeared very quickly (B. Bell, D. Veitch *pers. com*.). At the time it was thought that lack of breeding cavities, water, suitable habitat and/or return of birds to the source island (24 km) was the cause of failure. More recently three translocations have occurred to three islands, the habitat on each is similar. All have been deforested during their recent history and regeneration is at a variety of stages. Long Island contains the most diverse and oldest forest at 60 years old, Mana is the youngest with restoration replanting still occurring.

There was some doubt about the suitability of Mana for parakeets which still has extensive grassland and very young trees; natural and remnant kakariki populations are found in old forest and very few sites of regenerating scrub or grassland are occupied. Maori iwi (tribal) groups who have kaitiaki (guardianship) over the islands are fully supportive of the restoration efforts, including these transfers (Ngati Toa for Mana, and the four iwi with an interest in both Long Island and Motuara Te Ataiwa, Rangitane, Nga Toa Rangitira and Ngati Kuia. Ngati Kuia, who have kaitiaki over the Chetwode Islands also supported these transfers.

Twenty-seven birds were released on Long Island during 2002, 27 on Mana Island during 2004 and 45 on Motuara Island during 2007. Birds were caught in mist-nets over water sources, the limiting factor on the source island. Approximately even sex ratio was taken, with sexing done based on bill width and length measurements, (which for Mana Island transfers were checked with DNA sexing). Bill length less than 127 mm was female for the 21 birds whose sex was confirmed. Each translocation built on information from the previous and detailed planning and debriefing occurred to ensure those involved maximised learning. Birds destined for Mana Island were disease screened for *Chlamydia*, *Psittacine circovirus*, *Salmonella*, *Yersinia*, *Campylobacter*, *Coccidia*, nematodes and haemoparasites, a complete blood count (CBC) and physical exam was also taken. Disease screening was negative for all tests and CBC was within the normal range. Birds transferred from Long to Motuara Island were tested for avian malaria and 16% were positive (Tompkins, 2008). Birds were caught over several days and held in portable aviarys. The aviary was furnished with branches, natural perches, natural food species and many water containers which allowed for both bathing and drinking. Their diet was supplemented daily with sunflower seed, budgie seed mix, frozen mixed vegetables, apple, pear, grape and walnut. Natural food was also added each day. Food was presented in a variety of ways over the entire aviary to ensure encounter rate with food was high. Birds were transferred in transfer boxes up to four birds per box and were released directly from release boxes to the forest at the destination island.

On Mana volunteers searched for individually colour-banded birds weekly for the first month and fortnightly for an additional month to determine presence of transferred birds. Monitoring thereafter was *ad hoc*. but occurred approximately monthly for the first year and 26 birds were known to be alive during the two month post-release period. Within a year, a minimum of 12 birds were still present on Mana and apparently began breeding immediately because unbanded birds were seen within two months of the release, we believe it unlikely that birds flew to the island because of the 60 km straight line distance to the closest population (which was the source). Copulation was observed by the second month, and the first nest was observed after eight months. Nests have since been found in kingfisher (*Halcyon sancta*) nest holes, wooden bait stations, nest boxes specifically placed for kakariki and holes in large marcrocarpa trees (*Cupressus macrocarpa*).

Five years later numerous large flocks are seen on Mana Island but no census has been attempted. Less data is available for Long or Motuara Island where monitoring could not be undertaken as intensely. On Long Island breeding was confirmed within 12 months and the population quickly grew to population of ~400 birds in 2009, seven years after release.

Despite Motuara not being colonized during the five years when birds were present on Long Island, at least one transferred bird flew the 1.5 km back from Motuara to Long, the source population after being transferred. Little is known about the colonization ability of kakariki although anecdotal observations record kakariki colonizing Titi Islands, 6 km from the source and after predators had been removed. Within a year of transfer to Motuara unbanded birds were seen as a family group although it is not known whether they were bred on the island. Although population growth has been much slower on Motuara than Long or Mana, two years after release a small population appears to have established on the Island. The islands are open to public visitation and all are showcased as predator-free restoration sites where fauna can survive in habitats free from mammalian predators.

All three projects have had interest and support from local communities. The transfers were managed in partnership between New Zealand's Department of

Conservation and local iwi, and for Mana Island in partnership with the community group Friends of Mana Island (FOMI), who support restoration effort by providing funding, volunteer labor and logistic support.


Releasing yellow-crowned kakariki on Motuara

Major difficulties faced

- Yellow-crowned kakariki are known to die from stress from handling. During this operation we were aware that handling must be minimized. Of the 99 birds handled two died from stress related causes.
- The limited access to all three sites limited the amount of monitoring that could be done and so only broad scale results could be obtained for the transfer outcomes. It was difficult to monitor dispersal due to the lack of technology available to track individuals over large distances and time.
- Relatively small number of founders was used and the genetic effects of the small population are unknown. Further research on impacts on diversity over time, and how to manage these impacts is needed.
- The short-term holding facilities where small and we were uncertain how birds would cope with the stress of limited space. We believe the aviary set-up used during these three transfers were ideal for short periods (up to four days).

Major lessons learned

- Kakariki are flexible in their habitat requirements and can adapt to new foods (including in the captive environment and grassland habitats), locations and nesting sites.
- Kakariki are easy to re-introduce and populations quickly increase at release sites provided predators can be eradicated.
- Information sharing and involvement of stakeholders (especially iwi and community groups such as FOMI) during all phases of the translocation ensured translocation were undertaken without fault.
- Kakariki are prone to stress from handling.

Success of project

Long and Mana Islands:

Highly Successful	Successful	Partially Successful	Failure
√			

Motuara Island:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

All Islands:

- Kakariki are popular and highly visual to public visitors.
- The range of this species has been extended and these populations have the potential to re-establish from the islands to mainland sites.

Long and Mana Islands:

- High survival, high site retention and large populations were established quickly.

Motuara Island:

- A population has established, but after two years the population is still low; population growth has been much slower than Long or Mana Islands.

Acknowledgments

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Using captive-bred helmeted honeyeaters to establish a new population and supplement an existing population, Victoria, Australia

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Introduction

The helmeted honeyeater (*Lichenostomus melanops cassidix*) has declined to one small population comprised of about 15 breeding pairs inhabiting a narrow remnant of riparian swamp forest at Yellingbo in central, southern Victoria. Recently, a second population has been established by the release of captive-bred birds into riparian habitat buffered by a 16,500 ha conservation reserve, Bunyip State Park, 30 km south-east of Yellingbo. The re-introduced population totals about 40 individuals, including 10 breeding pairs. In addition 17 pairs are currently held in captivity at two locations - Healesville Sanctuary, Victoria and Taronga Zoo, New South Wales. Now restricted to dense, swampy, riparian forest, the helmeted honeyeater has suffered from clearing of vegetation for agriculture, and habitat degradation due to reduced stream flows caused by water extraction and drought/climate change. Increased competition and predation resulting from altered avian community dynamics may also constrain population growth. Because it is a subspecies, the helmeted honeyeater has not been assessed by IUCN but it qualifies as critically endangered under Criterion C2ai. An intensive recovery program began in 1989 and has continued for 20 years (Menkhorst, 2008). A bibliography of research and management of the helmeted honeyeater is provided in Menkhorst (2008) (available online at: www.environment.gov.au/).

Captive-bred helmeted honeyeater released at Yellingbo, Victoria, Australia © P. Menkhorst

Radio transmitter being glued to the back of an anaesthetized helmeted honeyeater before release © I. Stych

Goals

- Goal 1: Manage the captive population of helmeted honeyeaters to maintain a viable captive population and produce at least 15 young/year that are available for release; maintain at least 95% of the wild heterozygosity in the captive population.
- Goal 2: Develop release strategies that encourage birds to form fidelity to a site and establish a new breeding colony.
- Goal 3: Increase the number and size of wild populations-attain at least 200 wild individuals spread between at least two self-sustaining populations, at least one of which is in a separate water catchment to the remaining wild population at Yellingbo.
- Goal 4: Investigate the value of release of captive-bred birds to supplement the declining population at Yellingbo.
- Goal 5: Identify and conserve other patches of suitable habitat for future population expansion and re-establishment.

Success Indicators

- Indicator 1: Annual production of at least 15 independent young available for release.
- Indicator 2: Establishment of at least one self-sustaining population in a different water catchment to the remnant wild population.
- Indicator 3: Reversal of the decline in number of breeding pairs at one Yellingbo breeding site.

Project Summary

Relevant Ecological Attributes**:** Helmeted honeyeaters are territorial, sedentary and aggressive towards potential competitors. Territories are clumped into colonies in patches of suitable habitat and there is a degree of communal defence of the colony area. The birds are long-lived, lay multiple clutches through an extended breeding season, and have high survivorship after fledging (Smales *et al.*, 2009). Females disperse from their natal territory before the breeding season after their birth and almost all successful dispersals are to a different colony. Males remain in their natal territory longer and most remain for life within their natal colony. Release sites should therefore be spread along a length of riparian habitat with the aim of establishing several colonies so that females have options for dispersal between colonies.

Feasibility: Captive management of the helmeted honeyeaters began in late 1989. Recognizing the small population size from which to draw founding individuals, the maintenance of heterozygosity in wild and captive populations has been a priority. This has been pursued via standard zoo studbook protocols and, for the wild populations, by the manipulation of pairings or transfer of eggs or young between populations, as required.

Release aviary at the Bunyip State Park
© P. Menkhorst

The feasibility of using captive-bred birds to re-establish populations of helmeted honeyeater in unoccupied habitat was investigated through a series of trials that included:

- Translocation of wild birds (most returned to their former colony (within 2 km) or eventually disappeared).
- Housing decoy males in an aviary in the hope of attracting dispersing females to the site (no evidence of visits by females over six months encompassing the female dispersal period).
- Release of family groups after breeding in on-site aviaries in the hope that offspring will be attached to their natal site (some success but labor-intensive and expensive).
- Release of potential partners for resident males (one successful pair bond developed and nests built but breeding unsuccessful).
- Hard release of family groups including dependent young (no evidence of improved success rates over release of mixed-parentage groups).
- Hard release of groups of captive-bred birds of varying age and sex ratios (first -year birds seem to survive better and have a greater chance of establishing territories than older birds).
- Once breeding at the release site had been achieved, nest supplementation with eggs or chicks from captive or wild nests (mixed success to date).

The availability of suitable habitat away from Yellingbo was assessed by the development of a habitat suitability model based on studies of helmeted honeyeater ecology and habitat utilization. Sites of historical records were visited to search for secure areas of unoccupied habitat that best fitted the model; these areas were then assessed for their suitability as future release sites. To inform the development of longer-term captive-release strategies, we modeled the reproductive potentials of the captive and re-introduced populations to improve understanding of the demographic boundaries operating (McCarthy *et al.*, 2004). The most effective and economic release strategy was found to be the release of groups of independent young during autumn after housing them in an on-site aviary for up to seven nights. Riparian vegetation in Bunyip State Park was found to best fit the criteria for a release site, in terms of habitat suitability, site security and capacity to manage the surrounding land.

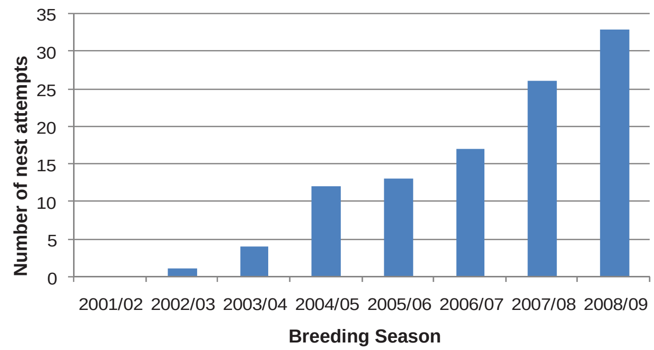
Implementation: Re-introduction to Bunyip State Park began in 2001 with the release of 11 birds and has continued annually, totaling 108 birds over nine years. Survivorship of released birds is summarized in *Success of project* section. Breeding of released birds began in the second year of the release program and the annual number of nest attempts at Bunyip State Park has increased steadily. Releases at a second site, 1 km upstream of the first site, began in 2005 and the first breeding at Site 2 occurred the following year. A third release site was established in 2008 between the other two.

Post-release monitoring: Monitoring of released birds is undertaken by applying individually recognizable leg bands to all birds prior to release, and recording all subsequent sightings. The project's Field Ornithologist and volunteers regularly search for color-banded birds and record their location and behavior. In 2004, 12 of 17 released birds were radio-tagged with a transmitter glued between their scapulars. It was hoped that they would lead us to an unknown site utilized by missing birds. However, some transmitters detached prematurely and the remaining tagged birds only made local movements during the life of the transmitter. Current resourcing levels do not allow for incorporation of radio-telemetry as a routine monitoring strategy. Post-release monitoring should continue for at least two breeding seasons after the last release so that success can be described in terms of the proportion of released birds entering the breeding population.

Major difficulties faced

- Production of adequate numbers of independent young from the captive colony. Although breeding participation in captivity is high, the proportion of infertile eggs has constrained growth of the captive population. Hatching success and fledging success were also lower than expected and not significantly better than in the wild population. This situation is steadily improving as captive husbandry is refined through experience and the application of advanced technologies.
- The small number of birds available for release limits options and opportunities for an experimental approach, thus limiting our capacity to learn by doing.
- Variability in breeding success within the captive population means that some pairs are over-represented in the potential release cohorts and release of full siblings or other closely-related birds is difficult to avoid.
- Nest predators reduce breeding success of the wild populations. A suite of indigenous bird and reptile species prey upon eggs and nestlings of the helmeted honeyeater. This has constrained the rate at which the re-introduced colony is able to grow, and attempts to identify and manage potential nest predators have consumed considerable time and resources.
- Drought: the re-introduction program has corresponded to 11 years of below average rainfall resulting in significant change to the hydrological

Fig. 1: Number of nest attempts (egg laying confirmed or inferred) at Bunyip State Park/Tonimbuk, breeding seasons 2001-2002 to 2008-2009



characteristics of the creek system. As well as affecting the timing and success of breeding (Chambers *et al.*, 2008), the rainfall deficit has likely reduced the availability of food in the riparian zone, in the form of plant exudates and arthropods. Consequently, we have felt it necessary to provide supplementary food to the released birds for longer than we would have liked.

- Even with a full-time Field Ornithologist dedicated to the task, monitoring survival and breeding success in the increasing population of released birds, and providing supplementary food to them, is labor-intensive, time-consuming and difficult to resource and maintain over an extended period.
- In combination with the dry conditions, the threat of wildfire is serious and on-going. Wildfires have threatened the Bunyip State Park release site in two of the past six summers, most notably in February 2009.

Major lessons learned

- Success in developing and maintaining a viable captive population cannot be assured and the effort required may be difficult to predict - captive management of the helmeted honeyeater has proven problematic compared to other members of the Family Meliphagidae, for example the regent honeyeater (P. Menkhorst unpubl. data). Some ‘pairs’ housed together never form a pair bond, others produce infertile eggs, and the captive population has proved to be susceptible to a range of diseases.
- The costs of housing birds in release aviaries for extended periods (including the time demands on skilled keeping staff) are not justified by any clear advantage in terms of survivorship of released birds.
- Pairings amongst released birds tend to occur within release cohorts so release cohorts should not include closely-related individuals.
- The potential impact of indigenous predatory species needs to be a component of pre-release planning, including careful assessment of options for their management.
- The preparation of emergency response plans helped ensure that adequate resources were available to protect critical habitat and the captive population during a bushfire emergency.
- The tasks of post-release monitoring and supplementary feeding would not have been achieved without on-going assistance from trained volunteers from a community support group, the Friends of the Helmeted Honeyeater.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Individuals released under all of the scenarios described above have survived for six months or longer. Of 95 captive-bred birds released at Bunyip up to the end of 2008, 31 (33%) are known to have survived for at least one year, and 21 (22%) have successfully bred in the wild. At Yellingbo the equivalent figures from a total of 59 released birds are: 23 (39%) and 14 (24%) respectively. The re-introduced wild population in Bunyip State Park produced 31 fledglings during the 2008-2009 breeding season.
- The re-introduced population has grown steadily in number and in breeding participation but is still too small to be considered self-sustaining.
- The re-introduced population at Bunyip is conforming to the natural dispersal system of female dispersal and male fidelity to the natal colony, thus supporting the strategy of creating several separate colonies spaced along the streamside habitat.

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Attempted re-introduction of the western bristlebird in south-western Australia

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Introduction

The passerine family Dasyornithidae includes only one genus (*Dasyornis*) and is endemic to southern Australia. All three species are considered threatened, with the western bristlebird (*D. longirostris*) being considered Vulnerable by the IUCN and both State (Western Australian) and Federal wildlife conservation agencies. It is also listed under CITES. The species is endemic to the south coast of Western Australia, where it currently occurs from near Albany east to Hopetoun; its historical distribution is poorly known, but it previously also occurred west of Albany, as far north as Perth. Western bristlebirds are cryptic, primarily insectivorous, and occupy sometimes overlapping home-ranges in near-coastal open to closed, floristically diverse heath 0.5-1.5 m high (e.g. Smith, 1987). The only feasible census method is by aural survey. The species has long been known to be threatened, and susceptible to inappropriate fire, particularly extensive wildfire (Burbidge, 2003). The whole population number of the western bristlebird is not known with certainty, but in 2001 was considered to be about 620 pairs. However, due to recent wildfires, it is now about 320 pairs, about two-thirds of which are in the Two Peoples Bay/ Waychinicup/Mt. Manypeaks area, with the remaining 125 in the Fitzgerald River National Park.

Goals

- Goal 1: The overall aim was to increase the number of distinct subpopulations and decrease the risk of loss due to wildfires.
- Goal 2: Identification of potential translocation sites with suitable habitat, and appropriate management.
- Goal 3: Development of translocation techniques for bristlebirds.

Western bristlebird © S. J. Nevill


Radio-tracking released birds © Abby Berryman

- Goal 4: Establishment of at least one new sub-population near Walpole, west of Albany, but within the known historical range.

Success Indicators

- Indicator 1: Persistence of bristlebirds at a site for a year would indicate that translocation methods were appropriate, and that site selection was likely to have been appropriate.
- Indicator 2: An increase in the number of singing males [as indicated by 'A' calling birds; Smith (1987)] would confirm that target site selection was appropriate, and that generation of a self-sustaining population might be feasible.
- Indicator 3: Overall success would be met through the establishment of a self-sustaining population-overall risk to the total population from fire would be reduced, and the geographic extent of the species increased.

Project Summary

Feasibility: Translocation techniques used were based on those developed for the similar-sized noisy scrub-bird (*Atrichornis clamosus*) (Danks, 1994). In addition, facilities and equipment developed for the scrub-bird translocation program were able to be utilised for the bristlebird work. The target area was known to include similar habitat to that occupied by western bristlebirds east of Albany, and was known to contain vegetation with a mix of fire ages, including an extensive area that was long unburnt. The target area was in a national park, which provided security of tenure, and local managers were confident of being able to provide appropriate fire management, both before and after translocation. Local managers were also conducting a low-level cat control program, which was intensified in the proposed release area.

Implementation: In the austral spring of 1999 and 2000, a total of 15 western bristlebirds were captured from Two Peoples Bay Nature Reserve, held in aviaries (from 1-5 days) until several birds were available for release, and the weather at the release site was predicted to be favourable. In the aviaries, all birds settled in readily, and all commenced feeding within an hour, with almost all feeding on the supplied invertebrates within 15 minutes of release into the aviary. Birds lost weight following capture, but re-gained weight in following days, and most were released at greater than capture weight. One male started singing territorial songs within 24 minutes of being placed in an aviary. Birds were released in the Nuyts Wilderness in the Walpole-Nornalup National Park, near Walpole, about 130 km west of Albany. In October-November 2007, a further


Releasing western bristlebirds © A. H. Burbidge

three birds were caught at Two Peoples Bay, held for up to three weeks, and translocated to D'Entrecasteaux National Park, less than 10 km from the earlier release site, and in contiguous habitat. In the 2000 release, faecal samples were collected and screened for oocytes, cysts and eggs of protozoans and helminths. Results of all tests on all seven birds were negative except that the sample from one bird contained a very low number of eggs of a nematode, *Capillaria*. In 2007, we took blood and faecal samples from all three birds. All were clear except one male, whose heterophyl/lymphocyte ratio indicated possible stress or virus. As the sample was taken towards the end of a period in the aviary, it was concluded that stress was the most likely cause. As wild birds would be expected to experience some stress when brought into captivity, this was not thought to be an issue of concern.

Post-release monitoring: All birds were fitted with small radio-transmitters to facilitate monitoring, particularly as females do not sing as much as males, and it was unknown how much males would sing at the release site. However, most males started singing territorial ['A' song; Smith (1987)] within a day of release. Females are less likely to be heard calling, but on the morning after release of the first four birds in 1999, at least three of them were heard calling and, as judged by frequent dueting, two birds seemed to have paired up already. This pair moved about 1.8 km through suitable vegetation during the first weeks following translocation. In 2000, birds were released at the same location, and another two birds also began dueting within 24 hours of release. We interpreted the early singing, especially dueting, to mean that the birds were finding enough food to behave normally towards other birds. It suggested the habitat at the release site was appropriate, and it facilitated censusing this otherwise cryptic species. Despite a severe large wildfire started by lightning in March 2001, which burnt approximately 2,800 ha of the release area, at least seven bristlebirds were still calling in late 2001, and at least five birds in late 2002.

However, surveys conducted from October 2003 to mid 2005 found only one bird calling, and no bristlebird calls were heard in October 2005 or later surveys despite thorough searches. Interestingly, the bird heard in 2003 had moved back to the vicinity of the release area, where there had been an intense fire 2.5 years previously. In the case of the 2007 release, all three birds were radio-tracked and were heard calling in the weeks following release, and the female and one of the males appeared to have formed a pair. Interestingly, this female and the first male were caught in the same home range at Two Peoples Bay, but following translocation the pair did not reform, the female instead pairing up with the second male; they were still together nearly two months later. However, there was no evidence of persistence of any of these birds beyond four months. Local volunteers played a major role in the ongoing monitoring of the released birds.

Major difficulties faced

- Bristlebirds proved very difficult to catch in 2007, but reasons for this are unknown.
- We captured twice as many males as females, making it difficult to establish a founder population with an unbiased sex ratio.
- A major wildfire in March 2001 burnt approximately 2,800 ha of the release area. The birds avoided the fire but it still represented a major difficulty because it made large areas of habitat unsuitable for bristlebirds. Nevertheless, 6-7 months later, at least seven birds were still present nearby.
- Despite attempts to control feral cat populations, some large cats were observed in the area following the translocations, and it is believed that cat predation may have contributed to the eventual failure of the translocations.

Major lessons learned

- A well-functioning recovery team, including both researchers and on-ground managers, meant that well-informed decisions could be applied quickly when difficulties and challenges were encountered.
- Considerable volunteer assistance was required throughout the project, particularly in monitoring.
- Five birds persisted for at least two years and one bird for at least five years, despite a major wildfire and the presence of feral cats. This satisfied Success Indicator 1, and suggested that the translocation methods themselves were appropriate, but release site selection is important and ongoing management critical.
- The lack of long term persistence (or establishment) of the population suggested that effective predator control may be essential for success. However, it is also possible that year-round food supply might have been inadequate, but we do not have data to test this suggestion.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The logistics of the project did not cause major difficulties, because a) we used infrastructure and built on techniques and procedures for scrub-bird translocations and b) all major decisions were based on productive interactions within a team involving persons with specialist knowledge of threatened birds

including bristlebirds, and field-based staff with specialist knowledge of land management, particularly in relation to fire.
- Habitat at the release sites seemed to have been appropriate, at least for short -term persistence.
- The founder population size was too small, and the sex ratio biased.
- Most birds moved into vegetation of a younger fire age than predicted, meaning that knowledge of habitat preferences was increased.
- The population did not persist, and while the reasons for this are unknown, cat predation is suspected to be part of the cause. The large wildfire may also have played a part, by forcing birds into less suitable habitat.

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Re-introduction of the Mount Lofty Ranges southern emu-wren to Cox Scrub Conservation Park, South Australia

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Introduction

The Mount Lofty Ranges southern emu-wren (MLRSEW) (*Stipiturus malachurus intermedius*) is a small (7 g) endangered (Australian Government *Environment Protection and Biodiversity Conservation Act 1999* and South Australian *National Parks and Wildlife Act 1972*) passerine (Maluridae) with a restricted distribution in dense swamp and dry-heath habitats in the Mount Lofty Ranges-Fleurieu Peninsula region of South Australia (SA). Only around 20 local populations remain, comprising 250-500 individuals (2008 estimate). Range contraction has been caused primarily by habitat loss due to extensive clearance of native vegetation for agricultural development, with bushfire, population isolation, small population size and diminished habitat quality due to stock grazing, succession and climate change threatening remaining populations.

The MLRSEW has consequently been the subject of a comprehensive recovery program (MLRSEW and Fleurieu Peninsula Swamps Recovery Program, administered by the Conservation Council of South Australia since 1995). Population re-establishment is central to the strategy for down-listing from endangered, and the MLRSEW is a prime candidate for translocation. It is a weak flyer and requires densely vegetated corridors for dispersal. Colonization of isolated unoccupied habitat and supplementation of declining populations are very unlikely because its population and habitat are highly fragmented. Thus, translocation is considered an appropriate management option for establishment or supplementation of populations. This paper reports on the first-attempted re-introduction of the MLRSEW, conducted in 2001-2002.

Goals

The overall aim of the re-introduction was to re-establish the MLRSEW in Cox Scrub Conservation Park (CP), an area from which it was extirpated due to fire in 1983.

Main Goals:

- Translocate 30 adults (1:1 sex ratio) in 2001.
- Translocate a supplementary 20 adults (1:1 sex ratio) in 2002.
- Conduct intensive monitoring at source and release sites during 2001-2003.
- Satisfy predefined success indicators.

- Review the translocation for the 2001-2003 period.

Emu wren - male

Success Indicators

Release Site

- Re-introduced population in September 2003 (i.e. start of 2003-2004 spring-summer breeding season) is equivalent in size to founder group.
- Founder-group (mature) progeny are present in September 2003.

Source Site

- Most (>50%) specific (capture and removal) trapping locations are reoccupied by December 2003.
- Successful reproduction (independent young) occurs in most (>50%) reoccupied locations by December 2003.

Overall Success

- Short-term (as at December 2003): removal and reintroduction are successful.
- Long-term (>2003): re-introduced population increases in size.

Project Summary

Feasibility at the release site: Cox Scrub CP (544 ha; 50 km SSE of Adelaide, SA) was selected as the release site because it included a large area (>100 ha) of habitat, was occupied prior to a fire that burnt-out the park in 1983, and because of its nature reserve tenure. MLRSEW habitat at the site mainly comprised low (<10 m) open (<70% foliage cover) eucalypt-dominated mallee, over dense heath shrubs and sedges.

<u>Source site</u>: Deep Creek CP (4,558 ha; 80 km SSW of Adelaide, SA) was selected as the source site because of its large (300+) MLRSEW population in habitat similar to vegetation at the release site (Wilson, 2000; Wilson & Paton, 2004).

<u>Pre-transfer assessments and planning</u>: A feasibility study (Wilson, 2000) confirmed the suitability of the release site and provided recommendations regarding source population, founder group, timing of transfers, and monitoring. A translocation proposal (Pickett, 2001) following IUCN and SA Government guidelines was subsequently prepared. Pre-transfer surveys were conducted in 2001. Candidates for translocation and potential trapping locations were identified at the source site. Specific release locations were identified at the release site and the absence of MLRSEWs confirmed.

Implementation (founder population): The original plan was to transfer 30 MLRSEWs in 2001 and a supplementary 10 individuals in 2002, but the latter was increased to 20 in an effort to quickly boost the re-introduced population. The MLRSEW is monogamous (Pickett, 2000), so a founder population sex ratio of 1:1 was desired. The actual founder population comprised 46 MLRSEWs:30 (1:1, including 13 putative pairs) transferred in June-July 2001 and 16 (1:1, including seven putative pairs) transferred in July-August 2002. Its composition differed to the target because trapping in 2002 did not meet requirements, with nine surplus males released at capture sites because corresponding females were not acquired. Founders were sourced from three areas to hedge against genetic uniformity.

Trapping, transfer and release: Transfers were conducted just prior to or around commencement of the MLRSEW's breeding season (August-March). Apparent pairs captured at this time were likely established and time between release and commencement of breeding would be minimal. Trapping, in mist nets, aimed to capture both members of a putative pair more or less together. Captives were color-banded and held in boxes, where they were provided with foliage cover and food. MLRSEWs were transferred to the release site by road (75 km), generally on the day of capture or early the following day, and released following a brief acclimatization/feeding period (in holding boxes) at the release location. Individuals were held, transferred and released in the same pairs/groups as captured. Single individuals were released with other single birds, near release locations of previously released single individuals (usually opposite sex), or near release locations of pairs or groups.

Releases were spread across 13 specific locations in 2001 in an effort to distribute pairs across the best habitat, but this approach was abandoned in 2002 because all individuals released in 2001 dispersed from their respective release locations and most putative pairs did not remain intact. Releases in 2002 were near two areas occupied as a result of the 2001 releases.

Post-release monitoring:
Release Site: Monitoring at the release site during the first three breeding seasons comprised area-searches. The entire release site was searched at least once each season. Areas where MLRSEWs were found were subjected to intensive follow-up surveys. Subsequent partial monitoring focused on areas occupied during the first three breeding seasons.

- 53% of first cohort observed post-release, but only 25% of second cohort.
- All individuals dispersed from their respective specific release locations (0.2-1.8 km), but some moved to release locations.
- Only 33% of settled pairs were originally captured as same pair.
- Founders and progeny successfully bred, but only around half of all pairs bred each season.
- Productivity in first and second breeding seasons (1.6-2.8 offspring/breeding-pair/season) was greater than in third season.
- Annual (apparent) survival of founders averaged only 32%.


Emu wren release site

- Some breeding pairs (home range ~1 ha) and unpaired breeding-age founder-group progeny were widely scattered across the release site.
- At least 15 individuals present September-December 2003, including four breeding pairs and 10-13 (fledged) founder-group progeny.
- At least 17 individuals present 2006-2007, all founder-group progeny and including six breeding pairs.
- At least several pairs evident 2009-2010.
- Most observations in areas previously identified as habitat.
- Substantial (drought induced) dieback of habitat during 2002-2004.

Source Site: Monitoring at the source site during the first three breeding seasons comprised transect surveys and area-searches. Transects were through trapping areas and area-searches focused on specific trapping locations. Subsequent partial monitoring comprised transect surveys as part of ongoing general monitoring.

- Evidence of reoccupation (as at December 2003) was recorded at almost all (95%, n=16) specific trapping locations.
- Evidence of breeding (as at December 2003) was recorded at most (58%) specific trapping locations for which there was evidence of reoccupation, but independence of young was not recorded in all cases.

Major difficulties faced

- The target founder population was not acquired.
- The MLRSEW is a very small and relatively cryptic bird that is difficult to monitor using survey techniques employing direct-observation, however the species is too small and its habitat too dense to facilitate radio tracking.
- Translocated individuals dispersed widely across the release site.
- Widely scattered breeding pairs and unpaired breeding-age progeny reduced the reproductive capacity of the reintroduced population.
- There was probably undetected dispersal from the release site to unsuitable nearby areas and beyond.
- Re-introduced MLRSEWs may have dispersed away from specific release locations because of unfamiliar social and physical environs (i.e. in an effort to locate familiar home range areas).

- Predation may have contributed to poor performance of the re-introduced population.
- Post-translocation monitoring revealed that habitat quality at the release site was generally poorer than the feasibility study indicated.
- General habitat quality at the release site declined (to marginal in many areas) post-translocation due to below average seasonal conditions.
- Post-release transect and area-search monitoring was arduous and expensive.

Major lessons learned

- Translocated MLRSEWs survived, settled and reproduced, but production did not offset substantial losses and the reintroduced population declined.
- In terms of relative habitat suitability, the pre-translocation habitat assessment was confirmed with regard to general distribution, but quality might not have been as adequate as initially thought.
- Future capture, holding, feeding, transfer and release methods for translocation of MLRSEWs should be modeled on those applied 2001-2002.
- Future assessments of MLRSEW translocation feasibility should include consideration of potential ‘dilution effects’ due to release patch size (e.g. the likelihood of pairing amongst dispersed founders and their progeny).
- Micro-selection of specific release locations within habitat is unnecessary because reintroduced individuals are likely to disperse away from their respective release locations for reasons unrelated to habitat suitability.
- Translocation of pairs is not essential because putative pairs are unlikely to remain together following release and new pairs will readily form and breed.
- Rather than undertake comprehensive and expensive studies of marked individuals, broad (e.g. grid-based) pre- and post-translocation monitoring of presence/absence and productivity should be considered for determining source population response to translocation.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Pre-defined success indicators (see above) were partially met. Factors most likely contributing to reduced performance include drought, undetected dispersal beyond the release site, predation, unfamiliar release-site environs, widely dispersed pairs and unpaired individuals, and marginal habitat quality. Despite not fully satisfying all predefined success criteria, the translocation was successful in a variety of very important ways that contribute to MLRSEW recovery efforts such as listed below.
- Re-establishment of a small resident breeding population, which has persisted for at least nine years.
- Development/refinement of trapping, holding, transfer, release and monitoring methods specific to the MLRSEW.
- Knowledge of the species’ response to translocation.

- Confirmation of the practicability of translocation as a MLRSEW population management tool.

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Re-Introduction of the Socorro dove, Socorro Island, Revillagigedo Archipelago, Mexico

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Introduction

The Socorro dove (*Zenaida graysoni*) is currently extinct in the wild and was endemic to Socorro Island, Mexico. The last written account mentions the killing of several doves in 1972 (Velasco-Murgía, 1982). However, interviews with credible sources note its presence on the island as late as 1975 (Captain J. Durán Hernández, pers. comm.). Thus, its extinction coincides with the construction of the naval airstrip and accessory roads in the mid 1970s (Jehl & Parkes, 1982). Doves brought to California in 1925 allowed breeding efforts in the United States (Gifford, 1927) and shortly thereafter in Europe (Nicolai, 1991). Breeding in the United States languished in the early 1990s; hybridization with mourning doves (*Zenaida macroura*) occurred in private aviaries and the zoos hosting the species transferred their doves to individuals (P. Kandianidis, pers. comm.; J. Passantino, pers. comm.). The situation in Europe was different, by 1995, the European Endangered Species Breeding Program (EEP) of the European Association of Zoos and Aquaria (EAZA) became the backbone of global breeding efforts. The Revillagigedo Archipelago was declared a Biosphere Reserve in 1994, lending a solid basis to collaborative re-introduction efforts with Mexican authorities and other organizations.

Goals

- Goal 1: To re-establish a demographically viable wild population of Socorro doves using blood lines that better represent the original genome.
- Goal 2: To maintain an international captive meta-population to preserve extant blood lines and supplement re-introduction efforts.
- Goal 3: To establish a long-term monitoring program to evaluate and monitor the success of re-introduced individuals and their progeny.

Success Indicators

- Indicator 1: Genetic evaluation of captive Socorro doves to determine the extent of hybridization with mourning doves to detect candidate bloodlines for re-introduction.
- Indicator 2: Expansion of the captive breeding partnership in Europe, the United States and Mexico to create a meta-population capable of providing individuals to re-introduction efforts without jeopardizing the demographic and genetic wellbeing of the species.
- Indicator 3: Sampling of pathogens and disease of captive bred individuals and wild birds on Socorro Island to assess the risk of epidemics.
- Indicator 4: Identification of former range and habitat requirements of the species.
- Indicator 6: Removal of introduced grazers and feral predators.
- Indicator 7: Habitat restoration in potential release areas.
- Indicator 8: Construction and operation of a breeding station to provide acclimated offspring for release on Socorro Island.
- Indicator 9: Construction and operation of a release station on areas where habitat restoration has been implemented.
- Indicator 10: Establishment of permanent territories and successful reproduction in the wild by released individuals.

Socorro dove at Frankfurt Zoo
© Stefan Stadler

Project Summary

Shortly after the Socorro dove was presumed extinct in the wild (Jehl & Parkes, 1982), Luis Baptista characterized morphological and behavioral traits of the species. Dr. Baptista visited Socorro Island several times between 1988 and 1995 to determine the feasibility of the project. He found favorable conditions such as significant native forest habitat. The re-introduction program, also known as *The Socorro Dove Project*, has progressed as information drawn from ongoing research is incorporated in implementation strategies (Horblit *et al.*, 2005 and references therein). In its current form, the re-introduction program consists of two parallel initiatives: 1) the international *ex situ* captive breeding program and 2) the *in situ* breeding program and habitat restoration. To determine the impact of hybridization on the extant captive population, DNA fingerprinting and DNA sequencing of Cytochrome C were conducted among a large number of putative Socorro doves from the United States and Europe in the late 1990s (J. E. Martínez-Gómez, unpublished). Banding patterns from these birds were compared to those of known hybrids and pure doves descending from the original Californian stock (L. F. Baptista, P. Kandianidis, & J. Passantino, pers. comm.). Results showed that hybridization was pervasive in the United States but that

Habitat on Socorro Island

European doves showed very similar banding patterns to pure doves. Because recurrent backcrossing to Socorro doves could yield doves with no trace of the hybridization event, it was decided to use the putatively pure European Socorro doves to lower the risk of introducing elements of an alien genome.

In Europe, a broad partnership has been established. Today, twenty one institutions led by the Frankfurt Zoo constitute the European Breeding Program (EEP) for this endangered species. This program monitors genetic and demographic parameters in the captive population and currently maintains ~100 doves. Originally, birds for re-introduction were going to travel directly from Europe to Mexico. However, avian influenza outbreaks throughout Europe in 2005 prompted the Mexican government to ban the importation of any birds from Europe. To work within this constraint and maintain the safety of avian populations, captive breeding of European stock will be undertaken first in the United States and then expanded to Mexico prior to any transfer to Socorro Island. By establishing a larger captive meta-population the overall negative impact of any catastrophic loss on Socorro Island would be minimized. In October 2008, twelve Socorro doves were imported from both the Paignton Zoo and the Edinburgh Zoo to the United States by the Island Endemics Foundation and the Albuquerque Zoo. After USDA APHIS quarantine they were transferred to the Albuquerque Zoo in November 2008. Since then, the doves have bred successfully and have been distributed to additional zoos in the United States. After establishing a robust captive meta-population in the United States, Socorro doves will be transferred to partner zoos in Mexico. Concurrent to the international captive breeding program, several actions have been and are being implemented for the re-introduction program on Socorro Island following IUCN Re-introduction Guidelines. Between 1993-1997 a partnership with the Mexican Navy was established to control introduced sheep and cats to protect other critically endangered endemic species on Socorro Island. The Mexican Navy conducted the successful eradication of rock doves (*Columbia livia*) by 1994 to remove this source of a potential disease vector (Admiral P. León-Herrera & Captain M. A. Ramos-Real, pers. comm.) In addition, the Mexican government supports an on-going program to remove introduced sheep from Socorro Island to prevent further loss of native habitat (A. Aguirre, pers. comm.).

Information about distribution in the wild has been gathered (e.g. localities of museum specimens; S. Bunnell, Sr. unpublished field notes; Captain J. Durán

Breeding Station built by the Mexican Navy and Island Endemics Foundation © Juan Martinez

Hernández, pers. comm.) to compare with recent vegetation surveys to determine the species historic range, habitat requirements and vegetation restoration needs. Also surveys to sample for avian pathogens and disease have been carried out in 2004 and 2009 to estimate the risk of epidemics on both incoming Socorro doves and the native avifauna (Yanga *et al.*, in press; J. S. Carlson *et al.*, unpublished). In 2001, a covenant between the Mexican Navy and the Island Endemics Foundation was established to build a Breeding Station on Socorro Island. This facility was completed in November 2004 and is ready to receive Socorro doves to begin breeding efforts *in situ.* Offspring from this effort will then be moved to a release station, yet to be constructed, in order to start the soft release of doves to the wild.

Major difficulties faced

- The six-year term of the federal administration, coupled to the presidential election cycle in Mexico, affects consistent long-term planning and coordination for the establishment of a multi-year conservation project.
- Although several government environmental authorities support the Socorro Dove Project a better coordination with the Ministry of Agriculture (SAGARPA) is required. The perceived risk of avian influenza from imported birds impeded the return the Socorro dove directly to Mexico. Our disease work had demonstrated that Socorro doves from the European Breeding Program did not represent any risk for the spread of Avian Influenza.
- The National Commission for Natural Protected Areas (CONANP) has no permanent presence on the island and has not yet implemented an enforceable management plan for this insular area, which harbors the largest number of critically endangered avian species in Mexico.
- For NGO´s contributing to the conservation of Socorro Island in particular, and the Revillagigedo Archipelago in general, it is necessary to guarantee continuous access to the island. On occasions, civilian personnel are not allowed to the island. It is critical for The Socorro Dove Project to have continuous access to the island. Without continuous access, the survival of the doves used in the *in situ* captive breeding and release programs on the island would be threatened.

Major lessons learned

- The re-introduction project must be considered as a long-term endeavor with multiple success indicators that can be partially achieved according to social and political circumstances.
- The Socorro Dove Project has benefited from a broad and international partnership which has enabled work on many fronts and brought a suite of talents to bear on the Project that no individual partner possessed.
- The perseverance and unfailing will of the captive breeding community that has saved the Socorro dove for more than 80 years provided a solid basis to secure the survival of this species. This is a prime example of a successful trans-generational campaign to save an endangered species.

Success of Project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Although both the international breeding and restoration programs on Socorro Island are moving forward the project must be considered partially successful until the Mexican Government guarantees continuous access to the island to implement adequate *in situ* captive breeding, release and monitoring of individuals.

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The history and success of noisy scrub-bird re-introductions in Western Australia: 1983-2005

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Introduction

The noisy scrub-bird (*Atrichornis clamosus*) is a small, sexually dimorphic, semi-flightless obligate insectivore, endemic to the south coast of Western Australia between Two Peoples Bay and Cheynes Beach east of Albany. The scrub-bird occupies dense low forest and scrub vegetation that provides for cover, nesting habitat and well developed leaf litter invertebrate food resources, generally in long unburnt vegetation. The scrub-bird is a winter breeder, and has a low fecundity with each breeding female producing only a single offspring in a year (Danks, 1997). Territorial males sing loudly and frequently during the breeding season and counts of these males provide an index to the total population. The scrub-bird is listed under CITES App. I, as Vulnerable by the IUCN and Australian Commonwealth, and as Endangered by the Western Australian Department of Environment and Conservation. Following 72 years without records, the species was rediscovered at Two Peoples Bay in 1961, when the population index was 45 (around 100 individuals). Since then, re-introductions and habitat management have led to the population index reaching 770 in 2001, however wildfires between 2000 and 2005 significantly impacted over half of the optimal scrub-bird habitat in the Albany area, leaving a population index of 343 in 2005 (Burbidge *et al.*, 2005).

Goals

- Goal 1: To develop translocation techniques and strategies for the scrub-bird based on wild-caught individuals.
- Goal 2: To increase the total population size, with the long term goal of removing the species from the threatened list.
- Goal 3: To establish geographically distinct populations, in order to

Male noisy scrub-bird © A. Danks

reduce the impact that the loss of any sub-population has on the overall population.

Success Indicators

- Indicator 1: Techniques developed for routine capture, holding, transporting and monitoring.
- Indicator 2: Source populations able to withstand removal of birds.
- Indicator 3: Singing males still present in the release area in the season following their release. This allows assessment of habitat suitability before release of females.
- Indicator 4: Number of singing males at the release site exceeds the number of males released. This is the only practical indicator of recruitment.
- Indicator 5: Habitat is protected from wildfire and potential predators, with specific fire protection and predator control strategies in place.
- Indicator 6: Improved conservation status reflected in IUCN categories and in the long term delisting.

Project Summary

Following a 5-year captive breeding trial that produced only one additional scrub-bird, it was realised that creating new populations would require wild-caught birds.

Table 1: Summary of Noisy Scrub-bird translocations and their outcome

Translocation Site	**Source**	**Release Years**	**No. of Birds (M:F)**	**Success/Fail (year number of males exceeded number released)**
Manypeaks	Lakes, Mt Gardner	1983,1985	31 (18:13)	Success (1988) (despite major wildfire in 2005)
Nuyts	Mt Gardner, Lakes	1986,1987	31 (16:15)	Fail
Quarram	Mt Gardner, Lakes	1989,1990	26 (15:11)	Fail
Mt Taylor (1)	Mt Gardner, Lakes	1990,1991, 1992	12 (6:6)	Success (1993) (lost after wildfire1994)
Bald Island	Mt Gardner	1992,1993, 1994	11 (8:3)	Success (1997)
Mermaid	Mt Gardner	1992,1993, 1994	10 (8:2)	Success (1999)
Stony Hill	Mt Gardner	1994	5 (5:0)	Fail
Darling Range (8 separate sites)	Mt Gardner, Angove, Manypeaks	1997,1998, 1999,2000, 2001, 2002, 2003	80 (60:20)	Fail (most sites) (Singing males persisted at several sites, evidence of breeding at one site)
Porongurup	Mermaid	2006	8 (8:0)	Fail (wildfire in first year)
Mt Taylor (2)	Mermaid	2007	5 (5:0)	Fail
TOTAL			**219 (149:70)**	

Wildfire at Two Peoples Bay in 2006 © S. Comer

Fortunately, the population at Two Peoples Bay Nature Reserve was increasing at the time, indicating it might be capable of sustaining the removal of individuals for a translocation program. Capturing the semi-flightless, cryptic scrub-bird presented a major challenge. Only two had ever been caught alive. However, techniques were developed for the routine capture of adult males and females and these basic methods have been used in all subsequent translocations (Danks, 1994 & 2000). Nevertheless, over the years these methods, plus transport and holding techniques, have been modified to improve their effectiveness.

Implementation: Between 1983 and 1989 founder groups of around 15:15 were released at each of three sites (Table 1). This strategy was revised in order to reduce capture effort and the impact on the source population of the removal of relatively large numbers of birds, particularly females (Danks, 1994). From 1990 smaller numbers of males were released first at a new site to ‘test’ suitability of habitat. The persistence of males through to the next breeding season indicated that the habitat provided suitable food resources to support scrub-birds, and also that there were no significant predation issues. Females were then released in the second year. Individual captured birds were held temporarily (up to two weeks) in aviaries near the capture site. The health of each bird was monitored through observation of their behaviour in the holding aviary as well as general inspection in the hand. In later years more rigorous health screening was carried out. The birds were transported to the release site (often remote and difficult to access) in padded carry boxes by 4WD vehicle, boat, helicopter and on foot where they were released directly into dense vegetation (hard release). Selection of translocation sites was based on visual assessment of habitat structure (vegetation post-fire age, density of cover), similarity to known scrub-bird habitat, assessment of leaf litter invertebrates (not all sites), and capacity of management with respect primarily to fire management, and control of predators (Danks, 1994 & 2000; Danks *et al*., 1996). In total 219 birds have been released in nine areas (Table 1). There were only two mortalities, which were confirmed by autopsy to be individuals carrying high parasite burdens and therefore more likely to be affected by the stress of capture and handling. The low rate of loss indicates that the processes of capture and handling were appropriate.

Post-release monitoring: At release sites the regular counting of singing males in the years immediately following release determined both the subsequent


Noisy scrub-bird with transmitter © A. Berryman

release of females and in the longer term whether the translocation had been successful (Table 1). From 1992 the movements of translocated birds were monitored using radio-telemetry. This was usually only useful for the first few weeks as the transmitters have limited attachment life, and generally battery life is restricted to 4-6 weeks. Of the large number of birds that were radio-tracked following release several provided information on immediate post-release survival. At one site in the Darling Range two individuals were predated within days of release, but it was not possible to identify the predator.

Monitoring of the source populations was also a key aspect of this program. Between 1983 and 1999 Two Peoples Bay Nature Reserve (TPBNR) provided a total of 168 birds (110 males:58 females) for the re-introduction program. The Mt Gardner sub-population provided 138 of these, 30 came from the Lakes sub-population). The effects of this removal were monitored by annual census of the territorial males, and by documenting the number of days taken for a territory to be re-occupied by another, previously non-singing male. Despite the removal of birds the population index continued to increase on Mt Gardner until 1996, when it started to decline. No more birds were captured from this area after 1999 in order to allow the sub-population to recover. Since then birds have been sourced from other sub-populations in the Albany area including Manypeaks (10), Waychinicup NP (13), and Mermaid (14) which were begun as re-introductions, and Angove-Normans (14). The Angove-Normans and Manypeaks areas were impacted by wildfires in 1999 and 2004 respectively, but monitoring of birds in the Waychinicup and Mermaid sub-areas suggest no long term issues with removal of birds.

Major difficulties faced

- Despite refinements over the years each translocation event required considerable time and individual effort for release site survey, assessment and selection; capture and care of captured birds; radio-tracking and monitoring of release sites; monitoring of source populations.
- Short term and unreliable funding resulted in large turnover of technical staff, and loss of skills from the program. Considerable time and effort were constantly required to ensure the program was adequately funded.
- Difficulties in monitoring survival of birds post release - which was almost completely reliant on being able to find singing males. This is particularly

difficult at sites distant from Albany, partially due to the lack of experienced survey personnel and extensive release area habitat requiring survey effort.

- Difficulties in determining optimal release habitat qualities - for example, leaf litter food resources have been assessed by wet-pit trapping of invertebrates, but these trapping methods are no longer viewed favourably by ethics committees. Knowledge of vegetation types able to support scrub -birds has grown with experience. However, the suitability of release site habitat is still difficult to predict.

Alan Danks with local community members at Mt. Taylor Release site in 2007 © A. Berryman

- Three translocation sites, Mt. Manypeaks, Porongurup and Mt. Taylor were impacted by wildfires, as has the Angove-Normans source population. Despite pre-suppression fire management and increased fire fighting resources over the period of the re-introduction program, wildfires are increasingly likely to impact on scrub-bird populations and re-introduction sites because of the well documented and ongoing decline in rainfall In south-western WA in recent decades due to global warming.

Major lessons learned

- While some translocations have failed, the overall strategy of establishing distinct sub-populations has been extremely successful in improving the status of the scrub-bird.
- The volume of work required to complete monitoring of source populations and released birds, in addition to that required to carry out the translocation, could not be achieved without the input of volunteers.
- Close monitoring of the impact of the removal of birds is essential to ensure that source populations are not depleted. Knowledge of vegetation types able to support scrub-birds has grown with experience. However, the suitability of release site habitat is still difficult to predict accurately.
- Management of release areas, particularly fire management and feral predator control, is critically important and requires ongoing liaison and communication with land managers.
- Capacity of land managers to manage threatening processes in an active adaptive management framework is enhanced through regular communication and involvement in recovery team meetings and communication with the recovery team.

- A multi-species recovery team that deals with species occupying similar habitats or geographical areas, and faced with similar threats, has been beneficial to the program by facilitating knowledge transfer, ready sharing of equipment and facilities, and coordinating recovery efforts across these species.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Overall this project has been successful. Translocation (introduction and re-introduction) has increased the population size, area of occupancy and extent of occurrence of scrub-birds such that wildfires have not resulted in the total loss of the species.
- The project has seen the development of translocation techniques and skills that enable birds to be captured and re-located successfully.
- The project is not considered highly successful as there are still issues with determining what is likely to be suitable habitat for translocations.

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Translocation of lesser short-tailed bats to Kapiti Island, New Zealand: release site suitability and post-release monitoring

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Introduction

The lesser short-tailed bat (*Mystacina tuberculata*, hereafter 'short-tailed bat') is considered Vulnerable by the IUCN, partly due to predation from introduced mammals. The New Zealand Department of Conservation's (DOC's) management plan includes establishing populations on islands free of pest mammals (Molloy, 1995). A small, genetically distinct population was recently discovered in the Tararua Ranges in the south of North Island (Lloyd, 2003). DOC considers this population to be an evolutionarily significant unit, and lists it as Nationally Critical (Hitchmough *et al.,* 2007). To help secure the lineage DOC translocated twenty bats to Kapiti Island, a nearby pest-free island (Ruffell & Parsons, 2009). The few bat translocations that have been attempted elsewhere have failed. Bats have the ability to home, and dispersal from the release site was demonstrated or suggested as the cause of failure of several previous bat translocations (Ruffell *et al.,* 2009). As such, DOC's translocation protocol used techniques to reduce the likelihood of dispersal following release. These included the release of captive-reared juveniles to minimize any imprinting on the source location, a two-month captive period in an aviary at the release site to reduce the stress of translocation and encourage imprinting on the release site, and the provision of supplementary food and roosts inside the aviary following release. The translocation was conceived and implemented by DOC. Our role in the translocation was habitat assessment prior to release and post-release monitoring in the year following release, and this report is restricted to these topics.

Lesser short-tailed bat in the aviary prior to release

Goals

- Goal 1: Prior to release, assess the suitability of

Typical habitat quality at the release site

Kapiti Island as a release site for short-tailed bats in terms of its ability to provide roosting habitat. This was a potential issue because the species roosts communally in large, old-growth trees, whereas much of the island's forest is regenerating (Ruffell & Parsons, 2007).

- Goal 2: Assess the short-term success of the translocation, by 1) determining whether bats remained on the island following release and 2) determining if bats maintained condition in the 12-months following release (Ruffell & Parsons, 2009).

Success Indicators

- Indicator 1: Roosting habitat would be considered suitable if suitably-sized cavity-bearing trees occurred at densities similar to those in forests supporting natural short-tailed bat populations (Ruffell & Parsons, 2007).
- Indicator 2: The translocation would be considered successful in the short term if bats remained on the island and maintained bodyweight in the 12-months following release. Breeding of released individuals would also indicate short-term success, but absence of breeding would not constitute failure because it is unknown whether short-tailed bats breed in their first year of life (Ruffell & Parsons, 2009).

Project Summary

Feasibility: The feasibility stage of the translocation was carried out by DOC and is outside the scope of this report, with the exception of the assessment of the suitability of roosting habitat on Kapiti Island. We sampled cavity-bearing trees in each major habitat type and classified them as potentially suitable roosts if tree and cavity dimensions fell within the range of those of known short-tailed bat roosts. We estimated that the island contained thousands of potentially suitable roost trees, and concluded that roosting habitat on Kapiti Island should be able to support a population of short-tailed bats (Ruffell & Parsons, 2007).

Implementation: The implementation stage of the translocation was carried out by DOC and is outside the scope of this report. Release methods are briefly described in the introduction.

Post-release monitoring: We monitored the translocation in the year following release to determine whether bats remained on the island and maintained condition (body weight) (Ruffell & Parsons, 2009). We used three methods to


Diseased bat with inflamed & scabbed ears

determine how many bats remained on the island following release. First, the aviary (in which they were kept prior to release) was left open following release, and we monitored its entrance each night with an infra-red video camera. By keeping track of every entrance and exit following release we could determine the number in the aviary at any time. The maximum number found in the aviary then gave a lower limit of the number of bats on the island at that point in time. Second, we marked bats by catching them when they roosted in the aviary (but no more than once per week), or by harp-trapping at night in the area surrounding the aviary. The number marked also established a lower limit of the number that remained on the island. Third, we radio-tagged two individuals prior to release so that we could track them if other methods failed. The maximum number of bats found in the aviary by video monitoring was ten, three days after release. The number caught and marked was nine, and these bats were all still alive eight months after release. Both bats fitted with radio-transmitters remained on the island following release (Ruffell & Parsons, 2009).

We monitored the condition of the bats by weighing them whenever they were caught, and tested whether the bats lost weight over time. In addition, supplementary feeding progressed from nightly, to periodic, to no feeding, and we tested if weights varied across these feeding regimes. Bats did not show a significant trend in weight loss when regressed across time, although a decrease in weight between periodic supplementary feeding and no feeding bordered on significance. However, weights of bats at the end of the study were well within the range of weights of bats from natural populations (Ruffell & Parsons, 2009). Although bats appeared to maintain normal weight, all bats captured eight months after release had scabbing on the distal ends of their pinnae, some had infected skin beneath, and two were balding. The bats were held captive in the aviary and examined by a vet, who prescribed a course of antibiotics and anti-parasite medication. At this point the study ended (Ruffell & Parsons, 2009). Bats were later re-released by DOC, but were returned to captivity permanently when the problem recurred (J. McIntosh, pers. comm.). A team of vets working on the problem has been unable to determine its cause (L. Adams, pers. comm.). However, two aspects of the translocation may have increased the likelihood of disease. First, captive-reared juveniles may have been prone to disease because they were immunologically naive to environmental pathogens. Second, the bats used the aviary extensively following release, whereas natural populations


Bat with balding on the ventral surface

change roosts frequently, possibly to prevent a build-up of pathogens and parasites (Ruffell & Parsons, 2009).

Major difficulties faced

- Post-release monitoring was made difficult by the fact that short-tailed bats are highly vagile and difficult to observe in the wild. Our monitoring focused on the area surrounding the aviary because bats could most easily be captured and video-recorded there. However, we have no information on any bats that may have remained on the island but left the area of the aviary.
- Detecting change in the condition of the population was made difficult by small sample size, and by the fact that bodyweight may not have been a sufficient indicator of condition. We were unable to statistically detect a loss of condition based on bodyweight measurements, despite the fact that by the end of the study all bats were diseased.
- We were unable to identify the cause of the disease which affected all bats captured at the end of the study. This made it difficult to understand how best to manage the problem, to predict whether it would affect the success of the translocation, or to make changes to the translocation protocol so as to minimize the likelihood of disease in future attempts.
- DOC conducted the feasibility and implementation stages of the translocation, and we cannot comment on any difficulties that may have been faced at these times.

Major lessons learned

- Short-tailed bats can be kept at their release site and survive initially following translocation using DOC's release protocol. This is the first demonstration that any species of bat can be translocated, and DOC's release protocol may be applicable for translocations of other species of bat (Ruffell & Parsons, 2009).
- The aviary was invaluable for post-release monitoring because it provided a location from which bats could reliably be observed and captured. Without the aviary it would have been exceptionally difficult to establish how many bats remained on the island or to monitor their condition. Because bats are generally highly vagile and difficult to observe this would be true for translocations of other species (Ruffell *et al.,* 2009). However, use of the aviary may have contributed to the disease observed (Ruffell & Parsons, 2009).
- Disease was the determinant of the translocation's outcome. We are uncertain whether this was a random event or if disease would be likely to occur in future

translocations. It is possible that factors such as immunological naivety or high use of the aviary increased the likelihood of disease, and modifying the translocation protocol to avoid these factors could increase the likelihood of long-term success in future translocations (Ruffell & Parsons, 2009).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- All previous translocations of bats had failed, with dispersal from the release site the likely cause in several cases. Our study provided the first evidence that bats can remain at the release site and survive initially following translocation (Ruffell & Parsons, 2009).
- The translocation was ultimately unsuccessful, with DOC taking bats into captivity due to disease (Ruffell & Parsons, 2009).

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Re-introduction of rock hyraxes in KwaZulu-Natal, South Africa

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Introduction

Rock hyraxes (*Procavia capensis*) are internationally Red Listed as 'Least Concern' (IUCN, 2008), and in South Africa they were once listed as vermin (Lensing, 1978). However, about 10 years ago, populations in the KwaZulu-Natal province (KZN) became locally extinct from an unknown cause. Subsequently, rock hyraxes have been purchased at annual wildlife auctions in the province for re-introductions, but with no post-release monitoring to determine their success. We therefore chose to monitor the post-release success of re-introducing rock hyraxes into the 656 ha Umgeni Valley Nature Reserve, near Howick, in KZN, which previously had naturally occurring rock hyraxes.

Goals

- Goal 1: Successful re-introduction of rock hyraxes.
- Goal 2: To provide further insight into the fate of translocated/re-introduced rock hyraxes, through post-release monitoring.

Success Indicators

Indicator 1: Self-sustaining population of released animals within one year.

Anaesthetized rock hyrax with radio-collar & ear tag

Project Summary

There were two source populations for the re-introductions a) rock hyraxes kept in captivity for an unrelated research study for 16 months (i.e. 'captive') and b) wild rock hyraxes. Both groups of rock hyraxes were caught at Ladysmith, KZN, about 150 km away from the release site, where they had reached "pest" proportions.

After three months of intensive disease and health monitoring, in November

Typical rock hyrax habitat (yellow arrow showing a released rock hyrax)

2006, 17 rock hyraxes (three adult females, four adult males, two juvenile females, six juvenile males, and two pups) were hard released, mimicking the methods used by the local conservation authority. The released hyraxes (with colored ear tags distinguishing sexes) were monitored daily for the first week, which subsequently decreased in stages to monitoring once during the fourth and fifth months. Each monitoring day was from 15:30 hrs to 18:30 hrs and 06:00 hrs to 09:00 hrs the next day. Monitoring protocol changed from observing the released hyraxes at the release site (within an extensive cliff range), to additional observations at two new sites along the cliff edge, and then to walking two transects along the cliff edge and face (0.95 km and 0.61 km), above where they were released and where there was suitable hyrax habitat. Both transects were walked twice in one monitoring session. A day after release, a maximum of 58% of the released rock hyraxes was seen, and four days after release, captive rock hyraxes occupied various sites other than the release site. The pups were last seen alive 17 days after release and two days later, one of them was found dead. After 87 days after release, none of the captive hyraxes were located.

The wild hyraxes, one juvenile male, one subadult male, two subadult females (one pregnant), and five adult females (all pregnant), were held for 14 days in a metal weld-mesh holding cage at the release site. They all underwent pre-release health checks and were marked with differently colored cable-ties in alternate ears, and all, except the juvenile male, were fitted with radio-collars before being released in October 2007. Monitoring was conducted daily for the first week after release and then every few days until the end of the project. Monitoring sessions alternated between morning (start at 07:30 hrs) and afternoon (start at 16:30 hrs) and lasted until each radio-collared hyrax was located. A 3-tier Yagi aerial and a wide-range receiver (DJ-X10, Alinco Inc., Japan) were used to locate individuals, and positions recorded using a Global Positioning System (GPS) (Garmin 12XL). Nearly all released hyraxes died within 18 days of release, with most being predated (n=6) by caracal (*Caracal caracal*) and crowned eagle (*Stephanoaetus coronatus*). We assumed accidental death from drowning for one hyrax. The fate of the juvenile male was unknown.

An assistant searching for the released rock hyrax near the release site

Major difficulties faced

- Deciding to anaesthetize pregnant females for testing, and to include pups in the release. The decisions were based on preventing additional stress that would be caused by postponing the release. Consequently, one pregnant female did not recover from anesthetic, one pup died from accidental injury during capture process, and the group may have dissolved upon release as a result of the stress.
- Unable to reliably locate released "captive" rock hyraxes after release and then losing track of them altogether.
- Dispersal of released "captive" rock hyraxes from release site.
- Catching rock hyraxes was more difficult for the second release, such that it took eight days to capture nine individuals. This probably caused additional stress to individuals and resulted in a low sample size.
- Whilst in the holding cage the six pregnant "wild" rock hyraxes gave birth to pups, about four days after the pre-release measurements were taken. Some pups were found dead still inside their birth sacks, while others were alive for one day before being found dead and partly eaten.
- High predation, from caracal and/or crowned eagle.
- Refer to Wimberger *et al.* (2009) for further details.

Major lessons learned

- Individual identification and radio-telemetry are vital for post-release monitoring.
- Most of the large ear tags used in the "captive" rock hyrax release were ripped out, and so it seems the small cable ties used in the second release was a much better option for tagging.
- It is possible to place a radio-collar onto the neck of a species without a well-defined neck (rock hyraxes), except that one rock hyrax slipped out of its collar within a few days post-release.
- The importance of social cohesion for a successful release and thus one must never assume that individuals will stay together after release. Our suggestions therefore include capturing family groups (Shier, 2006), or artificially constructing groups that are allowed to bond for several months before release (Jordon, 2003). The latter should be held at the release site in a larger holding cage than that used in this study. The cage should include a rocky habitat with crevices, so that the rock hyraxes could have the opportunity to establish

areas and paths needed to escape from predators once released (Jordon, 2003).

- Refer to Wimberger *et al.* (2009) for further details.

Success of project

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- All wild rock hyraxes, except one whose fate is unknown, were found dead within 18 days of release. Consequently a high or total mortality is assumed for the captive rock hyraxes, which could not be found after three months post-release.

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Woylie re-introduction as part of the Australian Wildlife Conservancy's endangered species recovery program at Scotia Sanctuary, far western New South Wales, Australia

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Introduction

Woylies (*Bettongia penicillata*) were recently reclassified as critically endangered from least concern-conservation dependent following a precipitous decline over 3-5 years (Orell, 2009). Of the two recognized subspecies, *B.p.penicillata* in eastern Australian is extinct, leaving *B.p.ogilbyi* extant in south-western Australia. Today, the woylie is restricted to the south-west of Western Australia, plus several re-introduced populations further east. Three of the re-introduced populations are managed by the Australian Wildlife Conservancy - a non-government organization whose mission is the effective conservation of Australia's wildlife and its habitats. Karakamia has a 251 ha fenced, feral-free area; Yookamurra has a 1,100 ha fenced, feral-free area and Scotia, a large property (64,653 ha) in far-western NSW includes the largest fenced, feral-free area on mainland Australia (8,000 ha in two contiguous blocks). At each location, introduced species (including European foxes, cats) were eradicated from the fenced areas before several highly threatened taxa, including Woylies, were re-introduced. Re-introduced species at Scotia are: boodie (*Bettongia lesueur*), bilby (*Macrotis lagotis*), bridled nailtail wallaby (*Onychogalea fraenata*), greater stick-nest rat (*Leporillus conditor*), numbat (*Myrmecobius fasciatus*) (all previously listed as extinct in NSW), and mala (*Lagorchestes hirsutus*). Translocations of black-eared miner (*Manorina melanotis*) bolstered an existing, small population.

Goals

- Goal 1: To establish a total woylie population in Scotia of over 150 individuals, that is part of a larger meta-population of over 500 individuals spread over at least two sites.
- Goal 2: To establish a woylie population in Scotia Stage 2 that is large enough to function as part of a larger Scotia woylie meta-population requiring minimal management, other than genetic supplementation once each generation to maintain genetic diversity (i.e. over 100 animals).
- Goal 3: To determine whether competition with boodies is a limiting factor for woylies in the more arid parts of their distribution.

Success Indicators

- Indicator 1: Population persistence for at least 50 years with supplementation occurring on a frequency equivalent to once each generation to maintain genetic diversity.
- Indicator 2: More than 35% of woylies' surviving one month after release, which have lost less than 30% of pre-release body mass.
- Indicator 3: Pouch young surviving to permanent pouch exit and young at foot evident nine months after release.
- Indicator 4: Independent sub-adults exceeding 10% of the population at 15 months post-release.
- Indicator 5: F_2 generation exceeding 5% of the population two years after release.
- Indicator 6: Average population size exceeding 150 three years after the release.

Close-up of a woylie

Project Summary

Feasibility: Existing distribution maps suggest woylies were found in a broad range of habitats. Scotia is within this distribution range; its habitats are dominated by mallee eucalypt vegetation atop red sand dunes, with *Casuarina pauper* woodland in the swales. The main agent of decline for Woylies (and other native mammals of similar size) is predation by introduced species, especially foxes and cats. For example, the Woylie made a promising, albeit short-lived recovery in southwest Australia during the 1980s following widespread poisoning programs that targeted foxes (Orell, 2009). The removal of introduced predators such as foxes (*Vulpes vulpes*), feral cats (*Felis catus*) and possibly also introduced herbivores such as rabbits (*Oryctolagus cuniculus*) and goats (*Capra hircus*) rather than habitat selection, are a pre-requisite for the Woylie's survival. Two feral-free, fenced contiguous reintroduction sites of 4,000 ha each are present at Scotia–Stages 1 and 2. Scotia is owned and managed by the Australian Wildlife Conservancy (AWC), which derives most of its operational funding from private donations.

Implementation: Woylies were re-introduced into Scotia Stage 1 in 2004 (172; Finlayson *et al.*, 2008) and have persisted until now. However recruitment has been poor and the population has declined. In contrast, the boodies that were also re-introduced to Stage 1 have increased strongly, and it seems likely that this congener is out-competing the woylies there. Consequently, another re-introduction of woylies was carried out into Stage 2 in 2008, this time in the absence of boodies. Fifty-seven woylies were captured overnight at Karakamia and flown to Scotia the following day. Males and females were then kept separated in quarantine pens for one month where they were fed and watered *ad libitum*, and thereafter they were released into Stage 2.

Typical woylie habitat © Matt Hayward

Post-release monitoring: The two populations have been surveyed (by trapping) four times a year since 2005. The Stage 1 population increased initially because of successive translocations, but after these were completed, the population declined steadily. In contrast, following a single translocation, the Stage 2 population has increased. Individuals from the initial re-introduction are still being trapped (i.e. post-release survival is high) and females invariably have pouched young and breeding amongst F_1 individuals has been detected. In contrast, females in Stage 1 (in the presence of boodies) are successfully reproducing, but they are failing to raise young to independence; this indicates a nutritional constraint during lactation, probably due to competition with boodies.

Major difficulties faced

- **Drought:** Scotia has experienced below average rainfall (<250 mm) for the past decade. This is likely to limit the growth of plants, and exacerbate nutritional constraints of woylies.

Fig. 1: Population estimates for woylies in Stages 1 and 2 and boodies (*Bettongia lesueur*) in Stage 1.

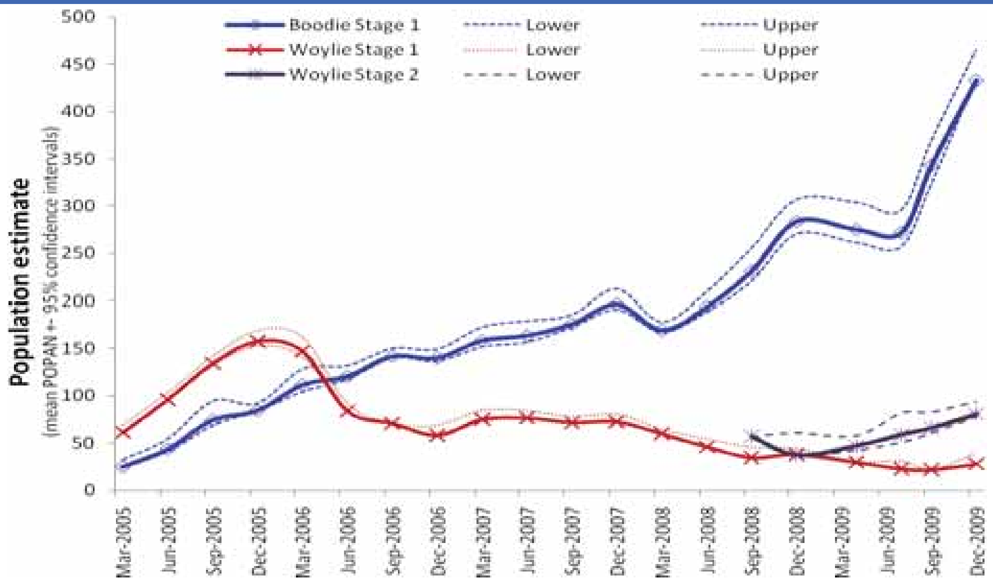
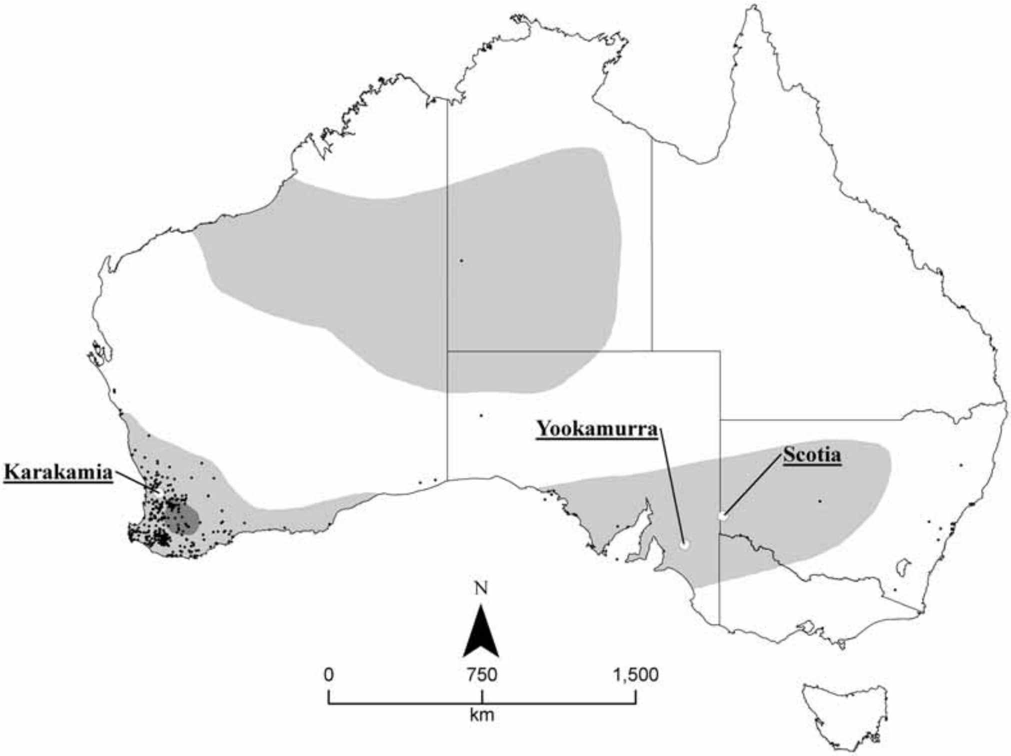


Fig. 2: Current distribution of the woylie (dark grey) with historical distribution (light grey) and locations (points) - Adapted from Nelson (1992).



- **Finding a source population:** By definition, it is difficult to find sources of highly threatened species. The woylie has declined dramatically in the past three years (95% decline; Orell, 2009); the only high density population that has not declined is the AWC-owned Karakamia Sanctuary population in the northern jarrah forest of Western Australia, making it the only population available to use in a re-introduction. Monitoring at Karakamia has demonstrated that it was unaffected by the removal of 57 individuals for the re-introduction to Scotia.

Major lessons learned

- **Confirming the historic distribution and habitat preferences of the species to be re-introduced:** Existing woylie distribution maps are extrapolated from a handful of observations by early European explorers (see figure 1, Nelson *et al.*, 1992) and memories of Aboriginal people (Burbidge *et al.*, 1988). The accuracy of these extrapolations is probably poor, and overlooks finer-scale habitat preferences and community ecology. The poor performance of woylies in Stage 1 compared with Stage 2 suggests that in the particular environment of Scotia, boodies have a competitive edge over woylies. Ecological niche modeling is required to develop a more thorough understanding of the pre-European distribution of the woylie and probably the majority of Australia's arid zone fauna. This knowledge is critical for conservation management.

- **Re-introduction success relies on removing the original agent of a species decline:** In Australia, numerous re-introduction programs have failed because of predation by introduced foxes and cats. The recent decline of the woylie in Western Australia suggests reducing the density of introduced predators is insufficient, especially if it leads to meso-predator release. Fencing for conservation is an essential tool to separate biodiversity from the threat of predation, and can be integrated into programs with a variety of different conservation management approaches.
- **Adequate monitoring is a critical element of conservation activities:** The decline of the woylie over the past three years has been described via an index of capture success (Orell, 2009). There are several reviews assessing the value of indices compared to population estimates. When animals are to be removed from populations, it is crucial to know how many individuals are available to ensure the source population is not decimated by the re-introduction project. Techniques such as mark-recapture or distance sampling are fundamental to modern conservation biologists and should be employed wherever feasible rather than index methods.
- **Continued research into the autecology of the woylie is required:** Despite being the subject of intensive study for over a decade (via Western Shield), we lack information about critical aspects of woylie ecology, such as:
  - ⇒ Pre-European distribution of the woylie.
  - ⇒ Population limitation factors in the absence of introduced predators (e.g. competition and disease).
  - ⇒ Nutrient requirements, particularly during the late stages of lactation.
  - ⇒ Methods to estimate carrying capacity via the availability of food resources.
  - ⇒ Diet compared to resource availability.
  - ⇒ Ecology outside the jarrah forest.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
The woylie re-introduction to Scotia was carried out in two stages; the monitoring information below relates specifically to the population in Stage 2:

- Reason 1: It is too early to determine whether the re-introduction project to Stage 2 has been entirely successful.
- Indicator 1: total Scotia population exceeds 150 individuals, however evidence to date (persistence, recruitment, and population increase in the absence of boodies) suggests the re-introduction will be successful.

- Reason 2: All other applicable indicators have been met well before their deadlines. For example:
- Indicator 2: More than 35% of woylies' survived the first month after release into Stage 2: 84% of these founder individuals have been recaptured in the five trapping sessions post release. These founder individuals have not declined in body mass, easily exceeding the 30% threshold allowed for in the indicator.
- Indicator 3: Pouch young have survived to permanent pouch exit and young at foot were evident six months after the release.
- Indicator 4: Independent sub-adults (new recruits) exceeded 10% of the population at 12 months post-release.
- Indicator 5: F_2 generation does not exceed 5% of the population yet; however, the existing population growth and recruitment suggest they will within two years of release.
- Thus, three of the five re-introduction success indicators have been satisfied well before the deadlines, suggesting the re-introduction is likely to be ultimately successful.

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Re-introduction of the 'extinct in the wild' South Australian mainland tammar wallaby on Yorke Peninsula, Australia

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Introduction

Tammar Wallabies (*Macropus eugenii*) are one of the smallest of the wallaby family (~5 kg) and are distinguished by a dark grey-brown coat, with a pale buff grey belly, reddish-brown arms, feet and flanks and a faint white cheek stripe. Prior to the 20th century, two distinct sub-species inhabited South Australia. Today, only the Kangaroo Island (KI) sub-species remains extant (*M. e. decres*). The South Australian mainland sub-species (*M. e. eugenii*) was extinct by the


Tammar wallaby © SA DEH

1930s, due to broad-scale clearance of its preferred habitats for agriculture and predation by the introduced European red fox (*Vulpes vulpes*) (Jones, 1923-1925; Jones, 1975). The mainland sub-species is listed as 'extinct in the wild', under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999. However, morphometric and genetic studies conducted in the 1990s (Poole, *et al*., 1991; Taylor & Cooper, 1999) revealed that feral populations of tammars in New Zealand had originated from mainland South Australian stock. These New Zealand populations were derived from a private menagerie established in the 19th century by Sir George Grey (former Governor for South Australia, 1841). The rediscovery of this extinct sub-species and the intention of New Zealand's conservation agency to initiate a feral wallaby control program provided the impetus to repatriate the wallabies to their former range in Australia. A detailed translocation proposal was developed to guide the re-introduction program (DEH, 2004).

Goals

- Goal 1: To establish a captive breeding colony of mainland tammars, to enable the production of individuals for a re-introduction program.
- Goal 2: To select a suitable release site within the wallaby's former range and manage current threatening processes.
- Goal 3: To establish a self-sustaining, free-ranging, viable population of mainland tammar wallabies within their former range.

Success Indicators

- Indicator 1: The production of sufficient individuals to enable numerous re-introduction events to occur.
- Indicator 2: The development and maintenance of an essentially fox-free release environment and the mediation of other significant threatening processes.
- Indicator 3: A re-introduced population of mainland tammars exhibiting a positive population growth rate.

Project Summary

Establishment of a captive colony: During 2003-2004, 85 adult wallabies (33 males:52 females) and seven female pouch young were repatriated from New Zealand. The wallabies were held in captivity at Monarto Zoo, where comprehensive health and disease checks were performed, followed by a strict six month quarantine period. From 2004, female KI tammars were used as surrogate mothers in a cross-fostering program (see Taggart *et al.*, 2005), to increase the reproductive output of the mainland tammars. Between 2004 & 2006, 110 mainland tammar young were cross fostered, with a survival rate of 80%. The cross-fostering program ceased in 2007, due to an outbreak of macropod herpes virus (MaHV-1) within the KI tammar surrogate population. Between 2004-2007, the captive breeding program produced a total of 178 wallabies for re-introduction. The program ceased in 2008, with the remaining 42 wallabies scheduled for relocation to display populations at Australian Zoos, enabling the potential re-constitution of the breeding population at a later date.

Site selection and management: Following a rigorous selection process, Innes National Park (NP) (Yorke Peninsula, South Australia) was chosen as the re-introduction site because the park i) is located within the species historic range, ii) is of sufficient size to sustain a population of tammars, iii) contains large areas of suitable habitat and iv) retains on-site personnel, enabling regular monitoring and management. An intensive predator control program was established in 2003 to control the abundance of European red foxes (fortnightly 1080 ground baiting), and continues to date. Analysis of fox activity (passive tracking stations; Engeman & Allen, 2000) between 2003 and 2007 indicated a significant reduction in fox abundance on the park. In 2006, a community-based fox control program was initiated on lands surrounding Innes NP, to reduce the immigration rate of foxes into the park and thereby lower the intensity of predator control required on the park. By 2008-2009, 24 landholders were participating in the program, covering approximately 60,000 ha.

Population re-introduction: Prior to release, health and condition checks were performed on all wallabies. The identity of each wallaby was recorded using sub-cutaneous passive integrated transponders and each wallaby was fitted with either a radio or GPS tracking collar, to monitor post-release survival. Re-introduction events followed “hard-release” protocols, with the wallabies held for several hours, until dusk, in temporary pens. Two release sites were utilized, spaced 1.5 km apart. Demographic data were collected on the population post-release, via. radio-telemetry, trapping and spotlight surveys. A trial release of ten tammar wallabies was undertaken in November 2004. All survived the first three months, before four were taken by a fox during a single week. The fox control program was intensified and no further predation was noted. At 12 months post-release, only four wallabies remained alive (40% survival). The additional two mortalities were due to a collision with a car and death from unknown causes. A second release of 36 wallabies was undertaken in June 2005. Ten of these wallabies died within the first month and a further nine had died by the end of three months. Autopsies attributed these deaths to cachexia (i.e. starvation), believed to be due to low nutrient levels in winter feed and the inability of animals to transition and survive winter conditions. Following the onset of warmer weather and improved pastures, the survival rate increased significantly. Fox predation was implicated in subsequent deaths and, by the end of 12 months, only five wallabies remained alive (14% survival). The remaining five animals were observed to recover their condition and to have successfully raised young. The learning from the second release was that winter is an unsuitable time to undertake re-introductions - of this species, due to low nutrient levels in available forage.


Tammar cross-foster © Julia Bignall

A further 36 wallabies were released in October 2006. Ten wallabies died within the first month from an unknown infection (evidenced by haemorrhagic lungs at autopsy), but the survival rate subsequently stabilized. At 12 months post-release, 22 wallabies remained alive (61% survival). A planned release for 2007 was postponed due to the discovery of MaHV-1 within the captive tammar populations. However, subsequent analysis of blood samples collected from local western grey kangaroos *(Macropus fuliginosus*) and the Innes' tammar population confirmed the presence of MaHV-1 at the site. A fourth release of 43 wallabies occurred in October 2008. Of these, seven died within the first month and an additional five were known to have died within the first 12 months (70% survival). However, radio collar malfunctions meant the fate of an additional 11 wallabies was unknown. It is possible that up to 24 may have died during the first 12 months (47% survival rate).

Current estimates suggest that there are between 36 and 49 re-introduced wallabies alive on Innes NP, following five years of releases. The wallabies are known to be breeding at the site, with fourth generation Innes-born animals detected. In total, 22 Innes-born wallabies have been captured, of which 13 are thought to have subsequently died (41% survival rate). It is highly probable that there are numerous Innes-born animals that have evaded capture, further contributing to the population.

Major difficulties faced

- Following early discussions with landholders adjacent to Innes NP, strong opposition to the re-introduction developed within the local farming community (Peace, 2009). The primary point of contention revolved around the potential for the Innes population of mainland tammars to quickly become over-abundant and migrate off-park, resulting in significant damage to crops across the southern Yorke Peninsula and subsequently impacting on farm productivity. Although an early goal of the Recovery Team, the concept of re-establishing the mainland tammars across Yorke Peninsula was quickly reversed, in response to the community's concerns. Local distrust of the capacity to manage the wallaby population remains strong.

Tammar release in 2008 © Jasmine Swales

- Due to the relatively small size of Innes NP (9,232 ha) and the creation of a dispersal sink, an intensive effort was required to manage the abundance of European red foxes.
- Disease and health issues had a significant effect on survival rates following the second and third releases at Innes NP and disrupted the captive breeding program at Monarto Zoo. The observation that cachexia led to significant mortalities - following the second release, provided valuable insights into the suitable timing for subsequent releases. An unidentified virus resulted in considerable losses during the third re-introduction. A census of pathogens at the release site may have enabled better preparation prior to the releases.
- All released wallabies were fitted with tracking devices that incorporated mortality sensors, allowing for the rapid retrieval of corpses. However, the distance between the release site and wildlife veterinary facilities made it difficult to positively identify the cause of death in many instances. This was somewhat overcome by training local national park staff in field necropsy techniques.
- An unforeseen threat to the wallabies at Innes NP was collisions with vehicles, resulting in the mortality of at least six individuals. Innes NP is a major tourist destination in South Australia, with many visitors using the bitumen road that encircles the park to access its numerous beaches. To limit future tammar losses, the speed limit was reduced along the section of road adjacent to the wallaby release site, warning signs were erected and rumble strips were installed on the road.

Major lessons learned

- It is essential that community consultation occur well in advance of any planned re-introductions to identify and clarify any issues and to develop community support and ownership for the project. Substantial confusion developed in the current project, because the community was equating the release of mainland tammars on Yorke Peninsula to the status of Kangaroo Island tammar wallabies. Foxes have not become established on Kangaroo Island and agricultural clearance has resulted in the creation of large areas of the wallaby's favored edge habitat. As such, Kangaroo Island tammars exist at high densities and are considered a pest species.
- Re-introduced cohorts suffer from initial heavy losses, particularly during the first month post-release. However, survival rates stabilize after several months

and the wallabies acclimatize to their new environment and commence breeding.

- Despite the considerable effort allocated to fox control, it quickly became apparent that even low densities of foxes could severely impact on the Innes' tammar population, as witnessed by the loss of 40% of the first release group to (arguably) a single fox. With fox control at a maximum possible level, the success of the program hinged on whether reproductive output would outweigh the losses incurred from (primarily) fox predation. The answer to this question is, as yet, unclear.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Despite numerous re-introductions over five years, it remains unclear as to whether a self-sustaining population of tammars has been established on Innes NP.
- Managing the complexities of this project has required a collaborative effort by dedicated staff from a wide range of institutions, including State and regional conservation agencies, tertiary institutions and zoos.
- This project demonstrated the feasibility of cross-fostering to accelerate the production of individuals of this species for reintroductions. On average, cross-fostering resulted in a two to three fold increase in production of young.
- Community engagement was handled in a reactive fashion and required the allocation of considerable resources during the first 18 months of the program.
- The intensive monitoring program enabled the identification of causes of mortality (predation, cachexia, vehicle collision, virus), allowing for the implementation of management actions and the modification of release protocols.
- Although the level of fox immigration into the core re-introduction site is considered low, it is not apparent whether predation is being offset by recruitment.
- The intensive community engagement and monitoring program were only possible because of the allocation of two dedicated staff to the project.
- The low density fox environment on Innes NP has also providing a haven for a range of other National and State threatened species, including malleefowl (*Leipoa ocellata*), western whipbird (*Psophodes nigrogularis nigrogularis*), hooded plover (*Thinornis rubricollis*), painted button-quail (*Turnix varia*) and heath goanna (*Varanus rosenbergi*). The influence of the fox control program is further highlighted by the recording of a bush stone-curlew (*Burhinus grallarius*) in the reserve in early 2009; a species which has not been recorded on the Yorke Peninsula for more than 40 years.
- The primary contemporary risk to the program is an insecurity of funding support.

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The re-introduction of the yellow-footed rock-wallaby to the northern Flinders Ranges, South Australia

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Introduction

While the yellow-footed rock-wallaby (*Petrogale xanthopus*) is classified at species level by the IUCN (2008) and the Australian Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 as 'Near Threatened', there are two disjunct sub-species. The nominate sub-species *P. x. xanthopus* occurs in limited areas of South Australia and New South Wales, where it is listed as ‘Vulnerable’ and ‘Endangered’ respectively. Historical data suggests that there has been a decline in yellow-footed rock-wallaby numbers since early European settlement, in large part due to pastoral development and intensive hunting for pelts. Today, the major threats are competition with introduced herbivores, and predation by introduced predators, primarily foxes (*Vulpes vulpes*). Rock wallabies *P. x. xanthopus* disappeared from Aroona Sanctuary, in the northern Flinders Ranges in 1983. The suggestion to trial the re-introduction of captive-bred rock-wallabies to the wild was first raised at the National Rock-Wallaby Symposium of 1994. Genetically managed and successful captive breeding of the species at Adelaide Zoo meant that this was the obvious location from which the re-introduction could be co-ordinated. The first re-introduced captive-bred yellow-footed rock wallabies were released into Aroona Sanctuary in September 1996.


Yellow-footed rock wallaby © T. P. Morley

Goals

- Goal 1: Trial the viability of the re-introduction of captive bred yellow-footed rock wallabies.

Aroona dam © T. P. Morley

- Goal 2: To establish a self-sustaining population at the re-introduction site.
- Goal 3: To include the local community in a partnership with the project that involves all aspects of the re-introduction.
- Goal 4: To establish guidelines for the re-introduction of rock wallabies which can be utilized by other conservation programs.

Success Indicators

- Indicator 1: Identify vital considerations for the successful re-introduction of captive born macropods.
- Indicator 2: A self sustaining population in the short, medium and long terms.
- Indicator 3: Adoption of a conservation project by local community for sustainability.
- Indicator 4: Ensure accurate and eitiological diagnosis of cause of death. This would further define the primary threatening processes acting upon captive-born, re-introduced, YFRW.

Project Summary

Feasibility: The Aroona Sanctuary (declared 1995) is located approximately 560 km north of Adelaide in close proximity to the township of Leigh Creek, in the arid environment of the northern Flinders Ranges. There are several other protected areas in the region including the Flinders Ranges National Park, Gammon Ranges National Park and the Lake Torrens National Park, all with boundaries within a 100 km radius of the Aroona Sanctuary. The property occupies an area of approximately 3,485 ha and is characterized by a diverse range of landscapes from wetlands, saltbush rangelands and rocky outcrops. Aroona Sanctuary provides an important refuge for native flora and fauna and acts as an important cultural, educational and recreational site (Robins *et al*., 2007).

Ferris & MacDonald (1995) states that the Aroona Sanctuary was chosen as the preferred site for re-introduction of the yellow-footed rock-wallaby for several reasons, including:

- A suitable habitat.
- The area is surrounded by reasonably sound fencing as at the time the area was actively managed by environmental staff from Electricity Trust of South Australia (ETSA).
- ETSA was already conducting some feral animal control.
- The security of the long-term nature of the project through the site's tenure.

- The infrastructure created for the coalmine and Leigh Creek township provides excellent accessibility for such a remote and arid site.
- Yellow-footed rock-wallabies had been recorded in the vicinity but were thought to now be extinct.

Implementation: Feral animal control commenced in July 1995, prior to the initial rock-wallaby release. Vegetation assessments were undertaken using photo-monitoring, grazing exclusion areas and visual monitoring. Release animals were selected based upon genetics, age, body condition, reproductive fertility, dental health, physiological stress response and health. An extensive trapping program, targeting any macropod within a 50 km radius of the release site, was conducted in the year before release to provide a detailed list of parasites and disease endemic to the release area. All proposed release animals were tested to be free from any locally exotic diseases and an attempt was made to insure inherent immunity was encouraged against parasites identified in the wild populations. To reduce the impact of the sudden changes in gut flora required in a hard release, animals were housed in large enclosures supporting mature growths of native vegetation and supplementary foods were kept to a minimum. Six weeks prior to release food types, similar to those at Aroona Sanctuary, were introduced to the enclosures.

To maximize genetic diversity of founder animals and encourage cohesion between the individuals immediately after release, joeys were removed from females one month prior to release (and hand-reared to remain in captivity). Diapause joeys, sired previously by genetically unrelated males, would subsequently be born around the time of release and emerge from pouch 5-7 months later. In addition, the pouch young manipulation stimulated all females to undergo an oestrus period at the time of release. Combined with housing the group as a functioning colony in captivity, the reproductive state would encourage cohesion in the group at release. This would reduce the likelihood of immediate and risky dispersal from the release site prior to individuals setting up home ranges. Added benefits of the reproductive manipulation is that there was minimal energy demand on the mature females at release with nil or minimal lactational demands and no risk of joey rejection. All rock-wallabies were transported to the release site by car. Fresh fecal pellets collected from the pre-release enclosures were spread on the rocky outcrops of the site prior to release. The rock-wallabies were vet-checked on site, and released in the late afternoon. Exposure of the release, and post-release monitoring to the local community has been extensive, and resulted in positive and encouraging support. This was greatly assisted by the involvement of the Leigh Creek Area School.

Post-release monitoring: Ten wallabies were released in September 1996, with a further two in 1997. Using three hand-held radio-tracking receivers, the wallabies were tracked remotely, using triangulation from fixed points over the release gully. This method was chosen to avoid human interference but allow constant monitoring for rapid retrieval. They were first tracked four hours post-release, and then every six hours thereafter for the first six weeks. Tracking teams were rotated every five days, with one day cross-over for continuity.

Release gully © T. P. Morley

Triangulation allowed for the movement patterns to be plotted. After six weeks, a single radio-tracking receiver was used twice daily, purely to determine whether an animal was still alive and/or in the area. Any animals returning a mortality signal were tracked down and presented for a thorough pathology investigation. In 1998, with the financial assistance of Leigh Creek School, three tracking stations were erected, allowing animals fitted with radio collars to be monitored, and the success of the population to be established. Software provided by Flinders University allowed this monitoring to occur 24 hours per day. Mark-recapture monitoring by PhD student Steve Lapidge (quarterly, 1998-2001) concentrated on research into diet and reproduction. From 2001-2008, bi-annual monitoring of the population, through trapping and radio-tracking, continued through a partnership involving Zoos South Australia, Conservation Volunteers of Australia (CVA) and Flinders University, supported by invaluable assistance from Flinders Power and the Leigh Creek community. Today, the biannual population monitoring is undertaken by Zoos SA, with data being included in state-wide yellow-footed population monitoring by Ecoknowledge.

Major difficulties faced

- Aroona Sanctuary encompasses Aroona Dam, a permanent water supply that attracts introduced herbivores and carnivores, along with above-normal macropod numbers. The artificially high presence of these animals places greater stress on the habitat in which the rock-wallabies live. Yellow-footed rock-wallabies do not require large, permanent water sources, and so Aroona Dam could arguably be hindering the population.
- On-going communication and education has been required to ensure continual support from the local community, particularly from some of the pastoralists.
- The temporary nature of the mine and its support of Aroona - hopefully the status of “Sanctuary” will add some security for the site.
- Unable to sustain momentum and run further projects in this location. Scope for introduction of genetically unrelated animals or other species has not yet been realized. Consequently, the project is running at a low input, maintenance level and local support is fading with a changing community.

Major lessons learned

- Captive-bred rock-wallabies are suitable for release.

- Dispersal and starvation shortly after release can be minimized with pre-release conditioning and reproductive manipulation.
- A comprehensive veterinary component to the program is vital.
- Community involvement allows growth and sustainability of a project.
- “Dead animals” are not a “failed project” if a high standard of post-release monitoring reveals the cause of death and thus progress.
- A small team working with simple, logical, science-based objectives can go a long way, with minimal funding and in a short time.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Captive-bred rock-wallabies were released successfully. Since the initial release, multiple generations of rock-wallabies have been born and survived on the site for over 13 years, with more than 70 different animals recorded.
- The local community has played a large role in the success of this project. After 14 years there is still some local involvement through feral animal control, the pre-baiting of traps for population monitoring, land management and general conservation consciousness.
- Methodologies and experiences acquired through this release have been used for later rock-wallaby releases, namely the re-introduction of the Victorian brush-tailed rock-wallaby (*P. penicillata penicillata*).
- Successful collaboration of many partners from government, private, industry and community.
- Prompted specific and detailed genetic investigation of the yellow-footed rock wallaby.

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The re-introduction of African wild dogs in South Africa

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Introduction

The African wild dog (*Lycaon pictus*) is classified as 'endangered' according to the 2009 IUCN Red List of Threatened Species. Major threats to wild dogs include human-induced mortality, habitat transformation, prey depletion and exposure to infectious diseases (Woodroffe *et al.*, 2004). Therefore, the traditional focus of wild dog conservation efforts has been mainly on mitigating these negative factors in the few remaining viable populations in large protected areas (Woodroffe *et al.*, 2004). However, considering increasingly fragmented landscapes, the absence of sufficiently large protected areas containing suitable wild dog habitat aside from Kruger National Park is exactly the problem in the context of South Africa. After a population and habitat viability assessment for wild dogs in southern Africa was conducted in 1997, a complementary conservation strategy was proposed (Mills *et al.*, 1998) and subsequently implemented (Davies-Mostert *et al.*, 2009) in South Africa: separate subpopulations of wild dogs in several small (<1000 km²), geographically isolated and predator-fenced conservation areas are managed as a single metapopulation. This innovative but intensive management approach involves the re-introduction of wild dogs into suitable conservation areas, and periodic translocations among them to mimic natural dispersal and maintain gene flow.

Goal

- The predetermined goal was to create a second viable population of wild dogs in South Africa to supplement the one occurring in Kruger National Park (Mills *et al.*, 1998).

Success indicator

- The predetermined indicator of success was to establish a so-called 'managed metapopulation' with a minimum total of nine packs of wild dogs over a 10 year period (Mills *et al.*, 1998).

Project Summary

Ideally, species should be protected in areas large enough to allow for natural demographic and genetic processes. However, in reality, species often occur in small and isolated patches of suitable habitat embedded in human-dominated landscapes. In the context of South Africa, numerous such conservation areas have been created after political transformation that has led to increased legislative and socio-economic incentives for conservation, with financial considerations being the main driver. Following on the proposal of Mills *et al.*

(1998), the Wild Dog Advisory Group of South Africa (WAG-SA) was formed to guide and implement the metapopulation management plan (Davies-Mostert *et al.*, 2009). Membership of WAG-SA is broad and includes conservation scientists, managers and policy makers. WAG-SA members meet quarterly to discuss issues pertaining to, for example, the translocation of wild dogs among existing sites and re-introduction into new sites. Wild dogs have been re-introduced into nine state protected or privately owned areas that together form the official metapopulation (Davies-Mostert *et al.*, 2009), with additional re-introductions into four private game reserves whose owners are not WAG–SA members (Gusset *et al.*, 2008). Through these re-introductions, the geographic range of wild dogs in South Africa was expanded by about 4,600 km². The number of wild dogs in the official metapopulation peaked at 264 animals in 17 packs (Davies-Mostert *et al.*, 2009), and thus exceeded the size and density of the naturally viable wild dog population in Kruger National Park. The inherent vulnerability of small subpopulations, however, has entailed increased management requirements and thus limited the animals' behavioural decision to disperse and form a new pack.

Radio-collared wild dog destined for re-introduction in South Africa © Markus Gusset

Many early attempts to re-introduce wild dogs met with limited success due to various, often unknown causes, and re-introduction is not considered a high priority in wild dog conservation (Woodroffe *et al.*, 2004). Nevertheless, particularly with the implementation of the metapopulation management plan, wild dogs have been successfully re-introduced into various sites in South Africa, with high survival rates of the released animals and their offspring, and with offspring produced in all release areas (Gusset *et al.*, 2008). Wild dogs clearly do well in these small areas, as manifested in favourable demographic parameters (Davies-Mostert *et al.*, 2009). Wild dog re-introductions and translocations are considerably expensive, logistically complex and labour intensive (Lindsey *et al.*, 2005). However, these challenges seem not to have deterred those in charge from re-introducing wild dogs in South Africa. (The willingness to harbour wild dogs was an overwhelmingly important aspect in re-introduction site selection.) It is unlikely that the money spent on the managed meta-population in South Africa would have been made available to wild dog conservation elsewhere. Furthermore, re-introduced wild dogs can at least partly offset financial expenditures, as they can be used profitably and sustainably for ecotourism (Lindsey *et al.*, 2005). Besides financial benefits attributed to the wild dogs'

Release of wild dog in South Africa
© Michael Somers

improved profile from the mid-1990s, there is evidence for re-introduced wild dogs to have beneficial consequences as an umbrella, flagship and keystone species. Collectively, this will hopefully provide incentives for owners of small conservation areas to form larger conservancies by removing internal fences.

Another achievement is a better understanding of what makes wild dog re-introductions successful thanks to continuous pre- and post-release monitoring and evaluation (Gusset, 2009), although data recording has at times been insufficient. Perimeter fences can at least partly prevent wild dogs from straying onto neighbouring land and thus coming into potentially fatal contact with humans. Nevertheless, deliberate and accidental killing by people still accounts for the majority of fatalities in the metapopulation. Canine distemper and rabies transmitted from black-backed jackals (*Canis mesomelas*) were the only natural causes wiping out two entire re-introduced subpopulations, while timely vaccination attenuated a further rabies outbreak. Wild dogs bred or raised in captivity can be used for re-introduction, if necessary, when first bonded with wild-caught animals to facilitate the transfer of socially learned survival skills. Keeping wild dogs in a pre-release enclosure to ensure social integration in artificially composed packs before release is the most important factor in promoting re-introduction success (Gusset *et al.*, 2008), as wild dogs rely on a cohesive social group for survival and successful reproduction. This can be particularly important for wild dogs captured as ‘problem animals’ that do not constitute natural disperser groups. However, problems in finding suitable mates prevented natural pack formations after release. Continuous translocations of wild dogs among the small, geographically isolated release areas will be an unfortunate necessity, unless levels of natural dispersal can be sufficiently enhanced by increasing human tolerance of wild dogs to ideally render a self-regulating metapopulation possible.

Major difficulties faced

- The collective impact of wild dogs on game species affects predator - prey relationships, necessitates costly restocking of the prey base or leads to the removal of wild dogs.
- Problems with wild dogs breaking out of release areas and coming into conflict with human interests lead to retaliatory killing, laborious recapture or removal of wild dogs.

- The placement of wild dogs relies on demand and supply, which leads to the conundrum of intermittently having to manage ‘surplus’ animals of an endangered species.
- The uncoordinated re-introduction of (unidentified) wild dogs into private game reserves whose owners are not willing to participate in the official metapopulation.

Wild dog snared on a farm in South Africa
© Craig Jackson

Major lessons learned

- Metapopulation management is likely to become increasingly important for a wide range of species due to intensifying habitat fragmentation that prevents natural immigration.
- Applying an evidence-based approach to complement the experience of conservation practitioners improves the efficiency and effectiveness of re-introduction attempts.
- Promoting re-introduction success in social species like wild dogs depends on behavioural considerations that need to be incorporated in management decisions.
- Implementing a national conservation strategy involving multiple stakeholders (government, community and private participants) with different objectives is possible.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reasons for success/failure:

- The predetermined goal of creating a second viable population of wild dogs in South Africa was achieved, but there are difficulties (see above) that limit this conservation strategy.
- The predetermined success indicator of establishing nine packs of wild dogs in the managed metapopulation was reached in half of the allotted 10 years.
- The project was successful owing to a strong collaborative approach under the leadership of WAG–SA, paired with the willingness to try and learn from new approaches.

- Despite initial doubts, wild dogs have proved to be a species behaviourally amenable to re-introduction, which is encouraging for metapopulation management elsewhere.

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Re-introduction and translocation of golden lion tamarins, Atlantic Coastal Forest, Brazil: the creation of a metapopulation

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Introduction

The golden lion tamarin (*Leontopithecus rosalia*), IUCN listed in 2003 as Endangered B1ab(iii), appears in the Brazilian Red List as Endangered (2009), CITES App. I (1975). This species is found in the lowland Atlantic Forests of the state of Rio de Janeiro, a biodiversity hotspot. The Golden Lion Tamarin Conservation Project (GLTCP) has focused its current conservation efforts on the region of the São João river watershed, where over 90% of the existing population lives and where there is the largest amount of remaining forests. The region has multiple land uses, agriculture, cattle and urban expansion predominate. The coastal areas are under intense urbanization pressure. The golden lion tamarins have been used effectively as a flagship species for the conservation of biodiversity in the Atlantic coastal rainforest of Brazil (Dietz, 1994).

Goals

- Goal 1: Re-enforce and expand the wild population by increasing its size, genetic diversity and genetic flow to form a functional metapopulation.
- Goal 2: Contribute to the science of conservation biology by testing the most cost-effective methods for re-introduction, translocation and management of a meta-population.
- Goal 3: Increase available habitat by protecting forest patches in private lands that receive reintroduced animals, creating linkages between forest patches by

construction of corridors and promoting the creation of protected reserves, public and private.

- Goal 4: Increase conservation education and outreach programs to influence public opinion and policy at local and national levels.
- Goal 5: Manage the wild and captive population as a single metapopulation.

Success Indicators

- Indicator 1: Number of surviving and reproducing tamarins in private lands and reserves (objective is a minimum of 2,000 tamarins in viable connected habitat by 2025) in viable populations managed as a metapopulation.
- Indicator 2: Measures of genetic diversity over time: pedigree analyses and molecular genetics.
- Indicator 3: Total area of habitat protected formally or by personal commitment that has wild living tamarins (minimum objective is 25,000 protected and connected hectares by 2025).
- Indicator 4: Number of private landowners adhering to the re-introduction program and to the conservation of the golden lion tamarins.
- Indicator 5: Number of viable populations.
- Indicator 6: Inclusion of the conservation agenda in the land use planning of the region.
- Indicator 7: Number of scientific publications, theses, dissertations and other academic documents.

Project Summary

The GLTCP has used both re-introduction and translocation as part of a broad conservation program to save the species from extinction and to protect its habitat, the lowland Atlantic forest (Kleiman & Rylands, 2002; Oliveira *et al.*, 2008). The conservation goal, defined in 1984 and modified by successive PHVAs (1991; 1997; 2005), is to have 2,000 tamarins living in 25,000 ha of protected and connected forests. Currently, we estimate 1,600 tamarins in about 15,000 ha of forest (Holst *et al.*, 2006; Oliveira *et al.*, 2008). In the early 1980s there was a strong need to augment the population and to expand its geographic distribution in the wild. Tamarins were first introduced into a protected area (The Poço das Antas Reserve) and thereafter into privately owned forests in order to protect those remaining habitats. Re-introductions occurred from 1984 to 2000 (159 animals) and a group of five wild-born animals were re-introduced in 2005. The initial conditions that supported the re-introductions included: a self-sustaining captive population, a protected area,

Golden lion tamarin with young

knowledge of behavior and ecology from captive and field studies, the presence of an *in situ* conservation program and sufficient resources (Beck *et al.*, 2002; Kleiman *et al.*, 1991). The forests in the region were fragmented and the wild populations were isolated from each other, most consisting of small groups. The involvement of local landowners also was key to developing a pro-conservation attitude in the region. Today, over 40 properties have descendants of the re-introduced tamarins and >10 have become formally designated as Permanent Private Reserves (RPPNs).

Conducting transects in the forest

The re-introduction project used a soft release protocol and tested the influence of pre-release training, post-release management and origins (wild versus captive) on survival to two years after release or birth in the wild (see Kleiman & Rylands, 2002). Survival was significantly higher for those under intense post-release management and the wild-born offspring of the re-introduced adults. There was extensive monitoring after release to account for animal losses, to gather data on body condition, demography, genetics (pedigree and molecular) and behavior (Beck *et al.*, 1991; Kleiman *et al.*, 1991). The behavioral data allowed us to compare the performance of animals and their wild-born offspring in behaviors related to survival and reproduction (Stoinski *et al.*, 2002). The data on demography, genetics and body condition allows us to model population viability and to adaptively manage the groups and populations. The re-introduction protocol is well established. The translocation of wild tamarins used the knowledge developed from the re-introduction project and ecological studies as well as a 1991 complete census to move isolated groups of tamarins from small patches of forest that were at high risk of loss to a large protected area (2,400 ha) of good quality habitat (see Kleiman & Rylands, 2002; Kieurlff & Rylands, 2003). From 1994-1997, six social groups (42 animals) were translocated to forest managed by the national railroad company. In 1997, the government transformed this forest into the União Biological Reserve. The groups were monitored to gather data on demography, genetics, behavior and habitat use. This population has expanded to over 200 animals. This project provided valuable information about behavior and habitat use after colonization of a new area.

One key aspect of the success of these conservation efforts has been the multi-institutional commitment in both *in situ* and *ex situ* conservation. The involvement of zoos (>100) was crucial for maintaining a well-managed captive population and for supporting the *in situ* efforts. One innovation was developing and implementing “free-ranging” exhibits in zoos, which provide tamarins the opportunity for complex interaction with a natural environment, and allow the observers to judge the capabilities of individual animals. A system of “gateway” zoos with free-ranging exhibits was established to channel the re-introductions (Stoinski *et al.*, 1997). A second key aspect was the Brazilian team, which was institutionalized as an NGO in 1992: the Golden Lion Tamarin Association (i.e., Associação Mico Leão Dourado). This team of local well-trained and motivated individuals has carried out monitoring and management of the animals, identified potential forest patches for re-introduction and developed education and outreach programs, influenced public policies locally and nationally. The AMLD also deals with threat reduction, e.g. reducing poaching and hunting, further habitat destruction and controlling invasive introduced marmosets. The NGO has been instrumental in developing a conservation attitude in the region, mainstreaming the conservation agenda in watershed management plans, recruiting local landowners for the re-introduction program, maintaining conservation education programs and developing a model landscape approach to connect the populations of tamarins (see Kleiman & Rylands, 2002; Oliveira *et al.*, 2008)). The translocation team helped to establish interactions with government and NGO institutions in the coastal towns that harbor small forests with groups of tamarins. One important partner is Brazil’s Ministry of the Environment (through IBAMA and ICMBio) which manage the reserves, provides logistic support and head the Internal Management Committee for Lion Tamarins (ICCM). Universities and research institutions from the United States (University of Maryland, Smithsonian’s National Zoological Park) and Brazil (UENF; FIOCRUZ; CPRJ) have contributed with studies on tamarin ecology and behavior, parasitology, vegetation quality, and threats to the tamarins (introduced marmosets and hunting).

The GLTCP uses the knowledge obtained and the database created from over 25 years to manage the wild populations as a meta-population (Oliveira *et al.*, 2008; Holst *et al.*, 2006). Three of the six existing potentially viable populations were the result of reintroduction (N>600 individuals) and one the result of translocation (N=200), that is, more than 50% of the tamarins and habitat available. These populations contribute to retention of overall genetic diversity, reduce the effects of genetic drift and inbreeding, and add new genetic diversity from captivity and from the isolated coastal populations (Dietz *et al.*, 2000; Grativol *et al.*, 2001). The meta-population management includes establishing connectivity among populations through forest corridors and translocations. Additional, re-introductions are not planned but have not been excluded as a possibility to form new populations as additional forests are acquired or to replace locally extinct populations. The challenges posed by meta-population management will require new techniques for translocation, e.g. where, when and how animals should be moved so as to optimize the impact on demography, genetic flow and spatial distribution over the landscape. Additionally, more efficient methods for monitoring population size and spatial distribution are being developed to evaluate success and increase cost effectiveness.

Nest box at re-introduction site

Major difficulties faced

- Mortality of captive born animals.
- Complex research permit structure.
- Need for intense and long-term monitoring.
- Introduction of non-native invasive marmosets.
- Access to forests in private lands.
- Lack of a scientific knowledge base about re-introductions at onset.
- Changing government organization and national economic conditions (e.g. inflation and currency).
- Securing funding for a long term project.

Major lessons learned

- Importance of a well managed self-sustaining captive population.
- Importance of long term post-release monitoring.
- Importance of a well trained knowledgeable local field team and scientists.
- Importance of a scientific (experimental) approach, i.e. hypothesis testing.
- Importance of strategic planning, adaptive management and critical evaluation.
- Importance of developing strong institutional and fund raising capabilities.
- Need for a multidisciplinary approach.
- Need for strong local leadership.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The descendants of the re-introduction program represent over 50% of the tamarins living in the wild.
- A series of techniques for re-introduction have been tested and we can now do them reliably.
- The geographic distribution increased by 60%, with many private landowners protecting remaining forest.
- The translocation project resulted in a self-sustaining population in a newly designated protected area.
- A metapopulation of six sub-populations has been established with a feasible management plan.

- A local public that is more conscious and supportive of conservation initiatives.
- Positive input into the local economy.
- Training of numerous Brazilians in wildlife conservation and management.

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Habitat Ecologique et Liberté des Primates: re-introduction of central chimpanzees to the Conkouati-Douli National Park, Republic of Congo

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Introduction

The overall mission of the Congolese based charity Habitat Ecologique et Liberté des Primates (HELP) is to "protect primates, their habitat and everything that ensures the balance of their existence". The re-introduction of central chimpanzees (*Pan troglodytes troglodytes*) is one activity that HELP executes to realise this mission. All species of chimpanzee are classified by IUCN (2008) as Endangered, listed on CITES App. I and Class A of the African Convention. Chimpanzees are also protected under Congolese law and classified as "espèces intégralement protégée". Whilst the reasons for diminishing chimpanzee populations are largely understood (high levels of habitat destruction and degradation, poaching and disease transmission), they are not declining or easily reversible. The HELP re-introduction site is located within the Conkouati Douli National Park (CDNP), Republic of Congo, on the border with Gabon. The CDNP, an area of high biological importance, covers 500,000 ha and contains a large mosaic of vegetation types. Within the CDNP chimpanzees are released into the 'Triangle', an area of 21 km² delineated by two rivers. Due to the presence of natural bridges chimpanzees can cross the rivers to use neighbouring areas of the larger CDNP.

Released chimpanzee with infant © HELP

Goals

- Goal 1: To re-introduce a self-sustaining population of central chimpanzees and restore chimpanzee numbers and viability to the CDNP.
- Goal 2: To ensure effective long-term management of the release site within a legally protected area.

- Goal 3: To contribute to the protection and conservation management of the CDNP.
- Goal 4: To develop a model for re-introduction of chimpanzees by monitoring, evaluating and reporting on the release process and post-release adaptation of the chimpanzees.

Success indicators

- Indicator 1: High post-release survival rate of released individuals.
- Indicator 2: Nutritional and behavioural independence of released individuals.
- Indicator 3: Display of behaviours (social, feeding, nest building etc.,) similar to those observed in wild chimpanzees.
- Indicator 4: Interaction and integration with wild con-specifics.
- Indicator 5: Reproduction (within released population and between released and wild populations).
- Indicator 6: Long-term persistence of released chimpanzees.
- Indicator 7: Improved legal status for the area.
- Indicator 8: Increased protection and biodiversity of other key species at the release site.
- Indicator 9: Increased knowledge of issues surrounding re-introduction and improved practice.

Project summary

Hunting of wild animals for food is common across West and Central Africa but has increased in recent years due to socio-economic pressures. When chimpanzees are hunted for meat, dependant young are sometimes captured alive, sold as pets or kept as 'attractions'. Chimpanzees recovered by HELP are often only a few months old and frequently arrive in poor physical and psychological shape. Still mother-dependant, they are too young to be released into the wild immediately. Options for their long-term future must consider their welfare but also potential risks to wild populations, humans and the released individuals (see Tutin *et al.,* 2001). Planning for the re-introduction took many years. Three forested islands on the Conkouati Lagoon (bordering the CDNP) were used as training grounds to facilitate development of crucial skills needed to survive in the wild. Human support was gradually reduced as the chimpanzees formed social groups. Supplementary food was provided as the islands were too small for nutritional independence. However, since 2005 chimpanzees are taken directly to the release zone to facilitate re-acclimatisation from the start[1]. The infants range as they please but are accompanied by human caretakers and provided with supplementary food as they are too young to survive without support. These chimpanzees are considered part of an ongoing rehabilitative phase and are not included in the post-release survivorship figures (Table 1).

[1] - Prior to transfer chimpanzees undergo a period of quarantine in accordance with the Pan African Sanctuary Alliance (PASA) guidelines

A preventive medical program was established to monitor the pre-release health of the chimpanzees to prevent the introduction of disease into the CDNP. Medical and behavioural profiling determined that the colony was free of all major pathogens and excluded a small number with

Conkouati release site with released chimpanzee sitting on a fallen tree trunk © HELP

physical incapacities or behavioural abnormalities from release. Existing alliances were analysed to guide composition of release groups. Genetic analysis revealed no relatives in the colony.

The decision-making process that led to the choice of the release site involved many considerations (see Tutin *et al.,* 2001). It was concluded that the release could contribute to broader conservation activities in the CDNP. Ground surveys identified the 'Triangle' as suitable habitat for the release zone. It had clear natural boundaries, few signs of human activity, a high diversity and density of known chimpanzee foods including key fallback foods, plus a low density wild population.

Between 1996-2001, 37 (27:10) wild-born[2] chimpanzees were released in stages, primarily in groups or pairs with known individuals. Smaller groups were led to join their group mates after release. No supplementary food was provided post-release. Chimpanzees were located by radio telemetry on a daily basis. Behavioural data were systematically collected every ten minutes from nest to nest (approximately 06:00 hrs-18:00 hrs). Females ranging with wild chimpanzees were monitored less regularly to facilitate integration. Since 2008 the regularity of post-release monitoring has gradually decreased. This reflects a change in focus to facilitate full reinsertion to the wild by gradually decreasing the presence of humans. Vulnerable chimpanzees, i.e., males and females with infants, continue to be followed on a regular basis. As of November 2009, 35% of released chimpanzees are nutritionally and behaviourally self-sufficient and living independently (Table 1). Some have been free-ranging for 13 years. Analyses

[2] - There is one exception; a female was released nursing a 2 month old infant born during the pre-release phase

Table 1: Status of released chimpanzees as of November 2009

Status	Overall	Females	Males
Alive	35% (13)	37% (10)	30% (3)
Dead	24% (9)	11% (3)	60% (6)
Unknown	38% (14)	52% (14)	-
Relocated	3% (1)	-	10% (1)

Figure in brackets represents numbers

Use of radio telemetry and African elephant in the CDNP © HELP

demonstrate activity budgets, dietary range, and social composition and organisation comparable to wild con-specifics (Farmer *et al*., 2006; Le Hellaye *et al*., 2009).

The status of 14 females is unknown although it is likely that they are consorting with wild chimpanzees. Females have disappeared for periods ranging from 8-21 months before reappearing in the release zone, and several are known to have regular contact with wild chimpanzees (Goossens *et al*., 2005). Wild females normally migrate into new communities around the time of sexual maturity. If we include these females with those that are confirmed alive the survival rate increases to 73%. Mortality rates are higher for released males. Over half of these deaths are attributable to attacks by wild con-specifics. This concurs with our understanding of wild chimpanzee behavioural ecology. One male was returned to a pre-release island as he was unable to sustain himself. He will be re-released in 2010. This intervention has been required on three previous occasions for males. Seventeen offspring (10:6; 1 unknown) were conceived and born in the wild to 12 of the released females. As of November 2009, 35% (n=6) of infants were alive. Male infants have a higher mortality rate than females. The same has been found in wild chimpanzees throughout their lifespan. Nearly half of all infant deaths are attributable to attacks by wild chimpanzees. Infanticide (inter- and intra-group) has been widely reported at many long-term wild chimpanzee study sites.

Major difficulties faced

- Having to learn by trial and error as the very nature of the program was pioneering (1st project to re-introduce chimpanzees to natural habitat and systematically document the process and results).
- Negativity toward re-introduction of chimpanzees as a wildlife management tool.
- Securing the necessary funds for the re-introduction, and sustainable funding to provide long-term support for post-release monitoring. This is particularly important for species like apes that have slow reproduction rates and long life spans.
- Capturing the chimpanzees from pre-release islands and transporting them to the release site.
- Immediate flight response of some chimpanzees upon release.
- Challenges faced in locating chimpanzees without tracking devices.

- Injuries and fatalities of released chimpanzees, particularly males, inflicted by wild con-specifics.
- Civil unrest.

Major lessons learned

- The planning process for re-introduction can take many years but is crucial to program success.
- Chimpanzees need to be provided with pre-release surroundings that represent, as closely as possible, the natural physical and social environment.
- Whilst it is important to gradually decrease human contact and presence during the pre-release phase to help create a cohesive group, some ongoing contact is required to facilitate the release process and post-release monitoring and support.
- Combining training grounds with release site avoids the need for capture and transportation and may facilitate adaptation to the natural environment from the beginning[3].
- Staff known to the chimpanzees should be present during the release, at least initially, to provide psychological support.
- Chimpanzees should be introduced to mock collars before release to facilitate their acceptance.
- All chimpanzees should be released carrying some form of telemetric device to facilitate post-release monitoring and support.
- Chimpanzees should be released in groups with known individuals to provide an environment of mutual post-release support[4].
- A phased approach to re-introduction may facilitate survivorship by introducing newly released (naive) chimpanzees to more experienced released individuals.
- Chimpanzees are most vulnerable immediate post-release and the stress of transfer from a pre-release site may cause them to flee.
- Only small groups should be released to facilitate post-release monitoring and support.
- Sufficient numbers of experienced staff should be available to follow every individual released in case the group splits.
- Post-release monitoring and support is integral to successful adaptation and high survivorship.
- Experienced on-site veterinarian and veterinary intervention is crucial to increasing survivorship, particularly for males.
- Male chimpanzees should not be released into areas with wild con-specifics without considering the risk of high mortality rates.
- Distance between released chimpanzees and trackers should be strictly observed to facilitate adaptation and development of normal behaviours, prevent human-directed aggression, and facilitate interaction between released and wild chimpanzees[5].
- Released chimpanzees interacting with wild con-specifics should not be followed if this may negatively impact the interaction and impinge possible integration.

[3] - It is too early to determine the survivorship of chimpanzees that have been directly transferred to the release site versus those that spent time on pre-release islands

[4] - Advances in radio collar development include Store-on-Board and GPS/ Argos Systems. Implants are being pioneered with released orang-utans and they may offer an alternative to radio collars

[5] - The IUCN Best Practice Guidelines for the Re-introduction of Great Apes recommend a distance of 10m between researcher and released ape

- Systematic data collation is crucial to support the evaluation process.
- Pre-release baseline data should be collected on the presence and abundance of key plant and animal species and habitat quality so that the impact of re-introduction can be properly assessed.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- High survival rates (confirmed 35%, assumed 73%) with long-term persistence (some released chimpanzees have been free-ranging for 13 years with an average duration of seven years).
- The chimpanzees are behaviourally and nutritionally independent with a diet and range of behaviours comparable to wild con-specifics.
- Several females have successfully interacted, travelled and integrated with wild chimpanzees.
- Several females have successfully reproduced and reared young. Confirmed paternity of a released male demonstrates that they too can successfully reproduce.
- The re-introduction has restored the density of chimpanzees in the release zone from a low 0.14-0.33 individuals/km² (Tutin *et al.*, 2001) to a more normal range of 1.05-1.90 individuals/km².
- HELP in conjunction with other stakeholders were instrumental in highlighting the biodiversity of the area that lead to its classification as a nationally recognised protected area in 1999.
- The permanent presence of HELP has led to a significant reduction in poaching and deforestation in the release zone and adjacent areas, benefiting wild chimpanzee populations and other sympatric fauna.
- The viability of re-introduction as a management tool for chimpanzees in African sanctuaries has been highlighted through the publication of HELPs data in peer reviewed journals. As a direct consequence, seven sanctuary members of the Pan African Sanctuary Alliance (PASA) are actively engaged in one or more

Released chimpanzees grooming © HELP

elements of the re-introduction process and many others now have it as a long -term goal.

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Re-introduction of the Sumatran orangutan in Sumatra, Indonesia.

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Introduction

Today the orangutan occurs only on the two islands of Sumatra and Borneo, with ~90% of the population in Indonesia and around 10% in the Malaysian states of Sabah and Sarawak (Yuwono *et al.*, 2007). The Sumatran orangutan (*Pongo abelli*) and the Bornean orangutan (*Pongo pygmaeus* sp.) are considered two distinct species, both of which are protected under Indonesian law and listed on App. I of CITES. The Sumatran orangutan is considered Critically Endangered by the IUCN (IUCN, 2009) with an estimated population of ~6,600 (Wich *et al.*, 2008). Only six of the remaining 10 forest blocks occupied by wild Sumatran orangutans are considered to contain viable populations (Wich *et al.*, 2008; see also Singleton *et al.*, 2004). The IUCN/SSC Primate Specialist Group named the Sumatran orangutan as one of the 25 primates most endangered in 2006-2008 (Mittermeier *et al.*, 2007). There is only one existing re-introduction project for the Sumatran orangutan that is the Sumatran Orangutan Conservation Program (SOCP). The SOCP is a collaborative program involving the Indonesian Government's Department of Forest Protection and Nature Conservation (PHKA), the PanEco Foundation, Frankfurt Zoological Society and the Indonesian Yayasan Ekosistem Lestari (Foundation for a Sustainable Ecosystem). SOCP currently operates facilities in two main locations for the rehabilitation and re-introduction work: a medical quarantine centre for orangutans near Medan in North Sumatra, and two release sites at the edge of the Bukit Tigapuluh National Park in Jambi Province, Sumatra.

Infant orangutan at the first stage of rehabilitation

Goals

- Goal 1: To create a new sustainable population of re-introduced Sumatran orangutans in an area considered to be a part of their natural range until at least the 1830's.

- Goal 2: To increase the geographic range of Sumatran orangutans by establishing a genetically unrelated founding population in order to maximize genetic diversity among the wild-living population and to reduce or offset the risks from external threats (habitat loss, poaching, disease pandemic, natural catastrophe) to the remaining wild populations in the north of the island.
- Goal 3: To provide ex-pet orangutans with enhanced welfare and a viable chance of survival and reproduction in their natural habitat.
- Goal 4: To provide a safe place for Sumatran orangutans that for whatever reason cannot be released to the wild.

Two orangutans after release

Success Indicators

- Indicator 1: An acceptable proportion of orangutans surviving for at least two dry- seasons (considered to be around 70% of individuals released based on data available to date) in the forest without food supplementation.
- Indicator 2: Reproduction (both conceptions and births) occurring in the wild with infants being adequately mother reared.
- Indicator 3: Dispersal of individuals away from the re-introduction sites.

Project Summary

SOCP provides the only legal facilities to rehabilitate and re-introduce confiscated orangutans in Sumatra. Public education programs are also undertaken to highlight the socio-economic impact of the trade in orangutans and the loss of its forest habitat. Habitat loss, mostly for timber or plantations, continues to be the biggest threat to the orangutan. Forest blocks become increasingly fragmented and human-orangutan conflicts increase in number, often leading to the killing of the animals and the capture of any surviving infants. Inadequate law enforcement and corruption continue to be the source of the deficiency in wildlife and environmental protection. The reintroduction goal of SOCP was to establish a program for ex-pet orangutans in Sumatra that improves the welfare of confiscated individuals and establishes a new 'wild' population of orangutans in Sumatra. A purpose-built medical quarantine center was completed in 2002 to care for 'ex-pet' orangutans. The centre is in Batu Mbelin in the village of Sembahe, North Sumatra and the location was chosen for its clean water supply, ease of access to Aceh (then off-limits due to civil conflict), with access to good medical facilities (medications, laboratory tests, etc.) and an airport in Medan, yet sufficiently remote to avoid uninvited visitors; due to its quarantine function the centre is not open to the public. SOCP has good relations with the local communities near the centre employing local staff and purchasing most of the orangutan's daily fruit and vegetable supplies from local farmers.

New ID, medical, and behavioral record files are created for each orangutan upon arrival at the centre and after an initial adjustment period more extensive health checks are undertaken by two full-time Indonesian veterinarians. Routine health screening includes testing for TB and other respiratory problems (chest x-ray, PPD tests, and from 2009 also culture of sputum samples). Blood samples are taken and tested for hepatitis A, B and C, herpes simplex virus, and routine haematology. Faecal samples are taken to check for intestinal parasites and pathogens (Strongyloides tends to be the most prevalent). All checks and tests conform to accepted veterinary guidelines for orangutans (from workshops in Balikpapan (2001) and Palangkaraya (2002) and a recent orangutan veterinary training course in Wanariset Samboja in 2009. All of the orangutans at the centre have had close contact with humans and zoonoses are fairly common. Each orangutan is given a microchip inserted near the left scapula, a tattoo of their unique house number is made on the inside right thigh, fingerprints are taken, and photographs are taken of face and dentition, all for identification purposes. After all health checks are complete the individual can then be transferred to much larger socialization cages. For most, this is the first direct contact they have had with other orangutans since they were first captured and their mother killed.

The release station near Bukit Tigapuluh National Park was selected after numerous extensive field surveys carried out all over the island between 1996 and 2000. Firstly, the National Park itself (140,000 ha) is a protected area, and its surrounding buffer zones form a continuous lowland forest tract of some 350,000 ha, all of which is below 700 m a.s.l. and therefore potential orangutan habitat (orangutans are few or absent in Sumatra at altitudes of 1,000 m a.s.l. or more). Orangutans were also absent from these forests since the 1800's (at that time a legal requirement for potential orangutan re-introduction sites under Minister of Forestry Decree No. 280, 1995). Moreover, fruit tree densities and fruit availability were found to be comparable to, if not better than at the well known orangutan research site at Ketambe, in Aceh province, where orangutans are known to thrive at densities of around 5 individuals/km^2. Given this, even extremely conservative predictions (for Sumatran orangutans) of the density of the re-introduced orangutan population, e.g. 1 individual/km^2, would still allow for a potential population of some 1,400 individuals in the National Park alone, and as many as 3,500 individuals or more in the entire area. The first orangutans were transferred to the Jambi facility in 2002, and the first releases took place in January 2003. Today over 100-indiviuals have been released back into the forest and at least three individuals have conceived and given birth in the wild, and have proven excellent mothers.

Due to the natural socioecology of orangutans, the rehabilitant orangutans are often released individually or in pairs during the fruiting season in order to give them the best chances of re-adapting to living permanently in the forest. Each orangutan is followed from night-nest to night-nest and data is collected on the individual's range-use, diet, activity, and social interactions. Phenology plots are also established in the forest and monitored monthly to assess what food and how much is available to the orangutans both within and between years. A wildlife protection unit patrols permanently around the forest collecting presence/absence data and monitoring for illegal logging activities or other threats to the orangutans.

Conducting medical checks on orangutan

Major difficulties faced

- Long-term continuous monitoring of the progress of every individual released is not possible. However, many individuals can be followed and observed and much data on others is still obtained from random encounters as people are working in and patrolling the forests constantly.
- Encroachment and conversion of habitat to plantations remains a considerable threat and difficult to control, especially in the buffer zone but also even at times within the National Park itself. Some key tracts of the buffer zone, for example, are currently targeted by the Pulp and Paper companies and for conversion to monoculture Acacia plantations.
- A general lack of will amongst the Conservation Department to follow up orangutan confiscations with actual prosecutions. An instruction by the Director General of Forest Protection and Nature Conservation (No. 762/2001) actually encourages its staff to accept voluntary handover of illegal pet orangutans and not to prosecute offenders.

Major lessons learned

- As one of the newest orangutan re-introduction programs in Indonesia it has benefited from the experiences and lessons learned by the others, designing its facilities and procedures accordingly.
- The project was established and designed by people already having many years experience working with orangutans and in tropical forests, under a variety of settings. This has helped avoid common pitfalls and in garnering donor and other support.
- Vets, scientists, and field staff continue to monitor all aspects of the program to ensure that SOCP continues to adapt and change with the latest scientific information.
- SOCP continues to expand by combining reintroduction with habitat conservation, education units, ranger patrols, and research on wild orangutans. SOCP actively recognizes that the success of the re-introduction program is not solely reliant on the rehabilitation of individual orangutans, but a

complicated effort requiring science, education, and working with local human populations.

- The Indonesian government is a necessary and an integral part to help confiscate, release, and protect the orangutans. We continually encourage and facilitate them to play an increasingly active and constructive role at all stages of the process.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- SOCP is the only program to date to create a new population of re-introduced Sumatran orangutans the wild.
- This population is in a part of their historic range area where previously no orangutans existed for up to 150 years.
- The geographic range of the Sumatran orangutan has been increased.
- There is now a safety net population of wild living Sumatran orangutans, if ever a catastrophe should befall the more northern wild populations.
- Using the data so far available, SOCP appears to have one of the highest survival rates of any primate re-introduction program.

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Re-introduction of Bornean orang-utans to Meratus protected forest, East Kalimantan, Indonesia

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Introduction

The orangutan is the only great ape living in Asia and 90% of the population lives in the forests of Indonesia. There are two species of orangutan, the Bornean orangutan (*Pongo pygmaeus*, divided into 3 subspecies: *P. pygmaeus morio, P. pygmaeus wurmbii* and *P.pygmaeus pygmaeus*), and the Sumatran orangutan (*Pongo abelii*). *Pongo pygmaeus* is classified as endangered and *Pongo abelii* as critically endangered (IUCN Red Data List, 2008), and listed on CITES App. I. Habitat destruction and fragmentation are the greatest threats to wild orangutans and are responsible for the drastic reduction in their numbers. Over the past 20 years, 4 million ha (of a total 13 million) of orangutan habitat have been converted for agriculture and palm-oil plantations (UNEP, 2007). Wanariset Orangutan Re-introduction Project (WORP) was established in 1991 by the Balikpapan Orangutan Survival Foundation (BOSF). The project rescues and rehabilitates orphaned orang-utans and releases them back to their natural habitat (Smits *et al.*, 1995). Between 1991-2008, WORP released more than 400 orang-utans to two release sites; Sungai Wain and Meratus forest, East Kalimantan, Indonesia. At the end of 2009, 220 orangutans reside at the Wanariset Centre in Samboja (pre-release rehabilitation centre) in various stages of rehabilitation, destined for release (Siregar, 2009).

Orangutan with young

Goals

- Goal 1: To rehabilitate and re-introduce orphaned orangutans into natural habitat.

- Goal 2: To establish a viable and self-sustaining ex-captive orangutan population in the wild.
- Goal 3: To support law enforcement activities of the Indonesian Natural Resources Conservation Department and other agencies to protect orangutans.
- Goal 4: To increase the protection of re-introduction sites and surrounding areas.

Success Indicators

- Indicator 1: Self-sustaining ex-captive orangutan populations.
- Indicator 2: High survival and reproduction rates leading to an increase in the total number of orangutans in East Kalimantan.

Project Summary

Habitats were surveyed and assessed (Sungai Wain: 9,783 ha and Meratus forest: 28,261ha), in 1990 and 1993 respectively, to determine food availability and carrying capacity for released orangutans. Sixty-three wild orangutans live in Meratus forest following translocation due to forest fires. Candidates for re-introduction were selected from those having reached the final stage of the rehabilitation program. Selection criteria focused on acquisition of key behaviours and medical status. Specifically each animal must: 1) have a minimum age of five years, 2) have a minimum weight of 13-15 kg, 3) spend more than 50% of its time in social interactions with con-specifics, 4) spend more than 50% time of its time at the top of the cage and 5) have a clean medical record e.g. be free from infectious bacteria or viruses (Smits *et al.*, 1995). All animals were fitted with subcutaneous chips in their neck (with serial numbers) to enable identification at a later date (e.g., if they are latterly re-captured).

The orangutans were transferred by truck to the forest edge, and then by helicopter to the release site inside the forest. Here, the orangutans were housed for one or more days in a holding cage to facilitate acclimatisation to the forest. The door was then opened and the orangutans were free to explore the forest or to remain inside the cage until they were more confident. The release period was timed to coincide with the early fruiting season so that there would be sufficient food for the orangutans. However, supplementary food (mainly fruit) was provided for one month post-release (which was gradually reduced) to provide additional support to the released orangutans. It was assumed that following this initial period of nutritional support, natural food abundance in the area would be sufficient for the released orangutans.

A post-release monitoring program was designed to determine the behavioural adaptation of re-introduced orangutans and evaluate the rehabilitation and re-introduction approach taken by WORP. Newly re-introduced orangutans were monitored on a daily basis until they left the area. Focal animal sampling was conducted from dawn to dusk. If no orangutans were found close to the release cage, surrounding areas were searched, and any orangutan located followed (Siregar, 2009). Surveys were conducted 4-6 days every month to locate ‘missing’ orangutans. Food plants were marked along transects (25-50 m on each side) surrounding the release cage to determine plant species consumed by the orangutans and to make a comparison to wild orangutan diet. Between 1992-2002, WORP released 88 orangutans in six phases to Sungai Wain forest and 345 orangutans in three phases (including translocations) to Meratus forest. Post-release monitoring has been limited and cannot determine precise survivorship but short surveys conducted in 2000-2002, 2004 and 2009, and anecdoctal data, indicate some degree of success. In the 2002 survey, 14 orangutans released at Meratus forest were encountered at the release site, along transects, and far from the release zone close to a logging camp. In 2004, 20 orang-utans were re-sighted, and in 2009, 16-18 orangutans, but it is not confirmed if these are the same animals seen in 2002.

Orangutan feeding in the forest

Seven orangutans were transferred from Sungai Wain to Meratus forest as they left the release zone and disturbed human settlements close to the forest. One orangutan was removed from Meratus forest due to ill health and later re-released to Sungai Wain. Three females released at Sungai Wain, and two at Meratus forest successfully reproduced and reared offspring. Three females released at Sungai Wain in 1992 and 1993 at approximately five years of age, were sighted in 2001 carrying offspring. Two females released to Meratus forest in 1997 and 2001, at approximately five years of age, were sighted carrying offspring in 2002 and 2009. One infant died of unknown causes at approximately one year old. Surveys determined that released orangutans consumed a total of 109 plant species at Sungai Wain (Peters, 1995) and 80-100 at Meratus (Siregar, 2009)

Major difficulties faced

- Inadequate pre-release training and inappropriate training environment to facilitate acquisition of key skills needed to survive post-release.
- Inadequate knowledge of wild orangutan maternal behaviour to know how best to replicate this in the captive environment.
- Overcrowding in pre-release cages makes skill training for release difficult.
- Inadequate criteria to assess readiness of orangutans for release, compounded by difficulties in conducting behavioural assessments in overcrowded enclosures.
- Released orangutans exhibited deficiencies in key skills such as foraging, nest building and arboreal living arboreal. The orangutans spent a great deal of time on the ground, were unable to build nests, and foraging was based on the sampling of any edible food encountered, and this was primarily at ground

level. Only a small number of orangutans showed the necessary skills needed to fully adapt to independent forest life.

- Inadequate post-release monitoring; too short (2-4 weeks) to determine adaptation and survivorship of orangutans.
- Locating the orangutans post-release.
- Released orangutans straying into and disturbing human settlements.
- Limited habitat protection of release sites by government authorities. There are approximately 220 orangutans at WORP but further releases have been terminated at Meratus forest since 2002 due to habitat destruction by illegal loggers.
- Weak law enforcement implementation to prevent illegal hunting and pet-trade.
- The rehabilitation component is expensive and limited funding is available for what is principally a welfare focused program albeit with conservation impacts.

Major lessons learned

Lessons learnt in the preparatory and pre-release rehabilitation phase:

- Relevant pre-release training must be provided at each stage of the rehabilitation process (from nursery to socialisation cage).
- Selection of candidates for release must include behavioural and medical screening.
- A method for monitoring behavioural progress in the rehabilitation phase, and readiness for release, should be developed and implemented.
- Records on the behavioural progress of each orangutan should be maintained as a part of individual assessments. This should be included in the program management manual.
- Captive management and specifically enrichment (environmental and social) should be designed to stimulate the development of key skills such as foraging, arboreal movement, nest building and social interaction. Enrichment materials should be made from natural substrates such as branches, leaves, vines, etc., to encourage nest building and arboreal movement.
- Natural and un-chopped fruits should be given to practise foraging and food processing, and facilitate acclimatisation to natural food items that will be encountered post-release.
- Minimal human contact and interference, unless necessary. Orangutans should be allowed to behave as they wish without human interference. This will also reduce dependency on humans.
- The program should develop a comprehensive preventative health program to protect both staff and orangutan health.
- Only long-term staff that meet the health requirements outlined in the preventative health care program should be allowed direct contact with orangutans. Visitors and short-term staff/researchers/volunteers should not be allowed contact with the orangutans.
- Forest technicians should be taught basic concepts and issues surrounding orang-utan behaviour, welfare and ecology, and data collection skills to support the re-introduction process.
- Pre-release rehabilitation and release site should be one and the same (transfer to site would follow an appropriate period of quarantine) to provide

the best possible training grounds and negate the need of transfer between sites. If this is not possible skill training in a semi-ranging area should be incorporated as early as possible.

Lessons learnt at the release phase:

- The re-introduction area must be adequately surveyed to determine food seasonality, availability and abundance.
- The release site should be located far from human settlements and activities to avoid human-wildlife conflict and re-capture or re-location.
- The program concurs with recommendations that advise releasing into areas with no wild orangutans but if this is not possible to areas that contain less than 50 individuals and/or with a density of less than $0.1/km^2$ (Rosen & Byers, 2002).
- Orangutans must be encouraged to spend time off the ground.
- Orangutans should be released at an appropriate age which will depend upon acquisition of key skills needed to survive post-release.
- Orangutans should be released in small groups to facilitate post-release monitoring and support for each individual.
- Soft release is recommended. Orangutans need post-release support until they are nutritionally and behaviourally independent.
- Post release support and monitoring can identify if intervention is required and ultimately increase rates of survivorship.
- The location of released orangutans must be regularly monitored (to determine if they remain inside the protected area or not, or are re-captured and kept as a pet by villagers, etc.).
- Implants are presently being trialled at another orangutan project and if successful may provide a solution to problems in tracking orangutans post-release.
- Post-release monitoring should be conducted for 1-2 years as this will provide a better indicator of adaptation and survivorship.
- Re-introduction requires long-term investment and commitment to ensure success.
- Monitoring and evaluation must be integrated into program design. There must be continual review of individual orangutan behaviour, data collection methods and rehabilitation/release methods to facilitate a lessons learnt process and ultimately increase re-introduction success.
- Orangutan re-introduction needs to demonstrate successes, challenges, and lessons learnt for donors to invest in this form of wildlife management.
- Habitat protection and law enforcement are crucial to protect the habitat of the re-introduction orangutan.
- If re-introduction is to be considered a conservation tool, there must be collaboration with relevant institutions, a multi-disciplinary approach adopted, and this form of wildlife management must be incorporated into international and national conservation strategies.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- A small number of released orangutans have been successfully free-ranging (nutritionally and behaviourally independent) for over 10 years.
- Some females have successfully reproduced and demonstrated successful mothering skills.
- Through an awareness program, local communities and logging companies now report if released orangutans leave the release zone, and disturb camps, settlements or plantations. Previously the orangutans would have been killed or captured and kept as pets.

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The re-introduction of the black rhinoceros to North Luangwa National Park, Zambia

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Introduction

Until the 1960s, the black rhinoceros occurred throughout much of sub-Saharan Africa, with Zambia as a major range state for the subspecies *Diceros bicornis minor* (Ansell, 1969). In many countries though, the black rhinoceros was eliminated by illegal killing, with its horns in demand as knife handles in Yemen and medicine in eastern Asia. The black rhinoceros is critically endangered (IUCN, 2009) and on CITES App. I (CITES, 2009). Zambia's wildlife suffered from extensive poaching during the 1980s and, in 1998, the black rhinoceros was declared nationally extinct. Zambia adopted a national rhino strategy during 2005. North Luangwa National Park covers 4,636 km² in the Luangwa Valley in north-eastern Zambia. It is topographically, botanically and spatially diverse, with a range of mainly-woody vegetation types. The North Luangwa Conservation Program (NLCP) was started during 1986 by the Frankfurt Zoological Society (FZS) to support and strengthen the Zambia Wildlife Authority (ZAWA), enabling effective management of the park and surrounding Game Management Areas. FZS and ZAWA signed long-term management agreements and, after 17 years of support,

Black rhino cow and calf in North Luangwa © NLCP wildlife numbers had increased and poaching was under control. Re-introduction of the black rhinoceros was an obvious next step in the conservation of the park.

Goals

- Goal 1: The re-establishment of a viable, breeding, free-ranging population of the black rhinoceros in North Luangwa NP, to enhance the conservation status of the species and to improve the ecological integrity of the area.
- Goal 2: Establish the capacity within ZAWA to protect and monitor rhino populations over the long-term.

Success Indicators

- Indicator 1: The transfer of at least 20 founders to North Luangwa NP within a three-year period.
- Indicator 2: The founders are breeding within sanctuaries.
- Indicator 3: The population is free-ranging, breeding and secure.

Project Summary

Black rhinos are large, long-lived browsers that reproduce slowly. Males are territorial. The re-introduction proposal was assessed against IUCN and SADC RPRC guidelines (Dunham, 2001). North Luangwa vegetation is mainly *Combretum-Terminalia*, mopane and *Brachystegia* woodlands, and wooded grassland. The park contained 500+ rhinos (Caughley, 1973) before poachers eliminated them. ZAWA, with NLCP support, now controlled poaching and approved the re-introduction. No Zambian rhinos survived and animals were obtained and moved internationally. NLCP promised continued major support. Security was a priority and local involvement was important. Preparations included identifying a sanctuary, recruiting security personnel, training a rhino security team, and building staff houses, holding pens and the sanctuary fence. Considerations for sanctuary sites included browse availability and security, including all-weather access to the fences. Twenty rhinos were captured in South Africa (Kruger National Park (NP)-12, Marakele NP-1, Pilanesberg NP-2 and Great Fish River Reserve in Eastern Cape-5). They were penned for 4-6 weeks, in quarantine, and to ensure that they tolerated confinement, were suitable for translocation and ate browse, lucerne and cubes. Some were trained to feed in transport crates. All were treated for internal and external parasites to comply with Zambian veterinary regulations. Rhinos were flown in individual crates, in batches of five, in a transport plane to an airstrip in North Luangwa (May 2003 (2 males:3 females), June 2006 (3 males:7 females) and May 2008 (2 males:3 females).

At North Luangwa, the first animals spent 10-20 days in individual pens to recover from the stress of travelling and become accustomed to local browse. They were fitted with horn-implant radio transmitters, given a prophylactic drug against trypanosomiasis and their ears notched. All rhinos came from areas without tsetse flies and were naïve to trypanosomes. Pyrethroid-treated tsetse targets were placed near the pens and throughout the sanctuary. The first five rhinos were released one at a time over five days with sub-adults and adult females released first. This allowed more vulnerable and valuable animals to settle before meeting adult bulls. This sanctuary was 55 km^2 bounded by a four-strand electric fence, 1.2 m high. Security staff was deployed around the sanctuary. The next 10 rhinos were fitted with transmitters and, over four weeks, freed into a 150 km^2 sanctuary adjacent to the first. This sanctuary's fence had three strands and was 70 cm high. Later, this larger sanctuary was divided and two bulls removed from the section where the 2008 arrivals were freed. During 2007, concrete troughs were built for bone meal and salt and, during 2008, troughs were provisioned with *Kigelia africana* fruit, *Euphorbia* pieces, horse pellets, sweet potatoes, sugar cane, trace elements and vitamins. *Euphorbia* pieces injected with Ivermectin were fed to rhinos to reduce parasite loads. During March 2009, the fence separating rhinos released during 2003 and 2006 was removed.

Hercules aircraft delivering rhinos to North Luangwa © NLCP

Direct community involvement was difficult because the sanctuaries were far from the park boundaries and released rhinos were seldom seen. But many people including traditional leaders observed aircraft deliver the rhinos, or saw rhinos in pens. Local people suggested names for rhinos, and schoolchildren were given rhino information and coloring books. To minimize disturbance, initially monitoring was by aerial radio-tracking. Later, rhinos were radio-tracked from vehicles on the boundary, and monitoring on foot started three weeks after release. Condition assessment and collecting evidence that rhinos ate local browse were priorities. The monitoring strategy varied, with recently-released checked more frequently. An Eastern Cape cow, translocated during 2006, would not eat local browse in the pen at North Luangwa, but ate food from South Africa. She was released after three days in the hope she would find browse that she liked, but she did not. *Euphorbia* branches and *Kigelia* fruit were provided, but she ignored them. Later, she often returned to the pens. Twice she was immobilized, treated for possible diseases, given intravenous glucose and tube-fed. She died a month after release. Post-mortem examination provided no indication why she refused to eat local browse. Another Eastern Cape female died nine months after release: she had stayed close to the pens and lost condition. Post-mortem examination revealed a tooth abscess and that possibly trypanosomiasis contributed to her death. A month later, another female was lethargic and losing condition and so she was immobilized and treated with an antibiotic and antihelmintic. Her condition improved thereafter. Additional tsetse targets were placed in the sanctuary. One old bull died six years after release, following a fight between males. The first calf was born during 2005. By April 2009, its mother had calved again and two other cows released during 2003 had calved. A cow released during 2006 broke out of the sanctuary and was herded back, but escaped again. She remained outside, calving two months after release. By January 2010, no other cows freed during 2006 were known to have calved.

Major difficulties faced

- A key aspect was sourcing an appropriate aircraft to transport the animals from South Africa directly to a bush strip in North Luangwa. This aircraft had to be booked well in advance and aspects such as bad weather, permits and the unavailability of fuel had to be managed. The dates of the flights were fixed and could not be rescheduled if, for example, the capture of rhinos in South Africa was delayed.
- Political and financial constraints meant that a founder population of 20 animals could not be moved to North Luangwa within three years.
- The degree and duration of stress, both nutritional and parasite related, that the rhinos suffered as a consequence of unfamiliar conditions in a new area was unexpected. The stress was obvious and exacerbated by the sanctuary fences limiting movement, and possibly by competition for food with elephants.
- Rising costs meant that securing the increased funding required for the effective protection and management of the founder population has been a significant challenge.
- Removing the sanctuary fences (as was originally intended) has become a further challenge, because management now believes that it is easier to protect and monitor rhinos within a fenced area.

Major lessons learned

- Project preparation, especially on veterinary issues, required technical expertise of a high standard.
- Fighting between recently-released bulls and bulls freed earlier was prevented by releasing each group of rhinos into an empty sanctuary.
- A simple, low-cost, three strand electric fence was largely effective at containing rhinos within a sanctuary, but allowed some free movement by other species.
- Anecdotal evidence suggested that the pre-release pens should be positioned downwind of the sanctuary, so that when the rhinos (which have poor eyesight and thus rely strongly on their sense of smell) are released, they move both into the wind and into the sanctuary.
- There is a need for a formal strategy (based on key indicators) for removing sanctuary fences.
- The rhinos released in North Luangwa NP were donated by South Africa in a historic regional conservation effort that has furthered the conservation status of the black rhino and forged important bonds between the national wildlife authorities.
- This project required international and regional cooperation. The re-introduction of the black rhinoceros was an international initiative between the Governments of Zambia and South Africa, under the umbrella of the SADC Regional Program for Rhino Conservation. The implementing organizations

included ZAWA, South African National Parks, the South African North West Parks and Eastern Cape Parks Boards, the Namibian Ministry of Tourism, Environment and Natural Resources, the North Luangwa Conservation Program funded by the Frankfurt Zoological Society, and the Frankfurt Zoo.
- Safely moving rare and big animals over large distances and across international borders, as well as providing long-term security at their release site, was expensive and required multi-donor support. Major financial support for this project was provided by the Conservation Foundation Zambia, the US Fish & Wildlife Service, the Save the Rhino Trust Zambia, the Beit Trust, Horny@50, the Prince Bernhard Fund for Nature, the European Association of Zoos & Aquaria, Save the Rhino International, and FZS.
- Project management requires a flexible, adaptive approach; if one plan does not work, be willing to try another.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- Survival of the rhinos has been relatively high (90% survival during the first year post-release) and no rhinos have been poached.
- Population number is increasing, with the number of births (five by January 2010) exceeding the number of deaths (three by January 2010).
- Several calves born since the releases were conceived after their parents were translocated.
- The release phase of the project is incomplete, because the number of surviving founders is less than the 20 recommended by the SADC RPRC and a further five animals are destined for release in North Luangwa NP during 2010.
- Most of the rhinos are confined to the fenced sanctuaries and thus are not yet free-ranging.

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Re-introduction of the Asiatic black bear into Jirisan National Park, South Korea

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Introduction

Asiatic black bears (*Ursus thibetanus)* are distributed wildly in Asia, from Japan in the east to Iran in the west. Seven subspecies have been recognized: *U. t. japonicus* (Japan), *U. t. formosanus* (Taiwan), *U. t. ussuricus* (South East Russia, North and South Korea, and North eastern China), *U. t. gedrosianus* (Iran and Pakistan), *U. t. langer* (Western Himalayas), *U. t. mupinensis* (South Western China) and *U. t. thibetanus* (Other regions) (Pocock, 1932 & Wozencraft, 2005). Asiatic black bear is Vulnerable (IUCN category) and is listed in CITES App. I and endangered species category in South Korea. About 160 bears were captured in the Jirisan in the southern part of Korea between 1950 and 1970. Hundreds of wild bears might have existed in South Korea at that time (Han, 1997).

In the 1980s, a simple population survey on wild bears was conducted. According to the surveys of five mountains by the Korean Society for the Protection Wild Animals during 1980-1984, at least 50 wild bears had survived (Korea Society for the Protection Wild Animals, 1984). However the National Institute of Environmental Research stated that about 20 wild bears remained in South Korea and less than 10 bears existed at Jirisan National Park in 2001. As a result a re-introduction project was launched to establish a self sustaining population in Jirisan National Park.

Asiatic black bear (*Ursus thibetanus*)

Goals

- Goal 1: Restoration of Asiatic black bears in suitable habitat through developing public tolerance and political support.

Health screening of released bear after recapture

- Goal 2: Establishment of self-sustainable populations in Backdudaegan (ecological axis of Korean peninsula) area as well as Jirisan National Park in South Korea.
- Goal 3: Recovery of a healthy eco-system through the re-introduction of Asiatic black bears.

Success Indicators

- Indicator 1: Hibernation and survival after release.
- Indicator 2: Mating and breeding successfully in the wild.
- Indicator 3: Continuous monitoring and research after release.
- Indicator 4: Developing an image with locals and visitors that released individuals are not artificial or alien but a part of nature.
- Indicator 5: Establishing a self-sustainable population of Asiatic black bears in Jirisan National Park.

Project Summary

Feasibility: It is generally agreed that a wild animal population may be considered viable when population numbers and survival rates are such that the population has a 95% probability of survival over 100 years. However the bear population of Jirisan National Park (JNP), the largest population of Asiatic black bear in South Korea, was composed of between only five and eight bears in 2001. The theoretical surviving probability of the population after 100 years was therefore only 3% and appropriate measures were needed to establish self sustaining populations.

At the Asiatic black bear Population and Habitat Viability Assessment (PHVA) Workshop in 2000, which was held in Seoul, South Korea, the result of "vortex simulation modeling" suggested if we introduce six bear cubs every year for five years into Jirisan National Park (JNP), it would stabilize with a minimum viable population composed of 53 bears after ten years and 94% probability of survival after 100 years. According to the conclusion of this workshop several surveys and assessments on JNP were conducted and it was concluded JNP was good habitat for Asiatic black bear.

Implementation: In 2001, four captive cubs with radio transmitters were released experimentally to confirm whether the Asiatic black bear could adapt to the environment of JNP and to study re-introduction methodology in JNP by the National Institute of Environmental Research (NIER). But responsibility for the

Released Asiatic black bear

bear restoration was transferred to the Korean National Park Service (KNPS), Asiatic black bear management team (ABBMT) which was composed of biologists, ecologists, veterinarians and local communities in 2002. (ABBMT was reorganized and extended to Species Restoration Center (SRC) for Endangered Species in 2005). As a result of that we could obtain lots of information for the restoration of Asiatic black bear in Korea and the re-introduction protocol could be subsequently revised. And in September 2003, a Memorandum of Understanding on Asiatic black bear protection was signed between the Republic of Korea and Russia. On the basis of the MOU 18 wild cubs which were genetically very close to Korean bears (*Ursus thibetanus ussuricus*) were introduced from Russia and released into JNP between 2004 and 2007. And 11 cubs from North Korea were released between 2005 and 2009. Before release, all the bears were quarantined and a health screen undertaken.

Post-release monitoring: Every bear was released with a transmitter or GPS collar which have been monitored daily since release. Although all of the released bears adapted well to the wild and hibernated, a few had become so habituated to people that five were recaptured. Another eight bears died of diseases and poaching. However two bears gave birth to one and two cubs respectively, so a total of 19 bears were alive in JNP except for wild bears in March 2010.

The species restoration center (SRC) for endangered species that implements the Asiatic black bear restoration project has also used the opportunity to conduct research on bear home ranges, habitats, behavior, food resources and adjustments by the bears to the natural environment. We have also instituted conservation components involving education and cooperation with local communities, including compensation for damage from released bears. The primary damage from bears is to apiaries. Although Mt. Jirisan is a National Park, about 20% of the area is private land, which include some 500 apiaries. Damage to this property causes antipathy to the black bear restoration project. To reduce apiary damage, we monitored the bears’ movements, anticipated where damage might occur, and erected electric fences at 160 sites in 2007. As a result of these precautionary efforts, apiary damage in 2007 decreased 85% compared to 2006. We also tries to quickly examine sites of reported damage and compensate farmers for their losses.

Furthermore, we engage in discussions with local people, and send monthly mailings about the activities of the bears and the SRC, so they are well informed. We have also stressed the impacts of poaching: so far, 271 illegal snares have been removed with the cooperation of local communities and an NGO in 2007, including support of "honorary rangers" (designated local people). We produce and distribute promotional materials such as brochures, calendars, and web-based movies for public awareness.

Radio-tracking released bears

Major difficulties faced

- There is a lot of private land in the National Park and many local people produce profit there such as apiary and sapping trees. So bears and local people have to share the habitat and it is very difficult to obtain public tolerance for bear restoration.
- Due to overlapping of habitat between bears and humans, intensive management of the released bears (e.g. daily monitoring of bear locations, changing of transmitters annually, etc.) is required as people think all the damage from bears is the responsibility of the government including the National Park Service. As a result our budget is insufficient to cover human resources and research.
- Bears have lots of difficulties to enlarge their habitat to the other area due to isolation of JNP from other ecosystems.
- Although it is necessary to release additional individuals for establishing a self sustaining population, it is difficult to source similar subspecies such as the Korean bears

Major lessons learned

- Successful restoration is nearly impossible without public and political support and it is necessary to educate and publicize about the significance of species restoration.
- Without a large conservation area with suitable habitat, bear restoration results in several social problems.
- Recaptured bears that do not adapt in the wild are used in captive facilities as they have an important role in public education, captive-breeding and bear research.
- Before release all the bears have to be quarantined and diagnosed against diseases which could affect other wildlife.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Although we released young cubs, they did not only find winter dens by themselves but also hibernated successfully, mated and gave birth. It indicates the possibility of developing a stable population.
- A special organizations SRC, which conducts the restoration of endangered species as well as Asiatic black bear and which has continuous financial support.
  - ⇒ It is running the educational awareness program on restoration and conservation of wildlife through the withdrawal of individuals which have become habituated to humans.
  - ⇒ It is an established breeding facility for securing individuals for release and research.
  - ⇒ It is an established wildlife animal medical center for decreasing mortality by treating animals injured through poaching.
- A prompt and reasonable compensation system on damages from released bears is in place. We are preventing damage by informing people on the location of bears and through erection of electric fences.
- A continuous post-release monitoring program is being implemented.

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Conservation reinforcement of an introduced population of hirola antelope into Tsavo East National Park, Kenya

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Introduction

Hirola antelope (*Beatragus hunteri*), formerly known as Hunter's hartebeest (*Damaliscus hunteri*). True phylogeny determined recently, changing status from sub-species to a monospecific genus. Hirola now occupy a small part of the original range in north-eastern Kenya, within Ijara and Garissa Districts. Current southern boundary is the coastal forest zone and likely also the tsetse fly zone. Western boundary is the Tana River. North-eastern edge is heavily occupied by livestock, has a large refugee camp, and considerable insecurity. Eastern edge lies on the Kenya-Somali border. Hirola probably extirpated from Somalia but individuals from Kenya might stray across the border occasionally. World population of hirola has declined from ~14,000 in the mid 1980s to ~1,000 individuals currently. A second (introduced) population of ~100 individuals survives in the southern part of Tsavo East National Park. This population is the result of translocations in 1963 and 1996. The IUCN Red List currently lists the hirola as 'Critically Endangered (A1a). As a monospecific genus, *Beatragus* must, therefore, also be considered a Critically Endangered genus are protected under Kenyan law (since 1971) and in Somalia (since 1977).

Goals

- <u>Goal 1</u>: To reinforce the small population of ~76 individuals in Tsavo East National Park (the result of the 30 founders, all immature animals 9-12 months of age, released in 1963).
- <u>Goal 2</u>: To improve the genetic composition of the Tsavo population (due to the small founder numbers).

Richard Kock with immobilized hirola

- Goal 3: To develop an improved capture and translocation methodology after the high mortalities experienced in 1963.
- Goal 4: To improve basic scientific information including: the molecular phylogeny, anatomy and morphology, anesthetics, biochemistry, hematology, serology and other health parameters.
- Goal 5: To raise awareness about the serious situation for the species both within the Somali community in Ijara and Garissa Districts, more widely in Kenya and in the international conservation community.

Success Indicators

- Indicator 1: Minimum of 30% of captured hirola surviving to five months post translocation (an improvement over an estimate maximum of 20% in 1963).
- Indicator 2: Evidence for integration of translocates into the Tsavo herds and contribution to breeding.
- Indicator 3: Reduced mortality associated with capture and translocation to release estimated at 33% to 46% in 1963 to <25%.
- Indicator 4: The number of scientific publications.
- Indicator 5: A raised political and conservation profile of the species in north-eastern Kenya and the wider community based on reports, newspaper articles and meetings.

Project Summary

Feasibility: The translocation was justified based on a number of arguments: Scientific evidence of a minimum population of 302 hirola: aerial total count by the Kenya Wildlife Service (KWS, 1995) and an estimated population of 1725 (+/-482) hirola in 1993 based on 5 km transect aerial survey by the Department of Remote Sensing and Resource Surveys (DRSRS), Kenya. The cause of the population collapse from >10,000 to ~1,500 between 1983 and 1985 is thought to be a severe rinderpest epidemic. The apparent decline from an estimated 1,725 in 1993 to the total count of 302 in 1995 is thought due to recurrent rinderpest epidemics, which started in the range in 1993-1994. The only *ex situ* population is in Tsavo East National Park. This population had grown at a modest rate of ~5% per annum since introduction in 1963 but the low founder base (estimated at 11-19 animals at five months post-release) was a potential problem in the longer-term. The KWS had sufficient resources to undertake a translocation exercise.

The methodologies for capture of antelope had improved significantly since 1963. Chemical capture proved feasible during rinderpest surveys in 2004 but the survival rate was unknown. Soft-release was preferred to increase survival chances post-release but a suitable fenced predator proof release zone was objected to by a locally active NGO. The local community were consulted and agreed to the action. A Hirola Task Force (HTF), comprising all conservation agencies in Kenya and the Government, officially constituted by KWS, was established and agreed that translocation was justified.

Implementation: HTF mandated a translocation coordination committee. A team was built including; fund raisers, KWS staff (biologists, HQ and divisional managers and wardens, veterinarians, laboratory technicians, wildlife capture technicians, airwing, security, legal advisers and communicators), scientific colleagues from NGOs, and community representatives. It was decided to translocate a minimum of 35 hirola. Funds were raised. KWS provided some transport, including aircraft, and logistical support. The British Army provided trucks and catering support for the field team. The South African (Southern Parks) authority provided two experienced field technicians to assist in establishing new physical capture protocols for the hirola. The operation was coordinated by the Chief Veterinary Officer of the KWS, security by the operations division, and political aspects were covered by the KWS senior staff. The KWS Airwing provided reconnaissance aircraft, a helicopter for capture, and an aircraft for transfer of hirola to Tsavo. The team was deployed at the Tana River Primate National Reserve and at Ijara town. Animals were located, a fixed net capture system was built at several sites, and staff trained in its use. The helicopter was used to drive small hirola herds into the capture system. Seventy-five percent of the target hirola were caught, tranquilized and translocated by air to holding pens in Tsavo, held for three days, and free-released. This was continued until a political storm brew up; a high court injunction lodged by a politically motivated sector of the Somali community from Ijara delayed the translocation.

1994 view of the source habitat of the hirola, now part of the Ishaqbini Community Protected Area, specifically for hirola - a single hirola can be seen in the centre of the picture

After KWS authority was upheld in court, the final stages of the operation were concluded using helicopter capture. This change in capture procedure was necessary as the security of the majority of the team's personnel working in the area was compromised and they had been withdrawn. A total of 35 hirola were caught of which seven were immobilized from the helicopter. Of the 35 hirola captured, a total of six died; five from chemical capture stress and one from net injury.

Post-release monitoring: In 1996, 29 hirola were released and monitored (10 with radio collars and all with individual ear tags), using aerial, foot and vehicle patrols, and a dedicated KWS scientist, rangers and pilots. Seven of the females released were pregnant. Seventeen hirola survived >5 months, with higher survival amongst adult females and sub-adults than among adult males. Five of 29 are known to have died while the remainder of those missing had an uncertain fate. At least 16 (55%) of the 29 hirola from the 1996 translocation were alive two years later. None of the observed four births out of seven visibly pregnant translocated hirola resulted in surviving calves. Subsequent births did produce surviving calves and the surviving males are thought to have contribute to breeding. *Indicator 1* was satisfied (capture and translocation mortality to release was 17% and ~49% of the 35 'captured' hirola survived to five months post-release and ~59% of the 29 'released' hirola survived to five months post-release) but this could have been better if the political situation had not forced chemical dart capture from helicopter (five of the six hirola that died during capture/ translocation prior to release were darted from helicopter). *Indicator 2* was satisfied as the population was reinforced and introduced animals contributed to breeding. *Indicator 3* showed improvement but not to the extent planned reaching mortality of ~49% of the captured animals from the time of capture to five months post-release. If the net method had been used all through and a soft-slow release method (from a proposed fenced sanctuary in Tsavo East) used, the mortality would likely be considerably lower.

Despite the 1996 translocation, the hirola population in Tsavo remains relatively static at ~100 individuals. Factors thought to be depressing growth are predators, poaching and food competition with livestock. From samples obtained, the molecular phylogeny was published, confirming hirola to be the only surviving species in a resurrected genus. Considerable scientific and health information was obtained. Awareness, partly due to politics, was improved and this has resulted in a community conservancy; the community at Ishaqbini, Ijara District, is protecting >120 hirola.

Major difficulties faced

- Remote, logistically challenging and insecure zone.
- Historical animosity against the Kenya Government and the KWS (partly due to a number of Somali deaths from KWS anti-poaching operations) resulting in political interference.
- Technically difficult environment and species to work with - fragile antelope with susceptibility to capture stress complicated by high ambient temperatures ~50^0C during the day.
- Release site holds high predator populations: lion, leopard, cheetah, spotted hyena and occasionally African wild dog. Translocates

Hirola blindfold after capture in a game net and calves are believed to have been lost to predators during the post-release 'adaptation period'.

KWS Hirola translocation team in 1996 with the last captured, tranquilized and blindfolded hirola antelope

Major lessons learned

- Political heat was a major constraint but the resulting publicity led to significant improvement in knowledge and awareness amongst local people and leaders. This, in turn, resulted in major advances in local conservation measures and tolerance by pastoral livestock keepers to the hirola and increased *in situ* protection efforts. International awareness also resulted in more external financial and technical support for both populations.
- The opportunity to handle hirola during translocation led to major advances in scientific knowledge about the species.
- Improved and safe (physical) capture techniques for all ages and sex of hirola were confirmed and the high risk of chemical dart capture using helicopters was established.
- Post-release monitoring was essential to understand the degree and causes of success or failure of the operation. In this case, the high post-release mortality could probably have been reduced if the planned slow soft-release option had been implemented. After five months, hirola survival greatly improved suggesting that a period of predator-free adaptation would be ideal.
- A multi-disciplinary, experienced, scientific, technical and paramilitary team provided ideal staff for the translocation.
- The hirola is not easily translocated. Translocation requires a high degree of professionalism. and should only be done where the sub-population has potential for rapid growth. The hirola is a grazing ruminant with anatomical and morphological characteristics of an obligate grazer. This puts hirola in direct competition with other wild grazing antelope, cattle and buffalo, but they may benefit from management of the habitat for grazing species. Besides this specificity in diet, the hirola's vulnerability to predation, disease and most probably parasites make the options for establishment of sub-populations outside of its known former distributional range limited. The small captive populations of hirola in Europe and the United States were never sustained even though longevity reached >22 years. Disease was one cause of the loss of these captive populations. Improved management might improve the chance of success of captive populations of hirola, but the long-term maintenance of this species in captivity is likely to remain a challenge.

- Greater emphasis on monitoring to understand population drivers, improving habitat conditions, security, reducing livestock competition and controlling disease is needed to ensure recovery of the *in situ* and *ex situ* populations of hirola.
- Although establishment of founder populations is recommended using equal sex ratios for reasons of genetic representation, the high mortality amongst adult males experienced suggests this is not necessarily appropriate and translocating a higher proportion of females and juvenile males might be optimal.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Improved local, national and international commitment to conservation of hirola as a result of the project.
- Established the taxonomic status of hirola and confirmed it as one the highest conservation priorities amongst African mammals due to its phylogenetic uniqueness and current circumstances.
- Improved technical know-how on physical manipulation of the species which will reduce risks associated with future translocations.
- Provided the opportunity for the first detailed scientific study of the hirola (including a PhD on the behavioral ecology of hirola during the post-monitoring period). Confirmed susceptibilities to stress, predation and other important aspects. Obtained new information on social organization, feeding ecology, reproduction and other parameters.
- Probably increased the genetic diversity within the introduced Tsavo population.

Re- introduction of roe deer at Ajloun Nature Reserve, Jordan

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Introduction

Roe deer (*Capreolus capreolus*) was extinct from Arabia due to increased hunting pressure and partly due to the deforestation in its former habitat (Harrison & Bates, 1991). It inhabited the forested regions in northern Jordan valley and in the hills of northern Palestine (Carruthers, 1909), and most probably disappeared from Jordan at the beginning of the 19^{th} century (Amr, 2000).

The population in the Middle East is at risk, even though, it is considered as a Least Concern species according to IUCN (IUCN, 2008). The re-introduction program has take place in Ajloun Nature Reserve, which was established and managed by the Royal Society for the Conservation of Nature (RSCN) in 1989 and extends over $12km^2$ of mountainous terrain in the northern part of Jordan.

Goals

- Goal 1: To establish a viable population of roe deer in its former habitat in Jordan.

Success Indicators

- Indicator 1: Population size and structure of the roe deer.
- Indicator 2: Distribution of the roe deer.
- Indicator 3: Habitat quality of the roe deer release site.

Project Summary

The captive-breeding program started in a $0.02 km^2$ enclosure at Zubiya Nature Reserve. In August 2000, 14 individuals of equal numbers of males and females were transferred to Ajloun Nature Reserve. The reserve is characterized by the dominant evergreen oak (*Quercus calliprinos*), which is characterized by a maximum height of 5 m and classified as a Mediterranean shrub (Al-Eisawi, 1996). Other

Roe deer (*Capreolus capreolus*) © Khalid Al Masri associated tree and shrub species include the Palestinian pistachio (*Pistacia palaestina*), strawberry tree (*Arbutus andrachne*), Hawthorn (*Crataegus azarolus*), buckthorn (*Rhamnus palaestina*), and deciduous oak (*Quercus infectoria*) (Al-Eisawi, 1996), and it resemble the same characteristics of Zubiya Reserve. Only nine individuals (5 males:4 females) survived during transportation and were placed into a 0.01 km^2 breeding enclosure. The herd was supplied with 25-40 liters of water daily (around 1.65-2.65 l/animal). As well as, 50 kg of feed (3.4kg/animal) were provided twice per a day in rate of 25 kg at dawn and 25 kg in the evening. Faunal and floral surveys were conducted by the research and survey section of RSCN in order to identify species present at the site, their distribution and the major threats affecting them. All information was used to build up the management plan for the site.

The breeding program lasted almost 18 years, after that, a proposal was prepared in order to release the herd into the wilderness of Ajloun Nature Reserve. Accordingly; a set of operational objectives were established aimed to determine and prepare the releasing area, to select animals to be released, initiate the releasing program, establish a monitoring program and lastly to determine the preferable releasing time. On 19th of January 2006, 26 individuals (11 males and 15 females) were released in the reserve. As a follow up procedure, a rapid assessment survey was conducted, in order to draw a basic distribution map, collect data on feeding sources and habits and to find out threats on the herd as well as its effect on the reserve habitat.

During the survey, a global positioning system Garmin V with accuracy of +/-5m was used, and several methods were performed which included, a desktop survey of past reports and documents from the RSCN sections, which included data on the breeding and release program. Furthermore, a series of targeted visits through mid August and early September 2007 were performed and included several methods as visual census with counts in the early morning and at dusk at four main water sources and four vantage points. Methodical walks (spoor route) to record, any signs of deer through the accumulated droppings, footprints and deer paths, this method include areas ranging from dense to low vegetation cover. Opportunistic sightings, in addition to observations by rangers and/ or reserve staff. Lastly, local people and private landowners were interviewed in order to learn their views about the program and to obtain some feedback on the released deer.

The effective long-term management in the site will contribute to enhancing the conservation of habitat and species and reducing the main causes that led to the extinction of roe deer, also conducting several outreach programs targeted different stakeholders and local people. Periodic patrolling plans are accomplished by the reserve rangers inside and outside the reserve, and by the recent cooperation between the RSCN and the environmental police “Rangers”. Lastly, constant monitoring programs, which target habitat and deer population at Ajloun Nature Reserve, will indeed increase the success of the program and conservation measures.


Roe deer in natural habitat © Ehab Eid

Major difficulties faced

- A lack of official records that would have provided valuable information on mortality, behavior, activity, reproductive female status, and death factors during the breeding program.
- Lack of a model defining the numbers of years required to establish a viable population and likewise conditions, optimal numbers and status of individuals to be released per year.
- No detailed study on the effects of the released herd on Ajloun Nature Reserve was performed, especially the effects of roe deer on the general biodiversity and habitat composition of the area.
- The lack of socio-economic programs has led to several compliance from local people toward the release program.

Major lessons learned

- The effective long-term management in the site have a major role in achieving the major goal of the program, through enhancing the conservation of habitat and species and reducing the main causes that led to the extinction of roe deer.
- Conducting several outreach programs targeted different stakeholders and local people facilitate increasing awareness toward the importance of protecting endangered species.
- Periodic patrolling plans by the reserve rangers and cooperation with the environmental police "Rangers" assisted in improving habitat and species conservation.
- Constant monitoring programs, which target habitat and deer population at Ajloun Nature Reserve will play a major role into identifying success indicators and to find out the herd status over time.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- RSCN has managed to establish a viable population living freely in its former natural habitat, in Jordan under effective long-term management at the site.

- Permanent outreach programs to the local population and different stallholders is an important tool used to make aware of the importance of protecting endangered species.
- Periodic monitoring program for the released herd is an important tool to show the population trend.
- Implementation of a socio-economic program for stakeholders to increase participation and contribute to the success of the release program is needed.
- Secure continued funding and training on the deer management is still needed.

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Over 20 years of re-introducing the Arabian oryx in fenced and free-range protected areas of Saudi Arabia

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Introduction

The Arabian oryx or *Al Maha* in Arabic (Endangered & CITES App. I), is the smallest member of Oryx genus which is native to desert and steppe areas of the Arabian Peninsula and was declared extinct in the wild in 1972 in Oman. In Saudi Arabia the oryx the re-introduction program was started in 1989 by the Saudi Wildlife Commission. Concurrent conservation programs for the protection of large areas within the former range of the Arabian oryx, and the captive breeding of oryx at the NWRC in Taif have together enabled the restoration of the species in the Kingdom. The first re-introduction took place in Mahazat as-Sayd Protected Area (2,244 km^2) which was completely fenced in 1989 to prevent access by poachers and livestock.

The founder herd was as diverse as possible and comprised animals from national and overseas collections as well as the NWRC herd. The second release site is 'Uruq Bani Ma'arid (UBM) (12,600 km^2) situated on the western edge of the Empty Quarter. A total of 82 oryx (with almost equal sex ratio) have been released since 1990 to 2009 in Mahazat and since 1995 a total of 174 oryx (79 males:95 females) have been translocated. One hundred and forty-six originated from the NWRC captive breeding while 28 came from the Mahazat.

Collared Arabian oryx in Mahazat © M. Z. Islam

Goals

- Goal 1: To re-establish wild and self-sustaining populations of Arabian oryx in Saudi Arabia.
- Goal 2: To develop breeding techniques in semi-captive herds so as to allow the production of fit individuals.
- Goal 3: Studying the most suitable habitats and establish protected areas in which vegetation can recover.
- Goal 4: Managing the re-introduction of the herds in the protected areas.
- Goal 5: Re-introducing in suitable habitats, oryx from the "World Herd", in order to improve their genetic variability.
- Goal 6: Studying the ecology and biology of the oryx in protected areas.

Success indicators

- Indicator 1: The captive-breeding program at NWRC has achieved its expected goals.
- Indicator 2: The captive herd at NWRC is maintained for re-introduction programs for other protected areas.
- Indicator 3: The re-introduction of Arabian oryx in Mahazat as-Sayd for more than 20 years which now has a significant self sustaining population is considered to be a success.
- Indicator 4: After 14 years of re-introduction in UBM is also considered as successful as that also has a free-ranging population.
- Indicator 5: A website dedicated to Arabian oryx is hosted by the NWRC (*www.arabian-oryx.gov.sa*).

Project summary

Released animals were marked with suitable tags for identification and some fitted with radio collars to enable them to be relocated after release. The post-release progress of oryx has been carefully monitored and the information gained from early releases utilized in planning subsequent attempts where appropriate. We studied the behavioral ecology and reproductive physiology of the animals and as populations increased and animals dispersed into many small groups it become increasingly difficult to account for all the oryx each day. Monitoring of re-introduced populations is a key factor to evaluate the success of re-introductions and to implement management policies.

Population in Mahazat: The animals have been monitored since the beginning and population growth is monitored each year since 1988 to 2008. The numbers of animals present (including additional releases described above) since 1988 to 2008 are 9, 19, 31, 42, 89, 128,170, 221, 285, 355, 409, 415, 413, 469, 523, 547, 529, 605, 613, 550 and 324 respectively. Population declines resulting from food shortages or poor habitat are characterized by an increase in mortality among younger animals and a similar mortality pattern was observed both in Arabian oryx and Reem gazelles in Mahazat (Islam *et al*., 2007). There was a sharp decline in the oryx population of Mahazat in recent years during the summer months or in drought like situations. The rainfall in 1999, 2001, 2007 and 2008 were 4.27 mm, 11.45 mm, 0.01 mm, and 5.60 mm respectively, which has not been sufficient for the vegetation (grasses and trees) to regenerate. From 1998 to 2008, the number of dead oryx was 30, 34, 26, 35, 20, 37, 36, 12, 46, 71, and 159. In 2008 the skulls were mainly from previous years collected in 2008. Most of the dead animals were adults and also a few calves. Arabian oryx move long distances in search of food and the Mahazat fence prevents its movement especially during the stressful period when the food availability is extremely low. It is noticeable that many animals die near the fence.

Rangers monitoring Arabian oryx in Mahazat
© B. Pambour, NWRC

Active management plans of the ungulate populations in the Mahazat As-Sayd Protected Area were developed in 2008 and a previous plan was also discussed by the experts including ecologists, biologists, botanists, vets, sociologists and policy and decision makers to minimize periodic large-scale mortalities in the Reserve (Islam & Knutson, 2008). To deal with this situation, it was recommended that as many oryx and sand gazelle be removed from the protected area as possible. There is currently not enough vegetation to support the population and additional deaths appear imminent unless preventative action is taken. Because translocation or other means of removal were not readily available, supplemental feeding and watering is deemed as necessary to reduce the likelihood of mass mortalities.

Population in UBM: Uruq Bani Ma'arid Protected Area is one of the places, where free-ranging oryx population exist. The population of oryx in UBM in December 2008 was estimated as 200 animals by a survey using four fixed transect lines by vehicles and aircraft.

Post release monitoring: Due to aridity of their environments, oryx in the wild usually survive at low densities and therefore estimates of population size have a low accuracy, owing to the small number of individuals encountered during surveys in both the re-introduction sites. We used two methods of population size estimation in Mahazat, i.e., cumulated births and deaths recorded by field workers supplemented by transect counts on 14 lines by cars and aircraft. These monitoring efforts allow us to cross-check convergent indications, and to carry out surveys four times/year. In Uruq, we do intensive post-release population monitoring and also transects by vehicle and aircraft on four pre-defined transect lines twice a year to improve the monitoring efficacy for these large desert antelopes. A computer model was developed to evaluate the probability of extinction (frequency with which 100 initial population fall to zero within 100 years) of the predator-free Mahazat oryx population under various management options (Treydte *et al*., 2001). The probability of extinction was high when no management was applied to the population, probability of extinction varied between 0.3 and 0.92 according to combination of assumptions, whereas removing all oryx above 70% of carrying capacity provided the lowest probability of extinction, and the lowest population size variation whatever was the combination of assumptions (Mesochina, *et al*., 2003 & Islam *et al*., 2007). It is extremely important that the management of species is to be developed for the long-term solution of oryx in fenced protected area (Mahazat) and at the same time in unfenced or free-ranging re-introduction site (UBM).

Major difficulties faced

- No suitable habitat was available during the initial stages of re-introduction and fencing and protecting re-introduction sites was not possible.
- High mortality rates of adults as well as juveniles during summer in the fenced area of Mahazat as-Sayd is a serious issue and evidence that wild-born oryx are also in a poor condition during this period.
- A species management plan was available, especially for the fenced re-introduction site (Mahazat), but implementation was difficult.
- No study on the genetic diversity of oryx in the released sites has been done in recent years.

Major lessons learnt

- When wide-ranging species are confined to restricted areas, even if such areas are large, it is essential that an effective population management plan is in place BEFORE any re-introduction is carried out and that the plan is properly implemented. If this is not done, large-scale mortalities will occur.
- Prior to any transplantation, range conditions in the release area have to be improved and the area protected from livestock exploitation. Once pasture conditions show adequate signs of improvement and the site is adequately protected, re-introduction of the animals can be contemplated.
- The time of release should coincide with suitable vegetation conditions.
- Keeping the animals in pre-release enclosures within the re-introduction site to get them acclimatized to the natural environment and provide minimal amount of food and water.
- Regulate tourism in re-introduction areas as this can lead to increased habitat degradation.
- Strict law enforcement to minimize poaching of Arabian oryx.
- A public-awareness program had been started to inform citizens of the biological and historic significance of the Arabian oryx in the society.

Success of project

Mahazat as-Sayd Protected Area:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Uruq Bani Ma'arid Protected Area (unfenced):

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The Arabian oryx was considered extinct in the wild by 1972 (Henderson, 1974) from the Arabian Peninsula, now have self sustaining population in Saudi Arabia through the captive-breeding and re-introduction programs.

Acknowledgement

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Re-introduction and translocation of eastern bongo in Kenya; is it necessary and if so what are likely to be the most effective methodologies of achieving meaningful conservation goals?

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Introduction

The eastern or mountain bongo is currently only found in the wild in Kenya; surveys carried out by the Bongo Surveillance Program (BSP) confirm the existence of remnant populations in four isolated locations with no scope for natural migration between them; the Aberdare National Park, Eburu, Mau and Mount Kenya Forests. In the early 1980s it was estimated that the wild population of bongo in the Aberdares alone was well in excess of 500, however, in the last few decades there has been a rapid decline in the numbers of bongo due to poaching and human pressure on their habitat, with local extinctions in Cherangani, Mount Loldiani and potentially Mount Elgon and Chepalungu Hills. Wild bongo numbers in Kenya may now be as low as 100 or so animals. In 2004, a group of 18 Bongo were exported from North America to a captive facility at the Mount Kenya Wildlife Conservancy at Nanyuki where they joined a pre-existing captive herd. Despite a high level of mortality in the repatriated animals as a result of succumbing to theileriosis, this captive herd has expanded and there is mounting pressure to release these animals into the Mount Kenya World Heritage Site. However, it is suggested for several reasons the time is not right for any proposed release program for eastern bongo.

Bongo captured in camera-trap at night

Goals

- Goal 1: Determine more accurately the status and threats facing the eastern bongo in the wild.
- Goal 2: Develop a bongo conservation strategy in order to secure the remaining wild populations and allow them to expand.
- Goal 3: Implement a metapopulation management

plan to ensure the current rate of genetic drift in these populations is reduced and ideally reversed.
- Goal 4: Where possible expand eastern bongo habitat through reforestation projects.
- Goal 5: Maintain a genetically viable *ex situ* eastern bongo population as a resource to be made available to the Kenya Wildlife Service as required within the framework of a holistic conservation strategy for the species globally.

Success Indicators

- Indicator 1: On at least a bi-annual basis complete population surveys of the remaining eastern bongo populations.
- Indicator 2: Complete the assessment of the relative genetic health of both wild and captive eastern bongo populations in order to develop an appropriate global metapopulation management plan.
- Indicator 3: Completion of an integrated conservation masterplan for eastern bongo with the primary purpose of securing the species in the wild within Kenya in perpetuity.
- Indicator 4: A reduction in the rate of estimated genetic drift as calculated using Vortex to less than 5% per century (100 years) within Kenya.
- Indicator 5: A downgrading of the status of eastern bongo from critically endangered within 10 years.

Project Summary

Feasibility: The North American led bongo repatriation project carried out in 2004 highlighted various difficulties associated with a bongo repatriation project. Principle among these were the high mortality of repatriated bongo due to theilorosis, the failure to incorporate the captive Kenyan herd into the international bongo studbook, and the arguably apparent disconnect between the repatriation project itself and efforts to conserve declining but still viable wild populations at that time. Furthermore, it could be equally argued that this project was as much of a distraction from the main issues facing bongo in Kenya as it was a catalyst for their conservation. However, much has been learnt from this project and this captive herd at Nanyuki could yet play a vital role in the conservation of wild bongo by providing a surrogate herd for genetically targeted embryo transfers from outside of Kenya. In 2008 a population viability assessment was carried out by Jake Veasey with input from the Bongo Surveillance Program. This model was inevitably limited by the availability of solid data, however, it was useful in identifying probable outcomes based on educated assumptions, and was also be useful in identifying management priorities likely to yield the biggest conservation return.

Based on these assumptions; Vortex 9.94 reveals that there was a 89% chance of extinction of all bongo populations in Kenya within 50 years based on 500 iterations, and a mean time to total extinction of 30 years. Extinction in Mau and Eburu would be expected to occur within well under a decade based on the current set of assumptions. If all four populations are afforded comprehensive protection that is to say no reduction in carrying capacity due to illegal activity

Typical bongo habitat

(though still a 0.5% annual loss due to habitat/climate change) combined with a complete cessation of poaching, the likelihood of all bongo populations becoming extinct in Kenya over the next 50 years falls to 12%. However, even under this optimistic scenario with an expanding population of bongo, ~13% of the CURRENT genetic diversity will be lost in that 50 year period, on top of the ~15% or so that has been lost in the previous 50 years; highlighting the need for an effective and global meta-population management plan to coincide with effective protection. Moreover, a meta-population management to include the stable captive populations in Europe and North America which total in the region of 500 animals has the potential to further reduce the 12% extinction probability to close to zero as well dramatically reducing the ongoing loss of genetic diversity.

In order to consider releasing any bongo into Kenya whether they be from the captive Kenyan population at Nanyuki or from further afield, certain criteria should be met such as a) Current bongo populations must be secured, b) a long-term conservation masterplan should be in place for the species within Kenya, c) the genetic status of each population; wild and captive should be determined in order to optimise the re-introduction/restocking events and d) the issue of disease risk should be fully evaluated in order to avoid the potential transfer of exotic disease from captive populations into the wild Kenyan populations and/or to avoid high mortality rates amongst repatriated bongo.

Currently, Jake Veasey of Woburn Safari Park representing the European Endangered species Programme (EEP) for the Eastern Bongo is working in collaboration with Thomas Hildebrand of the Institute for Zoo Wildlife Medicine in Berlin to determine whether or not embryos could be created in Europe or North America for implantation to a captive herd within Kenya such as the one at Nanyuki. These embryos would be created by the specific pairing of captive bongo in order to best genetically supplement the existing wild populations based on a thorough genetic review of all populations. Not only would such an approach be highly targeted genetically, it will also be comparatively stress free and inexpensive and will result in babies being born in Kenya with all the advantages of acquired immunocompetence from their surrogate parents and early life exposure. Preparing them much more effectively for a subsequent release program where they can play a part in reinvigorating the genetic diversity of these impoverished wild herds.

Any future plans for the release of bongo descendant from any of the captive populations within Europe, North America or Kenya into the wild must also be mindful of the current IUCN Re-introduction Guidelines. Given the current ongoing decline in bongo numbers in the wild and the dearth of knowledge relating to disease risk and genetic health, the time is not right for an imminent release. However, with the benefit of two well managed captive herds in Europe and North America, and a potential surrogate herd within Kenya, there is the opportunity, possibly for the first time in conservation history, to implement an effective global meta-population management plan incorporating wild and captive populations with genes currently lost to the wild being returned from captive populations. For this to be possible, various obstacles do need to be overcome, not least of which is cessation of the current decline in bongo numbers.

Implementation & Post-release monitoring: Currently ongoing.

Major difficulties faced

- Continuing decline of eastern bongo in the wild due to habitat loss, poaching and potentially predation by predators previously absent or at lower densities within the current eastern bongo distribution.
- Isolation of remaining wild eastern bongo populations and close proximity to expanding human populations and associated livestock.
- Uncertainty about the relative genetic status of wild and captive populations and difficulties in collection genetic data from the wild populations.
- Potential disease risk posed by amongst other things a chronic wasting condition seen in some captive bongo for which there is very little known.

Major lessons learned

- Any re-introduction project must be set firmly within the context of a wider strategy for the conservation of the species.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
The recent repatriation can only be viewed as a partial success, the proposed future transfer of captive genes to the wild is currently in the feasibility stage.

- High level of mortality of repatriated animals.
- Unsuitability of these animals and their offspring for any imminent release program.
- Failure to incorporate the captive Kenyan herd within the international studbook and to manage their reproduction more effectively.
- These animals repatriated animals may yet form the basis of a vital surrogate herd and may also be suitable to supplement wild populations directly following a full genetic assessment of the remaining populations in the wild and captivity.

Re-introduction of the Amur goral into Wolaksan National Park, South Korea

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Introduction

Amur goral (*Naemorhedus caudatus*) is designated as Endangered species I, Natural monument in South Korea and internationally IUCN Red list VU, CITES App. I. In the past there were lots of Amur goral in the Korean peninsula, however indiscriminate development and illegal poaching have provoked fragmentation of habitat and decreasing of populations. Although totally 700 individuals are in South Korea, it would be extinct in 20 years if it were not for the enforcement of the population and because they are genetically vulnerable due to living in fragmented habitats and small population sizes. As Wolaksan National Park is historical goral habitat, a total of six individuals each were released in 1994, 1997 and 1998 to experimentally study their ecology and habit suitability. An additional 10 individuals were released in 2007 by the Species Restoration Center (SRC) of Korea National Park Service (KNPS). Now they are living well in the released area and SRC has monitored their ecology by radio tracking.

Amur goral with radio-collar

Goals

- Goal 1: Establishment of self-sustainable population in Backdudaegan (ecological axis of Korean peninsula) area as well as Wolaksan National Park in South Korea.
- Goal 2: Recovery of healthy eco-system through the re-introduction of Amur goral.

Success Indicators

- Indicator 1: Mating and giving birth in the wild.

- Indicator 2: Continuous monitoring and research after release.
- Indicator 3: Informing people that these species are not alien but part of the natural ecosystem.
- Indicator 4: Establishing a self-sustainable population and genetic diversity of Amur goral in Wolaksan National Park.

Amur goral in its rocky habitat

Project Summary

Feasibility: As Wolaksan National Park is historical goral habitat, it is one of the best areas for restoration of goral, because there are abundant food resources and it's possible to manage goral habitat efficiently. After Amur goral is designated as endangered species, bond of sympathy on restoration of goral developed fast among people, because they are not a savage beast such as bear and wolf, SRC of KNPS got involved in the project on restoration of goral based on "Comprehensive plan of restoration on endangered species" by the Ministry of Environment in 2007.

Implementation: We released six individuals between 1994 and 1998 in Wolaksan National Park. After release and through continuous monitoring we could study their ecology and home range, and we could confirm an increase in the population (initially 10 individuals) by fecal DNA analysis in 2004. However it was necessary to establish some teams to conduct monitoring and intensive surveys for more information. So a goral task force team was established which included biologists, veterinarians and local people under SRC of KNPS in 2006. An advisory committee was also organized and composed of several specialists for the restoration of goral, as a result of that there has been more scientific research and restoration of goral. Although released populations increased between 1994 and 1998, it was realized that the population would show a decrease in genetic diversity because of their isolated habitat and limited number of individuals. It was therefore agreed to release 10 more individuals from Kangwon province in 2007 by SRC of KNPS.

Post-release monitoring: Every goral was released with a transmitter or GPS collar and we have been monitoring daily since release. For more ecological information of goral we are analyzing their home range and routes of movements by radio tracking, habitat use and food resources through field surveys. We are doing also several veterinary examination such as analysis of blood chemistry, fecal parasite exam, etc. for studying physical features and infectious diseases. In addition to this research we are controlling poaching to remove threats that could increase their mortality rate in the habitat in Wolaksan National Park. Local people are also being involved in the restoration of goral by being recruited as members of "honorary rangers". So through these efforts we concluded that the home range of goral in South Korea was larger than those of Russia and Japan. We also managed to film the species in the wild including mating behavior, feeding and excretion behavior. Movements of the population were monitored by an infrared scouting camera.

Major difficulties faced

- Destruction and fragmentation of habitat.
- Natural selection based on inbreeding depression.
- Many populations inhabit localized areas resulting in severe competition of food resources.

Major lessons learned

- When we introduce the animals from other areas we should survey the release site to assess if it is ecologically suitable.
- Released animals should be monitored and managed to maintain genetic diversity continuously in their habitat.
- A suitable conservation area of suitable habitat, appropriate management and financial support is needed for the successful restoration of goral.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Introduced goral adopted well to the released area and increased their population.
- Some individuals moved into new habitat and it was good habitat for the goral.
- A special organization such as SRC which conducts the artificial restoration of endangered species including goral was established in KNPS.
- Financial support is also continuously available.
- A continuous post-release monitoring system has been running.

Re-introduction of Apennine chamois to the Gran Sasso-Laga National Park, Abruzzo, Italy

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Introduction

In the Holocene, the Apennine chamois (*Rupicapra pyrenaica ornata* Neumann, 1899), occurred through the Central-southern Apennines. In historical times, its range was limited to the Abruzzo Region, on the mountains of present day Abruzzo, Latium and Molise National Park (ALMNP) and on those of Gran Sasso-Laga National Park (GSLNP): here, the last chamois was shot in 1892, 100 years before the park was established. A population of <40 chamois survived in ALMNP, established in 1922. The World Wars marked two population bottlenecks (poaching), but numbers of chamois started growing since the 1970s. Because of its small population size (<1,500 presently), low genetic variability and small range, this subspecies is listed as Vulnerable (D1+2) in IUCN Red List; is present in App. II of the Bern Convention; is listed in Annex II and IV of the E.U. Habitat Directive, App. I of CITES, and considered “especially protected” by the Italian law 157/1992. Five sub-populations are being created in as many parks. The first release occurred in Majella National Park (MNP) in 1991, followed by GSLNP in 1992 and Sibillini Mountains National Park (SMNP) in 2008. Only the Gran Sasso release is a “re-introduction”; the others are “conservation introductions”.

Apennine chamois male in winter coat

© Sandro Lovari

Goals

- Goal 1: Creating a new, viable and geographically isolated population of Apennine chamois, in case of an epidemics or other catastrophic event affecting the source population in ALMNP.
- Goal 2: Returning a medium-size ruminant to

the appropriate Apennine ecosystems, through an operation of biodiversity restoration.

- Goal 3: Promoting the establishment of a new National Park from former Nature Preserves.
- Goal 4: Providing an attraction for visitors and, in turn, for the local economy.

Success Indicators

- Indicator 1: Establishment of a local herd within the three years release program.
- Indicator 2: Occurrence of a fair (over 20%) yearly growth rate.
- Indicator 3: Occupancy of the area predicted suitable for the chamois and development of new herds.

Project Summary

A feasibility study, based on RSG/IUCN Guidelines, was carried out in 1990 by experts from the University of Siena and the University of Bologna, to estimate the local ecological suitability, and the ALMNP (Tassi *et al*., 1992), for all other aspects, concentrating on: a) Evaluation of re-introduction sites: During the cold season, the Apennine chamois prefer forested slopes, moving to open areas and cliff ledges during the warm months. Adult males tend to live in woodland all year long, moving to Alpine meadows on September/October for pre-rut activities (Lovari & Cosentino, 1986). A suitable area of about 8,000 ha was found in Gran Sasso, with mixed beech (*Fagus sylvaticus*) forest, at about 1,800 m a.s.l., next to Alpine meadows (*Seslerietum* and *Festuco-trifolietum thalii*). Roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), wolf (*Canis lupus*) and golden eagle (*Aquila chrysaetos*) also occur in the area. An assessment of presence and impact of limiting factors (e.g. land use, tourist activities, poaching, stray dogs, competition/sanitary interference with livestock) was conducted. b) Reproducers and release protocol: About 30 chamois (sex ratio, 1:2) were darted, mostly in the wild (ALMNP, Val di Rose herds) and released in GSLNP. A darting device was used to administer xylazine and ketamine. Chamois from Park enclosures were also used, to minimize the impact on the source population. All darted chamois were checked for diseases, with no positive result (Gentile *et al.*, 2000).

Support of local communities: Two large enclosures (several hectares) for Apennine chamois were built in 1992 in Farindola and in 1993 in Pietracamela (municipalities near the release sites) with the help of local volunteers. The operations included two phases: the first one (1992-1994) was realized under the aegis of the ALMNP, the Italian Alpine Club and the WWF-Italy. From July to October, 26 chamois (15:11) were darted in ALMNP and transferred under narcosis by helicopter. Thirteen animals (5:8) were captive-bred. The chamois were marked at both ears with coloured plastic tags; four males and eight females were also fitted with a radio-collar. At the release site, the animals were recovered form narcosis by injecting an antagonist (Locati *et al.*, 1991) and released directly into the wild (Toso & Tosi, 1992). The second phase (1999-2001) was carried out by the GSLNP Agency, Siena University and Legambiente, through a E.U. Life project and nine more chamois (8:1) were darted in park enclosures, fitted with ear-tags and radio-collars, loaded on a 4WD vehicle in individual carrying crates and released near wild herds. The GSLNP was established in 1992, but it could start the re-introduction and monitoring programs only from 1995. From 1992 to 1996, monitoring was carried out by volunteers. In 1995-1997, all relevant field information was collected by two of us (C.A. and G. D.) on behalf of the park agency. Since 1998, counting and monitoring programs have been established, also through the support of two E.U. Life projects on these chamois (1999-2001 and 2002-2005); 2 counts/year (July and October) were organised (block-count, Maruyama & Nakama, 1983).

Chamois on Gran Sasso with town of Isola Del Gran Sasso in background © Gino Damiani

Information on population dynamics and space use patterns of the herds was collected. Radio-tracking was used to locate tagged individuals, as well as other members of the same herd. Success was poor in the first year probably because the first group of released animals (2:5) were all coming from captivity, except one female, and two females and one male were very young (< than two years old). Only the wild born female survived until the next release, in 1993. The second group was released in 1993 (5:4), and that released in 1994 (4:6, with six wild animals) joined the others, forming three stable and viable herds (Artese, 1998). Since then, chamois have shown a steady growth rate of 23% per year (Mari & Lovari, 2006), occupying most of the suitable area, with a total of 10 herds (340 individuals), by 2008.

Major difficulties faced

- To obtain funding for a long-term monitoring plan.
- Difficulty of getting reproducers in fair numbers.

Major lessons learned

- We suggest to release no less than 30 individuals with a 1:1 or 1:2 sex ratio, in a chamois re-introduction. Releases should be concentrated as much as possible in time to minimize dispersal, over a period as short as possible (one or two years).
- Sub-adult individuals, especially males, will tend to disperse. Preference should be given to adult (>5 years old) males as reproducers, especially in the first releases.
- The presence of several mature (7-9 years old) females will tend to reduce the dispersion of younger chamois. A conservative measure for the “source” population would be to capture a majority of wild two or three years old

females, *i.e.* with no kid at heel, especially if the re-introduction is carried out in summer/autumn. If so, leaving orphans will be avoided and young females should have a long reproducing life in the new colony.
- A well organised captive-breeding program, based on an inter-agency studbook, is fundamental to support re-introductions, when wild reproducers are not easily available.
- After the removal from the “source” population, the immediate release of reproducers to the new area is advisable (acclimatizing enclosures are unnecessary or even to be avoided).
- A monitoring radio-tagging program, if properly carried out, will allow the collection of important data on movements, habitat selection and adaptation to the area of re-introduction.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:
- In 2008, the GSLNP population reached an estimated number of 340 head, with a growth rate of 23% per year.
- Colonization of the expected suitable area for chamois, with 10 viable herds.
- Restoration of the trophic chain in the Apennine ecosystems; restoration of an additional prey for predators, *i.e*. wolf, golden eagle and brown bear.

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Two African elephant translocations into the Isimangaliso Wetland Park in Kwazulu/Natal, South Africa - one problematic, the other problem free

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Introduction

Genetic evidence suggests that there may be two (Roca *et al.*, 2001) or three (Eggert *et al.*, 2002) species of African elephants. The IUCN Red List assessment (2008) required more extensive research to support the proposed re-classification however, and this assessment was therefore conducted for the single species currently described *(Loxodonta africana* Blumenbach 1797*)*. The species was classified globally as "Near Threatened", but in South Africa as "Least Concern" (Friedman & Daly, 2004). Many national parks and reserves in South Africa have received elephants through translocations, principally from the Kruger National Park (KNP). Initially, these translocations were comprised of juvenile age classes, as the techniques and equipment for moving adult elephants or intact family units had not been developed. Elephant translocations currently offer few challenges as the techniques and the logistics (Dublin & Niskanen, 2003) have been well refined and understood.

This re-introduction experienced unique problems which is why this discussion is presented here. The iSimangaliso Wetland Park was South Africa's first National Heritage site. It has unique ecological processes and a wide biodiversity range. The 332,000 ha park contains eight interlinking ecosystems including fresh and saltwater lakes, marsh, swamp forest,

African elephant and calf © Neil Whyte

coastal dune forest, coastal grassland and bushlands, estuarine and marine systems.

Goals

The main goals of the re-introduction of elephants to iSimangaliso (Mulqueeny 2005) were:

- Goal 1: Restore and manage a demographically and genetically viable population in the Park, as part of a provincial meta-population management strategy.
- Goal 2: Maintain the population in a state where elephant associated ecological processes are restored and maintained.
- Goal 3: Manage the population in a manner that optimises their value as a tourist attraction.
- Goal 4: Gain an understanding of the role that elephant play in enhancing and maintaining the biodiversity of the Park.

Success Indicators

Indicators of success for the project were not defined prior to the introduction of the elephants but may in retrospect be listed as:

- Indicator 1: The establishment of a spatially stable elephant population (no break-outs from the park).
- Indicator 2: Attain a state where the elephants are habituated to people to conform with tourist objectives.
- Indicator 3: Attain a state where the elephants are shown or perceived to be fulfilling their ecological role.

Project Summary

With the exception of Tembe Elephant Park (TEP) on the Mozambique/South Africa border, there had been no resident elephant populations in KwaZulu-Natal between 1880 and 1980. The species had been common and widespread but was extirpated by indiscriminate hunting in the 19th century. Currently, the primary objective of most protected areas in KwaZulu-Natal is to conserve biodiversity. This, among other mechanisms, entails the re-establishment and maintenance of ecological processes. The re-introduction of elephant into the iSimangaliso was largely for these two reasons. iSimangaliso’s habitats are considered suitable for elephants and estimates of the carrying capacity of its respective vegetation types yielded a total of 286 (Mulqueeny, 2005). Mkhuze Game Reserve (MGR) has recently been incorporated into iSimangaliso. Prior to the two introductions covered in this account, a population had already been established in MGR (12 orphan juveniles introduced in 1994 and a family herd of 12 in 1996, all from KNP). The MGR population, however, remains for the moment geographically separate from the rest of the newly introduced population. Prior to the introduction, the electric fencing of an area in which the elephants were to be contained in iSimangaliso was mostly complete. A small holding boma was also completed. Translocated elephants are initially held in such bomas for about 24 hours to allow them to settle and familiarize themselves with electric fencing.

Damage to a car by aggressive elephants
© Leigh-Ann Morrison

Due to its close proximity and its rapidly growing elephant population, the Hluhluwe/ iMfolozi Park (HiP) was selected as the most appropriate source of elephants for translocation. The HiP population was originally comprised of 200 orphaned elephants that had been captured during KNP culls. These were translocated to HiP in small groups between 1981 and 1994 in 13 separate translocations. Of these 26 were known to have died. Of the survivors, 80 were males and 82 females (another 12 were of unknown sex). The surviving 174 coalesced into a single herd. Problems arose as mature adults were absent from the population which resulted in excessive aggression directed at both humans and rhinos. This was caused by abnormal musth cycles in males and excessive stress in cow/calf groups. In 2000 -2001 therefore, 10 adult bulls were introduced from the KNP in a successful attempt to stabilize aberrant behavior of young emerging bulls. In due course the orphan group achieved sexual maturity and escalating numbers necessitated population management. The decision to move some of these animals from HiP to iSimangaliso was the logical one at the time as there was no historical precedent which could have helped predict the problems that could arise with a second translocation of elephants from an orphan derived population. Further reasons for favoring this option were that it precluded trans-border, veterinary and phyto-sanitary concerns, and long translocation distances.

Attempts at pre-monitoring of the HiP herd were made to try to identify suitable social groups for the translocation to iSimangaliso. No such groupings could be identified as all of the translocated animals had remained in a single unstructured herd comprised largely of unrelated individuals. Of necessity therefore, selection of the animals for translocation had to be a rather random process. Twenty-four were captured in HiP in August and September 2001 and translocated to iSimangaliso. Three of these were young adult bulls which broke out of iSimangaliso. One found a gate that had accidentally been left open. The other two found a small gap in the fence between the lake and coast line. All three were captured and returned to HiP. The remaining twenty one were cow/calf groups who again formed a single herd in iSimangaliso. Composition of this herd was as follows 3 males (juveniles) and 3 calves; 10 adult females, 4 juveniles and 1 calf (Mulqueeny, 2005). This was thus the second translocation that these animals had experienced, and in this new environment there were unaccustomed disturbances prevalent. Logging of commercial plantations being rehabilitated for inclusion in iSimangaliso was being conducted 24 hours per day. This was associated with electric lights, chain saw noise and constant traversing by large timber trucks. For these young and inexperienced females this would have been extremely stressful, particularly as no older adults (matriarchs) were present to undertake leadership roles. These stresses induced problems with this group such as breakouts, the death of a calf and unusual aggression which led to two human fatalities.

A workshop was held at iSimangaliso on 14th February 2002 to discuss these problems and from this a recommendation was made that any further translocations should only be of elephants in intact family units accessed from habituated animals in the KNP. The translocation of two such families from KNP followed in June 2002 and June 2003. Composition of this herd was as follows males (10 juveniles, 1 calf) and females (6 adults and 1 juvenile). No such problems have been experienced with these animals.

Major difficulties faced

- The three adult bulls initially released in iSimangaliso escaped from iSimangaliso and had to be recaptured and returned to HiP.
- The initial cow/calf groups from HiP experienced considerable stress due to the young and inexperienced nature of the adult females faced with an apparently hostile environment. These stresses resulted in excessive aggression from these young females (probably due to the lack of the calming influences of older matriarchs) which culminated in deaths of two people. The first of the people killed was a gate guard who approached the elephants on foot in a dense young *Eucalyptus* plantation to get a better look at the elephants. The second was a woman who was one of five people in the cab of a three ton truck that was attacked by one of the adult females.
- The young adult cow responsible for this attack was identified from the vehicle paint which still adhered to her tusks and chips of ivory found in the cab of the truck, which matched the damaged tusk and she was euthanized. The elephant responsible for the first attack could not be positively identified as the attack took place late evening and it rained that night.
- One calf from the HiP group died, probably from hypoglycaemia, from extensive movements (flight responses) while trying to escape unfamiliar elements in their new environment (such as 24-hours per day logging and associated disturbances).

Major lessons learned

- Translocation of wild-caught juvenile elephants for re-introduction purposes (instead of in intact families) is to be avoided.
- The relocation of elephants more than once in their life times is a questionable practice, particularly if they originated from orphaned groups.
- While translocation is possibly the most humane of the options available for managing elephants, others (contraception and/or culling) may be more appropriate for populations derived from orphaned animals.
- Elephant proof fencing must enclose the entire area, as elephants thoroughly explore their new environments and are likely to find any gaps.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Although all of the success indicators have now been achieved, the problems with breakouts, calf mortalities and anti-human aggression exhibited by the HiP elephants probably render the project "Successful" rather than "Highly successful".
- Although it is not unusual for elephants to favor particular areas or habitats, it was hoped that they would utilize both the eastern and western sections of iSimangaliso more equally. Since introduction, they have concentrated in the western section of iSimangaliso and this may be a cause for concern in terms of their potential impact on other biodiversity elements in the area. Also, their relative absence from the eastern sections means that they are not contributing, as intended with their introduction, to the ecological processes there, and they are not contributing to the tourism value of that area.

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Conservation breeding and re-introduction of the pygmy hog in N.W. Assam, India

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Introduction

The pygmy hog (*Porcula salvania*) is the smallest, most highly specialized and most endangered of the world's wild suids. It was formerly known or presumed to occur across a narrow strip of early successional tall grassland plains along the southern Himalayan foothills, extending from N.E. Uttar Pradesh and S.W. Nepal in the west, to northern West Bengal and N.W. Assam in the east. However, all confirmed reports and most anecdotal accounts dating back to its description in 1847 refer only to the latter areas; and, most recently, only to N.W. Assam, where the species was 'rediscovered' in 1971 after it was long suspected to have become extinct (Oliver, 1980). By the early/mid-1980s the species was reduced to a single, fragmented population in the Manas National Park, possibly still extending into a neighbouring reserve forest when the Pygmy Hog Conservation Program (PHCP) was formally launched 1995. IUCN has long categorized the pygmy hog as Critically Endangered – Red List Category C2a(ii) – putting it among the most threatened of all mammals. It is listed on Appendix One of CITES and Schedule One of the Indian Wildlife (Protection) Act 1972. The species was formerly referred to as *Sus salvanius* as it was believed to be closely related to the Eurasian wild pig (*S. scrofa*). However, recent mtDNA studies have revealed that it belongs to a separate monotypic genus *Porcula*.

Pygmy hog female near nest © Goutam Narayan

Goals

The primary goal of the PHCP was to promote recovery of pygmy hog and to reduce further population decline, to ensure survival of pygmy hog into perpetuity. The specific goals were:

- Goal 1: To establish a captive population with aims to re-introduce the species to selected sites, and as an insurance against the possible early extinction of the species in the wild; to breed the animals at two or three different sites in order to reduce risks from any catastrophe at one site.

- Goal 2: To select unrelated hogs to form compatible social groups, and to prepare these groups for unassisted survival in the wild using a 'soft-release' protocol.
- Goal 3: To re-introduce viable number of pygmy hogs in properly restored and protected habitat managed on scientific principles based on recommendations of the project. Initially, the plan is to release the species to two or three different sites in Assam, and later to other areas of its former distribution.
- Goal 4: To monitor the re-introduced population and, if necessary, modify the re-introduction protocol to promote long-term survival of released hogs as well as all original inhabitants of the habitat.

Success Indicators

- Indicator 1: The captive hogs multiply under a well structured and planned breeding project in order to supply 10-20 hogs every year for release. Hogs are bred at two or more sites.
- Indicator 2: The selected social groups of captive hogs are genetically heterozygous, physically healthy and behaviorally secure, and are able to survive in simulated grasslands at a 'pre-release' facility under the 'soft-release' protocol without human assistance.
- Indicator 3: The selected release sites are protected and managed scientifically for proper restoration of the habitat. The major factors that were likely to have caused the disappearance of the species from the place have been addressed. Ten to fifteen hogs in three or four social groups are released once every year for at least three consecutive years at the selected site using 'soft-release' protocol.
- Indicator 4: The released hogs survive and adapt to the wild conditions, begin to breed and disperse. Monitoring, using direct and indirect methods, indicate survival of a large proportion of the released hogs, and provide evidence of increase in their population and dispersal to available habitat.

Project Summary

Feasibility: Wide-ranging distribution and status surveys conducted after the 'rediscovery' and in later years confirmed the continuing occurrence of this species in Manas and documented the occurrence of a number of other small, and highly fragmented populations in the reserve forest belt of north-western Assam, east of Manas, but all of these smaller populations were confirmed or feared extinct by the early to mid-1980's. Attempts to trace any other possibly surviving remnant populations elsewhere within their known or presumed former range in southern Nepal and north-eastern India, extending into extreme south Bhutan, south-western Arunachal Pradesh, were also unsuccessful (Oliver, 1980; Oliver & Deb Roy, 1993 & Narayan *et al.*, 2008). Unfortunately its last natural abode, Manas, is also threatened by political instability and other problems.

The main threats to survival of pygmy hogs are loss and degradation of habitat due to the expansion of human settlements, agricultural encroachments, flood control schemes and injudicious grassland management practices, especially extensive and indiscriminate burning of tall grasslands during the dry-season and replacement of these grasslands with commercial tree plantations. Pygmy hogs are clearly dependant on the continuing existence of these grasslands, which are likewise crucial to the survival of a number endangered species such as the one-horned rhinoceros (*Rhinoceros unicornis*), barasingha (*Rucervus duvaucelii ranjitsinhi*), water buffalo (*Bubalus arnee*), hispid hare (*Caprolagus hispidus*) and Bengal florican (*Houbaropsis bengalensis*). However, none of these other species appear to be as crucially dependant on the continued availability of the successional grasslands most prone to widespread and too-frequent burning and other disturbances, and are thus one of the first species to disappear from such habitats which may continue to support these other species (Oliver, 1980; Bell & Oliver, 1990 & Oliver & Deb Roy, 1993).

Pygmy hogs are dependent on, and specifically adapted to, undisturbed patches of grassland dominated by early successional riverine communities, typically comprising dense tall grass sward intermixed with a wide variety of herbaceous plants and early colonizing shrubs and young trees. most important of these communities for pygmy hogs are the grass associations dominated by *Narenga porphyrocoma*, *Saccharum spontaneum*, *S. bengalensis* and *Themeda villosa*, which form characteristic associations of 2 to 3 m height during secondary stages of the succession on well drained ground. Historically, these grasslands were probably maintained by changing river courses as well as by grazing and trampling pressures from large wild herbivores such as rhinos, elephants, buffaloes and deer. With extermination or sharp decline in large wild herbivore populations this control mechanism has become insignificant. Changes in river courses contribute towards emergence of new areas that get colonized by grass and shrubs, whilst older grasslands, grassy woodlands or riverine forests are eroded or submerged. Unfortunately, if the newly emerged areas fall outside protected areas they are quickly brought under human use, thereby preventing colonization by grassland flora and fauna. Grasslands in low-lying areas are still maintained by prolonged inundation, whereas those in well-drained areas are brought under periodic burning. However, as the remaining grasslands include various, commercially important thatch grasses, most of are subject to annual harvesting (even in protected areas) and virtually all of them are subject to wide-scale annual (in some areas, biannual) burning.

Most of this burning is conducted at the beginning of the dry season (i.e. in December, January or early February), in order to preclude the possibility of later, uncontrolled ‘hot’ burns, which are even more destructive. As a result, the regularly burnt grasslands are characterized by relatively uniform growth of a few, fire-resistant species and, hence, a chronic reduction in species’ diversity and the quality and carrying capacity of this habitat for dependant animal species. Too frequent burning also destroys the surface litter in which the hogs forage, along with the ground fauna (e.g. insects, annelids) that is an important part of the diet of pygmy hog as well as many other animals and birds. It also exposes the surface substrate that becomes hard and desiccated prior to the rains, making rooting more difficult and less profitable.

Pygmy hogs escaping from release enclosure at Sonai Rupai (see red circle) © Goutam Narayan

Implementation: The main aim of Pygmy Hog Conservation Program is conservation of the pygmy hogs and other endangered species of tall grasslands of the region through field research, captive breeding and re-introduction of the hog after adequate restoration of degraded former habitats.

Conservation Breeding: In 1996, six wild hogs (2:4) were caught from Manas National Park and transferred to a custom built research and breeding centre built at Basistha near Guwahati. The 3 adult females, which were pregnant from wild, produced healthy litters and the captive population increased to 18. Seven more litters were born in the following year and the captive hog population almost doubled to 35 in 1997. Similar success in captive breeding in subsequent years saw the captive population at Basistha rise to 77 in 2001, which constituted a 13-fold increase in the stock in 6 years. This unanticipated and rapid increase in the captive population required imposition of rigorous curbs on their reproduction. A population of around 70 hogs was maintained in captivity till 2007, and the first releases were conducted in 2008.

Site Selection and Habitat Restoration for Re-introduction: After extensive surveys and detailed consultations with the relevant authorities two sites were selected as being potentially suitable for re-introduction purposes, i.e. Sonai Rupai Wildlife Sanctuary and Nameri National Park. A third site, Orang National Park, was kept under observation to assess flood water levels in the rainy season, and later it was concluded that the grasslands in the northern part of the Park are suitable for releasing the hogs. These three sites fall within the species known or presumed recent range in north-western Assam, though no evidence could be found of the species continuing occurrence in these areas, despite the presence of suitable habitats. Of the first two sites, Sonai Rupai was selected for the first such releases on the basis that it contained considerably more tall grasslands than Nameri, but that this area had been generally neglected and that any such reintroduction attempt might also generate increased interest and resources to effect the enhanced future protection and management of the entire area. To these ends, the PHCP continues to work with the Sanctuary authorities and staff to improve protection and management and to control annual dry season burning of grass. Sanctuary staff was also trained in wildlife monitoring and habitat management to help in restoration of the grassland habitat and monitoring of released hogs.

Pre-release Protocol: Social groups of unrelated and mostly young hogs were integrated at Basistha breeding centre before being transferred to a specially constructed 'pre-release' facility in Potasali, on the outskirts of Nameri National Park, east of Sonai Rupai Wildlife Sanctuary. Every effort was made to 'pre-condition' the animals for eventual release by maintaining them in three separate social groups, in simulated natural habitats intended to encouraging natural foraging, nest-building and other behaviors; whilst also minimizing human contacts to mitigate tameness and other behavioral characteristics consequent upon their captive management. Radio-harnesses designed for post-release monitoring studies were also field-tested by trial attachments to two individuals in each group, but unexpected problems arose in the long-term use of these harnesses, if they were fitted too tightly they were prone to causing serious skin lesions and if too loose the hogs were able to escape from the harnesses. It is therefore proposed to secure radio implants for future trials. In the interim, alternative means of monitoring include have included camera trapping, training the animals to visit random bait sites and screening for field 'sign', such as forage marks, tracks, faeces and nests.

Re-introduction and Post-release monitoring: After five months tenure in the 'pre-release' enclosures at Potasali these hogs were transferred in early May to temporary 'soft-release' enclosures constructed for this purposes in a relatively secluded, but easily accessible area of natural habitat in the far interior of the Sonai Rupai Wildlife Sanctuary. These enclosures were also rigged with two lines of electric fencing and kept under continual surveillance as a precaution against potential predators and to deter incursion by wild elephants. The animals were maintained for a further three days in these enclosure before being released, by the simple expedient of removing sections of fence and allowing the animals to find their own way out. Sixteen pygmy hogs (7 males:9 females) were released in Gelgeli grasslands of Sonai Rupai in May 2008 and indirect evidences suggested that at least 10 - 12 continued to survive several months after release. Footprints of newborn hogs too were seen indicating successful farrowing in the wild by a released female. A video camera trap was also used carefully deployed near active nests and the hogs caught in camera appeared healthy and had shiny coats, unlike the somewhat emaciated hogs captured from the wild in Manas in 1996. Some of these individuals were identified by hair-clipping marks shaved before release. That the released hogs appeared to be in good health despite harsh weather and sometimes difficult foraging conditions up to nine months after their release was most encouraging in that it not only confirmed their survival, but suggested their successful adaptation to the wild after at least one or (in most cases) two generations of captive management. Following similar protocol, nine hogs were released in May 2009 and ten more in May 2010, thereby releasing a total of 35 hogs in different locations of Gelgeli grasslands in Sonai Rupai. Besides numerous signs of hog activity around the release locations there were a few direct sightings of the released adult and young hogs that had been born in the wild. However, to get a better idea about survival, breeding and dispersal of released hogs it may be necessary to recapture some of the hogs in Sonai Rupai and possibly insert radio implants in some for more accurate monitoring.

Major difficulties faced

Searching for pygmy hog signs in Sonai Rupai grasslands © Goutam Narayan

- The main difficulties in implementation of this project largely related to serious shortage of remaining suitable habitat for re-introduction. Although most of the remaining former pygmy hog habitats were inside Protected Areas, unscientific management of grasslands and lack of adequate protection were responsible for their degradation.
- Indiscriminate and often uncontrolled dry season burning of grass.
- Unsustainable and often ineffectively controlled livestock grazing.
- Unsustainable thatch grass and minor forest produce collection.
- Flash floods caused by natural or artificial dams.
- Failure of radio telemetry experiment on the hogs due to injuries caused by the harness.
- Poor economic condition of the communities living in the fringe areas of the concerned PAs resulting in their dependence on grassland resources for livelihood and their suffering due to human-animal conflict.

Major lessons learned

- If the recommendations made by research projects on sensitive/indicator species of the habitat are implemented, the chances of success increase. Besides studies on pygmy hog and its habitat (Oliver, 1980 & Oliver and Deb Roy, 1993), recommendations made for conservation of Bengal florican (Narayan & Rahmani, 1990) and hispid hare (Bell & Oliver,1990) contributed significantly to the success.
- The most important recommendations suggested controlling the indiscriminate dry season burning that were put deliberately by forest staff as an age old management practice, as well as by local inhabitants of fringe area villages and illegal intruders as this undoubtedly, and catastrophically, impacted on the survival of many smaller species including the pygmy hog.
- A well planned conservation breeding project capable of supplying adequate number of healthy individuals for re-introduction could be an important factor.
- It takes years, if not decades, of persistent efforts to implement a successful recovery program.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Highly successful conservation breeding project.
- Long-term commitment and dedication of all salient personnel and supporting agencies, both locally and internationally.
- The resilience of the grassland habitat which improves rapidly when managed and protected properly.
- The ability of the species to adapt to the wild if the grassland habitat is restored adequately.

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Augmentation of a Whibley Wattle population in South Australia by translocation

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Introduction

Whibley wattle (*Acacia whibleyana*) R.S. Cowan & Maslin (Leguminosae) has an extremely restricted distribution near Tumby Bay on south-eastern Eyre Peninsula, South Australia. The plant is a dense shrub growing to 2.5 m high and 4 m across and is endemic to this area, occurring in two disjunct populations (Salt-lake and Quarry) about 15 km apart. Recent surveys recorded 99 individuals at the Salt-lake site and 255 at the Quarry site (Jusaitis & Polomka, 2008). Each population consists of a small scrub fragment and several roadside occurrences, some with only a single remaining plant. All fragments adjoin arable farming land. Both populations lack juveniles (Jusaitis & Polomka, 2008), but this is unlikely to be due to limitations in seed supply (Jusaitis *et al*., 2009). Present threats include habitat fragmentation, restricted distribution, salinity, grazing, altered fire regimes, weed invasion, and lack of recruitment (Pobke, 2007). The species is listed as nationally Endangered under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and Critically Endangered under IUCN (2001) criteria (CR B1ab(iii)(v)). A trial was conducted to examine the effects of weeds and propagule type on translocation success, and a translocation was undertaken to augment and reinvigorate the Salt-lake population.

Goals

- Goal 1: Examine the influence of weeds and propagule type on translocation success.
- Goal 2: Augment the Salt-lake population of *A. whibleyana* by translocation.

Success Indicators

- Indicator 1: The completion of an experimental translocation to evaluate the effects of weeds and propagule type on establishment success.

Close up of *Acacia whibleyana* © M. Jusaitis

- Indicator 2: Survival, flowering, reproduction and recruitment of *A. whibleyana* over a period of 10 years following translocation.

Project Summary

Effects of weeds and propagule type: This experiment aimed to study the effects of weeds on translocation success, using both seed and transplanted seedlings as indicators. In a weedy section of the Salt-lake population, a split-plot design (3 replicates), with two levels of weeds (weedy, weed-free) as the main-plot factor, and two types of propagule (seed, transplanted seedlings) as the subplot factor, was set up. Fifty seeds were sown into a 1 m x 1 m subplot of each main-plot. At the same time, the second subplot in each main-plot was planted with 20 *A. whibleyana* seedlings. Seedlings were raised from seed sourced from the Salt-lake population and were 4 months old when planted in July, 1997. Seed and seedlings were sown and planted directly into the weedy sward. Weeds were eradicated from 'weed-free' main plots by spraying with 1% Roundup® (360 g/L glyphosate). Glyphosate-treated plots were kept weed-free by hand-weeding on each visit during the first 2 years of the experiment, after which time surviving *A. whibleyana* plants had grown sufficiently to out-compete weeds.

Two months after treatment, glyphosate-treated plots were weed-free, while untreated plots had 100% weed coverage. Nearly 5% of sown seed had emerged in both weedy and weed-free plots by this time. After a further 2 months, 10% of sown seed had germinated in weed-free plots, while only 0.7% (a single seedling) survived in weedy plots. The average height of seedlings did not differ between treatments over this 4-month period. No further seedlings emerged after this time. After 40 weeks, no seedlings survived in weedy plots while 8% remained in weed-free plots. Plants surviving in weed-free plots grew rapidly over this period, reaching an average height of nearly 70 mm. The critical time for survival occurred during the first spring when the majority of seedlings that had emerged in weedy plots died. This coincided with the period of most vigorous weed growth and competition. All remaining emergents in weedy plots were lost during the first summer, and survival in weed-free plots stabilized to about 7% of sown seed by year 7, remaining at this level through year 10.

Transplants showed significantly greater height gain in weed-free compared to weedy plots. In the absence of weeds, transplants grew at a similar rate to seedlings. Transplant survival in both weedy and non-weedy plots decreased sharply over the first 2 years from planting. Few plants were lost after year 2, and average survival stabilized at 42% after year seven, regardless of weed cover.

The choice of founder propagule (ie., whether seed or a transplant) was a critical determinant of success for *A. whibleyana* establishment in weedy sites. Weeds proportionately reduced survival and growth of seed founders far more than that of transplants. Furthermore, transplants had significantly more growth over their first year than did seed founders, a trait crucial for optimising competitiveness and survival. Growth, but not survival, of transplants was consistently lower in the presence of weeds.

Translocation: Seedlings were raised from seed collected in 1995 from the Salt-lake scrub, and were 10 months old (average height 60 mm) at the time of transplanting from 100 ml propagating tubes. On 19th June 1996, two replicates of 19 seedlings in each, and a third replicate of 20 seedlings were planted along a disused track at the Salt-lake scrub site. The site was weed-free, but the soil was compacted from past vehicular traffic. Plant survival and height were monitored on regular visits to the site.

Acacia whibleyana in flower seven years after translocation at the Salt-lake © M. Jusaitis

Transplants grew by over 500% of their original height during their first two years and were approaching 1 m in height by their fifth year. A decline in survival occurred over the first summer, during which 43% of transplants died as a result of falling soil moisture levels. Only 55% of plants survived to two years. Subsequently, as root systems became further established, mortality declined and 43% of transplants remained alive after 10 years. Surviving plants first flowered and set fruit in August 1999, during their third year of growth. Flowering and seed set have occurred annually after that, significantly augmenting the soil seed bank. However, seedling recruitment has not yet been observed, and may only occur following disturbance.

This translocation amounts to a 25% increase in the wild population of Whibley Wattle at the Salt-lake. Since this translocation commenced, its success has encouraged several more translocations to be undertaken along roadsides and on private land to further augment Whibley Wattle numbers in both the Salt-lake and Quarry populations. With the assistance of students and staff of the Tumby Bay Area School under the supervision of the local Threatened Flora Officer, Landcare Officer and Bush Management Advisor, further translocations were planted between 2003 and 2006 (Pobke, 2007). Their long term aim has been to rejuvenate, stabilise and interconnect Whibley Wattle population fragments to produce a stable and sustainable metapopulation.

Major difficulties faced

- Presence of weeds at most *A. whibleyana* population sites.
- Salt-lake scrub population is located on a road intersection and for a long time was used as a convenient short-cut by vehicles. The population was fenced in 1995, thus excluding vehicles and rabbits from the site.
- Severe fragmentation of remnant populations.

- Lack of natural recruitment. More time is required to determine how self-sustaining these populations are in the long-term. Significant “natural” recruitment is only expected following a disturbance event such as fire.
- Genetic erosion, particularly in the small roadside sub-populations.

Major lessons learned

- Natural recruitment from seed is unsustainable in areas of high weed abundance.
- Weed control is particularly critical during the first two years after planting, by which time transplants will have grown sufficiently to out-compete subsequent weed pressure.
- Low survival rates from seed indicate that sowing rates need to be inflated to compensate for the huge losses sustained during establishment.
- Use of transplants rather than seed as founding propagules will maximise the early growth rate of plants and optimise the success rate per propagule.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Demonstrated that the choice of founder propagule (seed *vs.* transplant) was a crucial determinant of success for *A. whibleyana* establishment in weedy sites.
- Demonstrated the importance of weed control to optimize establishment of translocants.
- Demonstrated successful translocation, establishment and reproduction of *A. whibleyana* at the Salt-lake site over 10 years of monitoring. Recruitment was not observed over this time scale, but may require a disturbance event.
- Increased the wild population of Whibley Wattle at the Salt-lake site by 25%.

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Translocation of four rare ironstone endemic species onto a pre-mined area at Beenup in SW Australia

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Introduction

Four ironstone endemics (*Lambertia orbifolia* subsp. Scott River Plains) (Scott River round–leaf honeysuckle) (IRP 178), *Banksia nivea* ssp *uliginosa* (formerly *Dryandra nivea* ssp *uliginosa*)(swamp honeypot)(IRP 255), *Grevillea brachystylis* subsp. *australis* (short styled grevillea) and *Darwinia ferricola* (Scott River bell) (IRP 176), all shrubs, except Lambertia a small tree to 5 m high, are reseeder species and killed by fire. They are restricted in distribution to rare winter wet ironstone habitats generally between Tutunup and Augusta in south-western Australia. The translocation site is at Beenup near Augusta. All species are vulnerable as most of their habitat has been cleared for agriculture or mining and the remaining habitat is often severely impacted by weeds, changes in hydrology, heavy grazing pressure and many habitats are infected by the root pathogen Phytophthora. All species are listed as declared Rare Flora under the Western Australian *Wildlife Conservation Act* 1950 and all, except the Grevillea, have interim recovery plans (IRP). They are all listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC Act). This translocation is fully consistent with the aims and recommendations of the Convention on Biological Diversity that was ratified by Australia in June 1993.

Goals

- Goal 1: Reducing the threat of extinction by learning how to establish new populations of these threatened plants.
- Goal 2:Contribute to the knowledge base of rare and endangered species through genetic analysis and propagation research.
- Goal 3: Improve understanding of the biology/phenonlogy of the plants and cultural techniques.
- Goal 4: Increase in biodiversity of the site.
- Goal 5: Contribute a better understanding of post-mining rehabilitation.

Success Indicators

- Indicator 1: Identify levels of genetic variability within and amongst populations of three of the four species and consequently identify where propagation material can be sourced without compromising local genetic integrity.

Left: translocation site prepared with two soil types & *right*: a few months after planting with irrigation system © Bob Dixon

- Indicator 2: Determine whether these species can be successfully propagated and grown on in a post mined situation.
- Indicator 3: Provide critical information on the biology of these species for management and conservation.
- Short-term success indicator: After one year 25% of the plants have survived.
- Long-term success indicator: Sustainability of the translocated populations by natural recruitment.

Project Summary

Feasibility stage: The translocation, a pilot study to see if rare species can be successfully established on pre-mined sites, is on an old mineral sand mine site previously covered in an 18 m clay stockpile. After removing the clay two soil types, brown sandy loam and grey sand with good seedbanks, were deposited on a site of approximately 0.2 ha to a depth of 30 cm over a solid ironstone base. The site was fenced to protect plants from grazing by kangaroos and rabbits and an irrigation system was installed but not fully utilized. Propagation material of the Darwinia and Banksia was sourced from two main areas, a local Nature Reserve and two local roadside populations (Governor Broome Road), the Grevillea was sourced from the mine site and the Lambertia from the Nature Reserve. Whilst seed was the preferred method of propagation we could not raise the Darwinia from seed and therefore had to propagate from softwood cuttings using a mixture of different clones. All species were planted on site, separating the nature reserve and roadside populations by the cental Lambertia planting, to evaluate any differences in survival and reproduction in relation to the genetic material used and different soil types. A genetic study on two of the four species, Lambertia had already been completed in another study and DNA could not be extracted from the Darwinia, indicated the following: Using AFLP on *Grevillea. brachystylis* subsp*. australis,* reasonably high levels of genetic variation were detected, but no significant genetic differentiation was detected among 5 populations found in remnant vegetation, revegetated areas or on a dam wall within the Beenup minesite ; *Dryandra nivea* ssp *uliginosa,* within the Beenup area there was weak or no significant genetic differentiation among populations, with the exception of

Left: *Lambertia orbifolia ssp.* growing with other indigenous species & *right*: a 6 m high *L. orbifolia* ssp. © Bob Dixon

the Governor Broome Road and Nature Reserve centre populations, which were found to be significantly differentiated (Krauss & Alacs, 2003).

Implementation stage: No indigenous communities interested or involved in the land affected by the translocation have been identified. The Aboriginal Sites Register maintained by the Department of Indigenous Affairs does not list any significant aboriginal sites in the vicinity of translocated population. Phytosanitary guidelines for the translocation were strictly adhered to and were primarily aimed at reducing the risk of introducing diseases, particularly root pathogens, and weeds to the translocation site. No flowering plants were translocated, avoiding the risk of inter-species pollen transfer within the nursery and resulting hybrid seed of nursery origin.

Post-release monitoring: Monitoring of plant survival, pests and diseases, growth rates, flowering and seeding patterns began within a few months of planting. Due to the high cost of travel from Perth, our home base, the site was monitored twice a year in autumn and spring. Monitoring for the first two years indicated, lower than expected, plant losses under difficult growing conditions on this very wet, wind swept and open site. However, some deaths were attributed to phytophthora and pythium species, probably translocated onto the site via surface water flow before planting began. A program spraying phosphoric acid in spring and autumn, appeared to control these diseases and prevent large scale plant losses. Weeds, especially *Hypochaeris* species, though present in large numbers are not highly competitive on this site. A plant survey of the site when compared to the surrounding area with amended soil, that is, previously used for agriculture but seeded and planted with indigenous species indicated over 50% more species are present on the translocation site with good soil seedbanks. The monitoring program, in line with the translocation proposal, ceased in 2007. At this stage the project was performing far better than predicted with all plant species flowering and producing seed, although only the Grevillea was recruiting from the soil seedbank. However, a visit in November 2009 indicated, though we expected higher death rates due to increased competition from indigenous species and cessation of the spraying program, the translocated plants were performing very well and all species were producing large numbers of viable seed. Seedlings are recruiting from the soil seedbank probably in large enough numbers to produce self sustaining populations of the Grevillea and Lambertia but in smaller numbers for the Darwinia and only one recruit has been recorded for the Banksia. The latter, even in natural populations, tends to only germinate after a major disturbance event such as fire.

Major difficulties faced

- Lack of knowledge of the biology of this species and cultural requirements.
- Unable to obtain DNA from *Darwinia ferricola.*
- Distance traveled and associated costs for site visits reduced opportunities to visit the site more frequently and lack of on-going funding for travel and monitoring.
- Having to cope with root pathogens.
- Site growing conditions for plants extreme e.g. bare soil and windy conditions sand-blasting plants.

Major lessons learned

- Rare plant species can be successfully established on previously mined areas with poor growing conditions.
- The Grevillea, though short lived in comparison to natural populations, produces large amounts of viable seed and natural recruits appear within two years of planting.
- *Darwinia ferricola* is able to re-propagate itself vegetatively. After wind blown sand covers most of the plant and it starts to senesce shoots form roots and they grow on producing flowers and seed (first time recorded for any Darwinia species).
- *Lambertia orbifolia* ssp Scott River Plains seed do not appear, despite windy conditions, to move far from the parent plants in the short term, seedlings are generally no more than 3 m away.
- Root pathogens such as phytophthora and pythium can be controlled on site, given the right treatment, and new recruits established.
- Close planting of small trees (Lambertia) on this site has not, as yet, resulted in high plant losses due to competition for moisture, nutrients and space.
- Rabbit proof fencing is critical for the first few years to establish plants as major grazing damage observed in other areas of the mine site.
- Essential to have good working relationship with sponsors (mine operators) and well trained volunteers are essential due to the volume of work and lack of resources.
- It was necessary to thin out some fast growing and highly competitive indigenous plants e.g. Acacia and Viminaria species to reduce competition on the rare species.
- This site will provide an excellent research facility for future generations of scientists and biologists to look at population dynamics and sustainability of populations.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- This was a well defined project, following translocation proposal guidelines, in association with mine site staff and Kings Park Volunteer Master Gardeners. It was underpinned by a research program based in Kings Park Science Directorate where new methods were constantly being developed on the propagation and biology of the species and research on genetic management. Guidelines were in place in the form of the Western Australian *Wildlife Conservation Act* 1950 and Interim Recovery Plans (except the grevillea) This translocation is fully consistent with the aims and recommendations of the Convention on Biological Diversity that was ratified by Australia in June 1993.
- This project also followed the Guidelines for the Translocation of Threatened Plants in Australia 2nd edition published by the Australian Network for Plant Conservation.
- All plants were raised in Kings Park Accredited Nursery (adheres to specific photosanitary regulations) which specializes in the cultivation of indigenous species.
- Plants monitored twice a year and ad hoc visits by mine staff reported any problems.
- High level of plant survival in such poor growing conditions.
- All species are now producing large amounts of viable seed.
- The use of phosphoric acid does not significantly affect the germability of *Grevillea brachystylis* ssp *australis* seed**,** using a standard cut test 98% of the seed was viable and ongoing germination experiments have produced germination rates up to 73% (6 weeks duration in a constant 18^{0}C).
- All species are recruiting from the soil seedbank indicating viable seed are being produced and conditions are suitable for germination and growing on.
- More time, e.g. at least 25 years, is required to determine if this site is naturally self-sustaining in the long term as most of these species are only expected to germinate en-mass after a disturbance event such as fire.

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Enhancement of Monarto mintbush populations in South Australia by translocations

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Introduction

Monarto mintbush, *Prostanthera eurybioides* F.Muell. (Lamiaceae) is a low, spreading, aromatic shrub growing to 1 m high, bearing small, violet flowers in leaf axils during spring. Plants are killed by fire, but natural recruitment from seed may occur in response to fire (Jusaitis, unpubl. data) or following hot, dry summers where elevated temperatures trigger loosening of the mericarp plug (Ainsley *et al*., 2008). The plant is endemic to South Australia and located in two disjunct populations, one at Monarto (near Murray Bridge) and the other centered at Mount Monster Conservation Park (near Keith). It occurs naturally on shallow, sandy loams associated with outcrops of granite or schist (Jusaitis, 2005).

Approximately 240 and 390 wild plants remain in the Monarto and Mt. Monster populations respectively. The species is listed as Endangered under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and Critically Endangered under IUCN (2001) criteria (CR B2ab(v)). Translocation trials were located at both population centers with the aim of enhancing natural populations while at the same time testing various techniques and management options.

Flowers of *Prostanthera eurybioides* © M. Jusaitis

Goals

- Goal 1: Determine the microsite requirements for translocation success.
- Goal 2: Examine the use of water storage crystals to improve translocation success.
- Goal 3: Examine the influence of weeds and herbivores on growth and survival of transplants.
- Goal 4: Enhance both populations of *P. eurybioides* by the use of translocation.

Fenced plot in grazing trial showing seven year old plants. © M. Jusaitis

Success indicators

- Indicator 1: The completion of an experimental trial to evaluate microsite requirements for successful establishment of *P. eurybioides*.
- Indicator 2: The completion of an experimental trial to evaluate the effect of water storage crystals on translocation success.
- Indicator 3: The completion of an experimental translocation to evaluate the effects of weed and herbivore control on the establishment success of *P. eurybioides*.
- Indicator 4: Survival, flowering, reproduction and recruitment of *P. eurybioides* over a period of 10 years following translocation.

Project Summary

Microsite requirements: A trial translocation to investigate planting microsite requirements was set up at Monarto. Three microsites were chosen; site 1 was open, exposed and rocky, site 2 was also rocky, but partly sheltered with scattered *Melaleuca uncinata* bushes, and site 3 had no rocky outcrops, and a thicker cover of *M. uncinata* bushes. Ten seedlings of *P. eurybioides* were transplanted into each site in June 1996, and survival and growth of transplants were assessed at regular intervals over the next 7 years. Marked differences in translocation success were observed between sites. Site 1 (open, rocky) outperformed the other sites, with 80% of plants surviving after 1 year, while sites 2 and 3 retained 20% and 0% respectively. Plants at site 1 grew steadily over the 7 years of assessment, while plants at site 2 had a lower growth rate. Site 3 plants declined rapidly in size over their first year, appeared more stressed and suffered more grazing than plants at the other two sites. Mortality was most severe over the first year from planting, after which survivorship stabilized.

Use of water storage crystals: Translocation trials were set up at both Monarto and Mt. Monster to study the effect of adding water storage crystals (hydrogel) to the planting hole at planting. Treatment plants received 200 ml of imbibed hydrogel placed at the bottom of the planting hole, while control plants received 200 ml of water per hole. At each site, four replicates of 20 plants (10 plants per treatment) were planted in early winter within the natural population. Plants were grouped in pairs (with and without hydrogel). Survival and growth of translocants were monitored over four years. At neither site was there a significant difference

Staff and volunteers out-planting at Monarto

© B. Sorensen

in survival or growth of plants in response to hydrogel over this time. Plant survival after 4 years averaged 92% at Mt. Monster and 45 % at Monarto.

Effect of weeds and herbivores: A translocation trial was set up to study the effect of weeds on transplant establishment. Cutting-derived *P. eurybioides* plants were transplanted into paired 1 m^2 fenced plots (3 replicates) at a weedy site within the Monarto population. One plot of each pair was kept weed-free by hand-weeding on regular visits to the site over 6 years. A year after planting, 60% of transplants survived in weed-free plots, while all transplants in weedy plots had died. Weed-free survivors were still present after 6 years, having reached an average height of 640 mm.

The impact of herbivores (rabbits, kangaroos) was investigated in separate trials at Monarto and Mt Monster. At Monarto, four 3-month old seedlings of *P. eurybioides* were planted into each of 6 replicate paired plots at each of two sites (Boland's Scrub and Monarto Zoo). One plot of each pair was covered with a wire basket to exclude herbivores, the other was left exposed. After 4 years, 46% (covered) and 8% (exposed) survived in Boland's Scrub, while 50% (covered) and 0% (exposed) remained at the Zoo site. Most plant losses occurred during the first year after planting.

At Mt Monster, eight 12-month old seedlings were planted into each plot of 3 replicate paired plots. One plot of each pair was enclosed by a 3 x 3 m chicken-wire fence designed to exclude rabbits and kangaroos, the other was left open. By year 11 (2006), transplant survival had stabilized at 96% (fenced) and 67% (unfenced). Frequent grazing damage was observed on exposed plants over that time, producing plants that were about one third the size of fenced (un-grazed) plants.

Natural seedling recruitment was first observed in fenced treatments 10 years after translocation (2005). These recruits flowered the following year. Since then, further recruitment has occurred annually in fenced plots. A few recruits were also observed just outside the fenced plots, obviously self-sown from fenced plants, but none were observed directly around unfenced translocants.

Translocation: In 1997, the Monarto population was enhanced by the translocation of 126 *P. eurybioides* seedlings. Twelve years after planting, 24% of these plants survived, although many were severely damaged by grazing. Grazing damage on mature plants was generally restricted to the lower 300 mm of the plant, implicating rabbits and possibly other smaller mammals as the predominant herbivores. Although these plants have flowered annually since 2001, no natural recruitment has been observed at this site.

In 1998, 35 seedlings were translocated at Christmas Rocks, and 22 at Kongal Rocks, both sites in the vicinity of, and having similar edaphic characteristics to Mt Monster. Plants at both sites flowered within two years of planting. Ten years after translocation, 88% and 57% of translocants survived at Christmas and Kongal Rocks respectively. Eleven years after planting, 147 seedling recruits were counted around translocants at Christmas Rocks, while 2 were found at Kongal Rocks. The low numbers recorded at the latter site may be due to competition from grassy weeds and bracken fern limiting recruitment.

Major difficulties faced

- Grazing by introduced or native animals.
- Presence of weeds at some sites.
- Some years of below average rainfall resulted in mortality of fenced, ungrazed plants at Mt Monster. This may be due to the size difference between grazed and ungrazed plants, the latter being significantly larger and having greater leaf surface area than unfenced, grazed plants. Larger plants would experience greater transpirational losses, and so would be more susceptible to water stress than the smaller, grazed, unfenced plants.
- Planting/fencing difficulties in rocky terrain.
- Lack of knowledge about seed germination when project started.

Major lessons learned

- The microsites trial showed that the presence of rocky outcrops together with a relatively exposed outlook are important determinants for translocation success for *P. eurybioides* (Jusaitis, 2005).
- Water storage crystals added to the planting hole did not significantly improve the recovery of this species.
- Weed control is essential when translocating *P. eurybioides* into weed-prone sites.
- Adequate grazing protection is important, particularly during the early stages of plant establishment, to encourage vigorous growth, rapid seed production and ultimately natural recruitment.
- Established plants are less susceptible to grazing damage once they reach their mature height.
- Seedling recruitment occurred naturally at Mt Monster after a series of hot, dry summers followed by good winter rains. Recruits were all found within 1-2 m of parent plants, suggesting that seed dispersal may be limited to this range.
- Marked differences exist between the two populations (Monarto, Mt Monster) with respect to recruitment success. No recruits were observed at Monarto

over 12 years of monitoring, whereas Mt Monster translocations recruited within 10 years of planting.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Demonstrated successful translocation, establishment, reproduction and recruitment of *P. eurybioides* at Mt. Monster and two nearby reserves (Christmas Rocks and Kongal Rocks).
- Demonstrated successful translocation, establishment and reproduction of *P. eurybioides* at Monarto, although recruitment was not observed during 12 years of monitoring.
- Early research on the effects of microhabitat, grazing and weeds on translocation success enabled scientifically based site selection and site preparation for subsequent translocations.
- Local volunteers contributed substantially to the on-ground tasks that were required.
- The project was based on good science from the outset, and sites were monitored and managed frequently over the long term.
- All four goals were successfully achieved, according to their respective success indicators.

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Translocation of the resinous Eremophila, from test tube, to a degraded bushland site in the wheatbelt of Western Australia

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Introduction

Eremophila resinosa (Myoporaceae) was declared as Rare Flora in 1982 under the Western Australian *Wildlife Conservation Act 1950* and is currently ranked as Endangered (EN) under World Conservation Union (IUCN 1994) Red List criterion It has an approved interim recovery plan (IRP No 266) and is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC Act). It is ("known from 24 natural populations and 697 plants") most of which are on a rehabilitated mine site indicating this species is a disturbance opportunist. Populations are centered around Westonia in the Eastern Wheatbelt of Western Australia. Plants are found in sandy loam to clay soils in open Eucalyptus (mainly mallee) woodland with a mixed but open scrub understorey. Its restricted distribution is due mainly to clearing for agricultural purposes and mining activity. Present populations are vulnerable on road verges due to frequent road maintenance, weed competition and liable to damage through frequent fire, herbicide and fertiliser drift from farming operations, grazing by rabbits and future mining operations. This translocation is fully consistent with the aims and recommendations of the Convention on Biological Diversity that was ratified by Australia in June 1993. NB: Text in quotations thus ("….") is quoted directly from: Department of Environment and Conservation (2008). Resinous Eremophila (*Eremophila resinosa*) Interim Recovery Plan 2008 - 2013. Interim Recovery Plan No. 266. Department of Environment and Conservation, Western Australia.

Volunteers planting seedlings on the extended site

Goals

- Goal 1: Reducing the threat of extinction by learning how to establish new populations of this threatened plant.

Left: Translocation site in August 2004 just after planting very small tissue cultured clones & *Right*: Volunteers monitoring seedlings planted in 2005 with good survival rates, plant form and growth indicating high genetic diversity © Bob Dixon

- Goal 2: Improve understanding of the biology/phenonlogy of the plant and cultural techniques.
- Goal 3: Increase in biodiversity of the site.
- Goal 4: Contribute a better understanding of rehabilitation of this species on degraded sites.
- Goal 5: Maintain a range of genetic diversity from minesite populations.
- Produce a minimum 50 greenstock of each clone (five clones in total 250 plants) and establish a self sustaining population of *Eremophila resinosa*.

Success Indicators

- Indicator 1: Determine whether these species can be successfully propagated by tissue culture and successfully grown on in a degraded site.
- Indicator 2: Provide critical information on the biology of these species for management and conservation.
- Indicator 3: Short term success indicator-after one year 25% of the plants have survived
- Indicator 4: Long term success indicator-sustainability of the translocated populations by natural recruitment

Project Summary

Feasibility stage: *"Eremophila resinosa* is a spreading shrub 40 to 80 cm tall by 60 to 100 cm wide with branches that are densely covered in short white woolly hairs and sprinkled with resinous wart-like projections." The greyish/green leaves are 4 to 8 mm long by 2 to 3 mm wide. ("The flowers are blue or purple with white spots inside. There are four stamens not exceeding the length of the corolla. The ovary is densely covered in short wooly hairs and is four celled with one ovule in each cell"). Flowering time is predominantly in November and December on new growth. The translocation site, with similar soil and vegetation type to natural populations, location was chosen due to its proximity to the town site and easy access. The project was initially a one year pilot study to see if this rare species

Left: In November 2007 poor growth close to tree roots (B) compared to (A) & *Right*: In November 2009 good plant growth after removal of the irrigation system © Bob Dixon

can be successfully propagated and established on a 0.2 hectare deep ripped, fenced and irrigated but degraded site. It was first planted up with five tissue cultured clones derived from plants cleared from the minesite. Initially the site was planted with 321 plants, a mixture of the clones planted in a grid pattern to maximise genetic diversity, in 2004. The following year more plants were cleared from the minesite, seed were collected from these plants, mixed with seed from the original 5 clones, and sown resulting in 257 seedlings planted on an extension of the original site. *Eremophila* species rarely produce good viable seed and are generally very difficult to germinate because of their hard woody fruit.

Implementation stage: No indigenous communities interested or involved in the land affected by the translocation have been identified. The Aboriginal Sites Register maintained by the Department of Indigenous Affairs does not list any significant aboriginal sites in the vicinity of translocated population. Phytosanitary guidelines for the translocation were strictly adhered to and were primarily aimed at reducing the risk of introducing diseases, particularly root pathogens, and weeds to the translocation site. No flowering plants were translocated, avoiding the risk of inter-species pollen transfer within the nursery and resulting hybrid seed of nursery origin.

Post release monitoring: Monitoring of plant survival, growth rates, flowering and seeding patterns began within a few months of planting. Due to the high cost of travel to the site it was monitored twice a year in autumn and spring. Lower than expected plant losses were recorded and deaths were generally attributed to poor water delivery, especially at the far ends of the trickle irrigation lines and stress due to competition from tree roots. Water was delivered from a tank through a trickle irrigation system using 2 litre/hour pressure regulated drippers, initially a pump was used to give good pressure and even delivery, however this was stolen after a short period of time and water pressure was not adequate there after. Survival rates have been remarkably good and 500 plants are still present on this site (as at 25th November 2009). Most plants flowered and produced viable seed the first year after planting and continued to produce seed every year since. Due to the large soil seedbank seedlings are recruiting but at this stage only four have been recorded and one has produced flowers and seed. Two weed species on site have proved to be difficult to control when using herbicides without risking significant off-target damage to the *Eremophila*, when appropriate hand weeding was carried out. Growth rates of indigenous species on site have been excessive when compared to adjacent areas necessitating cutting them down on two occasions, to reduce competition, this practice has now ceased. Since removing the irrigation system, now the plants are established, growth rates for both the *Eremophila* and indigenous species has declined. However, as expected, we have not recorded any substantial increase in plant losses.

Major difficulties faced

- Producing woody tissue cultured plants within a short time frame (1 year).
- Lack of knowledge of the biology of this species and cultural requirements.
- Managing people in remote areas to carry out essential tasks, especially watering, during summer.
- Distance traveled and associated costs for site visits reduced opportunities to visit the site more frequently.
- Managing weed control on site, especially as the best window of opportunity for control is often missed due to sporadic rainfall events.
- Lack of funding to cover long term monitoring and travel expenses.

Major lessons learned

- This species can be successfully established on degraded bushland sites given the correct site preparation, especially deep ripping, and management after planting.
- The Eremophila can be successfully propagated by both tissue culture and by seed, given the correct treatment.
- Rare species can be successfully translocated with a small budget, however there needs to be a high reliance on well trained volunteers.
- A weed free site should be chosen where possible to reduce maintenance costs and avoid off-target damage by herbicides. In arid regions weed seed can be viable in the soil seedbank for several years expressing high germination events under ideal growing conditions.
- Avoid planting close to trees to reduce competition from tree roots.
- Make sure your irrigation system runs under high pressure and use pressure regulated drippers to give the same output at each dripper.
- Essential to have good working relationship with sponsors (mine operators) and local government.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- This was a well defined project, following translocation proposal guidelines, in association with mine site staff, local government and Kings Park Volunteer Master Gardeners. It was underpinned by a research program based in Kings Park Science Directorate where new methods were constantly being developed on the propagation and biology of the species.
- Guidelines were in place in the form of the Western Australian *Wildlife Conservation Act* 1950 and Interim Recovery Plan.
- This translocation is fully consistent with the aims and recommendations of the Convention on Biological Diversity that was ratified by Australia in June 1993.
- This project also followed the Guidelines for the Translocation of Threatened Plants in Australia 2nd edition published by the Australian Network for Plant Conservation.
- All plants were raised in Kings Park Accredited Nursery (adheres to specific photosanitary regulations) which specializes in the cultivation of indigenous species.
- Plants monitored twice a year and watered by local government staff.
- High level of plant survival under arid growing conditions.
- All original clones survived in large numbers, as well as seedlings, increasing genetic diversity.
- Successful propagation methods developed.
- Most plants are now producing large amounts of viable seed.
- Plants are recruiting from the soil seedbank indicating viable seed are being produced and conditions are suitable for germination and growing on.
- A good suite of indigenous species are present on site despite using non-selective herbicides for spot spraying.
- Translocation site situated close to the town boundary on land which cannot be cleared for mining or other purposes.
- The site is easy to access, especially for water tankers.
- More time, e.g. at least 25 years, is required to determine if this site is naturally self-sustaining in the long term as this species is expected to germinate en-mass after a disturbance event such as fire.

Note: Two more translocation sites, using seedlings derived from other sources of seed and funded by the same mining company, were established in winter 2009 and the present number of plants on all three sites is over 2,000.

Conservation Status and re-introduction of Bermuda's Governor Laffan fern-an endangered endemic

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Introduction

Bermuda's most endangered plant species; *Diplazium laffanianum*, is of great historical significance to the island nation. The species has not been reported from the wild since 1905 (Britton, 1918) and was reduced to only five living specimens housed at the Bermuda Botanic Gardens by 2003. It is listed as an endangered species by IUCN but is not on the CITES App. I. The species was a personal favorite of one of Bermuda's early governors and was later named the Governor Laffan fern in his honor. Long periods of isolation from other continents have resulted in unique island plant species which are particularly vulnerable to extinctions. Islands that are densely populated by humans such as Bermuda face extraordinary challenges to conservation for their endemic flora and fauna. The Bermuda Botanic Gardens provided tiny samples of spores collected from the remaining specimens for *ex situ* plant research at Omaha's Henry Doorly Zoo where the spores were germinated and grown under sterile laboratory conditions. Subsequently, many cultures containing hundreds of juvenile ferns were returned to Bermuda. The timing of the initiation for the first cultures was particularly fortuitous since Hurricane Fabian crashed into Bermuda shortly after the spores were sent to the United States for germination and the last adult specimens remaining in Bermuda sustained sea water damage in the hurricane. The very existence of the last known adult plants was threatened and research producing additional young ferns was the only means to prevent its final extinction.

Close up of *Diplazium laffanianum*

Goals

- Goal 1: Bring the last known fern specimens into the reproductive stage to provide viable spores for *in vitro* germination.

- Goal 2: Develop a successful protocol and medium for micropropagation of the fern spores.
- Goal 3: Provide young ferns for Bermuda's Botanic Garden that would be used to rehabilitate the species in its host country.

Success Indicators

- Indicator 1: Successful germination and production of young ferns from the spore samples.
- Indicator 2: Produce large numbers of ferns for return to the host country Bermuda.
- Indicator 3: Re-introduce the young ferns to the local environmental conditions at the Bermuda Botanic Gardens for conservation research in Bermuda.

Project Summary

The Bermuda islands consist of more than one hundred islands and outlying islets, many of which are not inhabited by humans. However, the main islands are among the most densely populated places on earth and natural areas have been reduced to tiny fragments, pushing the endemic flora to the verge of extinction in some cases. Tectonic plate movement deep within the Atlantic Ocean separated the Old World and the New World approximately 200 million years ago and Bermuda was formed by volcanic activities along the fault line left by the tectonic plate movements. Bermuda sits on this volcanic base that is covered by a cap of limestone formed from countless marine organisms. The native topsoil is only a thin layer of reddish soil supporting its plant life. Most of the endemic flora and fauna probably arrived through natural dispersal from North America but many non-native species arrived with successive waves of human colonization that began arriving in the 1500s. The Governor Laffan fern (*Diplazium laffanianum*) is Bermuda's most threatened native plant species. *Diplazium laffanianum* is now extinct in the wild and the last specimen was reportedly seen in the wild in 1905. The last known plants languished in an obscure corner of the Bermuda Botanic Gardens until the 1970s when the last five plants were moved to the government's Tulo Valley Nursery for safeguarding. The fern was reduced to only five living specimens by 2003 and a protocol for propagating the species had not been developed prior to this time. The species historically occupied areas at the entrances to Bermuda's limestone caves but development and habitat deterioration had altered the areas so drastically that today the original habitat no longer exists. With such a small population left on earth these last few individuals may have limited genetic diversity but the decision was made that whatever genetic diversity the species may still posses was worth saving.

A collaboration between the Bermuda Botanic Garden and Omaha's Henry Doorly Zoo was initiated in order to save the species from disappearing altogether. The plant research laboratory at Omaha Henry Doorly Zoo was enlisted to propagate the species *ex situ*. Cloning one of the remaining specimens was not considered a good conservation practice and an alternative plan was developed to carefully tend the adult plants until they would begin producing spores in hopes of retaining what genetic diversity the last specimens might possess. After several months of care at the Bermuda nursery two of the remaining specimens produced small amounts of spores which were sent for culturing to Omaha's Zoo. After several attempts at culturing them the fern spores began to germinate rapidly and *in vitro* cultures containing hundreds of little ferns were hand carried back to Bermuda for growing on at the Bermuda Botanic Garden. A series of four shipments containing many young ferns have been returned to Bermuda over the last six years. The area where the species was last seen in the wild no longer exists as a natural area. Therefore the species must be cultivated and maintained *ex vitro* at the botanic garden for the foreseeable future or until a restored habitat location can be provided. Nursery personnel at Tulo Valley Nursery and the Ministry of the Environment in Bermuda reserve responsibility for monitoring the young plants and growing the ferns on to a mature stage. Any re-introductions made to the natural habitat are determined by the same Bermudian authorities.

Major difficulties faced

- Careful consideration must be made for the return of the ferns to the host country in order to coincide with the best growing months.
- Limited source materials from a small population.
- No published culture methods are available for the species.
- *Ex vitro* acclimatization methods are complex for this sensitive species.
- *Diplazium laffanianum* spores have a very limited viability period making propagation timing critical.

Major lessons learned

- Spore condition, type and age have critical impact on propagation of the species.
- Re-introduced ferns require careful monitoring.
- Adaptive management methods must be employed for the plants due to their specific growth requirements.
- Cooperation between collaborators is necessary for successful re-establishment.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- A species was saved from final extinction.
- The project continues to produce many young ferns *in vitro* for future re-establishment in Bermuda.
- Successful protocols were developed for propagation and acclimatization of this fern that are useful for the collaborators as well as to other plant re-introduction projects.

Reinforcement of the populations of critically endangered endemic fern *Diellia pallida*, Kaua'i, Hawaiian Islands, U.S.A.

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Introduction

Diellia pallida (Aspleniaceae) is the endemic fern to the island of Kaua'i. It is a species of the lowland diverse mesic forest or Diospyros/Metrosideros mesic forest communities on the northern slopes of the western ridges of Koke'e Mountains. The natural population of *D. pallida* consisted of 13 mature individuals on three sites, only eight of these were reproducing (Aguraiuja, 2004). *Diellia pallida* is federally listed as Endangered (U. S Fish & Wildlife Service Species List, 25th February 1994). Corresponding to the IUCN criteria (IUCN, 2001) this species belongs to the category of globally critically endangered plant species (Aguraiuja & Wood, 2002). Due to very small number of existing individuals, their very narrow distributions, obligatory out crossing and slow recruitment, *D. pallida* is a subject to increased likelihood of extinction through any stochastic extinction event. The major threats to extant local populations of *D. pallida* are habitat degradation by animals (substrate erosion caused by trampling of goats, pigs, mule deer, red jungle fowl) and direct disturbance (trampling, uprooting and browsing). Trampling and erosion are the major factors of high mortality in gametophyte generation and sporeling stage, what in long term may lead to the depletion of natural spore bank.

Goals:

- Goal 1: Protection of all extant individuals as the main spore source for the habitat.
- Goal 2: Establishment of experimental population patches within known historical distribution area.
- Goal 3: Establishment of new natural generations, population recruitment.
- Goal 4: Species survival on the landscape within its natural communities; self-sustaining persistence of the populations and their normal evolutionary process.

The endemic fern *Diellia pallida*

Diellia pallida habitat in Mahanaloa Valley in Kokee Mountains on the island of Kauai

- Goal 5: The model method for the conservation of critically endangered fern species of same growth form and life cycle specificities, in the tropics and elsewhere, where the habitat conditions allow the recovery/restoration of the species.

Success Indicators

- Indicator 1: Survival of out planted individuals, increased number of mature spore producing individuals in the site.
- Indicator 2: Establishment of new generation.
- Indicator 3: Colonization and establishment in new empty patches of suitable habitat, extended distribution.

Project Summary

The conservation oriented research of *Diellia pallida* was started with the condition assessment of extant individuals and populations (Aguraiuja, 2001). As emergency, the cages were put on last mature individuals protecting thus the last spore source against browsing by feral animals. The cages also helped to stabilize the soil around the plants. Few rhizomes, uprooted by feral pigs and goats, where planted into the neighboring fenced ex-closure. With these activities, detailed observations and documentation of the changes in population structure, the research was continued (Aguraiuja, 2005). Protection of mature individuals and coincident more favorable weather conditions during 2003-2006, resulted in a drastic increase of gametophytes and sporelings of *D. pallida* in two local populations, demonstrating that habitat conditions are still suitable for germination and establishment of younger stages. The analyses of population regeneration still showed very low survival of younger developmental stages. Regardless that hundreds of sporelings developed during the winters of more favorable years, less than percentage of these survived till next winter, mainly because of the trampling, wash out and erosion.

In 2006, the preparations for propagation and reinforcement experiment were started in collaboration with National Tropical Botanical Garden (NTBG). The encouraging factors were: the high natural germination in the habitat; *D. pallida* was tolerant to the replanting; empty patches of suitable habitat in the historical distribution area; some fenced ex-closures with suitable microhabitat conditions within historical distribution area. As the trampling and erosion were documented as main factor for the death of the individuals in younger stages, it was also decided to learn rescue the eroded sporelings and boost them up as emergency method for increasing the number of individuals. The main idea of recovery experiment was to reinforce the natural population by increasing the number of individuals and spore source of the habitat; to test if gradual imitation of natural population recruitment would influence the efficiency of population reinforcement efforts; and to test if establishment of experimental populations within fenced ex-closures would affect the dispersal of the species via colonization of new patches of suitable habitat within the whole historical distribution area.

Two parallel but complementary lines of research were conducted: 1) propagation efforts in the laboratory and nursery conditions; and 2) reinforcement experiment and observations of natural and experimental populations in the field. The propagation trials were started with the sowing of single individual spores (N. Sugii, Lyon Arboretum). It was learned then that *Diellia* gametophytes may perenniate and live three to four or more years, and that they may be obligatory out-crossers. The germination tests with the mix of spores originating from different individuals resulted in first sporelings and showed also that *Diellia* ferns are very slow in their younger life stages. It took a year from the sowing to the emergence of the first sporeling of *D. pallida*. The stock *ex situ* conservation collection was created and divided between the propagation nursery in Lawai'i (NTBG) and the restoration area of Limahuli Garden (NTBG). Considering the patchy distribution and availability of safe and protected sites, seven experimental population patches were established in 2007. According to the recovery criteria for the Kauai Plant Cluster (USFW 1995) and available micro-sites, 30 individuals were planted into each. Simultaneous surveys of population dynamics of natural and experimental populations were started. Since the survival has been highest in two sites, indicating that habitat conditions must be still suitable for *D. pallida* in there. Based on the analyses of the survival rates and microhabitat conditions of this first out planting, the optimum number of individuals will be worked out for the plantings during several consecutive years.

Major difficulties faced

- The uncontrolled disturbance by introduced game and feral animals in the habitat.
- The uncontrolled erosion in the habitat, scarcity of safe sites.
- The uncontrolled insect damage and fungal disease.
- Stressed mature individuals staying sterile, extreme population fluctuations during longer dry periods.
- Difficult to propagate the species, obligatory out-crosser.
- The native forest community loosing its structure: increased smothering effect of the leaf litter, less ground vegetation, drier soil.
- Only very small patches of the native forest community were protected by fences, most of natural germination areas were located outside of fenced areas.
- The current and historical distribution area is divided between several landowners.

Soil sampling for soil spore bank tests in the natural habitat

Major lessons learned

- The population monitoring showed that population dynamic followed the local climate pattern of the cycle of wetter and drier years, where the germination and establishment of new individuals was successful during the period of more favorable conditions and could completely fail during the drier period. The best timing for more successful population reinforcement activities would be during the winter months of wetter years.
- For more successful reinforcement and population recovery additional research of micro habitat conditions is needed, as the choosing the appropriate microhabitat site is crucial for the survival of the fern individuals.
- The boosting of disturbed individuals of *Diellia pallida* and propagation in ex situ conditions should be short-term and in toughening conditions for future planting into natural habitat, decreasing thus the after planting environmental stress and increasing the potential survival of the individuals in the site.
- The individuals of fern species *Diellia pallida* need after-care and site management during their first year in the site.
- The single out planting into the habitat equals to a single occasional natural distribution event. It may take very long time until structured self-sustaining population evolves naturally, particularly in relatively hard conditions of mesic forest on steep slopes, and probability for this event to happen is as big as that of extinction. It was learned that the out planting should be gradual during several consecutive years or by the cycles, imitating thus the natural colonization, population growth and establishment of structured self-sustaining population.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The appropriate habitat conditions still exist and support the establishment of new individuals, if protected against introduced animals.
- The methods and plan for further bigger population reinforcement within the whole distribution area on the landscape have been worked out and tested.

The initial results show that the recovery of the fern species *Diellia pallida* is possible. Since, the study of ecology, population monitoring, and restoration tests have been conducted within the framework of scientific research project initiated by the researcher. For further success in landscape level recovery of the species, the institutional collaboration for the protection of the sites, propagation of the plants, population reinforcement, conservation management activities and population monitoring, needs to be build up.

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Conservation introduction of the parasitic plant dactylanthus at Waipapa, New Zealand

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Introduction

Dactylanthus *(Dactylanthus taylorii* (Balanophoraceae), pua-o-te-reinga, wae-wae -atua) is New Zealand's only fully parasitic native flowering plant. A root parasite, it lives as a usually subterranean tuber attached to the root of several native angiosperm tree and shrub host species often associated with secondary (regrowth) broad-leaved forest (Moore, 1940; Ecroyd, 1996 & Holzapfel, 2001). Fossil records dating back 23 million years show the species in the past distributed over both main islands of New Zealand and some off-shore islands; today it is only found in ~85 populations on the North Island and one offshore island, though still over a wide range of climates and altitudes (Ecroyd, 1996 & Holzapfel, 2001). Dactylanthus is listed in New Zealand as nationally vulnerable (de Lange *et al.*, 2009); populations have severely declined mainly because fruit production is prevented by introduced browsers, in particular brush-tailed possums (*Trichosura vulpecula* Kerr), kiore (*Rattus exulans* Peale) and ship rats (*R. rattus* L.) (Ecroyd, 1996). Conservation management is guided by a recovery plan (La Cock *et al.*, 2005) and includes the establishment of new populations at sites where introduced browsers are managed or absent. Here we describe the first fully monitored and quantified experimental establishment trial at Waipapa, central North Island.

Dactylanthus habitat in the ecotone between open area & mature forest © S. Holzapfel/DoC

Goals

- Goal 1: Establishment of dactylanthus from seed.
- Goal 2: Robust evaluation of the effectiveness of two different sowing densities.
- Goal 3: Preliminary evaluation of the effect of dominance of host species and site exposure.

Success Indicator

- Indicator 1: Dactylanthus established and flowering long-term in at least one experimental plot.

- Indicator 2: Key data of sufficient quality and quantity collected and analyzed annually to allow robust evaluation of success and effect of variables.

Maturing fruit head of dactylanthus
© S. Holzapfel/DoC

Project Summary

Preliminary trials had indicated that dactylanthus could be established from seed, provided a suitable host tree was present (Ecroyd, 1996 & Holzapfel, 2001). In 1999 we established trial plots at Waipapa, central North Island, in the ecotone between mature podocarp forest and open frost flats, at sites with suitable host species but no natural population of dactylanthus. Twenty-four permanently marked seeding plots (50 x 50 cm) were established across four sites differing in host species dominance (3 main hosts), host age, and exposure (‘open’ or ‘closed’ canopy). Each plot received about 1,500 seeds of the same seed mix, the equivalent of a single fruiting head with moderate fruit set. Seeds were either sown over the entire plot area (‘broad’ sowing) or all seeds sown into a single, central 5 x 5 cm grid (‘central' sowing). Three plots of each sowing density were established at each site. Over ten years, monitoring was undertaken annually late in the flowering season, when most inflorescences had emerged through the forest floor. Data on the total number of inflorescences, their position and their sex were recorded. Dactylanthus is considered dioecious, i.e., each individual plant produces only inflorescences of one sex. Because dactylanthus individuals are long-lived, establishment within each plot was largely cumulative over the monitoring period. To ensure that establishment could only occur from the initial seed sown, plots were kept covered throughout the year with fine mesh cages to prevent entry by known pollinators, i.e., native short-tailed bats (*Mystacina tuberculata* Gray), and introduced ship rats (Ecroyd, 1996) or mice (*Mus domesticus* Sage & Sage). See Holzapfel & Dodgson (2004) for further details on methods.

Establishment of dactylanthus was confirmed for the first time four years after sowing, at one plot in each of two sites. The number of plots with dactylanthus increased steadily in the following years; ten years after sowing dactylanthus had established at all four sites and in 22 of the 24 plots. Total number of inflorescences and mean number of inflorescences per plot increased each year for most years, though successively smaller increases each year indicated that plots were nearing their maximum flowering capacity.

Central sown plots established plants earlier, while inflorescence numbers (and, by proxy, number of plants) per plot were higher for broad sowing, probably due to lesser crowding of plants compared to central sown plots. Inflorescence numbers per plot were as high or higher as in wild populations. A striking result was the high proportion of female inflorescences compared to males, ranging from 100 % to 69 %. This was in direct contrast to wild populations where on average males outnumber female inflorescences five to one (Ecroyd, 1996). The male proportion increased, however, each year for the four most recent years of monitoring and it is conceivable that over time the sex ratio at the trial site would become similar to that of wild sites. Whether these skewed and changing sex ratios mean that individual plants change sex, or that the species is not dioecious but monoecious and plants produce both male and female inflorescences in varying proportions over time, is an area of ongoing research. Establishment rates and inflorescence numbers were similar at the three sites that had closed canopy but different host species dominance and age. The open canopy site showed delayed establishment and only about a tenth of the number of inflorescences per plot compared with the closed canopy sites, and contained the only two unsuccessful plots. This might indicate that exposure influences establishment of dactylanthus, e.g., drier soil leading to higher seed mortality or fewer host roots being available for establishment. Because this particular site was the first of all four sites to be set up, however, it cannot be discounted that a suboptimal sowing technique at that early stage of the project ('starter-effect') rather than site conditions was responsible for the lesser success.

Major difficulties faced

- Ensuring that monitoring was carried out late in the flowering season each year so that most inflorescences could be counted. As flowering times varied from year to year this necessitated repeat visits in some years.
- The unexpectedly high number of inflorescences developing in the latter years of the study meant monitoring effort increased four-fold over the time of the project, putting pressure on resources and capacity required to maintain the same level and quality of data acquisition.
- The inability to distinguish whether the lesser success at the open-canopy site was due to micro-site conditions or because the sowing technique had not been optimized when the site was sown.

Major lessons learned

- Dactylanthus can be successfully established in the wild from seed, both through broad and central sowing.
- Establishment success was not correlated to a particular host species or -age but might be correlated to microclimate or other microhabitat conditions at the site.
- Sex ratio of inflorescences was opposite to that of wild populations, but similar to those in earlier pilot trials. Understanding this difference and the observed trend towards increasing 'maleness' over time is an important area for ongoing research.

- Success at this site has so far not been replicated at other sites using the same methods, meaning that not all conditions required for establishment have yet been identified.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Establishment occurred at all sites and in most plots, with the overall population vigor, size and flowering output comparable to or exceeding that of wild populations.
- Data of sufficient quality were obtained to robustly analyze the key components of the trial.
- Results have further advanced our understanding of the establishment and reproductive biology of dactylanthus.
- The success at the specific site has not been able to be replicated to the same extend at other sites, therefore a description of required standards for its use as a conservation management technique is still incomplete.

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Conservation and re-introduction to augment threatened orchid populations in Madagascar

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Introduction

Madagascar's orchids comprise approximately 1,000 currently classified species with nearly 80% endemism and many species that are on the verge of extinction due to the rapid conversion of forests to slash and burn agriculture. The island nation is a biodiversity hotspot of the highest concern according to IUCN. It is home to many animal and plant species found nowhere else on earth. The orchids in Ranomafana National Park are representative of orchid species that were once widespread in Madagascar's eastern rainforest region. The park offers a measure of protection to the orchids. However, most of the surrounding landscape has been burned and converted to crops in order to feed an impoverished human population. Malagasy orchids are among the island's most vulnerable plants partly due to the highly specialized niche they occupy in the forest which disappears quickly when the trees are destroyed by human activities or from the frequent cyclones that hit the island. A single downed tree may have provided support to dozens, and possibly hundreds of individual orchid plants, along with other epiphytic species. Illegal exploitation is another threat to the orchids.

Orchid seeds were collected in Ranomafana National Park under permits in collaboration with the Association Nationale Pour la Gestion Des Aires Protogees (ANGAP), the Madagascar Institute Pour La Conservation Des Environments Tropicaux (MICET), the University of Madagascar at Antananarivo and The Lab for Rare & Endangered Plants at Omaha's Henry Doorly Zoo, Omaha, Nebraska, USA. Concurrent propagation studies were conducted at the University in Antananarivo and at the Omaha Henry Doorly Zoo's plant research laboratory. The orchid plants resulting from the project were used for re-introductions

Re-introduced orchid on tree trunk

in Madagascar. Small samples of the remaining uncultured seeds were cryopreserved in liquid nitrogen at the zoo's frozen germplasm bank for use in future research projects and re-introductions in order to provide a back-stop to species extinctions.

Goals

- Goal 1: Conduct field surveys of the orchids found in Ranomafana National Park.
- Goal 2: Develop successful micropropagation protocols for the seeds.
- Goal 3: Provide biotechnology training and conservation education for Malagasy graduate students, professors, park guides and local residents near Ranomafana.

Success Indicators

- Indicator 1: Increase the number of orchid plants used for return to the native habitat, and re-establish them in areas where the seeds were originally collected, in order to augment current populations.
- Indicator 2: Long-term monitoring of success/failure rates for each of the orchid species re-introduced.
- Indicator 3: Develop a useful model for propagation and re-introduction to be used in Madagascar and other plant research projects conducted elsewhere.

Project Summary

The habitat where this project originated is a mountainous region characterized by high humidity, high rainfall and dense jungle that provides shady growing conditions. Eleven orchid species representing five genera were propagated *ex situ* and returned to Madagascar for re-introduction to the forest in Ranomafana National Park. The collection of 839 juvenile orchids represented members of Aeranthes-6 species, Aerangis-1 species, Bulbophyllum-2 species, Calanthe-1 species and Cryptopus-1 genera. Orchids are over-exploited, often illegally, all over the world and Madagascar has seen its share of illegal collection of orchids that wind up being sold in the marketplace. Political instability in the country and a burgeoning population searching for any means to support families often results in pressure upon plants with economic value. The collaborative project enlisted local residents and graduate students in orchid propagation and re-introduction to promote regional conservation. Students and professors from the Madagascar University were given biotechnology training for micropropagation, cryopreservation and re-introduction techniques previously developed at the Omaha Henry Doorly Zoo plant laboratory in the United States. Juvenile orchids produced at the zoo were transported to Madagascar after a rigorous phytosanitary inspection in the United States and were also quarantined upon arrival in Madagascar prior to re-introduction in the forest.

The plants that were returned to Ranamofana National Park were transported, still in sterile cultures, and were acclimatized to the light and humidity regimes right at the re-introduction site. Transporting the plants in aseptic cultures prevented any pathogenic material being transferred between the two countries in order to avoid any environmental problems in the rainforest. A local resident was employed to

Aeranthes orchid

assist with the re-introductions and to make monthly monitoring expeditions to the park for follow up with the plants. Epiphytic species were attached to the trees by using natural materials such as local mosses and vines. The Calanthe species is both an epiphyte and a terrestrial species that readily adapted to the natural habitat when planted in the detritus near the base of trees. The overall survival rate was greater than had been anticipated, particularly encouraging since this was a pilot project to test whether orchids could survive when re-introduced to the rainforest directly from sterile *in vitro* cultures. The Aerangis species survived at 75.86%, Aeranthes species survived at an average of 63.84%, the Calanthe species survived at 80%, Bulbophyllum species averaged 15.74% survival and the Cryptopus species survived at 100% after one year.

The Bulbophyllum species have roots that are thin and appear to have few reserves of nutrients or moisture and must be kept wetter than other species when they are reintroduced to the wild. Future re-introductions for that genus will be returned to the forest under improved techniques. All of the orchids continue to be monitored and after 5 years a number of the re-introductions have commenced blooming which indicates that those plants have now entered the reproductive stage, an important life stage for population sustainability. In order to engage Madagascar local schoolchildren in conservation they were taken on field trips to the park to observe orchids and other endemic plants in order to raise awareness of their own region's natural resources. An art contest sponsored at the local elementary school taught the children about the orchid structures and their particular role in forest biodiversity. Many of the schoolchildren had never before entered the park or been made aware of the importance the park's plant diversity holds for them and their country.

Major difficulties faced

- Timing of re-introductions with the proper season to increase survival rates.
- Choosing specific re-introductions sites and conditions that would allow orchid re-introductions to survive.
- The distance between the countries of the collaborators which increased costs.

- Concurrent studies at the Malagasy university were difficult due to inadequate facilities for aseptic micropropagation.

Major lessons learned

- *Ex situ* seed micropropagation allows for a large number of propagules produced. A single fruit removed from the wild produces many orchids with little or no impact on wild populations.
- Re-introductions are most successful for orchids when made at the outset of the rainy season to avoid excessive dehydration while plants are small.
- The host country will benefit most if project participants include local residents who have first hand knowledge of the local conditions needed for re-introduced plants.
- Each species has its own particular niche in the natural habitat which requires careful documentation and analysis to facilitate successful re-establishment.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- This is the first known project of its kind to detail a successful re-introduction of orchids directly from sterile *in vitro* cultures into the natural habitat.
- Engaging local residents and students made the project successful and at the same time raised public awareness of the natural resources.
- The majority of the re-introduced plants survived past the five-year mark and have gone on to begin their reproductive cycle, indicating successful re-establishment in the wild.
- Seed samples were cryopreserved at Omaha's Henry Doorly Zoo to preserve germplasm that in some cases is irreplaceable.

Experimental introductions of the heath spotted and early marsh orchids into a restored ecosystem in Switzerland

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Introduction

The heath spotted (*Dactylorhiza maculata*) and early marsh (*Dactylorhiza incarnata*) orchids are protected species in Switzerland and are listed on CITES App. II and the EU habitats directive. L'Etang de la Creule was constructed between 1993 and 1994, to channel run-off water from the banks of the A16 motorway to Courgenay. The basin is separated into two distinct areas by a dyke of large rocks, one part is for the water to settle and the other is of interest for development of flora and fauna. The south bank is managed to favor a diverse range of insect species. The north bank is steep and hot, and the waste water goes into a channel to the east. The sides of the pond are surrounded by a mixture of prairie flowers. The area is hidden from view by many native species of trees and bushes. Fifteen years after it was built, this artificial environment is home to more that 150 plant species. Many plant and animal species arrived spontaneously, without the intervention of man. The two orchid species have been introduced.

Goals

- Goal 1: *In vitro* seed germination from local plants of *Dactylorhiza maculata* and *D. incarnata*.
- Goal 2: Acclimatization of *in vitro* plants to cultivation in pots.
- Goal 3: Increased diversity of a restored ecosystem by introduction of two protected orchid species.
- Goal 4: Natural regeneration of introduced orchid species.

Success Indicators

- Indicator 1: Successful *in vitro* germination of *Dactylorhiza maculata* and *D. incarnata*.
- Indicator 2: Acclimatisation of plants to soil in Switzerland.
- Indicator 3: Survival and regeneration of introduced plants.

Project Summary

Feasibility: It is important to source plant material from a habitat similar to the introduction site and to cultivate plants under the conditions that they will encounter, in preparation for planting. In this experiment, plants were grown in

Flowers of *Dactylorhiza incarnata* (*left*) and *Dactylorhiza maculata* (*right*) © Samuel Sprunger

pots using soil from the introduction site. The pots were kept outside, in the same region as the re-introduction site, so that the plants would be exposed to local environmental conditions. It was important to grow the plants to flowering size before planting out to verify the species, as it can be difficult to identify them when collecting seeds after flowering has finished. Local agreements were needed to collect seeds and to carry out the introductions: Permission was obtained from the 'Ponts et chaussée Delémont, séction route nationale', the Swiss equivalent of the Highways agency. The restored area is of great interest to local people as the pond Etang de la Creule is new to the region. The cultivation in pots, reintroduction and monitoring was carried out in Switzerland, by Samuel Sprunger. The germination protocol was developed at Royal Botanic Gardens, Kew and production of *in vitro* plants was funded by and performed at Royal Botanic Gardens, Kew. Some seeds and plants were retained at Kew for *ex situ* conservation.

Implementation: Seeds capsules of *Dactylorhiza maculata* and *D. incarnata* were collected between 1999 and 2001, at Chevenez and Porrentruy, with the land-owners' permission. These sites were close to the planned introduction site. Artificial pollination was carried out so that seed collection did not deplete the natural populations. CITES permits were obtained to transport the seeds from Switzerland to Britain. Phytosanitary certificates were obtained to return the *in vitro* plantlets to Switzerland. The seeds were collected as green capsules and transported by post. On arrival at Kew, they were surface-sterilised by dipping in 99% ethanol then passed through a flame. This procedure was carried out three times for each seed capsule. The capsules were cut open inside a laminar flow bench, and the seeds were sown onto petri dishes of modified Greenaway medium (Salman *et al.*, 2002) and incubated at 20^{0}C in the dark. Although the seed capsules were green and intact, the seeds inside were brown and fully mature and some were banked for later use. Germination was successful, using freshly collected seeds which did not need to be bleached. Seedlings develop more quickly if grown together with a symbiotic fungus but this presents problems when moving plants from one country to another, since the natural distributions of fungal species are largely unknown. Therefore these seedlings were grown asymbiotically to avoid introducing non-native fungi. Germinated seedlings were


Overview of habitat
© Samuel Sprunger

transferred to fresh media in 0.45 kg honey jars and when shoots developed the plantlets were moved into the light. Subsequently they were transferred to fresh media every six months. In late 2002, the largest plantlets were transferred to plastic containers for transportation. They were carried by air as hand-luggage to Switzerland, where they were potted up. Plants were considered large enough to pot up when they had ½ to 1 cm tubers and roots. In spring 2003 plantlets were removed from the agar and rinsed with tap water to remove any traces of agar from the roots. They were potted up into compost containing calcareous soil from the proposed destination at La Creule, with 5-10% organic matter. Sand and leaf mould were added in the following proportions: Soil (8), sand (1) and leaf-mould (1). Three or 4 plantlets were placed into each 10 cm, plastic pot , placed outside in semi-shade and watered with rain water when needed. Each plant produced 2 or 3 leaves in the first year, and 50% flowered by the third year after potting. In June 2005, 15 pots of each species were planted out at la Creule. At this stage the plants were in flower or had immature seed pods

Post-release monitoring: *Dactylorhiza* species are dormant during winter, but in the year following their introduction, between 70% and 90% of the plants produced new leaves and flowers. In spring 2008, many young plantlets of both species were observed, some flowering for the first time, showing that natural regeneration had taken place and confirming that the habitat chosen was suitable for survival and natural regeneration of these species.

Major difficulties faced

- CITES permits are needed for certain plant material to cross international borders and this has a cost implication.
- It is not always possible to identify species when they have finished flowering and produced seeds, especially in areas where similar species occur together.
- Poor results have been obtained if *in vitro* plants are sent by post or as air cargo, so transportation relied on the goodwill of staff travelling to Switzerland for other reasons.
- Asymbiotic propagation is relatively slow.
- Disturbance of introduced seedlings by birds, animals and people.

Major lessons learned

- *In vitro*, asymbiotically raised orchids can be successfully introduced to a man-made environment.
- Source plants could be mapped or marked when they are in flower and a voucher specimen could be collected, to facilitate species identification.

- If propagation could be carried out in Switzerland this would avoid the need for CITES permits and locally obtained fungi could be used for symbiotic germination.
- Several years are needed to carry out and assess the success of such a project.
- Protection from disturbance by birds and animals may be needed, such as wire cages. Local education and interpretive information may reduce human damage.
- Collaboration between our organizations was beneficial to share expertise at different stages of the project.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- The plantlets survived transfer from *in vitro* conditions to cultivation in pots.
- The plants survived introduction in to a man-made environment.
- The plants reproduced in their new environment.

Acknowledgements
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Propagation and re-introduction of the western prairie fringed orchid in Nebraska, USA

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Introduction

The western prairie fringed orchid (*Platanthera praeclara*) is an endemic orchid that is protected throughout its range in the Great Plains of the United States and Manitoba Province in Canada. The orchid is on the IUCN Red List for North America. The species had not been successfully propagated prior to 1999, when it was successfully micropropagated from seeds at the plant research lab at Omaha's Henry Doorly Zoo and subsequently re-introduced to augment an existing wild population. The research project was initiated in the sandhills of Nebraska where the largest known population in the state is located on the Valentine National Wildlife Refuge. The orchid species is sometimes found in widely scattered and isolated populations throughout the eastern two-thirds of the state but most of those populations have only a few individual plants. The species is associated with a specific pollinator which is believed to be in decline across the range and the orchid is also highly dependent on a symbiosis with specific soil fungi which facilitate uptake of soil nutrients for plant survival.

Western prairie fringed orchid (*Platanthera praeclara*)

The research project involved propagation and re-introduction of the propagated orchids, isolation of the fungi associated with the orchid's roots and rhizomes in the wild and soil nutrient analyses of the natural habitat in order to identify environmental conditions necessary for survival. The primary aim was to create a profile of some of the factors in the environment that support the orchid and to assist wildlife managers in decision-making regarding currently known populations and identifying potential re-introduction sites.

Goals

- Goal 1: Propagate the orchid *in vitro* for use in wild population augmentation.

- Goal 2: Develop successful micropropagation protocols for the orchid seeds.
- Goal 3: Isolate the symbiotic fungus(i) from underground tissues of the orchids found in the wild.
- Goal 4: Analyze soil nutrients present in the orchid's natural habitat.
- Goal 5: Re-introduce micropropagated juvenile orchids to the wild.

Succes Indicators

- Indicator 1: Successful propagation of the species that had previously resisted attempts at seed propagation.
- Indicator 2: Isolation and characterization of suspected fungal symbionts.
- Indicator 3:Determining nutrients and minerals in soils at orchid sites and comparing them with nearby non-orchid sites.
- Indicator 4: Monitor re-introduced plants for growth and survival.

Project Summary

Due to its protected status under the US Endangered Species Act permits were obtained from US Fish and Wildlife Service and the Nebraska Game & Parks Commission to collect seeds from *Platanthera praeclara* on the Valentine National Wildlife Refuge. The terrestrial species makes a very sporadic appearance from one year to the next and is believed to survive underground for some of its life stages, which may be part of a species survival strategy in a harsh environment characterized by broad swings in temperature and rainfall. The orchid's sporadic show may also be related to a periodic unavailability of the suspected fungal symbiont(s) during natural fluctuations of surface waters that peak and recede within the habitat over the course of the seasons and years. The habitat is characterized by arid hills with low-lying sub-irrigated meadows between the sparsely grass- covered sandhills.

The orchid seeds are smaller than a single grain of dust and have both physiological and chemical dormancies which must be understood in order to get them to germinate. A multi-step process was developed to scarify and surface sterilize the seedcoats without damaging the bare microscopic embryo within prior to *in vitro* culture on sterile agar-gelled media. The germination is very low and generally was less than 6% and the sensitive seedlings were prone to easy die-back even under sterile *in vitro* conditions and were slow-growing. Juvenile plants used for re-introduction trials were grown *in vitro* at the lab for two to three years prior to planting-out. The orchids were kept in vitro under sterile conditions to reduce any chance of introducing pathogens to their specialized microhabitats in the wild. More than one hundred-thirty juvenile orchids were planted back in the habitat near the adult plants which provided the seeds that were collected three years earlier. Re-introduced orchids survived at a low rate but were encouraging enough to warrant further re-introduction investigation for the species.

To identify potential symbionts, a small amount of root tissue was collected in the wild and the fungi were then isolated in the laboratory. A total of twenty-seven isolates were cultured *in vitro* and fourteen of them were targeted as possible symbionts for the orchid. A small number of the *in vitro* grown orchids were inoculated with the suspected symbionts. Inoculated orchids grew equally well as

Orchid habitat in the Nebraska sandhills

non-inoculated orchids for a few weeks but those inoculated were more likely to die before maturity than the orchids that were grown in the absence of fungal inoculation. Soils were analyzed from orchid sites and nearby non-orchid sites to determine whether there were nutrients more or less prevalent in the orchid microhabitats. The soil analyses may help make it possible to test potential re-introduction sites for their soil contents prior to planting out *ex situ* produced orchids. Soil core samples were taken near adult *P. praeclara* orchids and at non-orchid sites nearby which appeared to be similar to the orchid sites. Soil cores were taken in spring, summer and in the fall and soil samples were almost always totally water-saturated when taken near an existing orchid, regardless of the season, while samples taken in similar-looking non-orchid habitat within 50 m of orchids were not saturated, indicating that water availability is critical to the orchids' survival. As a result of the soil analyses a general profile of nutrient, soil textures and water availability have been delineated for future *P. praeclara* re-introductions if, and when, they are made in this part of the orchid's native range.

Major difficulties faced

- A complicated and prolonged legal permitting process and many restrictions placed on the project since the study took place on federal land.
- Determining the best time to re-introduce the orchids to the natural environment when repeated measures were restricted by governmental regulations.
- The orchid species is extremely sensitive to root disturbance making handling of the seedlings difficult.
- Identification of preferred re-introduction sites.
- A concurrent eight-year drought was assumed to have had a detrimental effect on the re-introduced plants and may have skewed the outcome to some degree.

Major lessons learned

- The orchid species can be successfully propagated in asymbiotic cultures.
- Re-introductions of inoculated orchids were no more likely to survive after re-introductions than orchids that were raised asymbiotically *in vitro* and re-introduced to the wild.
- The species shows a preference for soils that are generally nutrient-poor but the element magnesium is abundant near existing *P. praeclara* orchids.
- Re-introductions are best made in the very early spring when the soil and air temperatures are still cool and there is ample soil moisture.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Survival of re-introduced orchids was generally somewhat lower than expected.
- Legal restrictions precluded adequate replications for the re-introductions which would have allowed a large study to be done.
- More than 98% of soil microbes are still unclassified by science, making fungal symbiont identification difficult.

Translocations of the critically endangered spiny daisy in the Mid-North of South Australia

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Introduction

The spiny daisy (*Acanthocladium dockeri*) is a low perennial shrub, with persistent woody stems, spine-tipped branches and small yellow flowers. The species is listed as critically endangered under the Commonwealth of Australia's Environment Protection and Biodiversity Conservation Act 1999 and is considered critically endangered under IUCN criteria (CRB1 and CRB2; IUCN 2001). The species was historically collected from western New South Wales (1860) and the South Australian Riverlands (1910). Despite searches of these areas in the 1990's, no populations were relocated and this unique daisy was thought to be extinct. In 1999, the species was re-discovered in the Mid-North region of South Australia and subsequent surveys found five naturally-occurring populations. All known

One year old translocated spiny daisy © SADEH populations are located on degraded road reserves, in either remnant native grasslands (n=4) or semi-arid shrublands (n=1). Relatively little of the species' habitat remains in the Mid North region, with the majority of grasslands on low hills and plains having been cleared for agricultural production. Although the species flowers prolifically, it exhibits very low levels of seed-set, resulting in no seedlings being observed in the wild (Jusaitis, 2008). The plant does, however, display vigorous root-suckering. Genetic analysis has revealed that each known population is comprised of a single genotype (Jusaitis & Adams, 2005). The clonal nature of this species, its high level of endemicity and its status as the sole representative of the genus *Acanthocladium* (Asteraceae) makes the spiny daisy a priority species for conservation action.

Goals

- Goal 1: Safeguard each of the five known genotypes against extinction, thereby maintaining the species' genetic diversity.
- Goal 2: Determine appropriate methodologies for the successful establishment of new populations of the spiny daisy.
- Goal 3: Determine if the species' inability to set seed can be overcome through cross-pollination between genotypes.
- Goal 4: Increase public awareness of the conservation status of the spiny daisy.

Success Indicators

- Indicator 1: The establishment of at least one translocated population for each of the five known genotypes, ensuring that all genotypes exist at no less than two locations in the field (one natural occurrence site and an additional translocation site).
- Indicator 2: The completion of an experimental translocation to evaluate the effects of weed control, herbivore control and the use of tree guards on the establishment success of spiny daisy.
- Indicator 3: The completion of an experimental mixed-gene translocation (all five genotypes), to assess the potential for cross-pollination between genotypes.
- Indicator 4: The establishment of display populations in public gardens, for public education and raising awareness.

Project Summary

Translocations to increase probability of long-term survival of genotypes: To guard against the loss of genetic variability, translocated populations are being established for each genotype. These populations are spaced sufficiently apart to ensure no inter-breeding. Prior to the establishment of any new population, translocation plans (Vallee *et al.*, 2004) and site management plans are developed. The two primary success indicators for these translocations were i) a 70% survival rate, over the first 12 months and ii) a 50% survival after 5 years, with an increase in the population's area of occupancy. The spiny daisy readily propagates from cuttings, enabling the rapid production of tube stock. A translocated population of the "Yangya" genotype was established in 2006, as part of the experimental planting trials (see below). In June 2007, a population of 24 individuals of the “Rusty Cab” genotype was established at a council reserve near Caltowie. The plants were watered once in summer 2008 and the survival rate over the first 12 months was 87.5%. A population of 24 individuals from the “Telowie” genotype was established in Mount Remarkable National Park in June 2008, representing the only population of this species on a conservation reserve. After 10 months, 71% survived, just within acceptable bounds. The majority of losses resulted from the drought conditions. The establishment of supplemental populations of the “Thornlea” and “Hart” genotypes is now a priority.

Assessment of techniques to improve success rate of translocations: Competition from environmental weeds and herbivory from the introduced white snail (*Cernuella virgata*) have been identified as key threatening processes for the spiny daisy (Clarke, Robertson & Pieck, 2007). A simple experiment was conducted to assess the extent to which these threatening processes would need to be mitigated, to allow for the successful establishment of a translocated population. A total of 400 individuals from the “Yangya” population were propagated (via. cuttings) and planted out along a roadside reserve containing a remnant native grassland community, in June 2006. A randomized block ANOVA design was used to assess the effects of weed and snail control (individually or together), tree guards and time on the growth and survivorship of individuals (20 plants per treatment block, four replicates). All plants were watered once during the summer months. Both survivorship and growth were monitored, on a six monthly basis, for 24 months. The plantings protected by tree guards (with no other site management) displayed significantly higher survival rates (78%) than any other treatment. Survival in other treatments was poor and ranged between 26% and 44%. Overall, survivorship was significantly higher in the first six months of the experiment, compared to the subsequent 18 months. The use of tree guards produced the only significantly positive growth rate, over the 24 months of monitoring.

We attribute the increased survival and growth of the plants with tree guards to the ability of the guards to protect plants from vertebrate grazing and moisture loss. Young spiny daisy shoots are particularly susceptible to grazing by feral European rabbits (*Oryctolagus cuniculus*) and brown hares (*Lepus capensis*). In contrast, weed control and snail baiting were of minimal benefit. This trial was conducted during a period of prolonged drought, highlighting both the hardiness of the spiny daisy and the effectiveness of tree guards at moisture retention. Logistics prevented the examination of the effects of weed and/or snail control, in combination with tree guards. However, the observed benefits of using tree guards alone suggested that any additional gains provided by weed or snail control may not be cost effective. This trial demonstrated that new populations can be established successfully without the need to undertake expensive site preparation works prior to translocations.

Field-based cross-pollination trial: With intra-population fertilization virtually non-existent, glasshouse and field-based trials have been undertaken to determine if cross-pollination will occur between plants from the five different populations. Twenty-five individuals from each of the "Yangya", "Rusty Cab", "Thornlea" and "Hart" populations were planted at a road reserve near Caltowie in June 2007 (randomised block design with all possible combinations), in an attempt to induce sexual reproduction. Following its discovery in January 2007, an additional 50 individuals from the "Telowie" population were propagated and added to the trial in June 2008. All plants were protected with tree guards, which were removed after 12 months, to allow free cross-pollination to occur. During the October 2008 monitoring period, 17% of plants were mature enough to display flowers or buds. Although too early to be conclusive, there has been no indication of successful cross-pollination or seedling establishment so far. If no significant seed set is observed over the next monitoring season, this may suggest that the spiny daisy is incapable of inter-clonal cross-fertilization and, therefore restricted to five genotypes. As such, the species will have little adaptive plasticity in the face of changing environmental conditions and may be totally dependent on further translocations into areas of suitable climatic regimes.

Members of the Biodiversity & Endangered Species Team (BEST) community group planting tubestock at translocation site © SADEH

Establishment of display populations: Translocated populations have been established at five public gardens for education purposes. These sites include three regional gardens and two accredited botanic gardens (Arid Lands Botanic Gardens and Australian National Botanic Gardens). Interpretative signage accompanies each translocated population. To date, these display populations have been established with only four of the five species' genotypes.

Major difficulties faced

- There is limited knowledge of the species ecology (e.g. historic range).
- The habitat of this species in the Mid North of South Australia is highly fragmented and degraded, resulting in difficulties in locating suitable translocation sites.
- The Mid North of South Australia has been in a prolonged drought since 2005. However, supplemental watering during the first summer after planting appears to have improved survival rates.
- The majority of translocations are conducted in degraded habitats, necessitating ongoing site management following establishment (weed and snail control).

- In the past, the sourcing of sufficient funding to undertake the translocations and ensure ongoing site management has been problematic. More recently, medium-term funding support for the project has been secured from Exetel, via the Foundation for Australia's Most Endangered Species (FAME).

Major lessons learned

- The spiny daisy is readily propagated from cuttings.
- The use of tree guards significantly increases the survival of translocants and negates the need for extensive site preparation works prior to translocations.
- Differences in both flowering time and intensity (between genotypes) further reduces the probability of successful cross-pollination.
- With only five known genotypes and an apparent inability to cross-pollinate, increasing the size of the gene pool appears unattainable.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The spiny daisy is readily propagated and translocated to new sites, allowing for the establishment of numerous supplemental populations.
- Aside from the apparent inability to facilitate cross-pollination between the genotypes, the project is well advanced in achieving its targets.
- There has been good collaboration between all agencies involved.
- Careful planning for translocations and subsequent site management.
- A collective knowledge has developed of the difficulties this species may face from future climate change.
- Dedicated participants.

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Conservation introduction of a locally extinct fern species in Estonia during 1998-2008

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Introduction

Woodsia ilvensis (L.) R. Br. has a disjunct circumpolar distribution (Hultén & Fries, 1986). The species has not been evaluated for IUCN yet, its condition and conservation status within the whole range varies from locally common to locally extinct (Torleif *et al.*, 1993). In Estonia, *Woodsia ilvensis* was historically rare. It was found growing in northern and north-western Estonia representing the south-eastern border of its Scandinavian disjunction, were few areas offer suitable habitat. First found in 1887, it was documented only in four locations in different times and has not been found since 1977. Initially it was assessed as critically endangered (Lilleleht, 1998) and until 2004 it belonged to I category of protected plant species (RT, 2004). Since 2005, it has been considered as naturally extinct species in Estonia (Kukk & Kull, 2005).

Considering that habitat conditions may have changed on previous locations, an experimental project was started to test if it would be possible to successfully introduce *W. ilvensis* into new localities where suitable habitat conditions exist.

Goals

- Goal 1: Testing the habitat suitability for population establishment.
- Goal 2: Establishment of a viable experimental population.
- Goal 3: Creating a local spore source for further natural dispersal of the species.

Success Indicators

- Indicator 1: Long-term survival of out planted individuals.
- Indicator 2: Establishment of new natural generations, population recruitment.
- Indicator 3: Colonization and establishment in new empty patches of suitable habitat, extended distribution.

Re-introduced individuals in 2009

Project Summary

Woodsia ilvensis is known as a fern of dry sunny or half shaded rocky habitats, on thin acidic soils on many different types of metamorphic and eruptive rocks. The older findings from Estonia were from the north-eastern coastal cliff. The most recent findings were from old stone fences piled from the stones collected from surrounding fields. While checking previous locations in Estonia during the period of 1994-2006, not a single individual was found. The two older locations were dominated by calcareous substrate. In two most recent locations the habitat was degraded - the stone fences were destroyed or removed. Considering that substratum reaction may be limiting factor and that changed habitat conditions may not support the species survival in previous locations any longer, the search for new apparently suitable habitats for experimentation of conservation introduction was started. There are only few areas of almost 'calcium free' environment in northern and north-western part of Estonia where vendian layer is denuded. These areas, some northern islands, stone fences and siliceous erratic boulders were checked for possibly suitable habitat.

In many regional floras, *Woodsia ilvensis* is mentioned sharing the habitat with *Asplenium septentrionale* (L.) Hoffmann. Both species are represented in Finland and on easternmost islands of Finnish Gulch (Glazkova, 1996). On its most recent location in Estonia, *W. ilvensis* was also found growing together with *A. septentrionale* (Hein & Puusepp, 1962), both currently extinct on this site. There is a single natural population of *A. septentrionale* growing on the south facing stone wall of the old churchyard on small island of Prangli. It was decided to consider *A. septentrionale* as the indicator for suitable habitat conditions and choose the north -facing side of the same stone wall for re-introduction experiment of *W. ilvensis*. As there was no natural source of local spores, all plants were grown from the spores received via the seed and spore exchange of botanical gardens. Only spores of wild provenance were used for introduction experiment (Joensuu HB, North-Karelia, spont.; Helsinki HB, Uusimaa, spont.). The sowings were made in laboratory conditions and timed for late autumn. Next spring young plants were planted into the mix of leaf mold, drained peatland forest soil and coarse sand, and thereafter taken into the shaded sphagnum beds, where they were kept and handled with minimal maintenance until planted into natural conditions.

In 1998, two years old individuals were planted onto the old north facing stone fence on the island Prangli. In 2001, a group of five years old individuals were added to that site. In both cases, the planting was timed to late summer and early autumn according to more moist weather conditions, thus giving plants enough time to get rooted before winter. The plants were watered only after the planting and then left into natural conditions without any maintenance or site management. The introduction on stone fence was successful. Some plants died during two first years, the rest survived and continue growing. The ferns are well adapted to the conditions of dry and open habitat conditions. They are tolerant to long droughts, drying and curling up the fronds during the dry months and turning back green and growing on after the late summer or autumn rains. The spores are produced yearly. The germination tests show that they produce viable spores. No sign of regeneration, natural recruitment or spread has been discovered yet. The number of fronds and rhizome tips is bigger for these ferns which were out planted when younger and smaller (two years old plants). The monitoring is conducted yearly. The growth, condition and vitality of single individuals are assessed. During each visit the whole habitat patch is searched for regeneration.

The results confirm that if the spores of *Woodsia ilvensis* would land on suitable substrate within suitable habitat in northern or northeastern part of the Estonia, they could germinate, the individual plants could get established and persist at least for a certain period of time. The ferns have been out in the habitat for eleven years without any maintenance. For now, the age of experimental individuals is 13 years and they have been growing in natural habitat for 11 years. As the ferns of this experimental population still increase in size and produce spores yearly, one may conclude that the habitat conditions of the site may be suitable for the species. Since, the population recruitment has not been observed.

Major difficulties faced

- More research on microhabitat requirements and conditions is needed, for selecting the exact locations for planting the individual ferns into natural habitat. Not only substrate reaction, but the moisture content and régime in the soil of the microhabitat could be vital for long-term survival, particularly in case of ferns of dry and mesic habitats. The ferns do not have a deep root system as most of flowering plants do. Rather thin additional roots grow out of the rhizome, and get their water and nutrition from relatively smaller soil area.
- Many fern species are sensitive to repeated planting. They may get disturbed and need a longer period for the recovery and after-care. For this reason it is important to consider which developmental stages could be best for the successful establishment in the habitat. Theoretically, it would be good to plant out the fern individuals in as early developmental stages as possible, enabling the longer period for adaptation with natural conditions and the rhythm of natural changes in the habitat. The ‘right’ developmental stages for out planting may be specific depending of autecological characteristics of the species and habitat conditions.

Major lessons learned

- The growing process is the continuous adaptation to environmental conditions. The ex situ propagation should be toughening the plants for future planting into natural habitat, decreasing thus the after planting environmental stress and increasing the potential survival of the individuals in the site.
- The single out planting into the habitat equals to single occasional natural distribution event. It may take very long time until structured self-sustaining population evolves naturally, and probability for this event to happen is as big as that of extinction. It was learned that the out planting should be gradual during several consecutive years or by the cycles, imitating thus the natural colonization, population growth and establishment of structured self-sustaining population.
- The optimal number of individuals planted per year and the numbers of years, necessary to promote establishment of a viable population, may be specific to

the species or the group with similar life strategy. Analyzing monitoring data of natural and experimental populations helps to specify these numbers.
- As the number of individuals and amount of spores/seeds is limiting in case of endangered species, it would be more sustainable and more effective to start with smaller experimental populations, gradually increasing the size and number of patches in accordance to the intermediate survival analyze.
- If appropriate habitat with characteristic community and habitat conditions could still be found, then any after-management of the site will not be needed.
- The best indicators for selecting the possibly suitable habitat were characteristic species of the typical to the species natural community.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- Though limited and patchy, the suitable habitat conditions for *Woodsia ilvensis* still exist in Estonia. The thorough preliminary analysis of historical and current natural distribution, the distance from closest natural spore source, availability of suitable habitat and microhabitat conditions, life history characteristics of the species and the structure of natural community, are essential for the successful re-introduction/restoration/recovery efforts.

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Juniper scrub restoration at the Cample Burn, Clyde Muirshiel Regional Park, Scotland

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Introduction

Juniper (*Juniperus communis* ssp. *communis*) is a UK Biodiversity Action Plan priority species that occurs in a number of habitat types listed under the EC Habitats Directive and Juniper scrub is recognised as a nationally scarce woodland type. The above species is globally the most widespread subspecies and is relatively common throughout lowland Britain on both limestone and acid soils, especially on the Chalk Downs of southern England and the Scottish Highlands. However, within Scotland juniper has been lost from 23% of areas in which it was formerly present and in a further 34% of areas its future is under threat in the short to medium term (Sullivan, 2003).

A survey of juniper by Plantlife recorded that of 453 sites around 40% had fewer than 10 plants (Long & Williams, 2007). There is concern for the viability of fragmented populations and that regeneration is likely to be limited as 67% of all plants recorded were mature, old or dead. This lack of juniper regeneration is a significant problem at the majority of sites across the British uplands and therefore planting schemes may be necessary to ensure the survival of this species at particular sites. In Scotland juniper may be found from coastal locations to high on the mountain tops. Although juniper is recorded close to the summit of Braeriach in Aberdeenshire at 975 m around 80% of all juniper are normally found closer to 400 m (Sullivan, 2003). The juniper within CMRP all occur at an altitude of between 300 to 450 metres. The juniper restoration project at the Cample Burn site is located within Clyde Muirshiel Regional Park, 30 km west of Glasgow and is also within a Special Protection Area for Hen Harriers.

Goal

- Goal 1: To safeguard the existing juniper.
- Goal 2: To naturally regenerate the juniper and propagate stock from locally provident plants.

Close up of juniper berries and leaves

Guided walk to a juniper exclosure

- Goal 3: To allow regeneration or to introduce mixed scrub woodland rowan, willow and birch) integrated with open heather moorland for nesting/hunting hen harriers.
- Goal 4: To encourage local involvement in the conservation and restoration of juniper woodland scrub.
- Goal 5: To promote the value of juniper scrub woodland in the natural heritage
- Goal 6: To extend Juniper scrub woodland across the Local Biodiversity Action Plan area.

Success Indicators

- Indicator 1: To safeguard all existing juniper stands within the Regional Park.
- Indicator 2: To plant out 1,000 juniper within a 17 ha exclosure.
- Indicator 3: To establish a second project area within the Clyde Muirshiel uplands for juniper scrub woodland habitat.

Project Summary

The Cample Burn site habitat is largely a blanket mire that contains *Erica tetralix, Calluna vulgaris, Scirpus cespitosus* and *Eriophorum vaginatum.* The land is farmed for sheep and was until recently also managed for grouse shooting by the rotational burning of small patches of heather. Anecdotal evidence has suggested that juniper in the Clyde Muirshiel hills was once relatively common, but written references only give a non specific description of it being frequent in woods and heaths. Juniper appears to have been lost through muirburn and overgrazing by sheep. In the Regional Park's 281 km^2 there are six mature juniper plants, two of which are female. In the surrounding council areas of Glasgow, covering over 6,000 km^2, there are only fifteen sites with juniper (Broome, 2008; *pers comm*). Fencing of the 17 ha moorland site was completed in January 2008 and the first thirty juniper were planted by volunteers at the Cample Burn site three months later form stock derived from local species. A group in the local village, the Lochwinnoch Community Garden, is nurturing the juniper cuttings that will be planted out over the next three years. However, the survival rate of the juniper from cuttings has been around 10% and only 60 juniper have been planted at the site so far. Juniper does grow better from seed, but berries have only been found occasionally within the Regional Park. It was suspected that the poor success rates of propagation may have been due to the mature plants and the small size of available cuttings that were less than half of the recommended length of 10 cm


Park staff with community gardener: Gordon Nicol

(Broome, 2003). For the Cample Burn site there were only a handful of juniper bushes from upland sites in its seed zone.
Initially, the sourcing of appropriate juniper was limited by guidance on semi-natural planting that recommended the use of seed/cuttings from within the same seed zone. However, due to the high failure rate of propagated cuttings it became unlikely that enough plant material could be collected locally. A solution was reached through a working group (South Scotland Juniper Network) where it was suggested by Forest Research that cuttings or seed collected could include sites with environmentally similar conditions. For the Cample Burn site locations were matched using a set of parameters developed by Forest Research to indicate a cool wet climate and a high nitrogen soil (Weber & Broome, 2008; unpublished). Four main areas had similar environmental conditions to Clyde Muirshiel.

However, two of these areas were not suitable as some of the species plants could not be confidently distinguished as sub-species *communis* or as *ssp. Nana.* Around 300 juniper cuttings were collected from bushes in the Pentland Hills, Edinburgh and over 1,000 seeds collected with the assistance of the Borders Forest Trust form a site near Peebles, in the Scottish Borders. Following forestry guidance the juniper seeds were treated with a 1% citric acid solution for four days, stored at 4^{o}C for 30 weeks and then planted out in seed trays (Broome, 2003). After two years the imported juniper will be transferred to the Cample Burn site.

Another aspect of the project has involved the promotion of juniper and this has been done through guided walks, treasure hunts, BBQs and interpretation panels. Leaflets on the restoration project have also been displayed at key sites across South West Central Scotland. Of the six juniper within the Regional Park area three are now fenced within the Cample Burn scheme, a small exclosure has been completed for one other site, one was already inside a fenced Reservoir and the sixth bush is relatively inaccessible in a steep sided gulley. All the planted juniper have shrub tubes to guard against roe deer and mountain hares and the plants are weeded twice during the summer. A few Rowan (*Sorbus aucuparia*) have regenerated within the exclosure and it is planned to introduce some eared willow (*Salix aurita*) to the site next year. After a wet summer the first year's planting appeared to be waterlogged and this may have led to the demise of fifteen juniper, while those planted the following year and in drier ground have displayed vigorous growth.

Major difficulties faced

- Commercially grown on stock was sold accidentally to another project.
- Due to the old age of the local juniper plants the cuttings were less than half the length recommended by the Forest Research.
- The juniper propagation had under a 10% success rate and the lack of local bushes severely limited the amount of cuttings available for propagation.

Major lessons learned

- Working with a cross boundary group helped to solve problems with lack of cuttings and seed and identified common propagation problems.
- The grant application benefited from being part of a joint partnership with Action for Mountain Woodlands.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The project is not finished and the limited success in propagation is likely to be overcome through increased use of seed.
- Several elements of the project have been very successful such as fencing the site, promoting juniper conservation and partnership working.

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