Global Re-introduction Perspectives: 2016

Case-studies from around the globe

Edited by Pritpal S. Soorae

IUCN/SSC Re-introduction Specialist Group (RSG)

RSG

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

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

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

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

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

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

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

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Dr. Shaikha Al Dhaheri
Executive Director, TMBS
Environment Agency - ABU DHABI

This fifth edition of the Global Re-introduction Perspectives has just been produced and I am happy and honored to present it to you. This book being available both as a hard copy and as PDF is distributed widely across the world and is a very important resource for re-introduction practitioners, researchers and students who are either planning, implementing their own projects or studying re-introduction biology.

The latest issue contains a wide array of projects ranging from corals to amphibians, crocodiles to condors and African lions to many plant species. All these come with different levels of success and some failures. This shows that re-introduction projects are never easy and require careful planning and implementation to succeed. However, projects, which have not been successful for one reason or another, provide valuable learning experience, so that those shortcomings could be avoided.

We at the EAD are also embarking on an ambitious project to re-introduce the scimitar-horned oryx to Chad and we realize that this project needs a lot of diligent planning and execution to be able to see this species successfully released back into its historic range. I am also delighted to see a UAE project in this issue on re-introducing mangroves into the UAE and hope that this effort would be able to offset some of the impacts of large-scale developments along the country's coastline.

Finally, I would like to thank all those who contributed their interesting projects to this issue and to Axel Moehrenschlager, the new RSG Chair, Mike Phillips of the Turner Endangered Species Fund, Richard Reading from the University of Denver/Denver Zoological Foundation and Simon Stuart of the SSC for supporting species restoration worldwide and to Pritpal Soorae for compiling these case studies

Axel Moehrenschlager
RSG Chair
Calgary Zoo

Re-introductions are powerful and important. They are powerful in terms of averting extinction, restoring ecological functions to ecosystems, and returning profound commercial, aesthetic, or cultural value. Re-introductions are important, because they can engage generations across the globe in immediate conservation action that has the potential to make a tangible and pervasive difference.

The mere idea of reversing ecological degradation, in an era when pressures and threats to species and ecosystems are ever increasing, yields two enriching feelings for conservation: hope and confidence. To me, hope already emanates through the ensuing pages when I see the extent of effort and collaboration involved - I thank all authors and their supporters for inspiring myself and others. The program evaluations suggest once again that re-introductions across taxa are frequently successful. A reflection upon the lessons learned from these case studies, conveys confidence that the science and practice is ever-improving to restore setbacks of the past and to tackle the challenges of the future. Having worked on re-introductions for a long time, and having seen several of the species described within these pages on various continents, I would like to say what many of our authors modestly might not. Re-introducing species is hard. Creating change is difficult. Some people invest their entire lives to bring back a single species, overcoming tremendous biological, sociological, or political obstacles. These champions need to be celebrated and supported.

With the backdrop of stories that follow in this book, I would like to reach out to those that may want to make a difference. To the policy-makers, I invite you to support actions in your jurisdictions that can yield real change and real support from your constituents. To potential organizations or individuals that have the means and desire to lend logistical or financial support, I invite you to embrace the positive difference you can make and the lasting legacy you could leave behind. Finally, to the potential champions that peruse these pages and may dream of saving species themselves, I invite you to contact us in RSG to inform us of your ideas, training needs, and opportunities for the future.

We all have a part to play: let's build upon our momentum to make a difference together.

Mike Philips
Turner Endangered Species Fund

The Turner Endangered Species Fund and Turner Biodiversity Divisions were initiated in 1997 with the aim of conserving biological diversity by ensuring the persistence of imperiled species and their habitats with an emphasis on private land. Since then we have been involved in numerous re-introduction projects to restore viable populations of imperiled plants, birds, fishes, mammals, reptiles, an amphibian, and an invertebrate. We have matured into the largest, most effective private effort in the world dedicated to saving vanishing species.

Since 2008 staff from both organizations has benefitted mightily from the first four issues of the Global Re-introduction Perspectives. My personal copies have been well used; they are dog-eared and hand-written notes are common on the margins of many pages. I am certain that the fifth issue, which is now in your hands, will be equally useful. The case studies presented here offer wisdom and practical insights useful to anyone working to ensure the persistence of imperiled species.

The breadth of the fifth issue ensures that it contains information of use to general restoration ecologists and species specialists. Indeed, with case studies on invertebrates, amphibians, fishes, birds, mammals, and plants from around the world, the fifth issue is a definitive primer on worldwide re-introduction efforts. In a world that is increasingly humanized, where wild and self-willed nature is being relegated to smaller and smaller patches of opportunity, such a primer is of incalculable value.

It was a high honor for Team Turner to work with Pritpal Soorae and the Calgary Zoo, Denver Zoo, Environment Agency and the IUCN Species Survival Commission to produce this important publication. It is altogether fitting to single out Pritpal and all the contributors of case studies for their commitment to restoration. Despite the increasing pressure and permanent consequences of the 6th great extinction crisis, the world remains defined by a wondrous diversity of life. As made clear in this issue of Global Perspectives, and the previous four issues, that can be our future if we so desire.

Richard P. Reading, Ph.D.
Associate Research Professor
University of Denver

Pritpal Soorae provides an amazing fifth installment of his work to summarize many of the world's translocation projects in this volume - Global Re-introduction Perspectives: 2016: Case studies from around the globe published by the IUCN Re-introduction Specialist Groups (RSG). It has been my honor and the honor of the Denver Zoological Foundation, with whom I worked until quite recently, to provide support for this important and impressive effort.

Now a five volume set, Pritpal has provided multiple case studies of a huge range of taxa from all over the world. I am heartened to see a vast improvement in many re-introduction and other translocation programs everywhere and know that these summaries form a good starting place for people, agencies, and other organizations wishing to embark on such conservation programs. Notoriously difficult, but increasingly common, translocations offer an important tool in our "toolbox" of conservation approaches that require continued refinement to increase success rates.

I congratulate Pritpal Soorae on his continued fine work and extend our thanks to Dr. Axel Moehrenschlager and the RSG for supporting this important publication, Dr. Simon Stuart and the IUCN Species Survival Commission, Dr. Shaikha Al Dhaheri of the Environment Agency - Abu Dhabi, Dr. Mike Phillips of the Turner Endangered Species Fund, and especially to the contributors to this volume for their excellent summaries of re-introduction case studies from around the world.

Simon Stuart
Chair
IUCN Species Survival Commission

It is hard to keep pace with the speed at which the IUCN SSC Re-introduction Specialist Group (RSG) is producing successive editions of the Global Re-introduction Perspectives. This is now the fifth edition, and as with the four previous editions, the breadth of re-introduction projects taking place around the world is truly remarkable. This fifth edition reviews projects covering corals, oysters, insects, fishes, frogs, crocodiles, turtles, tuataras and iguanas. Among the birds, there are featured projects on condors, cranes, rails, parrots, hornbills, woodpeckers, starlings, buntings and honey-eaters. For mammals there are case studies on Tasmanian devils, bettongs, quolls, manatees, lions, foxes, wolves, macaques, deer, rabbits, beavers and squirrels; and for plants there are projects on mangroves, clovers, pinks, wattles, narcissus, lavenders, rock-roses and lilies.

As expected, most re-introduction projects seem to be taking place in North America, Europe, Japan, Australia and New Zealand. However, this fifth volume also features projects from Argentina, Brazil, China, Fiji, India, Indonesia, Mexico, Morocco, Philippines, Singapore, Zimbabwe and United Arab Emirates.
Now that we have five editions of Global Re-introduction Perspectives, I hope that it will soon be possible for the RSG to set up an online searchable database comprising all 290 case studies published so far in this series. Such a database would allow users to search, for example, for case studies on all plant re-introductions, or all re-introductions in West Asia. This would make the extremely important information in the case studies available to a much wider audience.

I would like to thank the Environment Agency - Abu Dhabi (EAD), and in particular its Secretary General HE Razan Khalifa Al Mubarak, for the EAD's long-term and most generous support of both the RSG and the Global Re-introduction Perspectives series. I would also like to thanks the Denver Zoological Society, in particular Dr. Richard Reading, and the Turner Endangered Species Fund, in particular Mike Philips and Dr. Shaikha Al Dhaheri, EAD for their support for this publication. Special thanks are also due to the RSG Chair, Dr. Axel Moehrenschlager, and to the RSG's Program Officer, Mr. Pritpal Singh Soorae, who has also acted as the most dynamic and proactive compiler and editor of all five editions of Global Re-introduction Perspectives.

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

Pritpal S. Soorae, Editor

Introduction

This is the fifth issue in the *Global Re-introduction Perspectives* series and has been produced in the same standardized format as the previous four to maintain the style and quality. 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 the first issue I managed to collect 62 case-studies, the second issue 72 case-studies, third issue 50 case-studies, fourth issue 52 case-studies and this current issue has 54 case-studies. There are now a total of 290 case-studies available in this format.

These case studies in this issue cover the following taxa as follows:

- Invertebrates - 4
- Fish - 3
- Amphibians - 3
- Reptiles - 6
- Birds - 13
- Mammals - 16
- Plants - 9

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. A few promised articles were not submitted by the last deadline and hopefully if we do another issue we can present them there. 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:

1. North America & Caribbean - 10
2. West Europe - 17
3. South & East Asia - 7
4. Oceania - 13
5. West Asia - 1
6. Africa - 2
7. Meso & South America - 6
8. East Europe, North & Central Asia - 1

Success/Failure of Projects

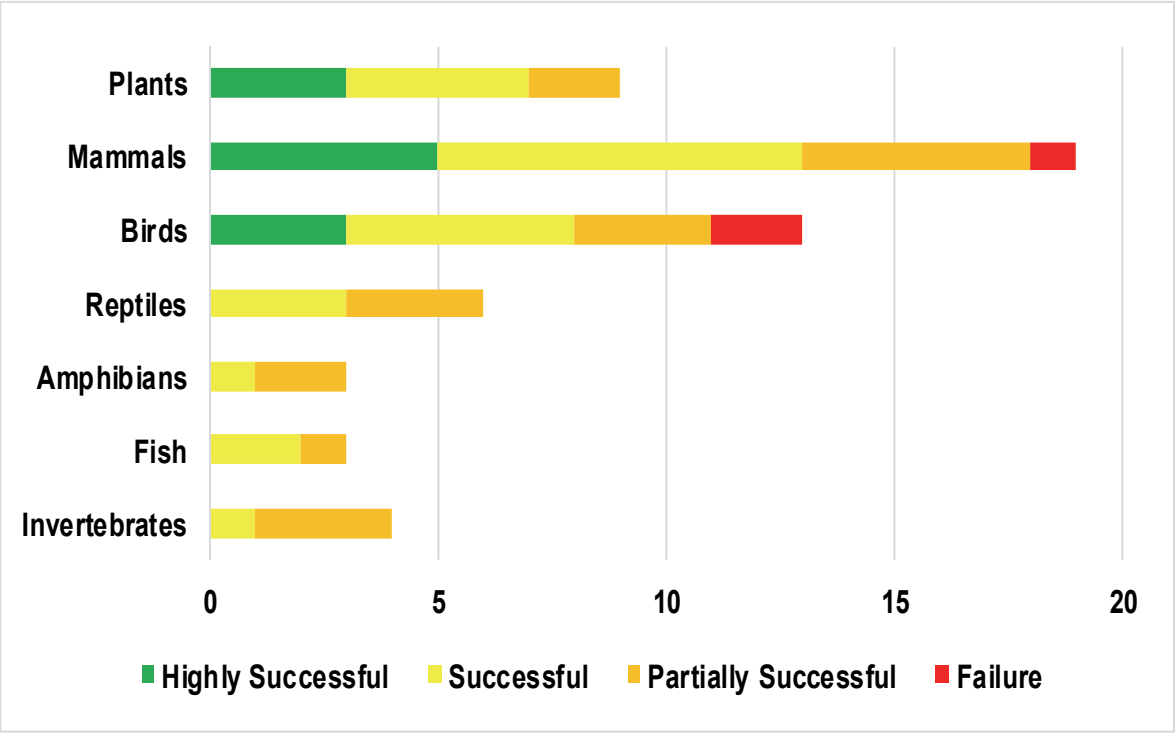
The projects presented here were ranked as Highly Successful, Successful, Partially Successful and Failure. Out of the 54 case-studies, there were some cases of multiple rankings as releases were conducted at more then one site. As can be seen in figure 1, 11 projects were Highly Successful, 24 were Successful, 18 were Partially Successful and 3 were listed as Failures.

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

Success according to the taxa

An analysis was done to gauge the three different levels of success (highly successful, successful, partially successful) and failure against the seven major taxa i.e. invertebrates, fish, amphibians, reptiles, birds, mammals and plants as can be seen in figure 2. Out

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



of the seven major taxa invertebrates, fish, amphibians and reptiles did not have a project ranked as Highly Successful. Successful and Partially Successful projects were recorded in all the 7 major taxa. Only the mammals and birds had one projects ranked as a Failure.

Future issues of *Global Re-introduction Perspectives*

If you need any further information on future issues 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: (*psoorae@wildlife-services.com*).

Experimental re-introduction of *Acropora* corals from Lakshadweep Islands to Mithapur coral reef, Gulf of Kutch, Gujarat, India

S. Subburaman[1], S. Goutham[1], Diresh Joshi[1], C. N. Abdul Raheem[2], Rahul Kaul[1], R.D. Kamboj[3], Sathish Trivedi[4], B. C. Choudhury*[1] & Vivek Menon[1]

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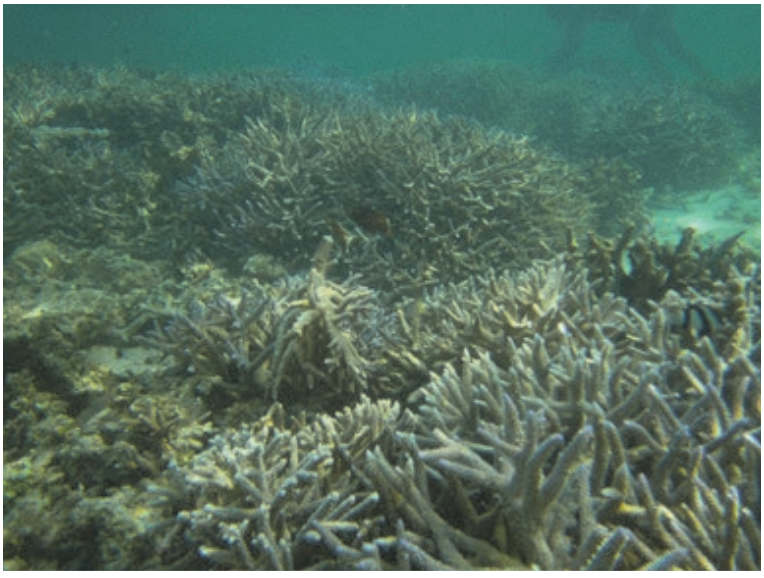
Introduction

Coral reefs are complex marine ecosystems that provide shelter, feeding and breeding grounds to nearly 25% of all marine life forms. The Gulf of Kutch (GoK) on the western coast of India, is one of the major coral reef habitats in the country and comprises 32 reef islands. However, the coral diversities in GoK are quite low compared to other coral reefs like Gulf of Mannar, Lakshadweep Islands and Andaman & Nicobar Islands. Extreme environmental variations and anthropogenic pressures have led to coral reef degradation in GoK. GoK is dominated by boulder corals and branching forms are completely absent. The dead skeletons of branching coral, *Acropora* sp. (*A. humilis*) have been reported at various locations of GoK. There have been no live branching corals reported, leading to the conclusion that *Acropora* species may have died out or has a restricted distribution in GoK waters.

Acropora spp. are listed in Schedule I of the Indian Wildlife (Protection) Act of 1972 and the IUCN Red List has listed *A. humilis* as Near Threatened. *A. humilis* has a wide distribution and is native to Indian, Atlantic and Pacific oceans. The restoration experiment was based on the available guidelines (Soong & Chen, 2003; Edwards & Gomez, 2007; Edwards, 2010).



***Acropora* colony at Agatti © S. Subburaman/WTI**

***Acropora* collection from donor colony**
© S. Subburaman/WTI

Goals

- Goal 1: Re-introduce locally extinct *Acropora* corals to GoK using a unique public-private partnership model.
- Goal 2: Establish artificial reefs and create conducive habitat for re-introduced *Acropora* and also other coral spawn to settle.
- Goal 3: Rescue and re-habilitation of boulder corals exposed during low tide.
- Goal 4: Remove all reef destructive fishing practices.
- Goal 5: Community awareness and involvement of communities in reef restoration activities.

Success Indicators

- Indicator 1: Successful survival of re-introduced *Acropora* corals.
- Indicator 2: Settlement and growth of corals (both natural and rescued) on established artificial reefs.
- Indicator 3: Reef destructive fishing practices stopped.
- Indicator 4: Increased communities awareness on corals and other reef biota.
- Indicator 5: Community involvement in coral rescue and restoration.

Project Summary

Feasibility: The project focused on restoring a small coral reef lying on the fringes of the Marine National Park in GoK using a unique public-private partnership model. The 10 km long Mithapur Reef is the westernmost reef of GoK and has only boulder corals. The livelihood dependency of local communities on this reef is high and reef destructive fishing practices (fishing using Calcium Hypochlorite, upturning the corals, etc.) is also documented. Historically branching corals, *Acropora* species were present along GoK reef (Pillai *et.al.*, 1979). However, presently, there is no record of live *Acropora* species, leading to the conclusion that the species may have died out or have a restricted distribution in GoK waters.

Branching corals provides refuge for fish fries and fingerlings to hide and act as nurseries. As one of restoration measures for the Mithapur coral reef, Wildlife Trust of India (WTI) and Gujarat Forest Department (GFD) planned to re-introduce *Acropora* species at Mithapur in partnership with TATA Chemical Limited (TCL) and Lakshadweep Forest Department.

Implementation: WTI surveyed the Mithapur coral reef in 2008. After initial assessments, WTI and TCL prepared a plan for restoration and recovery of the reef in collaboration with the two concerned forest departments. Twenty two fragments of *Acropora humilis* fragments that were 60 days old, growing in the *in-situ* nursery at Agatti lagoon (Lakshadweep Islands) were transported and transplanted in GoK during March 2012. This was the first long distance (1,300 km) coral translocation in India. The mode of transportation from the Agatti to GoK was by ship, rail and road. Four fragments died due to transportation stress (4 days of journey). Eighteen *Acropora* fragments (13 healthy fragments and five stressed fragments) were transplanted at two different locations in GoK (Subburaman *et.al.*, 2014).

Post-release monitoring: Post-transplantation monitoring continued for 6 months. All the five stressed coral fragments died after few days of transplantation. But the healthy fragments survived till September 2012. Later they also got bleached and died. It was observed that after south-west monsoon (during October 2012) more resilient and locally occurring boulder corals of GoK also bleached severely and many perished. Macro algae were the major competitors of translocated corals and caused damage to coral tissue. However, other competitors like *Hydrozoans* and *Ascidians* were also found invading the translocated coral fragments during the post transplantation monitoring.
One of the objectives of this project was to assess the survivability of re-introduced *Acropora* species in Gujarat waters. Oceanographic studies in GoK suggest that sedimentation is one of the major factors that restricting the coral survival. Edwards (2010) had recommended that a pilot study should be carried out before undertaking the full scale transplantation to avoid major loss.

Major difficulties faced

- Distance between the nearest *Acropora* donor site and recipient site.

Major lessons learned

- *A. humilis* can survive long distance transportation in experimental conditions.
- Branching corals can still survive in GoK (even though the experimental survival rate was only for few months).

***Acropora* in nursery in Lakshadweep**
© S. Subburaman/WTI

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Water turbidity caused by suspended particles.
- Strong water currents during south-west monsoon.

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The restoration of the short-haired bumblebee to South-East England, UK

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Introduction

The short-haired bumblebee (*Bombus subterraneus*), was once widespread across southern England, but post-1950s the population became isolated and patchy. It declined due to the loss of the species-rich grassland habitats on which it depends. It was last recorded in 1988 near Dungeness RSPB (Royal Society for the Protection of Birds) nature reserve in Kent, England but has not been found since, despite extensive searches. It was declared extinct in the UK by the IUCN in 2000. A population of UK origin survives in New Zealand, where they were introduced in 1895 to pollinate red clover. It is classed as Least Concern in Europe and appears stable in the Baltic and is increasing in Sweden. Short-haired bumblebees require continuous forage from May through to early September to allow the colonies to complete their lifecycle. Since 2000 there has been a concerted effort to increase the amount of suitable foraging habitat in the Dungeness and Romney Marsh area of South-East England and in 2009 there was sufficient habitat to start a re-introduction project. Initial plans were

Queen released in Dungeness in 2015
© Nikki Gammans

to bring the bees back from New Zealand but after limited success the project switched to sourcing bees from Southern Sweden instead.

Goals

- Goal 1: To re-introduce the short-haired bumblebee to the Dungeness and Romney Marsh area of S.E. England, UK.
- Goal 2: To establish suitable bumblebee habitat through Dungeness and Romney Marsh spreading into East and North Kent, England, which will also benefit other rare and declining bumblebees.
- Goal 3: To raise the profile of bumblebee conservation through public outreach.
- Goal 4: To extend the re-introduction to other areas of S.E. England.

Success Indicators

- Indicator 1: The identification of a suitable donor population of short-haired bumblebees with relevant permissions for their translocation.
- Indicator 2: At least 20 - 30 ha of suitable bumblebee habitat established within the Dungeness and Romney Marsh area.
- Indicator 3: Evidence of use of increased suitable habitat by other rare and declining bumblebees.
- Indicator 4: A self-sustaining and genetically viable population of short-haired bumblebees established in S.E. England.
- Indicator 5: The engagement of local landowners, voluntary conservation bodies, schools and the public in actively conserving bumblebees.

Project Summary

Feasibility: The project was established in 2008 by a partnership of Natural England, Bumblebee Conservation Trust, Hymettus and RSPB. The Dungeness and Romney Marsh area already had a good network of interested landowners and supported some scattered flower-rich habitat, including 4 ha restored from arable grassland on the RSPB's Dungeness Reserve. We had records of bees in the local area thanks to long-term transect monitoring by Brian Banks and Mike Edwards. A secure source of funding was provided by Natural England for an initial 3 year period with some funding and in-kind contributions from the other organizations. The appointment of a very

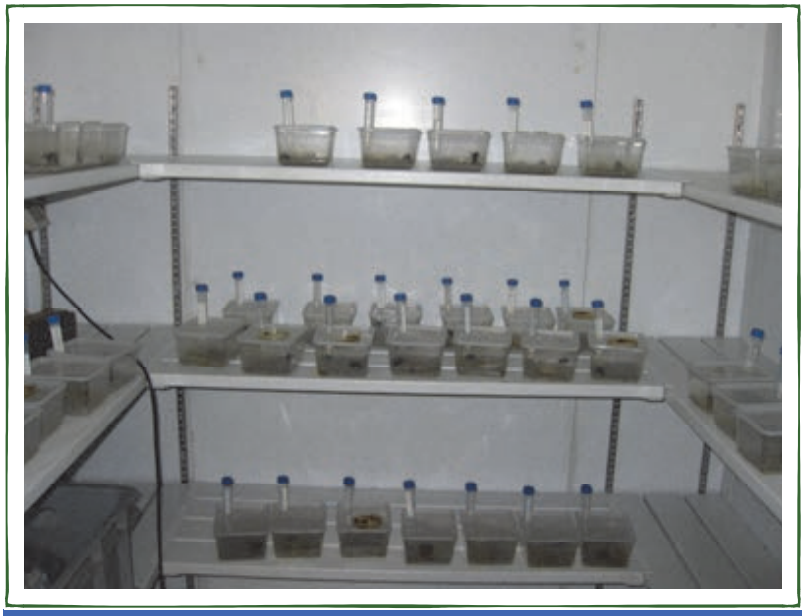
Project volunteers catching queen bumblebees in Sweden © Nikki Gammans

dedicated and enthusiastic project manager in 2009 marked the start of the project. Visits to New Zealand and discussions with bee experts in Europe provided knowledge of the foraging requirements, phenology and captive breeding techniques for short-haired bumblebees (Goulson & Hanley, 2004). The genetics of the population in New Zealand was being studied in comparison with those in Europe as part of a PhD (Lye *et al*., 2011).

Flower-rich habitat at RSPB Dungeness Reserve
© Nikki Gammans

It was initially planned to source the short-haired bumblebees from New Zealand, as these were of British origin. The distance between England and New Zealand and the difference in season between the two hemispheres presented a challenge. A number of options were considered. It was decided to catch queens emerging from hibernation in September - October and attempt to captive rear them in New Zealand, then translocate the new queens to England in April - May, after they had mated. They would undergo a shortened hibernation period so that we could release them in June giving them time to nest. We tested the feasibility of transporting live bees by air from New Zealand using the commoner species, *Bombus terrestris* and *B ruderatus.* The relevant permissions and licenses were sought and a Disease Risk Assessment was carried out by Zoological Society of London. Facilities for the captive rearing in New Zealand were provided by a commercial bumblebee breeder.

Implementation: Initially we considered that 20 - 30 ha of suitable habitat scattered through the project area was the minimum needed for the re-introduction to commence. By 2009 there was more than 30 ha within the Dungeness and Romney Marsh area, much of it on farmland supported by agri-environmental schemes and by 2015 over 1,000 ha has been recorded as suitable for bumblebees. The habitat is mapped through a rolling program of monitoring to assess its quality. Two attempts at captive rearing in New Zealand in 2009 - 2011 had very limited success and caused us to reconsider our plans. The genetics study showed evidence of inbreeding in the bees from NZ and suggested they originated from a very small source population. There was also evidence of genetic drift; the DNA from museum specimens in England was more closely matched with bees living in Sweden than with those from NZ. After consulting with Swedish bee experts, it was decided to source the bees from Skåne in southern Sweden where the population is increasing. Permission was



***B. subterraneus* queens in quarantine at Royal Holloway, University of London © Nikki Gammans**

sought to collect up to 100 queens emerging from hibernation each year, which is considered to be 0.01% of the population in Skåne. In 2011, 60 queen bees were taken for disease screening at Royal Holloway University of London and virus screening at FERA. Following a comprehensive Disease Risk Assessment and Disease Management Plan, approval was given by Natural England for 5 years of releases of bees from Skåne to Dungeness, starting in 2012. Each spring the queen bees are collected from two 48.3 km long transects, chilled and health-screened before being brought to England where they are put into quarantine for two weeks at Royal Holloway University of London. In late May-early June they are released at RSPB's Dungeness reserve from where they can disperse up to 16 - 24 kms.

Post-release monitoring: The project manager and a team of dedicated volunteers monitor 30 transects across the project area each summer and have recorded worker bees in three consecutive years, providing evidence of successful nesting. There is concentrated effort in August and September to find the sexuals (new queens and males) but without luck to date. In spring there are further searches for queens as they emerge from hibernation when the limited amount of forage makes it more likely they will be detected.

Major difficulties faced

- Problems with captive breeding and inbreeding depression in New Zealand.
- Low chances of re-sighting bees after their release due to wide dispersal distances.
- Lack of suitably large quarantine facilities or funding to enable scaling up of project.

Major lessons learned

- Undertake genetic studies at early stage of project.
- The value of having an enthusiastic and experienced project manager and a dedicated team of volunteers.
- The importance of landowner and local community engagement.
- The long-term commitment of project partners.
- A secure source of funding.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
Successes

- Although it is still too early to judge the success of the project in restoring the short-haired bumblebee, the first milestone has been reached with evidence that in at least three years the released queens have successfully nested and produced workers.
- Several rare and declining bees appear to have benefitted from the increase in flower-rich habitat, with an extension of range of *B. humilis*, *B. muscorum* and *B. ruderatus* from Dungeness to Romney Marsh. Two rare bees, *B. ruderatus*, *B. sylvarum* and *B. ruderarius* have reappeared in the area after a long absence (Gammans & Allen, 2014). The provision of extensive pollen and nectar-rich forage will also benefit other important pollinators such as solitary bees and hoverflies and moths.
- The project has provided a flagship for bumblebee conservation and has done much to engage local communities, schools and the public thorough walks, talks, farm and garden days, having stands at local shows and running identification courses.
- The quarantining of bees from Sweden has increased our knowledge of bumblebee diseases on the continent and in particular their parasites, with a scientific paper in preparation.

Failures

- The limited ability to captive rear short-haired bumblebees in New Zealand was partly hampered by the fact that they are ‘pocket-makers’, provisioning their larvae by constructing pockets alongside them into which returning workers drop pollen. It is far easier to captive-rear bumblebees that are ‘pollen storers’, as then you can provide the workers with pollen to feed to the larvae through regurgitation. Free-flying worker bees were required to provision the larvae and this created its own challenges.

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A restoration project of the Kumamoto oyster habitats in Haimen County, Jiangsu Province, China

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Introduction

The oyster reef is an important marine habitat for ecosystem services, including water filtration, habitat provision, shoreline stabilization, carbon sink and nutrient retention (Beck *et al.*, 2011). Liyashan oyster reef is located in the inshore of Dongzhao Port, Haimen County, Jiangsu Province. It is composed of 750 intertidal oyster reef patches, and the total area of the oyster reef is about 20 hm^2. The oyster reef supports abundant species and high fishery production, and is found to serve as the major spawning ground for roughskin sculpin (*Trachidermus fasciatus*) that is listed as the second-grade state protection animal.

Close-up view of Kumamoto oysters

Three oyster species namely the Kumamoto oyster (*Crassostrea sikamea*), Suminoe oyster (*Crassostrea ariakensis*) and Asian milin oyster (*Ostrea denselamellosa*), were identified to coexist on the intertidal oyster reef based on 16SrDNA gene sequence analysis (Quan *et al.*, 2012). The Kumamoto oyster was the

only species that formed the complex, three-dimensional reef structure at the intertidal zone. However, the natural oyster reef is rapidly degraded due to high sedimentation, habitat loss and overfishing. Its area had a decline of about 38.8% in the past decade. To protect the important biogenic reef, a restoration project was initiated to promote oyster population and reef functions in 2013 - 2014.

Goals

- Goal 1: Investigating the ecological status of natural Kumamoto oyster (*Crassostrea sikamea*) population and habitat at a natural reef.
- Goal 2: Assessing the feasibilities and ecological risk in implementing remote setting techniques for the oyster restoration project.
- Goal 3: Developing an efficient substrate materials and reef-establishing technique for the oyster reef restoration.
- Goal 4: Establishing self-sustaining oyster population at the restored reef.

Success Indicators

- Indicator 1: Reef area dimensions, oyster density and size-frequency, disease prevalence and intensity, gonad development status at the natural reef.
- Indicator 2: Oyster abundance and shell height, associated resident faunal community at the restored reef.

Project Summary

Feasibility: Before implementing the restoration project, we planned to restore the degraded oyster reef through two common methods: 1) supplementing the substrate for the oyster *C. sikamea* larvae, and 2) remote setting through re-introducing oyster spat from the oyster *C. sikamea* aquaculture zones. We did an initial field survey and sampling in May 2013 to assess the ecological status of oyster population and habitats at natural reef. It was found that the absence of substrate was the major limiting factors for the oyster reef restoration. The oyster recruitment rate at the natural reef showed large temporal and spatial variations. Additionally, we also carried out a field experiment that tested the ability of four substrates (oyster shell, clam shell, clay brick, and granite pieces) to attract oyster spat settlement as well as promote spat survival and oyster development. It is concluded that oyster shell was a low-cost and high-efficiency substrate material in oyster reef restoration. As the oyster population in the remote setting site (Xiangshan Bay) had higher disease prevalence and lower genetic biodiversity than natural counterparts at Liyashan reef, we decided to restore the oyster reef through adding the substrate rather than remote setting.

Implementation: A total of about 1,000 kg old oyster shell (≥6 months) were recycled from the oyster aquaculture zone in Xiangshan Bay as the substrate for oyster larvae setting. Each of the 16,000 nylon mesh bags (diameter 20 cm, height 50 cm & mesh 2 cm) was filled using old oyster shell. In early July of 2013, we laid up those bags in the intertidal zones to build up artificial oyster reefs. This project recycled oyster shells back into the Liyashan waters and created habitats where young oysters can attach and grow. We constructed a total of 53 small reefs (24 single-layer reefs and 29 two-layer reefs) at five restoration sites within the Liyashan marine garden.

Artificial oyster reef at Liyashan Marine Garden, Haimen County, Jiangsu Province

Post-restoration monitoring: In September/ December of 2013 and March/May of 2014, we revisited the restoration sites and investigated the oyster abundance and shell height, reef development (associated resident faunal communities) at the restoration reefs. It is found that the mean oyster abundance at the restored reefs ranged from 147 oysters/bag to 564 oysters/bag in May of 2014. The mean shell height significantly also reached 16.2 mm. The restored reefs had similar total abundance (2,326 ind./m^2) of resident faunal communities to adjacent natural reef. Most of single-layer reefs were partially or totally buried by silt or sand, while multi-layer reefs had greater oyster abundances due to its high vertical structure. Additionally, it is found that the reef at two restoration sites in the northwest part of the marine garden showed greater success than those at another three sites.

Major difficulties faced

- There were large inter-annual and spatial variations in oyster recruitments at natural reef, and it is difficult for us to determine proper site and time for restoration projects.
- High sedimentation at three restoration sites often buried the restored reef, and became the largest challenge for restoration efforts at Liyashan oyster reef.
- Limited primary production of phytoplankton at turbid waters lead to slow growth rate of the new-recruiting oyster spat at the restored reef.
- Extensive anthropologic disturbances (fishing) destroyed habitat structure of the created reef.

Major lessons learned

- Long-term monitoring (>5 years) is required to fully trace the development of oyster habitat and evaluate restoration success.
- More funding is required to proceed with restoration efforts of the Liyashan oyster reef.
- It is necessary to determine the suite sites and methods before implementing restoring efforts.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Multi-layer shell-in-bag reefs provided greater vertical structure that was conducive to recruitment and setting of oyster larvae.
- Most of single-layer reefs at three restoration sites were buried by silt and sand due to high sedimentation.

Acknowledgments

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Establishing additional populations of the wetapunga on islands in the Hauraki Gulf, North Island, New Zealand

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Introduction

Until very recently, the wetapunga (*Deinacrida heteracantha*) (Anostostomatidae : Orthoptera) was represented by a single natural population on Te Hauturu-o-Toi, (Little Barrier Island) on the north-eastern coast of New Zealand's North Island (Gibbs, 2001). Once common in the forests of northern New Zealand, these endemic arboreal nocturnal insects, one of the largest in the world, have suffered a severe range reduction as a result of the introduction of mammalian predators (predominantly rodents), habitat destruction and modification. Consequently, the species is currently listed as 'At Risk:Relict' by the government's Department of Conservation (DOC) (Hitchmough, 2013; Trewick *et al.,* 2012). In 1998, DOC published a Threatened Weta Recovery Plan (Sherley, 1998), which included a number of goals and objectives for safeguarding the future of this and other threatened weta species. Two of the key priorities listed were to establish captive-breeding programs and then to use the progeny to found additional populations on other islands in the Hauraki Gulf that are free of introduced mammalian predators.

Adult female wetapunga © Jane Healy

Goals

- Goal 1: Establish self-sustaining island populations to improve the long-term security of the species.
- Goal 2: Further the ecological restoration of the receiving islands through the introduction of a large, heavy bodied insect.
- Goal 3: Increase knowledge of wetapunga

breeding and re-introduction methods to aid in species management and future releases.
- Goal 4: Identify additional suitable islands or 'safe' mainland sites for releases.
- Goal 5: Achieve advocacy for wetapunga conservation through inclusion of additional Hauraki Gulf islands in wetapunga recovery initiative.
- Goal 6: Post release research into dispersal, habitat use and abundance over time.

Success Indicators

- Indicator 1: Persistence of all established populations at pre-defined monitoring intervals.
- Indicator 2: Populations disperse beyond release sites to additional available habitat.
- Indicator 3: Relative costs and benefits of release techniques (older/larger instars & fewer numbers *vs*. younger/smaller instar & greater number) assessed.
- Indicator 4: Greater awareness of wetapunga and their ecological importance amongst visitors to the islands and breeding collections, and the wider New Zealand public.

Project Summary

Feasibility: Wetapunga surveys conducted by the DOC since 2005 on Hauturu revealed that numbers were recovering following Pacific rat (*Rattus exulans*) eradication in 2004 (Green *et al.,* 2011). However, numbers were not yet considered high enough to support repeated collection of large numbers for direct wild to wild translocation. Therefore DOC coordinated a program to remove small numbers into captivity with Butterfly Creek and Auckland Zoo. Captive weta husbandry techniques with the genus *Deinacrida* had been developed as early as the 1950s by Dr Aola Richards at the Department of Agriculture and more recently at Wellington Zoo (Barrett, 1991) and Butterfly Creek. Four islands in the Hauraki Gulf, namely Motuora, Tiritiri Matangi, and two in the Noises group, Motuhoropapa and Otata, were selected to receive wetapunga. All are free of introduced mammalian predators, lie within the historic range of wetapunga and experience a climate closely matching that of Te Hauturu-o-Toi. Each island has a range of potential bird, reptile and invertebrate predators, though all are natural inhabitants of Te Hauturu-o-Toi and wetapunga are consequently adapted to survive in their presence. Both Motuora and Tiritiri Matangi are protected island reserves and possess suitable habitat of remnant native broadleaf coastal forest and extensive areas of native replanting.

There is an abundance of food plants and refuges for these large bodied insects. The re-introduction of wetapunga is included in the restoration plans for both Motuora and Tiritiri Matangi. Motuhoropapa and Otata islands, though smaller, have significant mature broadleaf forest cover. The Neureuter family, who have owned the Noises islands for more than 80 years, are fully supportive of re-introduction proposals and actively contribute to enhancing their islands natural heritage through association with DOC and other conservation bodies. Current and future wetapunga collection, captive-breeding and release are supported by

Overview of the collection site on Hauturu-o-Toi

relevant Māori tribes (iwi) who have customary authority or historical interests in the islands. Both Auckland Zoo and Butterfly Creek have pledged a long-term commitment to the program. Expert technical advice and coordination of the wetapunga recovery program, along with considerable logistical support continues to be provided by several key personnel within DOC.

Implementation: Founder populations of wetapunga were collected from Te Hauturu-o-Toi in 2008 (3 adult males:3 adult females), 2009 (6:6) and 2012 (12:12) for establishment at the collections of Butterfly Creek and subsequently Auckland Zoo, respectively. Wild collected adult wetapunga were quickly paired in captivity, with each female given breeding access to each male to maximise genetic representation. Every female mated and all laid eggs, the first of which hatched 10 to 12 months after the first female was observed ovipositing. Wetapunga were reared individually at Butterfly Creek to produce around 350 hatchlings, of which 50 mid to late instars (6^{th} - 11^{th}) were released onto Motuora Island (25 x 6^{th} - 7^{th} instars) in September 2010 and Tiritiri Matangi (25 x 8^{th} – 11^{th}) in December 2011.

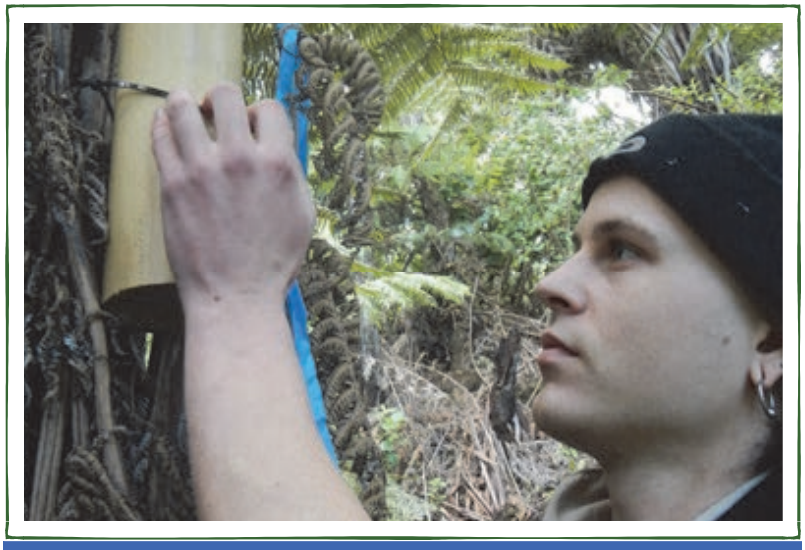
Larger specimens in later instars were favoured for Tiritiri Matangi due to the higher avian predation potential compared to that expected on Motuora. Wetapunga need to be 5^{th} instar or older before they can be accurately sexed and each release had roughly an even sex ratio. Each individual was placed into a short length of bamboo which was attached to host plant trees to provide a hide as protection from potential avian predators. All release trees were in close association with natural day time refuges for the wetapunga to move into post-release.

Individual rearing of wetapunga was established best practice for the species, as it ruled out issues such as cannibalism during moults and this was followed by Barrett in rearing the 2008 and 2009 collections. However, rearing enough specimens for releases had a significant impact on time and resources. Husbandry techniques were refined for higher yields at Auckland Zoo during 2013 through experimentation with communal rearing of nymphs to establish whether there would be similar survival rates. One hundred and twenty nymphs destined to be reared individually were housed in simple plastic perforated tubs and provided with a range of freshly cut native food plants, leaf litter, fish flake and a

refuge. They were then provided progressively larger plastic containers to accommodate their increasing size. Communal groups, mostly consisting of 10 or 20 nymphs, were reared in larger insect-mesh enclosures. A year later, no appreciable difference in survivorship between these methods was detected. Great breeding success was achieved from the 12 (6:6) adult founder stock with more than 1,500 first generation nymphs produced in 2014. Such results suggest that captive-breeding can reliably produce large numbers of first and second generation offspring for release, from modest numbers of founders.

In April and June 2014, more than 750 mid to late instar nymphs of roughly equal sex ratio were used to supplement the small populations already released on Motuora and Tiritiri Matangi by DOC and Butterfly Creek. Care was taken to keep early Butterfly Creek stock release sites separate from those established in 2014 so that subsequent generations and release cohorts are discernible from one another. Post-release surveys on Motuora and Tiritiri Matangi indicate that up to 20% of wetapunga remained 'faithful' to the bamboo they were released in and this is now proposed as a monitoring tool. Twenty pairs of first generation wetapunga were retained by Auckland Zoo to secure the second generation. These animals had produced more than 2,300 nymphs by June 2015. Communal rearing was adopted as the main husbandry method for these nymphs. In a departure from the earlier strategy of releasing a relatively small number of mid to late instar wetapunga, these second generation wetapunga are being released in larger numbers but at low to mid instar and directly into naturally occurring refuges on Motuhoropapa and Otata islands. Thus in June 2015, 944 wetapunga nymphs where released onto Motuhoropapa. Hundreds more are being reared for release later in the year as well as 100 larger animals for each of Motuora and Tiritiri Matangi. There will be further collections of small numbers of wetapunga from Te Hauturu-o-toi in the coming years to supplement the genetic diversity of the new populations.

Post-release monitoring: Adult wetapunga are predominantly monitored with baited tracking tunnels, though night time spotlight searches and refuge checking methods are also employed. Tunnels set on the ground over three consecutive nights with peanut butter as an attractant are effective at detecting presence of adults that are on the ground for mating and oviposition (Watts *et al.,* 2008). The monitoring program for re-introduced populations is arranged around wetapunga life



Bamboo releases on Tiritiri Matangi island

© Jane Healy

history, taking into account the time span required to reach maturity, including egg incubation. Wetapunga that reach adulthood will be detectable in baited tracking tunnels which will aid in determining survival of the founders and dispersal from the release sites (Watts *et al.,* 2008). Adult wetapunga survive for 12 - 18 months and the life cycle adult to adult takes approximately 2 - 3 years. Therefore tracking tunnels can be used to detect adults at this interval between generations. In June 2015 tracking tunnels indicated the presence of a first island-born generation at each of the first release sites on both Motuora and Tiritiri Matangi islands. This will be repeated in a further 3 years to detect the next generation. A self-sustaining population will be considered established when searches reveal wetapunga of mixed age class 10 years post-release. Monitoring on Tiritiri Matangi and Motuora, set up and coordinated by DOC, is undertaken primarily by personnel from each island's associated restoration society but also students, Butterfly Creek and Auckland Zoo staff and volunteers. Monitoring on Motuhoropapa and Otata will be undertaken primarily by Auckland Zoo staff.

Major difficulties faced

- Initial difficulties with determining the food preferences of 1st instar wetapunga during 2009 required intensive management at Butterfly Creek to overcome.
- Individual rearing was too labour intensive to produce high numbers for release.
- Unexpected and unprecedented breeding successes placed a significant strain on allocated resources at Auckland Zoo.

Major lessons learned

- Determination of the importance of protein and other key food preferences lead to greater survival of early instars.
- Group rearing methods are ultimately more cost effective than rearing wetapunga individually.
- With the proper guidance and a good working relationship, translocation permits can be written, submitted and processed in an acceptable time frame.
- Realistic budgeting of time for consultative elements of translocation proposals.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reasons for partial success:

- Recent monitoring on Tiritiri Matangi and Motuora has revealed the first indication of an island born generation close to the original release sites.
- Husbandry experimentation with communal rearing helped ensure large numbers of healthy and robust specimens can be reared with a degree of predictability.

- Large numbers of wetapunga can be reliably produced for population founding and supplementation.
- No shortage of suitable off shore island habitats available for re-introduction with the right level of protection.
- Full support and assistance from relevant islands restoration societies, iwi and DOC.
- Accessible technical expertise from DOC and legal and logistical support.
- Well-resourced through Auckland Zoo and Butterfly Creek with long-term commitment to the program.
- Significant and sustained multimedia coverage (TV, radio and press).
- Assistance from a large number of willing and able volunteers.

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Re-introduction of a native galaxiid (banded kokopu), after piscicide treatment, in two small streams and a reservoir, Wellington, New Zealand

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Introduction

Banded kokopu (*Galaxias fasciatus*) are a large amphidromous galaxiid endemic to New Zealand. Banded kokopu are of significant cultural and recreational value to both New Zealanders and indigenous Maori. New Zealand's Department of Conservation classifies the species as 'At risk - declining' (Goodman *et al.*, 2014). Although found throughout New Zealand, the current nationwide decline is due to widespread and significant habitat modification and/or loss and predation by invasive species (particularly salmonids) (McDowall, 2006). The species is typically migratory, although has the ability to form land-locked populations enabling both diadromous and non-diadromous recruitment.

The experiment was conducted in two streams and a reservoir which form the headwaters of Kaiwharawhara stream, in Wellington, New Zealand. The stream sites range from ~800 m to 1.3 kms in length, the largest stream had average flows of ~7 L/sec^{-1} and both are entirely enclosed by a native forested catchment before opening out to the reservoir. The reservoir is a decommissioned drinking water reservoir for Wellington city, with a capacity of approximately 40,000 m^3, maximum depth of 8 m and average depth of 4 m. It is the upper one of two reservoirs located within Zealandia, a predator-proof sanctuary for native species. Banded kokopu utilize the reservoir as the 'sea-going' phase of their lifecycle.

Banded kokopu © Lan Pham

Goals

- Goal 1: The restoration of the native banded kokopu population.
- Goal 2: To eradicate introduced brown trout (*Salmo trutta*) from the two tributaries and the reservoir.
- Goal 3: To observe successful recruitment of banded kokopu juveniles post trout eradication.
- Goal 4: To document the impact of prey reduction on the re-introduced banded kokopu.
- Goal 5: To document the recolonization of aquatic invertebrates.

Success Indicators

- Indicator 1: Re-introduced banded kokopu spawn successfully in the reservoir tributaries.
- Indicator 2: No brown trout are recorded in the two tributaries and reservoir, demonstrating complete eradication.
- Indicator 3: Record a measurable increase in banded kokopu juveniles in the spawning season following trout eradication.
- Indicator 4: Banded kokopu condition and mobility is not negatively impacted by a temporary absence of aquatic invertebrates.
- Indicator 5: Aquatic invertebrate communities recolonize within a 1 year period.

Project Summary

Feasibility: The focus of this project was two-fold. Firstly, we aimed to eradicate brown trout to allow the rehabilitation of the native banded kokopu population. Prior to the piscicide dosing, trout predation had virtually eliminated juvenile banded kokopu from the streams and reservoir, resulting in a skewed adult population and signaling eventual population collapse. Secondly, although banded kokopu are classified as in decline, this research was conducted with the aim of documenting the performance of the piscicide rotenone and its potential use as a conservation tool for removing invasive salmonids from other areas where they threaten the survival of highly endangered non-migratory galaxiid species.

We aimed to prove the use of the piscicide rotenone as a reliable conservation tool in the removal of invasive fish species in flowing water (Pham *et al.*, 2013). In New Zealand, 86% of our 28 galaxiid species are classified as threatened due to a range of threats, the primary being predation from introduced salmonids. Restoration actions such as salmonid removal typically involve manual mechanical methods such as electrofishing and netting, which have varied results and total eradication is difficult to monitor and achieve. Additionally this project aimed to communicate the benefits of targeted salmonid eradication.

Implementation: The Department of Conservation worked with Zealandia Sanctuary, Wellington Tenths Trust (the local indigenous runanga group) and Wellington Fish and Game in gaining consent for the project. Four Resource Management Act consents and one Fisheries Act permit were applied for and granted with conditions. In addition Animal Ethics approval was applied for, and

Typical kokopu habitat © Lan Pham

granted, from two of the collaborating agencies' Animal Ethics committees. Concerns over the downstream movement of rotenone were eliminated due to the ability of researchers and dam managers to lower the reservoir and close the reservoir valves, effectively holding rotenone-dosed water within the catchment until it had reached non-detectable levels.

Post-release monitoring: The University of Otago was involved in monitoring the condition, mobility and recruitment of adult banded kokopu, as well as the recolonization of invertebrates both before and after piscicide dosing. Movement and condition of adult banded kokopu was recorded using passive integrated transponder (PIT) tags.

Population structure was assessed using electric fishing methods over 50 m reaches. Invertebrate community composition and total density were recorded using surber sampling monthly, for 3 months prior to dosing and at 2 weeks, 1, 2, 4, 6, 9 and 12 months post dosing.

Our results demonstrated that aquatic invertebrate communities recolonized to post-disturbance levels within 1 year. Tagged and re-introduced adult banded kokopu suffered a decline in condition immediately after piscicide dosing however, levels of mobility (which would indicate severe food shortages see Hansen & Closs, 2009; Akbaripasand *et al.*, 2014) and most importantly spawning was not impacted. The streams have been monitored using spotlighting for 5 years in order to observe the presence/absence of trout and the recruitment of juveniles. No trout have been detected in this time, with healthy numbers of juveniles observed and the eradication has been declared successful following monitoring in summer 2015.

Major difficulties faced

- Accurately determining the distribution of brown trout in order to guide the placement of piscicide dosing stations.
- Gaining resource consents and permits from a wide range of stakeholders.
- Accurately determining dosage rates and travel times for the piscicide rotenone in flowing streams with considerable in-stream debris.
- Underestimating the length of time the piscicide would take to be flushed out of streams and reach non-detectable levels in reservoir.
- Changing the misconception that the eradication of trout would become widespread.

Major lessons learned

- Conduct repeated and robust surveying of fish distributions in order to guide correct placement of piscicide dosing stations.
- We would advise researchers and practitioners not to underestimate the complexity of small streams in estimating downstream travel time of piscicide. Carry out a variety of travel time experiments to determine as accurately as possible dosage rates and duration for the piscicide.
- More accurate determination of total dosage will enable use of the least amount of piscicide and minimize the extent of downstream habitat impacted, and reduce the amount of piscicide that will potentially accumulate in the downstream waterbody, thus shortening the time required to breakdown to non -toxic levels and become benign.
- The seasonal timing of the piscicide dosing may have been important in reducing the impact on adult banded kokopu. Dosing was conducted at the end of summer when temperatures are declining, along with the metabolic activity and energetic demands of the fish. If dosing had been conducted prior to summer coinciding with an increase in metabolic demands of the fish, reduced prey availability may have had a greater impact.
- The impact on post treatment spawning appears to have been minimal as 100s of juvenile banded kokopu whitebait were seen for the first time migrating back upstream after dosing the previous summer.
- Involve all interested stakeholders in the

Department of Conservation and University staff carrying out rotenone dosing of the Zealandia Sanctuary reservoir © David Moss

process and provide them with clear information which directly addresses concerns/misconceptions.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The banded kokopu population is showing clear on-going recruitment, and although adults did suffer a temporary decline in condition, this did not prevent successful subsequent spawning.
- No brown trout have been recorded in the treated areas, indicating full eradication has been achieved.
- Upstream trout free headwaters were identified and left untreated to serve as source of native fish and aquatic invertebrate recruits for downstream rotenone treated stream reaches.
- Juvenile banded kokopu numbers have greatly increased.
- Aquatic invertebrate communities recolonized within 1 year.
- The project is the first documented use of the piscicide rotenone in flowing water in New Zealand and proves the methodology as an important conservation tool for eradicating invasive species where they threaten endangered native fish.

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Re-introduction of the Morelos minnow in the "Barranca de Chapultepec" protected area, Cuernavaca, Morelos, Mexico

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Introduction

The Morelos minnow "Carpita de Morelos" *Notropis boucardi*, is restricted to a small system of streams located to the west of Cuernavaca, as well as in an endoreic spring (Hueyapan) of the neighboring municipality of Jiutepec, within a state protected area called "El Texcal". Three main threats to *N. boucardi* have been identified as: 1) water pollution, 2) water management/use and 3) invasive species. In the first case as the consequence of the growth of the city of Cuernavaca in the last 50 years, and the lack of appropriate wastewater treatment, most of the streams within the urban area of the city are polluted to a degree that *N. boucardi* cannot survive (Contreras-MacBeath & Rivas, 2007). A distribution study (Preciado, 2012) demonstrated that in a period of about 50 years, the species has lost 49% of its original distribution.

The species is listed as threatened by the Mexican environmental authority (SEMARNAT 2010), consequently, the State of Morelos, with the aid of the Biological Research Center of the Universidad Autónoma del Estado de Morelos, have put forwards a conservation strategy that involves protection of remaining wild populations and re-introduction of the species in areas where it once existed, such as the Parque Ecológico Chapultepec.

Morelos minnow "Carpita de Morelos"

Collecting specimens of the Morelos minnow

Goals

- Goal 1: Establish a viable population of *Notropis boucardi* in the "Parque Ecológico Chapultepec".
- Goal 2: Eradicate invasive fish species (*Oncorhynchus mykiss* and *Cyprinus carpio*) from the stream.
- Goal 3: Implement a monitoring program for the introduced population.
- Goal 4: Develop a communication strategy in order to gain support for the species.

Success Indicators

- Indicator 1: Re-introduced fish spawn naturally in the stream.
- Indicator 2: Alien *Oncorhynchus mykiss* and *Cyprinus carpio* are eradicated from the "Parque Ecológico Chapultepec" stream.
- Indicator 3: Monitoring program in place.
- Indicator 4: Agencies and stakeholders support and are involved in the conservation project.

Project Summary

Feasibility: This project followed the *Guidelines for Re-introductions and other Conservation Translocations* developed by the Re-introduction and Invasive Species Specialist Groups' Task Force (IUCN/SSC 2013), so biological feasibility was taken into account, thus prior knowledge of the species life history was included (Contreras-MacBeath & Rivas, 2007), and a study describing the genetic variations of each known population was conducted, in order to define the founding population (Rosas, 2013).

Because of the low number of individuals in the remaining populations of the species (Peciado, 2012), a decision was made to collect specimens for translocation only after the reproductive season, and to take small number of specimens from different sites.

The re-introduction site "Barranca de Chapultepec" is within the natural distribution of the species, and there are unconfirmed records of the species being historically present. Nevertheless an analysis of water conditions in the stream, as well as in the sites where the founding populations would be obtained was carried out, and as was expected, these match. With regards to social feasibility and regulatory compliance, the re-introduction site is a State Protected

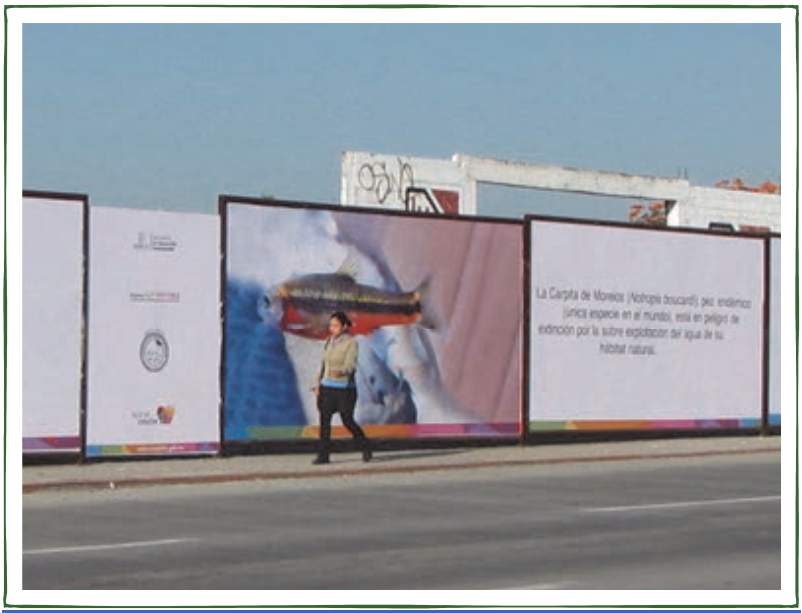
Area managed by the Ministry of Sustainable Development of the State of Morelos, which is a partner in the project. The Ministry provided the required permits and funds for this project. As will be described in the next section a communication strategy was put in place to gain support from different stakeholders.

Topiltzin Contreras-MacBeath with a minnow model

Implementation: In order to gain support for the conservation of *N. boucardi* from Federal and local authorities, as well as from the general public a communication strategy was developed. It included the publication of information related to this species in journals, books, magazines, and web pages as well as by articles in newspapers, radio and TV interviews, and in public and community meetings. The strategy included billboard signs describing the importance of *N. boucardi* as an indicator species for water quality that were displayed in different public spaces of the city. Due to this effort, *N. boucardi* is now recognized as a focal species in the State of Morelos, due to the fact that it represents the only endemic vertebrate of the State.

The first face of on-site implementation consisted in the eradication of invasive fish species (*Oncorhynchus mykiss* and *Cyprinus carpio*) from the stream, due to the fact that these predate and/or compete with *N. boucardi*. This was successfully carried out by means of a combination of electrofishing, and the use of nets with the aid of the workers of the Park. For this first re-introduction event, founders were obtained from “Barranca La Primavera” stream, which is about 3.2 km from the Park. Most of this stream has been heavily impacted by polluted effluents from surrounding urban area, but there is a residual population of *N. boucardi*, that is highly threatened. Due to small population size, only 72

Releasing Morelos minnows into the wild



Morelis minnow billboard for public awareness

specimens were captured and transported for their immediate release in "Barranca de Chapultepec" stream.

Post-release monitoring: A post-release monitoring program was established, in order to follow the introduced specimens. Preliminary data showed that a population had not yet been established, but recently evidence was found of a relatively large population, some 300 specimens, swimming near the release site. Many of these are fingerlings that were born this spring, that suggest that a viable population could be established soon. Nevertheless, multiple release events must be implemented in order to increase the chances of success. Monitoring revealed predation of introduced specimens by Muscovy duck (*Cairina moschata*) which is exotic to the Park and this was not anticipated.

Major difficulties faced

- Unforeseen threat posed by and established population of muscovy duck (*Cairina moschata*) which is exotic to the park. This has complicated our invasive eradication strategy, because even though there is now general support for elimination of exotic fishes. There is a local environmental group protecting Muscovy ducks.
- Due to the small size of natural populations, availability of founders is related to the reproductive cycle of the species, so it is a small window of opportunity of a couple of months following the rainy season.

Major lessons learned

- A good communication strategy is fundamental in order to gain support from different stakeholders.
- Taxonomical and population genetics information was crucial for a successful site selection strategy.
- The re-introduction program is at a relatively early stage and ongoing. Preliminary results make it evident that multiple re-introductions are needed in order to establish a viable population.
- In any re-introduction program such as this, it is necessary to look for the unexpected, such as what occurred with the invasive Muscovy duck that were found to predate on *N. boucardi*.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- We have found a breeding population at the release site.
- Several of the goals such as gaining public support, eradicating invasive species and establishing a monitoring program were met, but in order to obtain our main goal, which is establishing a viable population, more time is needed.
- However, due to our preliminary results we rank it as successful. We have now established a strategy to eradicate Muscovy ducks, at least from the introduction sites, in order to minimize predation.
- On the other hand, multiple re-introductions have to be carried out through a longer period of time, in order to increase the chances of establishing a long-term viable population.

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Re-introduction of giant kokopu to Nukumea Stream, New Zealand

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Introduction

The giant kokopu (*Galaxias argenteus*) is the largest of the galaxiid species and is endemic to New Zealand. Giant kokopu are mainly amphidromous, although they are also known to form land-locked populations in lakes. It is one of five galaxiid species that in its juvenile stage makes up the culturally and recreationally significant whitebait fishery in New Zealand. Giant kokopu occur widely at low elevations, although are rare in Northland, Auckland and on the east coast of both the North and South Islands of New Zealand. They typically inhabit slow flowing, deeper pools with an abundance of cover in streams close to the coast.

Continued habitat loss has contributed to the abundance of this iconic species declining across New Zealand. As a consequence they are listed as "Vulnerable" by the IUCN and as "At Risk- Declining" in the New Zealand threat classification. The Nukumea Stream is located in the Auckland region of northern New Zealand. It is considered one of the most intact and natural streams within the urbanized greater Auckland region. It is thought that giant kokopu were once common in the stream, but the last recorded sighting was in 2002.

Goals

- Goal 1: Re-establish a self-sustaining population of giant kokopu.
- Goal 2: Determine whether translocated fish are able to naturalize and survive in the receiving stream.
- Goal 3: Establish that there are no adverse ecological impacts on existing stream flora and fauna.
- Goal 4: Restore natural recruitment of juveniles to the catchment.

Giant kokopu © Paul Franklin

Success Indicators

- Indicator 1: Removal of the perched culvert in the lower reaches of the

stream that was impeding upstream migration and therefore restricting recruitment to the catchment.
- Indicator 2: Re-introduced fish successfully establish in the stream and survive for a minimum of 2 years.
- Indicator 3: Existing fish are not displaced by the re-introduced fish species.
- Indicator 4: A successful pilot study is followed by a larger scale release of fish in the stream.
- Indicator 5: Giant kokopu juveniles are present in the whitebait run.

Project Summary

Feasibility: This project was initiated as partial mitigation for the impacts of a large road that was being built through the upper catchment. The objective was to offset adverse ecological effects caused by the road through enhancing ecological communities in the stream. The Nukumea Stream is a small, second order catchment draining directly to the coast. Despite being located adjacent to the urban area of Orewa, much of the catchment remains in native bush cover and as a consequence the stream is considered of high ecological value. Despite this, there was evidence to suggest that giant kokopu may have become extirpated from the catchment with the last recorded capture in 2002. It was thought this was likely a result of a number of factors including a perched culvert in the lower reaches of the stream that was impeding upstream migration of the juvenile life-stage; low adult numbers meaning an inadequate pheromone cue for attracting juveniles into the catchment from the marine pool; and a decline in the broader marine pool of giant kokopu larvae due to loss of adult habitats and therefore reduced recruitment at a regional scale.

The relatively intact nature of the stream and its catchment, combined with a prevalence of suitable habitat for the giant kokopu, made it a good candidate for attempting to re-establish a local source population for the species.

Implementation: All giant kokopu are considered to belong to a single gene pool, eliminating this as an issue to be considered in translocating fish between catchments. However, it was necessary to provide evidence that giant kokopu had previously been present in the catchment in order to obtain a permit for the translocation. This was gained from records in the New Zealand Freshwater Fish Database (NZFFD), showing the last recorded captures occurred in 2002. It was also agreed that a pilot study be undertaken to evaluate the likely success of the re-introduction, prior to a full scale release being carried out.

Juvenile fish were sourced for the pilot study from a catchment on the west coast of the North Island. The fish were subsequently reared in captivity by Mahurangi Technical Institute to a size (≥150 mm total length) suitable for implantation of 23 mm HDX passive integrated transponder (PIT) tags. PIT tags were surgically implanted which allowed tracking of the released individuals over time. A total of 30 fish were initially reared, tagged, released and monitored for the pilot study. An important consideration in undertaking the re-introduction was to gain the approval of local indigenous groups. Following consultation to ensure that

Giant kokopu follow-up survey March 2010
© David Tate

appropriate cultural protocols were followed, approval was gained and the pilot trial was undertaken with the blessing of local groups.

Post-release monitoring: The perched culvert was removed in mid-2009 and the pilot release of 30 giant kokopu was carried out in December 2009. Routine monitoring showed that the re-introduced giant kokopu gradually dispersed from the section of stream (200 m) where they were released. Records from the fixed PIT antennae installed in the stream indicated that the number of fish detected moving in or out of the release reach each day declined rapidly over the first 3 months, and that no fish were detected moving in either March or April 2010.

Since that time, three different fish were subsequently recorded passing the fixed antennae at various times, particularly during winter 2010, until the removal of the fixed antennae in 2013.

It was expected that the fish would slowly disperse from the release reach in search of food and suitable habitat. However, the very low flows experienced during the summer and autumn of 2010 may have accelerated this dispersal because most of the deeper pool habitat preferred by giant kokopu was eliminated from the release reach. Consequently, the fish dispersed in search of their preferred habitats elsewhere in the stream. This made tracking the tagged fish and recapturing them more difficult due to them being spread across a much wider area. Trapping surveys targeting suitable habitat over a 2 km reach were subsequently implemented as the best way of trying to track and monitor the fish.

In the 2 year period following the release (2010 - 2011), recaptures of three of the 30 fish were confirmed. All three fish were in good condition and showed average annual growth rates of 10 - 20 mm per year. This suggests that these fish successfully adapted to living in the stream following their release. In subsequent surveys (2012 - 2015) no PIT tagged giant kokopu have been captured. However, three fish have been trapped that are suspected to belong to the release group due to the presence of healed incision marks in the location where PIT tags were

originally inserted. The discovery of a single large (355 mm TL) giant kokopu in the stream indicated that a small remnant natural population was also still present.

Major difficulties faced

- Obtaining agreement and approval for the re-introduction project from all agencies and stakeholder groups.
- Sourcing a sufficient number of fish large enough to be tagged with 23 mm half -duplex (HDX) PIT tags for the pilot study. However, 12 mm HDX tags have become available since 2010 which will help to reduce this issue.
- Effectively tracking and monitoring the low number of fish released as they progressively dispersed through the stream over time.
- Gaining backing for a follow-up release of giant kokopu following the successful pilot study.

Major lessons learned

- It can be very challenging to collect robust evidence that effectively demonstrates the success of a re-introduction project in an open stream system.
- Removal of small-scale migration barriers, such as culverts, can be a cost-effective way of achieving rapid biodiversity gains.
- Outcomes are dependent on all agencies and stakeholders fulfilling their commitments for the duration of the project.
- Successful restoration of a self-sustaining population of giant kokopu, even in a small stream, will likely take many years.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Removal of the perched culvert in the lower catchment has overcome a significant impediment to the upstream migration of fish and increased the abundance and diversity of fish present in the stream.
- Re-capture of a limited number of the re-introduced fish indicates that 2 years post-release the fish had become successfully established in the stream.
- There was no evidence of displacement or disruption of existing fish communities in the stream as a consequence of the re-introduction of giant kokopu.
- Securing support and commitment from all agencies and stakeholders for a follow-up full scale re-introduction of giant kokopu to the stream has been challenging and unsuccessful to date.
- The successful restoration of a self-sustaining population of giant kokopu in the stream will require a long-term commitment to the project from all Parties.

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

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Introduction

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

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

Northern corroboree frog

Release of 1 year old frogs

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

Goals

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

Success Indicators

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

Project Summary

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

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

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

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

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

Releasing tadpoles in the Northern Brindabella Mountains

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

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

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

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

Major difficulties faced

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

Major lessons learned

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

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

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

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

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Introduction

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

Agile frog © Jersey States Department of the Environment

Goals

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

Success Indicators

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

Project Summary

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

Agile frog head-starting container © Matt Goetz

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

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

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

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

Major difficulties faced

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

Major lessons learned

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

Agile frog release into a re-introduction site

© Rob Ward

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

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

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

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

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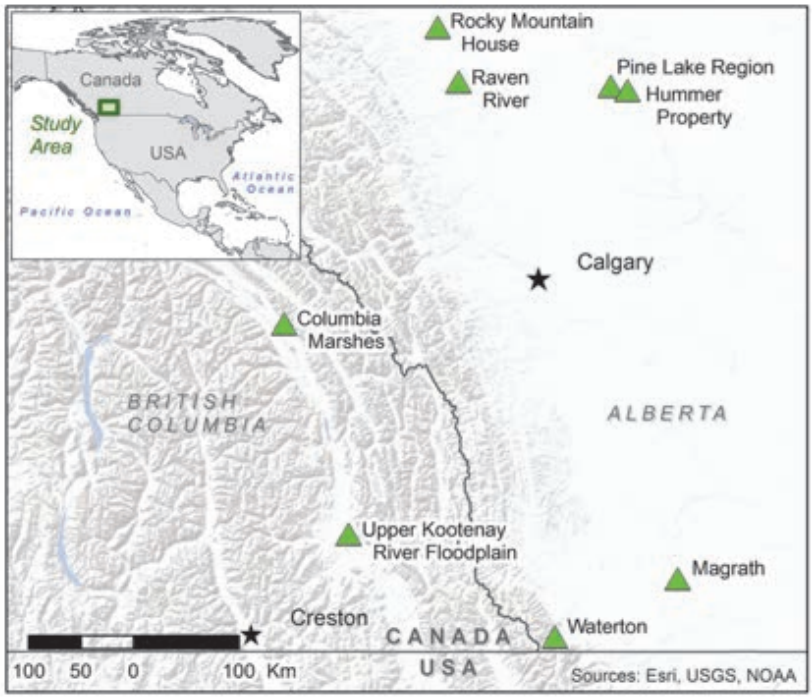
Introduction

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

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

Northern leopard frog in BC wetland

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



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

Goals

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

Success Indicators

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

Project Summary

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

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

Researcher working in the wetlands
© Larry Halversen

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

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

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

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

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

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

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

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

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

Researcher releasing tadpoles at reintroduction site

© Audrey Gagné-Delorme

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

Major difficulties faced

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

Major lessons learned

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

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

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

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

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Conservation Introduction of the Philippine crocodile in Paghungawan Marsh, Siargao Island Protected Landscape and Seascape (SIPLAS), Surigao Del Norte, Philippines

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Introduction

The Philippine crocodile (*Crocodylus mindorensis*) is the second most Critically Endangered crocodilian species in the world. Endemic to the Philippine Islands, this relatively smaller and wary crocodile was once widespread throughout the country. Extant population is now restricted to inland freshwater wetland pockets of northeastern Luzon and in central Mindanao. Isolated populations are also recorded in higher altitude (700 - 850 m above sea-level) and on small Island off Luzon with minimal habitats. Land conversion has poses more of a threat to the fragmented wild populations than direct hunting, illegal trade and human persecution. With the inferred population being not more than 200 mature individuals in its natural range, conservation actions are being directed to searching new viable habitats. In 2010, a natural limestone depression referred to as Paghungawan Marsh in Barangay Jaboy, Pilar, Siargao Island on

Release of crocodiles in Siargao Islands
© CPPI R. I. Manalo

Mindanao appeared to be an ideal habitat for Philippine crocodile. Although Siargao Island is not part of its known range, prey species and microhabitats are naturally available and capable of sustaining a small population of *C. mindorensis*. Thirty-six young crocodiles were therefore introduced into this area primarily for ecotourism.

Goals

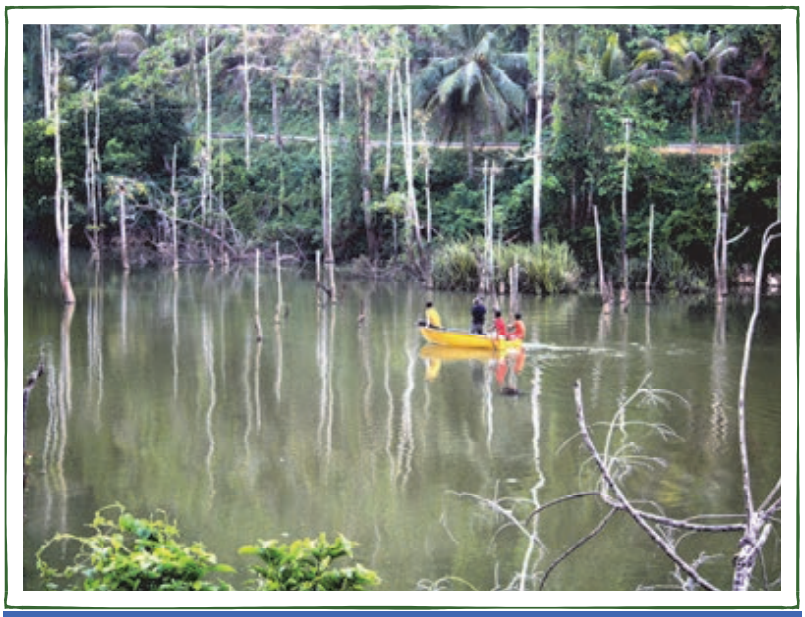
- Goal 1: Establish a protected wild population.
- Goal 2: Enhance current knowledge on the biology and ecology.
- Goal 3: Contribute to the ecotourism industry.

Success Indicators

- Indicator 1: Introduced healthy juvenile Philippine crocodiles thriving in the wild.
- Indicator 2: Crocodile monitoring manual/protocols exist, are well implemented and used in adaptive management.
- Indicator 3: Community-based sustainable ecotourism management plan exists and is being implemented.

Project Summary

Feasibility: The Philippine crocodile inhabits freshwater lakes, swamps, large rivers, and creeks. Major wetlands in the Island of Mindanao in southern Philippines used to harbor crocodile population in the past. Excessive hunting and land use change for agriculture and fishery development, reduced population viability and wetland habitats over time. The growth of human population in areas previously occupied by Philippine crocodiles resulted in natural resource use conflict. Good quality habitat plus legal instrument, government support and protection from resident human communities are the primary concerns. The historical distribution of Philippine crocodile based on the works of Ross and Alcala (1984) became the main blueprint of the Palawan Wildlife Rescue and Conservation Center, PWRCC (formerly Crocodile Farming Institute) from 1992 - 2008 to investigate known Philippine crocodile population and suitable habitat for the re-introduction. The release of progenies from the captive breeding programs to restock the wild population is the ultimate goal. Finally in 2009, the



Paghongawan Marsh, Jaboy, Pilar, Surigao Del Norte

first re-introduction was implemented in northeastern Luzon and central Mindanao. This re-introduction defined the initial approach to assess human and crocodile coexistence in the country. Likewise, the results have provided government reviews of strategies for this conservation introduction. In general, this project aimed to establish a viable and free -ranging population in appropriate habitats within a secured environment in Siargao Island Protected Landscape and Seascape (SIPLAS).

Community-based Crocodile monitoring
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Implementation: Habitat suitability assessments demonstrated that the Paghungawan Marsh, a sizeable freshwater marsh was an ideal habitat wherein critical resources such as food and microhabitat were naturally available. This also led to the discovery of amphibian species new to science including those species of flora and fauna that were recorded for the first time. Public consultations and awareness campaign were also intensively undertaken in nearby secondary and tertiary schools. Collaborative support from the Protected Area Management Board (PAMB), local residents of the impact areas, local government of the municipality of Pilar, and clearance from the Secretary of the Department of Environment and Natural Resources were secured prior to release. In support to the program, the SIPLAS PAMB designated the Paghungawan Marsh as Strict Protection Zone. In March 2013, 36 juvenile Critically Endangered Philippine crocodiles were introduced into Paghungawan Marsh in SIPLAS. These were progenies of the Philippine crocodiles previously maintained in semi-wild conditions without any supplementary feeding. The released crocodiles were subjected to veterinary and quarantine examination. The village council subsequently passed a regulation that prohibited the use of fishing nets and poisonous substance within the area of the marsh. Along with these, majority of the local residents organized themselves into a Jaboy Ecotourism and Conservation Organization (JECO), a duly registered community-based people's organization with the primary goal to protect, monitor and promote the Philippine crocodile as flagship species in Paghungawan Marsh. The crocodile research and conservation effort marks another milestone in the history of Philippine crocodile conservation. The Paghungawan Marsh is being organized for Community-based Sustainable Tourism (CBST) site featuring its natural, serene landscape and rich biodiversity through Crocodile Night Watch as major attractions. Other potential

tourism attractions of the area include guided tours of the marsh ecosystem and its endemic fauna.

Post-release monitoring: Sixteen months after the successful soft-release, the juvenile Philippine crocodiles showed signs of adapting to their new natural environment. Most of the crocodiles have been found resting in shallow water on vegetation in close proximity to each other while foraging at night. Aggressive behavior was not evident, contrary to previous reports in other localities. In several occasions, these crocodiles were observed to gain their hunting skills, searching for food during sundown under a limestone ledge that was that was surrounded by vegetation. Some crocodiles became wary and got disturbed by the bright red LED light in the course of photographing them. An average of 15 tapetal reflections from direct observation was recorded during night spotlighting monitoring in different locations in the entire marsh. Most of the observations were made within the release site. Juvenile mortality due to fishery accidental catch was also recorded. Crocodiles were trapped by gillnets installed overnight by fisherman. The use of fishing nets and hook-and-line has now been prohibited in Paghungawan Marsh by the village council. Vigilant members of JECO are being trained to be part of the Community Monitoring Group of the SIPLAS Biodiversity Monitoring System under the DENR - Protected Area Office. This intervention has enhanced community interest for ecotourism and their combined volunteer effort has contributed to the preliminary installation of the Paghungawan Marsh Adventure Tour.

Major difficulties faced

- Implementing public consultations and awareness campaign to gather community support for the Project.
- Changing the fishery resource use practices of the impact communities in order to create harmonious human-crocodile coexistence.
- Involving other government agencies to support the conduct of biophysical monitoring program.
- Piloting of sustainable community-based eco-tourism as leverage in securing alternative livelihood and sufficient freshwater fishery production.

Major lessons learned

- The territorial behavior of the released crocodiles develops as they approach different life stages.
- Biophysical monitoring during dry months with low water delimits the actual sightings to navigable area. However, recent changes in weather patterns have dramatically influence the amount of residual water of the marsh being a catch basin on this part of the Island. The increase of rainfall determines the extent of the marsh waterlogged area which caused the dispersal of crocodiles into adjacent suitable habitats.
- Sustained support from the community-based stakeholders can be fully achieved by carrying out a continued outreach program. Disseminating knowledge on the natural behavior of Philippine crocodile in the wild enhanced sustainable conservation management actions.

- The presence of heavy infrastructure development (which in this case is the upgrading of provincial road) caused the juvenile crocodiles to move away to adjacent waterlogged areas.
- These young crocodiles that experienced soft release conditioning have been observed to exhibits a more adaptive behavior in the new environment. They displayed well-developed predatory skills yet retained their reticence and wariness.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Active participation of the community in biophysical monitoring program as support mechanism on the post-release is being encouraged.
- Political will and regular patrolling of the members of Community Monitoring Group reduced the possibility of accidental fishery by-catch.
- The increased fish productivity is attributed to reduced fishing pressure (direct effect) because the presence of crocodiles discouraged the locals to fish intensively. This could have lead to the recovery of fish stocks, providing food for both crocodiles and human community.
- The capacities of local People's Organization towards sustainable management of their wetland resources are currently being improved. They are developing their skills for the implementation of community-based ecotourism.
- Local government has fully supported the implementation of the community-based sustainable ecological tourism for conservation of the habitat and the crocodiles.

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Restoration of the Bolson tortoise in the northern portion of its prehistoric range in the southwestern U.S.A.

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Introduction

The Bolson tortoise (*Gopherus flavomarginatus*) is the largest and rarest of five species of land tortoise native to North America. Prehistorically, its range extended throughout the Chihuahuan desert, from west Texas to southwestern Arizona and Oklahoma to Aguascalientes, Mexico (Morafka, 1982). Its current range is restricted to discontinuous basins ("Bolsons") in the Mapimi sub-province of north-central Mexico. The species is listed as "Endangered" in the US and Mexico, and it appears on CITES Appendix I. It was listed as "Endangered" on the IUCN Red List in 1982, but was down-listed to "Vulnerable" in 1996 because the previous steep population decline had slowed. There remains considerable uncertainty about the size of the extant wild population. It may consist of fewer than 2,000 individuals. The Bolson tortoise restoration effort on Ted Turner's Armendaris and Ladder Ranches in the species' prehistoric range in southern New Mexico began in 2006 with the acquisition of a private collection of 30 adults. This original group has produced over 500 new hatchlings to date. The captive population will be used to establish two or more wild populations on private and public lands in the northern portion of the species' prehistoric range.

Goals

- Goal 1: Generate large numbers of new Bolson tortoises that can be used to populate two or more assurance colonies on private and public lands.
- Goal 2: Protect the young tortoises from predation until they reach predator-resistant size.
- Goal 3: Release predator-resistant juvenile tortoises to establish new wild populations.
- Goal 4: Monitor released tortoises to ensure adequate survival, growth, and reproduction.

Success Indicators

- Indicator 1: To establish a robust breeding program to produce large numbers of genetically diverse juvenile tortoises during early stages of the project.
- Indicator 2: Find evidence for normal growth and behavior (burrow use, mating, foraging, brumation, estivation, etc.), and sexual maturation of juvenile tortoises (egg production by females of reproductive size and age).

- Indicator 3: Successfully release large juveniles into suitable habitat and observe high survivorship of released tortoises.
- Indicator 4: Find evidence of successful breeding in the restored population, including a documented presence of hatchlings and juveniles.

Bolson tortoise

- Indicator 5: Document new adults, including gravid females that are not from the initial released population, showing that tortoises hatched from natural nests and matured to adulthood. Find evidence for a population structure that consists of all age and size classes.

Project Summary

Feasibility: Fossil records establish the presence of large chelonians in the northern Chihuahuan desert as recently as 12,000 years ago. Their disappearance from this range coincides with human arrival (Zylstra, 2007). Another steep decline in Bolson tortoise numbers during the middle of the 20th century was caused by collection for food, and by habitat degradation (Bury *et al.*, 1988). Today, the only extant wild population is subdivided into clusters within isolated basins in the Bolson de Mapimi, comprising ~6,000 km^2 in north-central Mexico where the provinces of Coahuila, Durango, and Chihuahua meet (Bury *et al.*, 1988). One sub-population is protected within the Mapimi Biosphere Reserve (established in the mid-1970s), but protection for the other subpopulations is minimal or non-existent. Consequently, these sub-populations may be mostly extirpated today (van Dijk & Flores-Villela, 2007). In their current range, the Bolson tortoise continues to be threatened by habitat degradation due to human activities, and by collection for consumption. In 1989, the total tortoise population was estimated at 7,000 - 10,000 (Bury *et al.*, 1988), but the Instituto de Ecologia more recently estimated numbers to be as low as 1,600. Conservation efforts have been stifled by political unrest, cultural concerns, and dangerous conditions where the tortoises live.

Concerned over the species' long-term survival, the Turner Endangered Species Fund (TESF) and its partners initiated a recovery effort (Truett & Phillips, 2009) based on captive-breeding programs located at the Armendaris and Ladder Ranches, and at the Living Desert Zoo and Gardens State Park (LDZG) in Carlsbad, NM and the El Paso Zoo in El Paso, Texas, USA. Breeding programs at all locations are coordinated under the Bolson Tortoise Recovery Project

Bolson tortoise habitat

(BTRP), overseen by TESF. The goal of captive-breeding is to create a source of individuals to establish wild populations in the species' pre-historic range on private and public lands in the US (Truett & Phillips, 2009). Initial research to understand whether Bolson tortoises can thrive in northern Chihuahuan ecosystems has been taking place on both ranches. A robust breeding program has resulted in an expanding population of over 400 juveniles up to 8 years old.

Implementation:

Captive breeding and husbandry: The adult breeding colony on the Armendaris Ranch is housed in a large (~16.5 acre) enclosure surrounded by a 0.61 m perimeter fence that is designed to keep tortoises from leaving but does not protect them from predators. Their diet consists entirely of native forage plants within the enclosure. Regular monitoring and twice-yearly health evaluations since 2006 provide evidence that adult Bolson tortoises can thrive in New Mexico. Moreover, reproduction has been robust with females producing up to three clutches of eggs annually. Thus, we feel that re-introducing Bolson tortoises is a valid approach for restoring a viable population in the species' prehistoric range. To ensure a high degree of hatching success, we chose to place eggs in temperature-controlled incubators. Upon emergence from the egg and yolk-sac absorption, hatchlings are placed in outdoor predator-proof enclosures. We occasionally supplement hatchling diet with fast growing, non-native forbs and grasses (e.g. clover and Bermuda grass), but prefer to raise tortoises mainly on native forage (e.g. globe mallow). In 2013, we began keeping hatchlings "up" during their first winter to encourage robust growth during their first year (resulting in less time in pre-release enclosures). They are returned to outdoor enclosures as soon as spring weather allows.

Pre-release conditioning: Juveniles are housed in outdoor enclosures with native vegetation until they are large enough for release. We provide starter burrows, but tortoises also dig their own. The large outdoor space allows young tortoises to build muscle strength through foraging, dispersing, and building burrows, and allows them to find the best food sources and micro-environments. Moreover, juveniles learn to respond and adjust to daily and seasonal thermal changes.

Release: We began releasing juveniles that were large enough to resist most predator attacks (~110 mm shell length) into the predator-accessible adult enclosures in the fall of 2012. To date (fall of 2014), we have released a total of 87 juveniles. Each one carries a transmitter that allows us to locate them, study their behavior, monitor growth, and assess survival. Once we obtain the proper state and federal permits, we will release juveniles to unfenced ranch locations as well.

Post-release monitoring: This consists of regularly locating each tortoise by telemetry. Monitoring frequency decreases as tortoises settle in, and during winter brumation. As of the fall of 2014, 75 of 87 released juvenile tortoises were known to be alive (>75% survivorship). In general, juveniles settled within 100 m of their initial release site, suggesting that perimeter fencing may not be necessary. Most juvenile tortoises either dug burrows or modified existing rodent burrows. The cause of death for 11 juveniles that died following their release varied from probable kills by coyotes to other natural causes.

Major difficulties faced

- Bolson tortoises grow very slowly, requiring protection in predator-proof enclosures for up to 7 years or more; the time to release can be shortened by intense management during the first year or two of the tortoise's life, but the (potentially negative) long-term effects of this management are not yet known.
- Releasing tortoises from predator-proof enclosures to predator-accessible sites not only exposes tortoises to predators, but also to perils of translocation. Thus, it is important to provision tortoises well while they are still inside the head-start enclosures.
- Ensuring good tortoise growth rates (>10% shell length per year) requires intensive forage plant management inside head-start enclosures. During good years, this might mean daily harvest and delivery of wild-grown forage plants. In drought years, this might mean growing forage plants in a greenhouse and providing regular waterings inside head-starting enclosures. Both strategies can be labor intensive.
- Predators, such as coyotes and ravens, are abundant and will prey on tortoises once they are released outside of the predator-proof enclosures.
- Adequate monitoring of released populations is a long-term effort that requires long-term stable financial support.

Bolson tortoise hatchling

- The final success of the project cannot be assessed until the first generation of wild-born tortoises begin to reproduce, which may take 40 years or more from the initiation of the project.

Major lessons learned

- Projects involving slow-growing animals with a generation time of 25 years require a level of patience that often outlasts the attention span of managers and caretakers. Developing a long-term plan early on that provides benchmarks to be reached along the way can help to establish long-term commitments, refresh memories, and measure success along the way. This is particularly important when a species is introduced into an area in which it has not lived in thousands of years. Establishing independent populations in un-tested areas requires research to ensure that the chosen location can support the species.
- It is important to develop an understanding of the minimum number of adults required to establish a robust and viable population; in turn, it is important to take survivorship rates into account when planning breeding strategies that affect final population size many years in the future. Success requires the generation of large numbers of genetically diverse juveniles early during the project, and sufficient infrastructure to safely house such juveniles until they are large enough to withstand predation attempts after being released.
- Species that exhibit temperature-dependent sex determination (most, if not all, tortoise species) may require breeding support (in the form of incubators) for some years to build strong release cohorts and manipulate sex ratios to ensure adequate numbers of females for establishing independent populations.
- Managing cold-blooded herbivores like tortoises can be relatively easy if done correctly, but it is also relatively easy to make mistakes that may go unnoticed for a long time. Best management practices should include keeping the tortoises in spaces large enough to maximize the number of possible foraging choices as well as nesting sites. Translocations (including between enclosures) should be kept to a minimum, as complex social structures are easily disturbed.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success:

- The involvement of people passionate about the Bolson tortoise and dedicated to its conservation.
- The willingness of a private land owner (Ted Turner), who owns large tracts of minimally disturbed land, to share this land with endangered species and thus increase biodiversity.
- Finding and maintaining a large enough group of breeding adult tortoises that can serve as the founder population.

- The development of a robust breeding program that produces at least 50 new Bolson tortoises per year.
- The long-term nature of the project precludes labeling it as highly successful until the next generation of tortoises can be documented. However, with the current expansion of the US Bolson tortoise population from 30 to over 400, we hope to have ensured the persistence of our breeding group for at least another generation, which in the case of the Bolson tortoise means more than 50 years.

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Conservation of the European pond turtle through population reinforcement in Liguria, Northern Italy

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Introduction

The European pond turtle (*Emys orbicularis*) is classified as Near Threatened by the IUCN; although globally common, it is classified as Endangered or Declining in several European countries (including Italy: Ficetola *et al.*, 2013). Threats include habitat loss and modification, water uptake, fishing and other human activities (road traffic, nest predation & waste dumping), and competition with invasive species, including American freshwater terrapins, fish, crayfish and coypu. In the north-western Italian region of Liguria, the endemic subspecies *E. orbicularis ingauna* is considered endangered (Jesu *et al.*, 2004). Only one population remains in the Centa river valley consisting of few small and isolated sub-populations inhabiting Mediterranean streams and secondary habitats, such as ponds in abandoned clay quarries (Salvidio *et al.*, 2013). In 2000 a conservation project was undertaken with the involvement of public authorities (Province of Savona, State Forestry Corps, and University of Genova), private entities (Aquarium of Genova) and NGOs (Pro Natura Genova, WWF Liguria). Realized actions include the creation and restoration of sites, monitoring wild *E. orbicularis* and restocking individuals born in a local facility (Centro Emys in Leca di Albenga) and bred

European pond turtle basking © Pino Piccardo

European pond turtle habitat © Pino Piccardo

at the Aquarium of Genova. Since 2013, a European LIFE project (LIFE12 NAT/IT/000395) is assisting these conservation actions.

Goals

- Goal 1: Improve the habitat of *E. orbicularis ingauna* in the Centa river valley, with particular regard to nesting and basking sites.
- Goal 2: *Ex-situ* reproduction of *E. orbicularis ingauna* and release for reinforcement of the extant population in the Centa river valley.
- Goal 3: Eradicate invasive alien terrapins from all wetland areas in which *E. orbicularis* is present.
- Goal 4: Develop a veterinary protocol for assessing disease risks associated with the re-introduction programs.
- Goal 5: Increase public awareness of the need to preserve wetlands and to avoid the release of alien species, particularly turtles.

Success Indicators

- Indicator 1: Double the total population of *Emys orbicularis ingauna* (from about 50 - 60 to >100 individuals) and increase its reproductive rate.
- Indicator 2: Eradicate alien terrapins from sites occupied by *Emys orbicularis ingauna.*
- Indicator 3: Increase the number of sites occupied by *Emys orbicularis ingauna.*
- Indicator 4: Achieve successful breeding of re-introduced individuals.

Project Summary

Feasibility: This project aims to improve the status of the species in the region of Liguria by reinforcing the extant population through the release of captive-bred individuals. The release program will be supported by habitat restoration actions, by the concurrent removal of non-native turtles and by broader activities aimed at increasing public awareness of the threats faced by native turtles and the impacts caused by the release of non-native wildlife. Since sites are located within protected areas (Natura 2000 network), further man-made habitat modification is unlikely to constitute a threat for the extant populations. However, even in

protected areas sites still face threats from natural vegetation succession and silting-up of ponds. These processed are reducing the standing water surface available for *Emys orbicularis* populations: ongoing management of sites is required in order to maintain their suitability. Currently, small numbers and fragmentation leave the population vulnerable to stochastic events. High survival of adults is observed in the wild, but sporadic reproduction and high juvenile mortality hinder the formation of a well-structured and self-maintaining population. Therefore, captive-breeding should bypass the most vulnerable biological phases while habitat management and removal of alien terrapins will increase the reproductive success for *E. orbicularis*. Once a sufficient number of individuals have been released and a well-structured population has been established, the high natural survival of the species and the improvement in habitat are expected to allow its persistence into the future (Canessa *et al.*, 2015).

On the other hand, non-native turtles are widespread in the area, following the release of unwanted pets (Ottonello *et al.*, 2005). The large number of individuals and the effort required for locating and trapping them, particularly in light of the scarce resources available, make the complete eradication of these competitors of *E. orbicularis* a difficult task. Ultimately, the eradication of non-native turtles depends not only on removal of current individuals, but also on the prevention of future releases. In this sense, a broad strategy is required to combine direct conservation actions with education and awareness campaigns. The captive breeding center provides opportunities for engaging the public and interacting with local schools and visitors.

Implementation: Thanks to different financial instruments (Regional, Provincial and EU funds), sponsorship by the European Association of Zoos and Aquaria (EAZA) and the support of volunteers during the years allowed implementation of several actions during the project. In particular, a small natural area was acquired from its previous owners and declared as protected; three ponds were restored; and periodic habitat management is being carried out. Since 2008, more than 200 captive-bred sub-adults terrapins have been released at five locations. In 2014, the eradication program of aliens terrapins from the Centa River plain begun, resulting in the removal of 95 individuals to date. Invasive turtles captured belong to three different species: *Graptemys pseudogeographica, Pseudemys concinna* and *Trachemys scripta*. In particular, *T. s. elegans* represents 80% of

Hatchlings © Pino Piccardo

allochthonous animals found. An examination of data on the size of the individuals and on the consistency of juveniles suggests that *T. s. elegans* is able to reproduce in the area.

Breeding center © Dario Ottonello

Post-release monitoring: The restocked terrapins are seasonally monitored by intensive trapping. All released individuals are marked to facilitate identification. In addition, some of the individuals released are radio-tracked to obtain data about post-release survival and movement. Post-release monitoring suggests a successful establishment of released individuals in the wild, with recapture rates over 80%. However, to date no information is available about the successful reproduction by released individuals.

Major difficulties faced

- In Mediterranean climates, ponds are rapidly invaded by aquatic vegetation and filled up by siltation; therefore periodic management is needed.
- Difficulties in the eradication of *Trachemys scripta elegans* turtles reproducing within the area of occurrence of *Emys*.
- Continuous reduction in public funding for environmental conservation.
- Due to the slow life cycle of the species, there is a time lag between the release of individuals and the possibility to determine their reproductive rates in the wild.
- At the broader scale, the high level of anthropic modification of the Centa River plain makes it difficult to restore a good level of ecological connectivity between sites.

Major lessons learned

- Success depends on the effective collaboration of multiple agencies and stakeholders, particularly where multiple objectives are being targeted.
- Ongoing management of sites and non-native turtles is likely to be required beyond the end of the release program, to maximize the probability that the restocked population persists until a sufficient number of individuals have been established.
- To avoid the risk of spreading diseases in the wild population, a veterinary check-up of individuals prior to release is of fundamental importance.
- When the aim is to preserve a specific subspecies, as is the case for this project, a genetic study of the founding breeders is required to assess the risk

of genetic pollution through the introduction of individuals from other populations/subspecies.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The declaration of new protected areas and the restoration of existing ones, together with the release of individuals, have prevented the total extinction of the species after its rediscovery in the 1990s.
- The release of sub-adult individuals ensures high-post release survival, increasing the likelihood of establishment in the wild.
- The strong commitment and successful coordination of participants has allowed good progress towards all objectives.
- Widespread engagement of the public, particularly through activities at the captive breeding centre, has increased the perception of *E. orbicularis ingauna* as a local flagship species, and encouraged support by local communities.
- Evidence of successful breeding by released individuals has not yet been found.

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Re-introduction of tuatara to a mainland sanctuary within the species historic range in Hawkes Bay, New Zealand

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Introduction

Tuatara (*Sphenodon punctatus*) are medium-sized reptiles and the sole extant representatives of the order Rhynchocephalia, which arose ~250 million years ago in the late Triassic. Endemic to New Zealand, tuatara were widespread until human colonization and introduced mammalian predators resulted in extirpation from the mainland and their restriction to isolated, predator-free offshore islands (Gaze, 2001). Although listed as Least Concern by the IUCN Red List based on robust population sizes on a few islands, the New Zealand Department of Conservation's current Threat Classification System describes tuatara as Range-Restricted, conservation dependent and relict, having undergone a decline within the last 1,000 years and now occupying <10% of their former range.

Translocations to extend the range of tuatara have been essential to species conservation. In October 2012, as part of several unprecedented large-scale translocations within New Zealand, 40 adults and 20 juveniles were re-introduced to Cape Sanctuary, 2,500 ha of private land enclosed by a 10.6 km pest-proof fence on the Cape Kidnapper's Peninsula. We report on the re-introduction and acknowledge the collaborative efforts of the Lowe, Robertson, and Hansen families (landowners and funding

Tuatara (*Sphenodon punctatus*)

parties), Ngati Koata, Ngati Mihiroa, the New Zealand Department of Conservation, and the Victoria University of Wellington Reptile Conservation Research Group to facilitate this translocation.

Goals

- Goal 1: Secure the population viability and genetic diversity of tuatara by restoring a self-sustaining population to an area within their pre-human range (Gaze, 2001).
- Goal 2: Restore a coastal farmland landscape to its pre-human state through weed and pest control, as well as the re-introduction of native fauna and flora.
- Goal 3: Use a re-introduction and ecological restoration project to build collaborative relationships and transfer skills between researchers, Maori iwi, sanctuary staff and volunteers.

Success Indicators

- Indicator 1: Survival and growth of founders within 5 years of release.
- Indicator 2: Evidence of reproduction and recruitment of young in to the population within 10 years.
- Indicator 3: Evidence of a self-sustaining population within 100 years.

Project Summary

Feasibility: Cape Sanctuary is a privately owned, 2,500 ha sanctuary which contains a “seabird cell’, a smaller 1.5 ha enclosure surrounded by a 610 m predator-proof fence designed to provide the utmost protection for nesting seabirds. It is within this smaller site where tuatara were re-introduced in 2012. Prior to the founding of Cape Sanctuary, the Cape Kidnappers Peninsula was largely devoted to production, with land use centered on farming, forestry and tourism. Livestock grazing and invasive pests saw much of the native flora and fauna destroyed (McLennan, 2012). The isolated mainland location of the sanctuary, restricted access (Cape Sanctuary is not open to the public), pest and predator-proof fences, and ongoing pest control means that it is reasonably well-protected against reinvasions and has high potential for establishment of a viable tuatara population.

The presence of tuatara on the peninsula prior to human settlement supports this expectation (Miller *et al.*, 2012). Planting work within the seabird cell has begun to restore much of the native flora, however much of the peninsula is still grassland and it will be decades before a forest canopy regenerates.

Implementation: Tuatara are treasured in Maori culture, therefore the re-introduction to Cape Sanctuary involved collaboration between Ngati Koata (Maori tribe and guardians of the Stephens Island tuatara) and Ngati Mihiroa (guardians of the Cape flora and fauna), as well as the Lowe, Robertson, and Hansen families, the NZ Department of Conservation, and the Victoria University of Wellington Reptile Conservation Research Group. In October 2012, 220 adult tuatara were sourced from Stephens Island in the Cook Strait for re-introduction to sanctuaries across New Zealand. From this group, 40 (20 males:20 females) were re-introduced to Cape Sanctuary. Twenty juvenile tuatara were also re-

introduced. These juveniles were hatched from eggs collected from Stephens Island and head-started in captivity until ~5 years of age. These conservation translocations were the first of their kind to re-introduce tuatara to sites outside of their current ecological range.

Release site

Stephens Island is home to the largest population of tuatara, with an estimated 30,000 - 50,000 individuals occupying only 150 ha of land. Removal of animals from this population therefore carries the benefits of relieving some overpopulation pressure and safeguarding the species against natural disaster and disease outbreaks, as well as providing animals for re-introduction to sites within the historic range of tuatara. Prior to translocation tuatara were weighed, measured, and had samples taken for health screening purposes. These included cloacal swabs for *Salmonella* and *Campylobacter* analysis, blood smears for haemoparasite and white blood cell counts, and faecal matter for intestinal parasite screening. Tuatara were also checked for ectoparasites (ticks and mites) and fitted with uniquely coded passive integrated transponder (PIT) tags inserted beneath the skin for identification. Each animal was then individually packaged in an aerated postal tube and transported from Stephens Island by helicopter and car for re-introduction to their respective sites. As Cape Sanctuary is a mainland site and still vulnerable to introduced predators, tuatara were released in to the seabird cell. Artificial burrows (log piles, pipes, bore holes and wooden boxes) were installed to improve habitat.

Post-release monitoring: A permanent team of landowner-appointed staff currently manages Cape Sanctuary with assistance from volunteers and part-time staff and contractors. Since the 2012 release, Cape Sanctuary has been visited three times by the VUW Reptile Conservation Research Group for tuatara monitoring (Spring 2013 and Spring and Autumn 2014). Three to five people spent up to seven nights searching the seabird cell for adult tuatara each visit. A total of 85% of the founding tuatara were re-located. There was no measurable change in snout-vent length but mean percent mass increase in males was 11.59% and in females was 6.11%. This is a positive indication of habitat quality and prey availability at the introduction site. No evidence of recruitment has been observed. One fatality was observed in a male tuatara as a result of significant trauma to one eye, possibly caused by a seabird or collision with vegetation. A fourth monitoring trip will be conducted in Autumn 2015. It is accepted practice that a population must be monitored for at least the time needed for an individual

to reach sexual maturity before the success of a translocation can be determined. As tuatara may live for over 100 years, reach sexual maturity in their early teens, and females only breed every 4 years on average, monitoring is expected to continue for decades before the establishment of a self-sustaining population can be assessed.

Major difficulties faced

- Recapturing founders is challenging due to the cryptic and nocturnal nature of tuatara, the steepness of the cliff-side site, and the presence of numerous hides and burrows where animals can shelter. The limited ability to monitor survival and growth of all founders during a single trip means that repeat monitoring is required.
- Early stages of revegetation and little closed canopy can limit the range of tuatara from the safety of their burrows and reduce activity on bright nights (e.g. full moon, cloudless), making detection difficult, particularly of re-introduced juveniles and new recruits.
- Access to the site is via dirt and gravel tracks through farmland, so visits are only possible when the weather allows. If the weather is especially adverse and the track hazardous then monitoring visits have the potential to be cut short or extended by several days.

Major lessons learned

- Consistent with previous tuatara translocations and monitoring visits at other re-introduction sites, recapturing founders is difficult. Non-detection does not necessarily imply mortality and subsequent visits can uncover founders not seen since translocation. The inability to recapture 100% of founders after multiple visits is likely due to surveying limitations (e.g. terrain, small team covering a large area, cryptic species, and weather). Therefore, the number recaptured should be interpreted as minimum number alive and not representative of survivorship or translocation success (Nelson *et al.*, 2008)
- Limitations to detectability that should be considered for the timing of future monitoring visits include appropriate weather conditions for accessing the site and moon phase. Tuatara were observed to remain in burrows on bright nights, likely due to increased visibility from a lack of canopy, and thus the increased risk of predation by nocturnal birds of prey.
- Cooperation with stakeholders is invaluable in running effective monitoring visits. Assistance was provided regarding numerous aspects, from accommodation and voluntary assistance to information on notable tuatara sightings between visits. It is in the interest of the translocations success that there is communication and cooperation between stakeholders.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Founders have survived, are in good condition, and there has been a mean population weight gain, indicating that tuatara can survive and there are sufficient resources at Cape Sanctuary.
- Survivorship is probably higher than indicated by the 2013 - 2014 monitoring visits. It is likely that more founders will be recaptured in future visits.
- It is too early to detect recruitment to the population (females breed every 4 years on average, nests are cryptic, and hatchlings very difficult to locate) so success can only be defined on a short-term basis. Long-term monitoring (decades) is required to determine whether the population has become self-sustaining.
- Cooperation with stakeholders ensured that the organization and running of monitoring visits, recruitment of volunteers and sharing of information was efficient and effective.

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Head-start (re-introduction) program of captive-reared hawksbill turtles in the Yaeyama Islands, Okinawa, Japan

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Introduction

The hawksbill turtle (*Eretmochelys imbricata*, Linnaeus 1766) is one of the most common marine turtles throughout the tropical, and to a lesser extent, subtropical Atlantic, Indian, and Pacific Oceans (Mortimer & Donnelly, 2008). Juveniles and adults are known to feed primarily on benthic invertebrates, most notably sponges (Meylan, 1988). However, many hawksbill populations have continued to decline worldwide (Mortimer & Donnelly, 2008). Thus, in 1986, hawksbill turtles were named in the IUCN Red List, and are now classified as Critically Endangered (Mortimer & Donnelly, 2008). Tortoiseshell, as the beautiful scutes of the species' carapace are commonly known, has historically been prized as a raw material used in the creation of traditional craft objects. Hawksbill turtles were listed in CITES Appendix I, banning International trade in the material among member countries. Hawksbill turtles have been listed as a 1B (endangered) species in the Red Data Book of Japan by the Ministry of the Environment since 1991. To augment wild populations, an experimental head-start program of captive-reared turtles was implemented by the Yaeyama Station, at the National Center for Stock Enhancement (NCSE), Japan in 2003 (Yoseda & Shimizu, 2006).

Head-started hawksbill turtle tagged with an ultrasonic transmitter © Dr. Nobuaki Arai

Goals

- Goal 1: Assess post-release movements and home range compared to those of wild turtles.
- Goal 2: Assess behavioral patterns and daily rhythm compared to those of wild turtles.
- Goal 3: Assess ability of released individuals to forage for natural prey items.
- Goal 4: Assess post-release growth rate

compared to that of wild turtles observed during previously published studies.

Success Indicators

- Indicator 1: Establishment of a home range similar in size to that of wild turtles.
- Indicator 2: Released turtles are active in the daytime and rest under corals at night.
- Indicator 3: Feeding on the species' natural prey items without a learning period.
- Indicator 4: Demonstrate growth rates similar to those of wild turtles.

Project Summary

Feasibility: Our experimental area at the Yaeyama Islands, in Okinawa prefecture of southwestern Japan, marks the approximate northern limit of hawksbill turtle nesting grounds in the western Pacific. Several nesting events occur in this area annually. Meanwhile, there is feeding aggregation of immature hawksbill turtles around the Yaeyama Islands (Kamezaki & Hirate, 1992). Although hawksbill turtles had been historically harvested by local fishermen, the practice has been controlled by the regulations for the size and the number of turtles in the Fishery Act of the Okinawa Prefecture Fisheries Adjustment Commission since 1953.

Implementation: To increase the size of the wild hawksbill population, in 1999, the Yaeyama Station, at the National Center for Stock Enhancement (NCSE), of the Fisheries Research Agency in Japan, had begun to develop techniques required for the breeding, incubation, and rearing of hawksbill turtles, and had successfully bred hatchlings from long-term captive broods (Yoseda & Shimizu, 2006). Thus, it had been running an experimental head-start program for captive-reared turtles since 2003 (but terminated in 2010). To evaluate the effects of the head-start program, and the survival capabilities of head-started turtles in their natural habitat (ocean), we decided to conduct an experiment with which to compare the behavioral performance of head-started and wild turtles after release. Wild turtles were used as a comparative criterion and captured around the Yaeyama Islands. Because wild hawksbill turtles inhabiting the waters around the Yaeyama Islands range from 39 cm to 63 cm in size (straight carapace length, or SCL) (Kamezaki & Hirate, 1992), we used captive-reared turtles of the same size, reared for 2.5 years at the Yaeyama station from eggs laid on the adjacent beach.

Post-release monitoring: In 2005, the post-release movement and behavior of head-started hawksbill turtles were monitored using ultrasonic telemetry (Okuyama *et al*., 2010). We simultaneously released five head-started and five wild turtles into the water in front of the Yaeyama station. Two of the five wild turtles were recaptured at the location at which they had previously been captured. Moreover, the post-release dispersal patterns of the other wild turtles may indicate that they carry out a type of homing migration. However, the head-started turtles dispersed in non-uniform patterns. Four head-started turtles moved out of the monitoring area in different directions, whereas one turtle stayed within the monitoring area for approximately 10 months. These results might indicate

Yaeyama Islands release site

that head-started turtles wander aimlessly in their new surroundings. Signal reception patterns indicated that wild turtles were active in the daytime and rested under coral at night. Although the head-started turtles were also observed to rest at night, their resting places did not seem to be sheltered from hazardous sea conditions, and did not seem to facilitate efficient resting. Prey analysis of a head-started turtle recaptured incidentally by a local fisherman revealed that this head-started turtle is capable of foraging for demosponges such as *Chondrosia* sp., one of the natural prey items of wild turtles (Meylan, 1988). The growth rates of this particular head-started turtle were determined to be 1 cm in SCL and 0.11 kg in body weight over 88 days. These growth rates were similar to those of wild turtles both at the Yaeyama Islands and in other regions.

Major difficulties faced

- It is technically quite difficult to monitor the post-release behavior and movement of immature hawksbill turtles in the wild in detail.
- Although wild hawksbill turtles seemed to have established preferred settlement locations and home ranges in the waters around the Yaeyama Islands prior to the start of the experiment, head-started hawksbill turtles did not have home ranges to return to.
- Sea turtle hatchlings are thought to disperse from the beach where they were born by drifting on ocean currents. However, little is known about their migration ecology and their destination after leaving the Yaeyama Islands. Moreover, head-started turtles did not seem to disperse to the same locations that wild hatchlings reach, because they were too large to drift on ocean currents.
- Because it is thought to take a few decades for sea turtles to reach maturity, it is quite difficult to monitor/confirm whether the head-started turtles carry out homing migrations to the Yaeyama Islands to reproduce. Thus, it is difficult to assess whether the head-start program ultimately contributes to the enhancement of wild populations.

Major lessons learned

- Despite the difficulty of monitoring post-release behavior, we confirmed that a head-started turtle remained within the monitoring area and survived for at least 10 months under natural conditions.

- Prey analysis of a head-started turtle captured incidentally demonstrates that they can adapt their feeding habits to their natural environment.
- A growth rate similar to that of wild turtles was observed in a head-started turtle, which indicates that their ability to digest their natural prey is equivalent to that of wild turtles.
- Head-started hawksbill turtles appear to require pre-release training, such as exposure to structures or ledges in the rearing tank, so that they can learn to utilize similar structures in the wild for shelter during rest periods.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The head-started turtles demonstrated their ability to adapt feeding preferences to natural preys without a learning period, and then exhibited growth rates similar to those of wild turtles.
- The head-started turtles did not use coral structures for sheltering when they rested at night, indicating that the predation risk may be higher than that of wild turtles.
- Much of the ecology of head-started turtles under natural conditions remains unknown, including their process of settling into their natural habitat after release, and their reproductive migration/ecology upon reaching maturity.
- More long-term monitoring is required to better assess the survival and growth of captive-reared hawksbill turtles.

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Captive breeding and re-introduction of the Monuriki Island Crested Iguana in Fiji

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Introduction

The Fijian crested iguana (*Brachylophus vitiensis*) is an arboreal, herbivorous lizard found on only a small number of islands with native dry or littoral forest in western Fiji. Its population is secure only on the sanctuary island of Yadua Taba, where >12,000 individuals exist; this equates to over 200 individuals/ha in the best forest habitat. All other island populations appear to be low and declining (mostly <100 individuals), and survive on communally owned land which is mostly outside the control of central government legislation (Harlow *et al.*, 2007). The forest habitat that is essential for its survival continues to be burnt and cleared for gardens, coconut plantations and grasslands for goat grazing. In addition, exotic predators, especially mongoose (*Herpestes fuscus* and *H. auropunctatus*) and feral cats continue to spread across the Fijian

Monuriki Island crested iguana © Peter Harlow

Monuriki Island release site © Peter Harlow

archipelego, with devastating effects on ground nesting birds and many reptile species. The Fijian crested iguana is listed as Critically Endangered by the IUCN (2014), is on CITES Appendix I, is listed by the U.S. Fish and Wildlife Service as endangered and is protected in Fiji under the Endangered and Protected Species Act (2002).

Goals

- Goal 1: Halt the potential extirpation of the Monuriki Island crested iguana in Fiji.
- Goal 2: Successfully negotiate with the land owning clan of Monuriki Island to remove goats and/or capture and move the remaining iguanas into a captive-breeding facility.
- Goal 3: Capture, hold and breed a minimum of 10 pairs of Monuriki iguanas to maximize maintenance of genetic diversity.
- Goal 4: After goat removal, monitor vegetation recovery prior to releasing captive-bred iguanas.
- Goal 5: Replace the land owning clan's lost income from goats with funding from “Fijian iguana encounter” ranger-led, tourist visits to the island. Monuriki has the only wild Fijian iguana population that can be visited on a day trip from both a popular tourist region and a major Fijian city (Nadi).

Success Indicators

- Indicator 1: Obtaining approval from land owning clan to remove goats and/or capture and move remaining iguanas into captive-breeding.
- Indicator 2: Successful capture, captive husbandry and breeding of Monuriki crested iguanas to ensure maintenance of genetic diversity.
- Indicator 3: Successful removal of all goats from Monuriki.
- Indicator 4: Sufficient natural vegetation recovery on Monuriki after goat removal to eventually sustain a population of >1,000 crested iguanas.

- Indicator 5: Survival and growth of captive bred iguanas for 3 months post-release.

Project Summary

Feasibility: The crested iguana population on the small and uninhabited Fijian island of Monuriki (40.4 ha, 216 m a.s.l.) has been low and declining for years. In the 1980s there was still 'a high density of iguanas' on Monuriki (Gibbons, 1984), however less than 20 years later a survey suggested a total population of less than 100 iguanas remained (Harlow & Biciloa, 2001). Monuriki has no exotic predators, but had been used for goat grazing since at least the 1960s, and forest fires were a common event over the subsequent decades. Monuriki is a rugged and beautiful island, and has been utilized previously for filming movies such as "Castaway" starring Tom Hanks, and today is a very popular tourist destination with several boats and many people visiting everyday. Before the removal of goats there was a total absence of both ground vegetation and tree seedlings, and the remaining vegetation was dominated by just a few tree species, most of which were inedible to iguanas (Harlow & Biciloa, 2001). Monuriki Island crested iguanas are genetically distinct from all other crested iguana populations (Keogh *et al.*, 2008), and the 2008 Species Recovery Plan (Harlow *et al.*, 2008) prioritized Monuriki as the single most important site for immediate conservation action.

Iguana habitat on Monuriki Island
© Peter Harlow

In April 2010 a Memorandum of Understanding was agreed to and signed by 1) leaders of the Monuriki Island land-owning clan, the Mataqali Vunaivi, 2) The National Trust of Fiji Islands and 3) Kula Eco Park, Korotoga, Fiji, to remove goats from Monuriki and capture and remove the remaining iguanas for captive-breeding. Monuriki iguanas are on loan to Kula Eco Park, and the agreement is to return them and all their offspring when the vegetation had recovered after goat removal.

Implementation: Between April 2010 and February 2012, 21 crested iguanas were captured on Monuriki Island during nine field trips by National Trust of Fiji staff, and transported to newly established quarantine and captive breeding facilities at Kula Eco Park. Six additional iguanas were seen on these trips, but could not be captured. At Kula Eco Park iguanas

Yanuya school boy and Ramesh Chand release a Monuriki iguana © Nick Felstead

are normally kept singually, however they were paired for 3 - 4 months annually (~December to March) for breeding purposes. Eighteen of these iguanas have now bred, and the total captive pre-release population was 17 wild caught adults, 50 captive bred offspring and 22 fertile eggs. In late 2011 goats and Pacific rats (*Rattus exulans*) were eradicated from the island by Birdlife International - Fiji Program. Pacific rats are not known to be a predator of Fijian iguanas, and co-exist on all islands where both occur, and were eradicated from Monuriki because of its importance as a seabird nesting island.

Four wet seasons after goat removal the vegetation of Monuriki has significantly recovered. In mid-May 2015, 32 captive-bred crested iguanas, all implanted with unique PIT tags, were released into four different areas on Monuriki Island. Twenty-six, 2 to 5 year-old iguanas (Snout Vent Length 158 - 210 mm, mass 105 - 350 g) were fitted with small radio transmitters (Holohil BD 2, 1.8 g) prior to release for monitoring purposes.

Post-release monitoring: At 56 days post-release 18 telemetered iguanas were re-sighted - 9 or captured - 9, the captured individuals were measured and weighed, and the transmitters were removed before release. All transmitters are expected to drop off at the next skin shedding event, and indeed we found six transmitters had already been shed by day 56. The recovered transmitters showed no signs of trauma, which might indicate a mortality event. The nine recaptured iguanas had grown slightly in SVL length since release (mean 4.5 mm, range 1 - 11 mm: mean % increase in SVL = 2.4%, range 0 - 6.0%), however they had lost a small amount of body weight (mean 11.4% body weight, range 3.2 - 29.4%).

At release these iguanas looked a little ‘fat’, probably from their excellent captive diet, but by day 56 post-release they looked more like sleek, healthy wild iguanas and their new Body Mass Index matched closely to the five wild iguanas also captured during the post release monitoring. The observation of five wild sub-adult iguanas in one night of survey also serves as an indicator that the population that remained on the island is now recovering, as capture rates during the “harvest” period were less than one iguana per night. Based on GPS data,

these 18 iguanas had moved an average of 41.2 m since release (range 5.1 - 182 m).

Major difficulties faced

- Obtaining sufficient funding for all components of this 5 year project (landowner negotiation, iguana capture, building and staffing a captive breeding center, eradicating goats, vegetation surveys and biosecurity training for landowners).
- Lack of an overall planning team, and poor communications among disparate groups involved in the different aspects of this project.
- Low reproductive output of this iguana species (females lay 3 - 5 eggs every 2 years).
- No vegetation survey of edible plant species (for iguanas) abundance was undertaken prior to re-introduction.
- No long-term monitoring of the iguana population is planned due to limited resources.

Major lessons learned

- Fully involve landowners in all discussions and throughout the implementation of the project.
- Ensure that there is regular contact between the landowners and representatives of the project team to ensure that any grievances/misgivings can be allayed/addressed before they become a serious impediment to the future success of the project.
- Develop a detailed workplan, identifying the persons responsible for, and a time period required to deliver, each of the individual activities.
- Identify the project manager who has overall responsibility for delivering the project outcome - and has the authority to require individuals to deliver their components, and is responsible for keeping all records, including financial records, which must be available for audit and public scrutiny.
- Flexibility to identify and acquire additional partners and funding as the project progresses.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Landowner support and involvement at all levels made this project a success.
- Absence of exotic predators on Monuriki.
- Rapid vegetation recovery after goat removal.
- Successful captive-breeding and good record keeping by Kula Eco Park.
- The original goal to replace the land owning clan's lost income after goat removal with village-run, iguana based guided tours of Monuriki has not eventuated. This is a failure, but may still happen in the future.

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Re-introduction of the black-winged starling in Gunung Halimun Salak National Park, West Java, Indonesia

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Introduction

The black-winged starling (*Sturnus melanopterus*) is currently listed as Critically Endangered by the IUCN Red List due to intensive trapping for the illegal cage-bird trade. Formerly really common in open land areas, the species faced a dramatic decline until few individuals remain in localised areas (Birdlife International, 2012). It is also listed as protected species under the Indonesian law. To counteract the oncoming extinction of the species, Cikananga Conservation Breeding Centre (CCBC), situated in West Java, breeds the West Javan subspecies (*S. m. melanopterus*) for re-introduction purposes since 2007. On 23rd April 2013, 40 Black-winged Starlings were released in Gunung Halimun Salak National Park, one of the biggest National Parks of West Java. The release site is situated within a gold mine which recreates suitable habitat for endemic species. Since the release, intensive monitoring was performed to judge on the ability of captive-bred birds to cope with a wild environment and know better about the ecology of this quite unknown species. This re-introduction program is the first of its kind in Java since no release from captive-bred individuals happened before on this island.

Released starling © Anais Tritto

Goals

- Goal 1: High survival rate of the re-introduced population with an adequate demography of the population, necessary for normal social interactions and mating behaviors.
- Goal 2: Encourage the released population to be self-sustainable through breeding.
- Goal 3: Get valuable information on the ecology of the black-winged

starling that would increase knowledge on the species and provide guidelines for future releases.
- Goal 4: Develop a strong education program with local people to prevent bird-catching.

Success Indicators

- Indicator 1: Survival of most released individuals with adequate behaviour (feeding, roosting & nesting).
- Indicator 2: Successful fledging juveniles from supplied nest boxes or natural nests.
- Indicator 3: Data on various ecology aspects, such as feeding/roosting preferences, predator avoidance and breeding seasons.
- Indicator 4: Bird-catching evidences limited and involvement of local people in the success of the program.

Project Summary

Feasibility: The release site is situated within the Gunung Halimun Salak National Park in West Java and especially in a gold mine area, managed by an Indonesian company. The release site is around 95 ha and is composed of grasslands, villages and rice plantations surrounded by secondary and productive forests. The area was chosen depending on the black-winged starling ecology. Indeed, this species is an open-land bird, using mainly plantations and grasslands to forage for insects. Unlike the Javan munia (*Lonchura leucogastroides*) which is intensively trapped or chased, local people could find benefit from this species as they can use it as insect-regulator for the crops.

Implementation: In October 2012, the birds were transferred to the habituation cage (12 m x 5 m x 3 m) within the release site from the captive breeding centre after they received health check (screening for Avian Influenza and Newcastle Disease) and appropriate deworming treatment. They were chosen depending on their genetics (over-represented in captivity & unrelated) and demography to get a balanced sex-ratio. The birds were supposed to stay 2 months in the habituation cage but, due to a problem of organization between the stakeholders (gold mine, National Park & CCBC), the birds were released 6 months after they arrived on the site and on 23rd April 2013, the birds were soft-released. The cage stayed opened for the next month after release where the birds could find a secure place for roosting, the cage being closed at night. They also received a food supply for 1 month, composed of the original diet they received in captivity (papayas, bananas & dry pellets). Moreover, 25 predator-proof nest boxes were provided in the surroundings of the release site to offer them suitable nesting sites.

Post-release monitoring: The birds were monitored by visual observation and individually identified by their colour rings. Out of 40 birds released, 20 individuals could still be observed in the release site after 6 months (October 2013), using mainly the plantations surrounding the village, foraging for insects such as prey mantis, caterpillars and grasshoppers (the identification of insect species is in progress). From November 2013, only 6 birds could be observed in the area, mainly due to a release of a confiscated crested-serpent eagle (*Spilornis cheela*).

Starling release site © Fitryana April Hosiana

This release, without prior communication between the different stakeholders could be one of the reasons why the birds dispersed, as long as a decrease in the food availability (absence of mature fruits from the umbrella trees (*Maesopsis eminii*)). It is likely that these events forced the birds to disperse in an area where no educational awareness was performed on local communities and which led to intensive catching (Tritto, 2014).

The breeding season started in March 2014 and, to date (September 2014), is still running with four juveniles that successfully fledged out of the supplemental nest boxes from two different pairs. The captive-bred parents showed appropriate breeding behaviors, from nest building to the rearing of the chicks. In July 2014, bird catching resulted in one juvenile capture at the release site, but with the help of local people who are now devoted to the program and proud to have this species on their lands, the theft was aborted and the bird released. To prevent any more bird catching in the area, three security guards, from the village, were hired to protect the bird population and the nest boxes. The current population (September 2014) is now eight birds and new release will be implemented in the near future.

Major difficulties faced

- The food supply stopped quickly due to a problem of organisation between all the stakeholders which led to a high dispersion of the birds.
- Most of the birds dispersed to an unknown location, possibly in a place where no awareness program was implemented and were caught.
- The birds showed a wilder behavior along the year which led to difficulties to individually recognize and track them.
- Bird-catching evidences were noted on the site, some of them orientated to the black-winged starlings. This difficulty was counteracted by hiring security guards from the local community.

Major lessons learned

- Better communication and planning is needed between all the different stakeholders.
- The birds are able to cope with a wild environment as long as the interaction with human is kept to a minimum.

- By involving local people in the program (hiring local security guards, doing awareness and activities with the children & developing the community), bird catching stopped since all the villagers are proud to have this species and protect it from outsiders.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Some of the birds settled in the release site and presented adequate behaviors.
- Four juveniles successfully fledged 1 year after the initial release.
- The education awareness program should have started a long-time before the initial release and on a larger scope to prevent bird catching and involve local people from the start.
- The education awareness program was only performed by students and did not show any regularity.
- Sufficient staff was not present on the site to monitor and to do education with the local people. Recently, the conservation team was increased with a full-time field biologist and full-time education officer, both Indonesian, who could continue implementing the action plan.

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Andean condor conservation program in Argentina

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Introduction

For thousands of years, the Andean condor (*Vultur gryphus),* the largest bird in the world with flight capacity, has been honored by indigenous communities in South America who consider it to be a sacred link between space and men. Once abundant, this emblematic animal, a symbolic link to our past, has been converted, unfortunately, into a conservation challenge. The condors' range has shrunk rapidly in the last 100 years and it was even pronounced Extinct in Venezuela. The Condor is classified as CITES I and is listed as in Danger of Extinction by the USFWS, in addition to being on the IUCN's Red List and characterized as Vulnerable by the Secretary of the Environment and Sustainable Development in Argentina. For this reason, in 1991, the Andean Condor Conservation Program (PCCA) was founded. The PCCA started by performing genetic studies and documenting the captive condor population in a Latin American studbook. It developed artificial incubation programs and techniques for raising the birds in isolation from human contact and worked to rescue and rehabilitate wild condors. Through using these techniques, this conservation effort has succeeded in raising 47 chicks, rescue more than 120 wild birds and re-introducing 147 condors throughout South America.

Goals

- Goal 1: Optimize the breeding, rescue, and rehabilitation of the Andean Condor in both *ex-situ* and *in-situ* conservation plans for the species.
- Goal 2: Implement a cultural and educational outreach plan to spread the achievements and results of the PCCA's efforts, generating a change in the community towards valuing all forms of life and respect for the ancient traditions.
- Goal 3: Promote the training of volunteers, both domestic and foreign, student and professional, to ensure the functionality of the program, strengthen its results and promote

Released Andean condor

technical exchange, thereby promoting scientific development and education associated with the conservation of biodiversity.
- Goal 4: Use the collective power of regional, national and international governmental and non-governmental associations to bring about institutional participation in order to inform and influence political change in relation to the environment.

Success Indicators

- Indicator 1: Healthy and abundant *ex-situ* population, with reproductive capacity and identification of increased genetic stock documented in a Latin American Studbook under a cooperative management program. Increases in total number of condors (248 specimens registered in the Latin American Studbook), number of chicks born in captivity (47 within the PCCA), and number of birds rescued and rehabilitated (126 within the PCCA).
- Indicator 2: More condors successfully re-introduced into the wild (147 condors) with high survival rates (91.8%) and 5 chicks from released individuals. Growth in area of study of the flight of the Andean condor with more area monitored by satellite and GIS technology.
- Indicator 3: Increase in number of educative campaigns (9 in Argentina), ancestral ceremonies (at each stage of the PCCA and the annual calendar), exhibitions by the PCCA (7 exhibitions), publications, and media mention (all evaluated annually).
- Indicator 4: Successful recruitment of volunteers both domestically and internationally (40 volunteers annually).
- Indicator 5: Application of the ALPZA certification as an indicator of conservation leadership in Latin America (PC ALPZA #2). More such institutions involved with the PCCA (Total 81 institutions: two organized, five collaborated, 22 attend and 52 supported).

Project Summary

Feasibility: The Andean condor (*Vultur gryphus*), a species endemic to South America, occupies an immense range distributed along the Andean Mountain Range and the Atlantic Coast of Argentine Patagonia. In the wild, these birds have a low reproduction rate, only mating every 2 - 3 years and arriving at sexual maturity at around 9 years of age.

This emblematic species has been honored for thousands of years by the original communities of the region, but since the conquest of the Americas, its survival has begun to encounter some serious obstacles. Many in the rural parts of South America mistakenly believe that the condor kills cattle to feed and will therefore hunt the condor to protect their herds, while in reality, the condor is a scavenger. Condors are often the target of unscrupulous hunters and are victims of illegal toxins and the ingesting of lead bullets from the dead animals from which they feed. In addition, the increased prominence of electric wires severely alters the environment and can cause crashes and electrocution in the condor population. Considering the extraordinary flight capacity of this species, it is necessary to allocate many resources to studying and preserving the environments that are important to the condor. Challenges include the great distances involved, the

Andean condor community awareness program

inhospitable and rugged terrain, the isolation of the work, and the lack of communication, all of which result in a costly and slow process enabling project participants and materials to arrive at all points necessary to sustain educational and environmental activities. Because the habitat of the condor encompasses immense areas of land, targeted efforts to set aside condor-specific areas are extremely difficult. Political and economic instability in Argentina is another element that affect the project, but thanks to support from the international community and partnering zoos, PCCA has been successful in re-introducing over a hundred during the last 23 years in South America, helping to repopulate areas where the species had gone extinct.

Implementation: The PCCA maintains a Latin American Studbook for the Andean condor population. Under institutional agreements, the PCCA run an Artificial Incubation Center where eggs are incubated from both foreign and domestic Zoos. Likewise, the PCCA maintains a Rescue Center that provides a sanitary environment from which wild condors from all over the country can be rehabilitated. Both the individuals bred at the center and those that were rescued are kept in isolation from human contact until they are ready for release. Those condors that have flight experience can be re-introduced into the areas from which they were rescued. However, those who have not yet flown will be released in groups, from release platforms and monitored closely for at least a year afterwards until they are fully independent. The only place in Argentina that provides acceptable conditions for this sort of release is Paileman, on the Atlantic Coast, from which the PCCA has succeeded in re-introducing 44 condors into a zone they had been extinct in for over 100 years.

The project has also received support from indigenous South American communities who wish to continue honoring and coexisting with the condor. As a message of respect, ancestral ceremonies led by these communities occur before each release, at each stage of the program, putting forth prayers in the native language to encourage the veneration and support of the Andean condor and efforts to conserve it. This has proven to be a valuable education opportunity and draws hundreds of people to each release.

Post-release monitoring: Each condor is equipped with a subcutaneous microchip and numbered vinyl wing band for easy identification. The use of radio telemetry (Telenax, TXE-125W) and satellite transmissions (PTT 100 GPS Microwave) in conjunction with intense field work, has permitted the creation of a specific Geographic Information System that allows the close monitoring of each bird. Additionally, a special software called Decosat was developed that simulates the flight of the condors and enables the understanding of their flight patterns. The PCCA has been a pioneer in the development of this satellite technology, in 1997, which is particularly important in monitoring the birds in the vast swaths of rugged and isolated land that they occupy. As a result of this modern technology, it has been possible to monitor the adaptation of released individuals and recover much information about the species' roosting sites, nest, flight and habitat preference. Through this post-release monitoring, it is known that juvenile condors can occupy areas of up to 80,000 km^2 while adults can travel across a range of more than 150,000 km^2. Already, the PCCA has been able to confirm that the first rehabilitated condors from 1997 and those introduced along the Atlantic Coast have started reproducing with success.

Major difficulties faced

- The biggest difficulty is changing practices that directly affect the survival of the species, such as the use of illegal toxic baits (utilized by cattle ranchers, supposedly to control predators) and lead bullets, which are very popular among hunters.
- The great geographical range occupied by each bird makes field monitoring logistically difficult. The cost of satellite monitoring equipment makes it challenging to apply this technique to every released bird.
- Protected natural areas exist, but they do not cover the condor's basic needs.
- The wide ranges of the condor complicate efforts in the field further due to the lack of communication ability (no cell service or internet available in the rural base camp of the project), making the transport and coordination of workers and resources problematic.

Major lessons learned

- By uniting the *ex-situ* and *in-situ* aspects of conservation, it is possible to generate an integrated conservation plan for the species. However, it takes time and effort to start seeing results; the PCCA has put in more than 23 years of labor.
- The Artificial Incubation Center has demonstrated that in order to create an efficient conservation tool, one must work to unite domestic and foreign institutions. The condors bred here in isolation from human contact and fed with latex puppets have adapted perfectly to life in the wild and have come to reproduce with success.
- The creation of the Rescue Center has been instrumental in caring for over 120 wild condors in Argentina. While a small fraction of the condors (30%) were not able to survive due to the gravity of their injuries, 70% were able to recover and half of the total birds rescued returned to the wild. Since the Rescue Center must give an immediate response to each case and existing international law makes trans-frontier movement of animals very difficult, it is

Andean condor chick

recommended that each Andean country establish a rescue center for the species to allow efficient responses.

- Education and outreach programs are central in provoking a change in the perceptions and behavior of people towards a view favors the conservation of the species and the protection of its environment. The union of science (including the latest biotechnology) and the millennial worldview of the original South American communities, that has characterized the PCCA's work, has proven to be effective in implementing this strategy, spreading a clear conservation message and respect for all forms of life. The recruitment of qualified persons with experience in every level of the program is key in reaching these objectives and sustaining them over time.
- The collaborative efforts between the PCCA and partner institutions is also instrumental in achieving results. Each institution is like the feather of a condor: they are both small and large, strong and weak, but despite their differences each feather completes an important role in the flight of the condor.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- 100% of eggs incubated have hatched successfully; 47 condors were born under the watch of the PCCA and 100% have been released into the wild. Furthermore, more than 120 condors have been rehabilitated (though not all were healthy enough for release) after rescue in Argentina. In total, more than 147 birds were released throughout South America, including along the Atlantic Coast of Patagonia in Argentina, where they had been extinct. 44 Condors were released into the latter region, uniting areas of flight along the Andean mountains with those along the coast. The released condors have been reproducing since 2009.
- A focus on education has led to increased participation by the public and the success of a range of artistic and educative initiatives designed to spread information about the conservation needs of this emblematic species.

- Ultimately, the success of this project lies in its continuity. For 20 years the PCCA has worked towards protecting this species and has built a vast knowledge and technological base for the continued conservation of the Andean Condor.

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The Peregrine Fund's California condor recovery program, northern Arizona and southern Utah, USA

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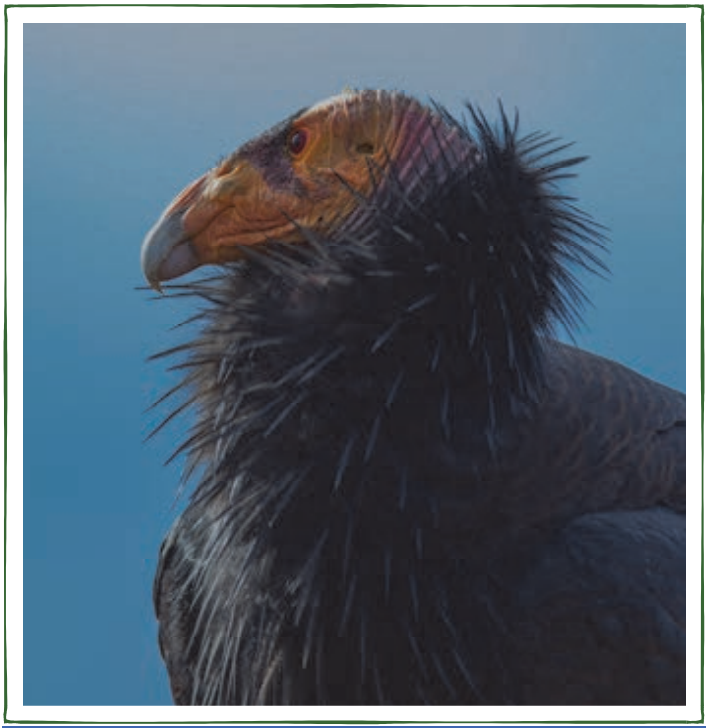
Introduction

Historically, the California condor (*Gymnogyps californianus*), North America's largest flying land bird, inhabited varying landscapes stretching between the Pacific and Atlantic coasts. A vast reduction of available food (carrion) in the form of now extinct Pleistocene megafauna resulted in a severe range reduction of the condor, leaving a remnant population along the Pacific coast subsisting in part on the remains of marine mammals (Chamberlain *et al.*, 2005). As part of an overall recovery program whose primary goal is to re-establish a population of 450 condors range-wide, a sub-population of over 70 condors now exists in northern Arizona and southern Utah. These free-ranging birds are a product of a re-introduction program beginning in 1996 under article 10(j) of the Endangered Species Act, a non-essential experimental population (USFWS 1996, Cade *et al.*, 2004).



California condor
© C. Parish, The Peregrine Fund

Despite an increasing population overall (captive and wild) - the result of a very successful captive-breeding program - the species remains listed as Critically Endangered on the IUCN Red List, and it appears on CITES, Appendix I and II (BirdLife International, 2013). Condors are slow to reproduce and require at least 92% adult survival for a stable population (Meretsky *et al.*, 2000). Persisting anthropogenic threats like that of lead poisoning among released populations require continued captive reproduction and release to replace fatalities.

Goals

- Goal 1: Contribute to overall condor recovery by establishing and maintaining a self-sustaining population of at least 150 individuals in northern Arizona and southern Utah.
- Goal 2: Reduce and eventually eliminate significant anthropogenic causes of mortality, particularly lead poisoning.
- Goal 3: Define and delineate suitable habitat by monitoring flock dispersal and analyzing collected data.
- Goal 4: Acquire a fuller understanding of the factors that influence pair formation and nest success.
- Goal 5: Increase local capacity for continued conservation efforts by engaging local and neighboring communities through sharing struggles and successes, thus making them a dynamic part of the program.

Success Indicators

- Indicator 1: Overall public acceptance of non-lead ammunition projectiles for killing animals whose remains may become available to scavengers in northern Arizona and southern Utah.
- Indicator 2: A strong trend of reduction in blood-lead levels and lead-caused morbidity and mortality among free-ranging condors in the region.
- Indicator 3: An annual adult survival rate of at least 92%.
- Indicator 4: A "normal" reproductive rate unaffected by lead-caused death among pair members and sufficient to population growth.
- Indicator 5: A local public pleased with and protective of the condor population in the region.

Project Summary

Feasibility: The fossil record holds evidence supporting the presence of the genus *Gymnogyps* back 100,000 years, although condors likely disappeared from the Grand Canyon region by the end of the last Ice Age (Emslie, 1987; Chamberlain *et al.*, 2005). Elsewhere, landscape changes (largely human-influenced) have both aided and hindered population stability. The introduction of domestic stock by Spaniards increased carrion availability, but the expanding human presence brought new threats to condors such as habitat loss, direct persecution, egg and specimen collection, and finally, lead poisoning that persists today. By the mid-1980s, 27 individuals remained, all in captivity, and seven pairs were selected for captive propagation.

A successful captive-breeding program, consisting of five institutions in three states and two countries, allowed for re-introduction in California, Arizona, and Mexico. With re-introduction, changing attitudes and land use policy, the population again stretches into the interior southwest.

Implementation: The Peregrine Fund began releasing condors in northern Arizona in 1996 (USFWS, 1996). Release candidates are brought to the release site at Vermilion Cliffs and housed in a 12 m x 18 m x 6 m flight pen to assess their suitability for release. Selected condors are fitted with radio-transmitters and

California condor release site
© C. Parish, The Peregrine Fund

then transferred to a smaller hackbox in full view of feeding areas and preferably, free-flying condors. Efforts are made to promote natural behavior to the extent possible (e.g. ample perches to encourage little to no ground perching, other than feeding, and food delivered under the cover of darkness to reduce association with humans). Mock, electrified power poles are placed both inside and outside of the housing facilities to discourage pole-sitting and to discourage any attraction to power-lines. Condors are soft-released, meaning the doors are remotely opened from an adjoining blind while additional field staff observe from a distance to monitor every move of departing birds during the ensuing days.

Post-release monitoring: Released condors are monitored by means of direct visual observation and radio-tracked with standard VHF (very high frequency) receivers and, in some cases, with GPS (global positioning systems) satellite-reporting technology. As of winter 2014, field staff were tracking and monitoring over 70 condors from the south rim of the Grand Canyon to the northern reaches of Zion National Park in southern Utah. Extended flights of more than 482 km have been documented, but the core of the population remains within a 112.6 km radius of the release area at Vermilion Cliffs National Monument in northern Arizona. Despite population dispersal and self reliance, staff continue to track and monitor the population afield, as movement data are vital to gaining and maintaining an understanding of variables contributing to mortality. In this regard, we are vigilant to any irregularity, including mishaps among recently released condors and condor-human interactions. These procedures have resulted in fewer adverse incidents.

When condor radio-signals become stationary, we respond immediately to determine the cause. We collect fatalities and quickly transfer them to laboratories where necropsies are performed to determine the cause of death. We carefully examine the site of each fatality to obtain additional evidence. We search for missing condors by fixed-wing aircraft. We monitor lead blood levels among condors that return to the release site, and treat condors showing high values or other evidence of dangerously high lead exposure. Lastly, we monitor pair formation, courtship, and other aspects of the nesting cycle.

Major difficulties faced

Condor field staff
© John Sherman Photography

- Avoidable, anthropogenic causes of mortality, particularly lead poisoning, have been the primary and persistent impediments to condor recovery.
- Although the process of identifying major threats and potential solutions in condor recovery has been relatively straightforward, effecting adequate and meaningful change is painfully slow.
- Initially, like many ESA species restoration programs, local communities feared that the re-introduction of the condor would somehow limit their freedoms, but through time and a better understanding of the protections afforded by the non-essential, experimental 10(j) designation, those fears waned.
- Condors are slow to mature, and do not do not produce viable young until their 8th year of life. The species also exhibits a low reproductive rate, producing a maximum of only two young every 3 years. As a result, population growth is slow, thus requiring long-term management and sustained financial support.
- High profile recovery efforts such as the California condor often attract large special interest groups whose agendas and/or reputations can negatively affect progress by either diluting or misrepresenting the core issues of the recovery program.

Major lessons learned

- Beyond the foundation of well-structured and detailed plans, nothing will better define problems and solutions than having the species in the landscape being tracked and monitored by field biologists.
- Patience, patience, patience. Without patience and a keen eye for detail, problems and potential solutions can be overlooked, or altogether missed. Where the ultimate goal of re-introduction is to recover a species, especially a long-lived species, the public and interested parties have a tendency to lose focus and even lose hope of eventual recovery. For this reason, we highly recommend setting, managing, and making known to all, reasonable expectations in the form of long and short-term goals or benchmarks.
- Species recovery is fertile ground for adaptive management. All too often, the tendency of scientists and biologists is to stick to a study design without

reappraisal. However, the flexibility of adaptive management in recovery efforts is much more effective, as is having the autonomy to make program-level decisions in a timely manner. At the same time, frequent re-evaluation protects against the sometimes-undesirable outcomes of abrupt changes. Efficient data collection and its timely examination aid in such reappraisals, and if appropriate data are collected in a consistent manner, then all decisions and results can be appropriately analyzed.

- While science should be the foundation of any re-introduction effort, one cannot rest at merely producing scientific results, even when they are perfectly in line with recovery goals. Scientific evidence alone does not build effective and lasting policy necessary to maintain a recovering, re-introduced species, nor does effective policy rest in well-written and well-guided suggestions. For policy to become effective, the problems must be credible to managers and the public, and ultimately, the changes must become part of the local culture.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Except for their predisposition to encounter lead within their food, condors tolerate a high level of intrusion and hands-on management, making possible the tracking, blood testing, and in some cases, invasive medical treatment. These characteristics have allowed for a greater understanding of the issues condors face.
- Despite the very long duration of the effort (condors were among the first species listed under the Endangered Species Act), governmental agencies, well-meaning policy, and the public continue with financial and moral support. This suggests that recovery is possible, even though painfully slow and arduous.
- One of the greatest successes of the Condor Recovery Program thus far is the cooperative nature of the program. Numerous players, including governmental and non-governmental agencies, have come together to see this process through. The continued strain of financial need is among the greatest stressors, but with many willing cooperators contributing their time and hands-on effort, the program has had many successes. True success, however, lies in the definition of recovery - a self-sustaining condor population - and will remain the ultimate goal of this effort.
- Lead poisoning accounts for greater than 50% of diagnosed deaths in the Arizona/Utah population and a likely substantial proportion of undiagnosed fatalities. Under current exposure conditions, it is not sensible to continue without the hope of further lead reduction. To eliminate the presence of available lead, or reduce it to a sustainable level of threat for the condor, program participants must generate effective policy that results in lasting change. That requires public acceptance and participation. Understanding that we, as a culture, are sometimes slow to change, program direction must

proceed in the direction of the social sciences. We must better understand how to share scientific findings with the public in such a way that brings about behavior and traditions that will ultimately ameliorate the problems revealed by the initial science. Doing so will complete the task, and allow this effort to become a true and lasting success in conservation.

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The Great Crane Project - common crane re-introduction in South-West England

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Introduction

The common crane (*Grus grus*) has a current world population of 360,000 and is categorized as being of 'Least Concern' (www.iucnredlist.org). In Europe, the main breeding populations are concentrated through Germany, Poland, the Baltic States and Scandinavia with breeding in western European countries very low in comparison. There have been significant historical declines in the European population with the species categorized as 'Depleted' in Europe. In the UK, drainage of wetlands and hunting during the Middle Ages led to extinction by 1600 (Stanbury, 2011). A natural recolonization began in eastern England during the 1980s with the resident population growing to 44 birds by winter 2010, and around 14 pairs (5 year avg. 2008 - 2012) breeding annually (UK Crane Working Group). In 2006, plans began on a UK re-introduction to help secure this vulnerable population. A translocation feasibility study was carried out in 2007 and The Somerset Levels & Moors (64,000 ha of low-lying peat-dominated floodplain) in the South West of the UK was selected as the most suitable re-introduction location. The first birds were released in 2010 with the project more than doubling the total UK population by 2014. The ultimate success of the project will depend on successful breeding into the future.

Goals

- Goal 1: To help secure the UK crane population.
- Goal 2: To establish a sustainable breeding population of cranes on the Levels and Moors.
- Goal 3: To use the re-introduction to build support for wetlands in the local communities.
- Goal 4: To enhance and create wetland areas for breeding cranes and other wetland species.

Success Indicators

- Indicator 1: To rear and release 100 birds over 5 years.
- Indicator 2: To establish 60% survival to adulthood.
- Indicator 3: To establish a breeding population of 20 pairs in South West of the UK by 2025.
- Indicator 4: To ensure 10 existing potential breeding locations are made secure for cranes.
- Indicator 5: To create 10 new potential breeding locations through habitat creation works.

Project Summary

Common crane

Feasibility: A feasibility study carried out in 2007 looked at the various habitat parameters that are pertinent to establishing cranes in the UK. An initial long-list of 11 potential sites was shortened to three after further assessment for their suitability. Availability of invertebrate-rich chick rearing habitat, presence of breeding zones, availability of winter feeding areas, likelihood of disturbance from people, disturbance by aircraft, density of potential predators, presence of powerlines, availability of suitable agri-environment schemes, and proximity to current areas used by cranes were all considered in this process. Following more detailed fieldwork and further analysis, the Somerset Levels & Moors was selected as the most suitable location in the UK for an introduction. During the feasibility stage, two of the project partners - The Wildfowl & Wetlands Trust and The Pensthorpe Conservation Trust, trialed rearing techniques for common crane chicks, with a 'crane-school' established at WWT Slimbridge, to costume-rear chicks from captive-sourced eggs.

Implementation: After funding was secured in the summer of 2009, a project manager was appointed and a project implementation group, consisting of specialists from the three conservation partners (RSPB, WWT & PCT) established to drive the project forward. A 'disease risk assessment' was commissioned (carried out by the Zoological Society of London); planning consent for building the rearing and release facilities was sought; and consent gained from the Dept. of Food and Rural Affairs (Defra) and Natural England for the release. This process included writing economic and biodiversity impact assessments, and a public consultation. Meetings were held with local landowners and a questionnaire survey was carried out to establish if this re-introduction was in the public interest and 95% of respondents wanted to see the common crane back in Somerset.

An agreement was drawn up with conservationists and the state authority for the Schorfheide-Chorin Biosphere Reserve in Brandenburg, Germany, to provide the project with up to 30 eggs per year for 5 years. Import licenses were secured for the transport of eggs to the UK, and CITES certification granted. The first eggs were collected in spring 2010, with up to 24 eggs transported back to the UK every spring each year until 2014 - a total of 121 eggs over 5 years. The eggs were taken to a purpose-built rearing unit at WWT Slimbridge, Gloucestershire, where they were hatched and hand-reared using a puppet/costume-rearing technique, developed from methods used in the whooping crane re-introduction in the USA (1984 to present). Strict biosecurity protocols were in place and targeted

pathogen screening and health examinations were implemented. At around 14 weeks old the cranes were driven in transportation crates to a pre-release, netted aviary in Somerset. Here they underwent a 'soft' release from their aviary into an adjacent predator-proof pen, and then out into the wider landscape. Supplementary feed was provided through the first autumn and winter to help 'anchor' the birds and to ensure they remained healthy. On release, the project team continued to work with the cranes in the rearing costumes to teach the birds to avoid predators and people. In total, 93 cranes were released between 2010 and 2014, with 74 currently known to be alive (November 2015). Despite some attempts in 2013 and 2014, breeding was not successful until 2015 where nine pairs bred and 4 chicks fledged and were recruited into the released population. Habitat creation works have been carried out to provide new crane breeding zones on five wet grassland sites on the Somerset Levels and Moors, with habitats enhanced on a further four and additional works planned for the summer of 2015. Community engagement activities have been carried out throughout the project including: involvement of local volunteers for rearing, monitoring and species protection work; an education program in local rural primary schools; collaborative creative arts activities; and the establishment of a stakeholder 'crane forum'. An interactive project website www.thegreatcraneproject.org.uk was set up and social media sites were established to tell the story of the project. Detailed reports were compiled annually and hosted on the website.

Post-release monitoring: All released birds were fitted with colored leg rings, to enable individual identification, and the majority were also fitted with leg-mounted radio tags. In combination, these have enabled 'on the ground' monitoring by project staff and a team of around 40 local volunteers from autumn release through to late Spring each year. Information has been recorded on the birds' general health and foraging habitats and entered into a purpose built database. Back-pack mounted GPS data-loggers, leg-mounted satellite PTT's, and leg-mounted GSM data-loggers have also been used during the project. These have enabled the remote gathering of detailed location and movement data which will be analyzed over the next 3 years through a PhD project. In addition, project and research staff and volunteers have put particular effort into monitoring molting birds, and carrying out daylight hour species protection watches of nesting pairs.

Researchers in the field © John Crispin

Major difficulties faced

- Gaining initial consent from DEFRA/Natural England.

- Achieving the target of 20 released birds each year, from a maximum of 24 imported eggs.
- Achieving successful breeding of released birds.
- Finding landowners willing to create breeding areas on their land.
- Finding locations where creation works will not compromise other conservation interests.

Major lessons learned

- Having a well-defined Memorandum of Agreement and good relationship with the egg donor partner has made the potentially difficult process of egg collection each year a great success.
- Having adequate staffing during the rearing phase, to ensure, for example, that birds have an appropriate level of exercise and food intake, which are essential in achieving a healthy population fit for release.
- It was well worth investment in a dedicated rearing unit and incorporation of strict biosecurity protocols, to safeguard chick health and prevent infectious disease.
- Ensuring a high degree of consultation with the farming community prior to release has been important to ensure that the birds are accepted, and to allay any fears.
- The local community engagement/education program has been very beneficial in helping to achieve the project's habitat creation aims, and ensuring a 'sense of ownership' of the released birds.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Survival rate of 80% to adulthood much higher than anticipated 60%.
- Target of 20 pairs by 2025 can not be assessed yet - but project on track.
- Successful fledging of four chicks in 2015 was a milestone for the project.

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Re-introduction of the oriental pied hornbill in its historical range in Singapore

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Introduction

The southern oriental pied hornbill (*Anthracoceros albirostris convexus*) is a common bird in most of its distribution area (CITES II) covering Malaysia, Sumatra, Java, Bali, Borneo and other islands in the region. This highly adaptable bird thrives in numerous urbanized areas throughout its range and shows remarkable tolerance for human presence. Never the less, it had been extinct in Singapore for over a 100 years when a pair of birds were sighted nesting in Pulau Ubin (a small island north-east of Singapore) in March 1994. When the Singapore Hornbill Project was initiated in 2004, the birds were still only present on this island and had not re-colonized the heavily developed main island of Singapore.

Goals

- Goal 1: In-depth study of the reproductive cycle through technology-assisted observations inside and around the nesting cavity (HD cameras, temperature and humidity sensors and weighing scales).
- Goal 2: Development of appropriate artificial nests to increase the number of potential breeding cavities in suitable areas.
- Goal 3: Identification and enrichment of nesting and foraging sites suitable for the species on mainland Singapore.
- Goal 4: Increase population in Singapore mainland.
- Goal 5: Assure genetic diversity of re-introduced population through input of non-consanguine individuals from captive stocks.

Southern oriental pied hornbill

Success Indicators

- Indicator 1: Collection of necessary data for an in-depth comprehension of the reproductive ecology

of the species, in order to establish a detailed list of requirements for breeding.

- Indicator 2: Utilization of artificial nests by potential breeding pairs in a wild environment where trees with large cavities have become scarce.
- Indicator 3: Colonization of improved environments (garden and parks on Singapore mainland) by breeding pairs.
- Indicator 4: Establishment of a viable breeding population throughout Singapore territory.
- Indicator 5: Successful breeding of non-related individuals.

Ringing hornbills

Project Summary

Feasibility: Oriental pied hornbills are large birds, nesting in tree cavities in which the female remains confined for the whole duration of the breeding cycle, entirely depending on the male for feeding and supply of nesting material.

In 2004, a field study was initiated on the sole existing breeding pair on Singapore territory. At this time, the species was confined to the small island of Ubin, north-east of Singapore. It led to much deeper investigations on the breeding-cycle with the monitoring of the nesting cavity and its surroundings through close-circuit television cameras. From the very start, students, volunteers and government agencies were involved in analyzing data with the objective of understanding the biology of the species, engage in its conservation and possibly, in its re-distribution over its historical range throughout Singapore. The species absence from the mainland for over a 100 years could be explained by the scarcity of suitable nesting cavities and foraging areas due to the intense urbanization of the original habitat.

Implementation: Suitable re-introduction areas were identified and enriched under the direction of the Singapore National Parks board while our team was working on the realization of artificial nests tailored to satisfy the needs of the species, assure safety from main predators (civet cats and reticulated pythons) and water as well as allow for further studies. The nests were first and successfully experimented on captive birds at the Singapore Bird Park.
A strategy was jointly designed by the Singapore Hornbill Project team and National Parks to distribute artificial nests and re-locate birds in such way as to

allow for a spreading of the newly introduced population throughout the desired range.

Nests were first placed in areas where they could attract visiting birds (from neighboring Malaysia) and offspring of the breeding pairs of Ubin, while the population was strengthened with two re-introductions (total of 3 birds) from captive stock donated by WRS (Wildlife Reserves Singapore). Several translocations of birds from the Ubin stock were also carried out to avoid in-breeding and assure genetic diversity. Genetic studies of wild and captive populations have been performed by the Singapore National University. The artificial nests were readily adopted by the birds and a resident, breeding population of southern oriental pied soon established itself across the island.

Post-release monitoring: Several artificial nests were equipped with high-tech monitoring devices to allow for in-depth studies of the breeding ecology of the species. The final version of the nest included 4 HD cameras with zooming capacity, temperature, humidity, CO_2 and oxygen sensors, 2 electronic weighing scales (on outside perch and inside the nest). All equipment was connected to 2 computers and recording 24 hours a day. Data collected through this close monitoring brought a very comprehensive understanding of the breeding ecology of the species as well as some startling discoveries such as infanticide-cannibalism. A couple of males were also equipped with specially designed GPS devices to measure and monitor their movements during the breeding season. These studies were publicized through public screenings of movies, public talks and scientific publications. After 6 years of efforts, the Singapore population was counted to be over 100 birds, with 10 confirmed breeding pairs. The majority started nesting in the provided nests and moved to natural cavities in the following breeding seasons. This seems to show that the number of birds will be regulated by the availability of nesting cavities across the territory and should not need intrusive management strategies in the future. Genetic diversity of the population, on the other hand, may require monitoring over the years.

Hornbill on tree in urban habitat

Major difficulties faced

- Identification of suitable habitat in a highly urbanized environment with few suitable natural nesting cavities and food shortage.
- Education of resident populations to avoid capture and/ or conflict with the birds.

- Assure the establishment of the birds on very small and highly disturbed territories.

Major lessons learned

- In a world with fast receding natural environments, the challenge of offering venues for wildlife in our highly developed urban areas should be explored further. Our cities can host certain diversity and number of wildlife if properly planned.
- This forest species has shown adaptability to urban environment and human proximity above expectations.
- Never the less, this adaptability should not be over-estimated and co-existence with wildlife in urban environments requires long-term and well-studied development.
- Co-existence with wildlife has a strong impact on awareness about environmental issues on resident populations.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Strong and durable support of local government agencies and partners.
- Successful enrichment of habitat to host birds.
- Overall positive response and interest of resident populations.
- Availability of high-tech equipment on site.
- Cohesion of the team for the whole duration of the project (6 years).

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Re-introduction of the vinaceous-breasted Amazon at the Araucárias National Park, Santa Catarina, Brazil

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Introduction

The Psittacidae family has some of the most threatened species. Two of the main reasons for the rapid and on-going population decline are habitat destruction and illegal nest poaching. The vinaceous-breasted Amazon (*Amazona vinacea*) is the most endangered parrot species of the Atlantic Forest, one of the world's top biodiversity hotspots *A. vinacea* historically occurred in Brazil from south of Bahia to Rio Grande do Sul, inland to southeastern Paraguay and southern Misiones, Argentina. It has become rare throughout its extensive range and its estimated population ranges from 1,000 - 2,500 individuals. Currently, it is listed on CITES Appendix I and II, the IUCN Red List (1) as Endangered with “a very high risk of becoming extinct in the wild in the immediate future”. In Brazil, the species is considered Vulnerable C1. Populations are considered extinct in some areas, including the Araucarias National Park (ANP), Santa Catarina, Brazil. The project to re-introduce *A. vinacea* in the Araucárias National Park, started in 2010. A total of 76 birds (69 victims of illegal wildlife trade, six offspring of confiscated birds which were born at the Curitiba Zoo and one fledgling rescued at the ANP) have been rehabilitated, released and monitored as part of the first parrot re-introduction effort in a National Conservation Unit approved by the Chico Mendes Institute for Biodiversity Conservation (ICMBio).

Vinaceous-breasted Amazon

Goals

- Goal 1: Select and rehabilitate *A. vinacea* victims of the illegal wildlife trade for release, according to their origin, health and behavioral status.
- Goal 2: Evaluate rehabilitated *A. vinacea* during the acclimation period at the Araucárias National Park and monitor released birds and their offspring.

- Goal 3: Search for and monitor nests used by released *A. vinacea*.
- Goal 4: Generate and provide scientifically sound information about *A. vinacea* conservation issues to stakeholders, including the local community, general public, scientific community and decision makers and regulators.
- Goal 5: Create socioeconomic opportunities for the local community based on the principles of green economy, having *A. vinacea* as a theme.

Success Indicators

- Indicator 1: Physically and behaviorally healthy *A. vinacea* confiscated in southern Brazil are selected for release in the Araucárias National Park.
- Indicator 2: Birds are evaluated during the acclimation period at the Araucárias National Park, released and monitored by researchers and local citizen scientists.
- Indicator 3: Nests used by released *A. vinacea* are identified and monitored.
- Indicator 4: Scientifically sound information about *A. vinacea* are generated and provided to stakeholders.
- Indicator 5: Socioeconomic opportunities for the local community based on the principles of green economy, having *A. vinacea* as a theme, are created.

Project Summary

Feasibility: Aiming to contribute to *A. vinacea* conservation, an on-going project was initiated in 2010 in order to re-introduce the species at the Araucárias National Park (ANP) giving it the social-environmental support necessary for the long term establishment of a viable population. *A. vinacea* was historically present the municipalities of Ponte Serrada and Passos Maia in Santa Catarina, Brazil (S 26° 39'-26°52', W 51° 47'-52° 02') which now constitutes the ANP. The 12,000 ha area was suggested as a viable re-introduction location at ANP management plan (ICMBio, 2010) (Rupp, 2009). ANP provides high quality habitat for the vinaceous -breasted parrot, as it provide both nest cavities and food availability from many trees, including the *Araucaria angustifolia* tree (ICMBio, 2010; Rupp, 2009). The local threats include the presence of domestic animals, over-harvesting of Araucária seeds and illegal nest poaching, which was the probable cause for local extirpation. In order to improve the chances of re-introduction success, a program to educate and generate work and extra income to the local community was implemented to contribute to the socio-economic development and environmental protection. Scientific information gathered has been shared with the scientific community and general public.

Implementation: Since September of 2010, a total of 102 birds have been through the rehabilitation process and 76 birds have been released as part of the first parrot re-introduction effort in a Brazilian National Park approved by the Chico Mendes Institute for Biodiversity Conservation (ICMBio). Protocols were approved by IBAMA, the Chico Mendes Institute for Biodiversity Conservation (ICMBio protocol number 25133 and 41776) and the Federal University of Santa Catarina ethics committee for animal research (PP00589). During the pre-release phase, which lasted approximately 4 months, data on behavioral time budget, weight and biometry were collected. Candidates had behavioral deficiencies and were trained daily to look for and manipulate natural

Educational awareness activities

food items, to avoid humans, to stay off the ground and to fly continuously with a radio-collar on. All veterinary exams suggested by the IBAMA 2008 Instrução Normativa 179 (3) and SISBIO license were performed.

All birds received leg bands from the National Center for Bird Conservation (CEMAVE) of Brazil and went through an acclimation period at the release site. Only birds which met the criteria necessary were released: 13 individuals in January, 2011 (Vanessa & Reche, 2012), 30 in September, 2013 and 33 in June, 2015. All birds were monitored throughout the study by a research team 2 days a month and daily by local citizen scientists through visualization, vocalizations and 48 birds were equipped with radio-collars (33 TXD-203C, Telenax, Mexico and 15 Pip Ag357, Lotek, Canada). More than 526,355 residents from local communities benefit from educational activities conducted monthly at properties, schools, local companies and through the radio by gaining new information about *A. vinacea*, the habitat they share and conservation issues. The species has become so popular locally that it was chosen by the community to represent the fauna in the logo of the Araucárias National Park, it is stamped on the back of local school buses and postage stamps. A line of “vinaceous-breasted amazon and Araucária” themed handcrafted products have been developed by a group of 5 local women named *Amigas dos Roxinhos*. The proceeds are used by the craftswomen as an extra source of income, which was an average of US$ 13,123 in the beginning of the project. This program has created an economic value to the Amazons in the wild.

Post-release monitoring: The project has shown vinaceous-breasted Amazons, victims of wildlife illegal trade, can be successfully rehabilitated for re-introduction purposes Released birds have adapted well to the natural environment, groups of 2 - 15 birds are observed frequently, although there was a confirmed mortality of 19.73% since January 2011. At least 6 pairs were identified, one tree hole used as a nest was located, a total of 9 offspring have been observed and one was rescued after falling in the ground and failure of reunion with the parents. These results indicate that it is possible to reduce threats at the release area with programs focused on socio-economic development and environmental protection. Data on parrots rehabilitation, release and monitoring, as well as the impact of the work on community members’ perception have been generated through the scientific method and shared in order to educate stakeholders

through reports, journal articles, and educational materials, such as pamphlets, educational campaigns, comic books, a website and social network updates, texts to the media/journalists.

Vinaceous-breasted Amazon in flight

Major difficulties faced

- Resistance from some Brazilian research scientists in recognizing re-introduction of Amazons victims of wildlife trade as a conservation tool.
- Demonstrating to the public that parrots are wild animals and should not be kept as companions.
- Coordinating a dialog among environmental agencies and stakeholder groups to reach agreement about patrolling of the release area.
- Assuring long-term financial resources to continue the project.
- Finding a good long distance monitoring equipment available for Amazons.

Major lessons learned

- It is possible to successfully release parrots victims from illegal wildlife trade, improving animal well-being, giving individuals a chance to play their ecological roles and contributing to species conservation.
- Involvement of local citizen scientists greatly increase monitoring success and improve patrolling efforts.
- Re-introduction success depends on close cooperation among diverse governmental agencies and local stakeholders and that can be achieved by the creation of a "*Amazona vinacea* protection network".
- Creating an economic value to amazons in nature greatly contributes to community members collaboration with re-introduction efforts.
- Establishment of a viable population is a long-term goal which will be achieved by releasing small groups and long-term monitoring.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Survival and reproduction of illegal wildlife trade victims released as part of the re-introduction effort.

- Decrease in the intensity of threats through the educational activities and socio -economic opportunities created to the local community.
- Creation of the "*Amazona vinacea* protection network" with government authorities and important stakeholders.
- Engagement of community and governmental agencies through local initiatives to support the species conservation (e.g. choice of species as symbol of the Araucarias National Park, picture of the species in all school buses, city stamp with the species as a theme)
- Scientifically sound information about *A. vinacea* and re-introduction efforts generated and provided to stakeholders.

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Nihoa Millerbird translocation from Nihoa to Laysan, Northwestern Hawaiian Islands, USA

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Introduction

The Millerbird (*Acrocephalus familiaris*) is an insectivorous passerine endemic to the Northwestern Hawaiian Islands (NWHI). The genus is widely distributed in Asia, Europe, Africa, and Australia, and 19 species are endemic to individual archipelagos or islands in Oceania. Two subspecies of Millerbird once occurred in the NWHI, *A. f. kingi* on Nihoa and *A. f. familaris* on Laysan. Destruction of Laysan's native vegetation by introduced mammals led to the extinction of the Laysan Millerbird by 1923. The Nihoa Millerbird persisted on Nihoa, a volcanic fragment 1,047 km to the southeast. The Nihoa Millerbird is designated as Critically Endangered by IUCN and listed as Endangered under the U.S. Endangered Species Act.

The NWHI stretch 1,700 km northwest from Nihoa to Kure Atoll. Access is restricted and transport to Nihoa and Laysan Islands is by sea only. Although modified by past human activities, the NWHI harbor a globally unique assemblage of breeding seabirds and landbirds, endemic plants, and insects, many of which also are imperiled. The NWHI and their surrounding waters are designated as Hawaiian Islands National Wildlife Refuge, Northwestern Hawaiian Islands Coral

Nihoa Millerbird on Laysan © R. Kohley

Reef Ecosystem Reserve, and Papahānaumokuākea Marine National Monument and World Heritage Site.

Goals

- Goal 1: Conduct background research on food availability on Laysan *vs.* Nihoa, morphometric sexing techniques, and husbandry required to safely support the birds for 8 days holding and transport.
- Goal 2: Translocate a total of 50 Nihoa Millerbirds (even sex-ratio) from Nihoa to Laysan Island in two or more cohorts in consecutive years.
- Goal 3: Establish a breeding and increasing population of Millerbirds on Laysan that increases the species' abundance and distribution, thereby reducing the overall risk of extinction.
- Goal 4: Contribute to two decades of restoration work by re-establishing *Acrocephalus familiaris* on Laysan, where the species was extirpated in the early 20th century.
- Goal 5: Stretch the boundaries of possible long-distance translocations in Oceania, and generate interest in and support for translocation/re-introduction as a practical tool for the conservation of endangered birds in Hawai'i.

Success Indicators

- Indicator 1: A comprehensive translocation protocol is developed, including a biologically supported decision to release Millerbirds on Laysan, methods for reliably sexing Millerbirds in the hand, and field-tested husbandry techniques for supporting the birds in captivity in healthy condition for at least 8 days, including at least 3 days at sea.
- Indicator 2: A total of 50 birds representing an even sex ratio is captured on Nihoa, transported to Laysan and safely released.
- Indicator 3: At least 50% of birds survive translocation; 75% of survivors exhibit breeding behavior and 25% of females produce independent young within 1 year. At least 70% of released birds survive for at least 1 year, breeding continues, and the species becomes established on Laysan.
- Indicator 4: Millerbirds are documented using multiple vegetation types for foraging and nesting.
- Indicator 5: Land managers, regulatory agencies, and the conservation and native Hawaiian communities in the islands are involved in and supportive of

this project and actively engaged in discussion of other endangered species translocation projects in the islands.

Project Summary

Feasibility: Creating a new population of Millerbirds on Laysan involved numerous biological, logistical, regulatory, and fiscal challenges. Owing to the extreme difficulty of accessing Nihoa and doing field work there, studies of the Millerbird's life history and ecology have been limited. The species' movements and territoriality, genetic variability, and sexual dimorphism were unknown prior to studies conducted in recent years in preparation for this translocation project. Monitoring surveys conducted since 1967 documented a widely fluctuating population with rough population estimates (with high variance) ranging from 30 to more than 800 individuals. Nihoa's very small size (72 ha) suggests that the highly territorial Millerbirds may reach carrying capacity at 1,000 - 1,200 birds. Threats from established invasive species (e.g., the gray bird locust (*Schistocerca nitens*) and potential future introductions make the future of Nihoa's endemic species uncertain. Laysan is much larger (415 ha), but has a maximum elevation of 15 m compared with Nihoa's 277 m, and somewhat different biota. Humans, livestock, and finally a rampant population of feral rabbits had severely degraded Laysan by the early 20th century, when *A. f. familiaris* went extinct. We therefore had to ascertain if Laysan had recovered enough in response to restoration efforts by the U.S. Fish and Wildlife Service since 1990 to again support Millerbirds. Transport by sea and establishing field camps in the remote NWHI are extremely expensive and logistically complex. Every trip must be planned in detail, adequately funded, and scheduled with flexibility to maximize the chance of success. Transport among remote islands in Hawai'i typically relies on various agencies' vessel schedules, and these typically are changeable without notice. Therefore a dedicated charter vessel was required to move birds. Nihoa is a site of high archaeological and Hawaiian cultural importance, and native Hawaiian representatives are involved in field work and overarching management decisions on the island.

Implementation: We conducted several years of research to answer outstanding biological and logistical questions. We confirmed that the habitat and prey-base (moths, flies, and other mobile arthropods) on Laysan were adequate, built a morphometric database and conducted genetic analyses that

Moving Millerbirds off Nihoa © R. Hagerty

validated sexing Millerbirds in the field. Holding small (~18 g), energetic, insectivorous birds in captivity, acclimating them to a novel diet, and maintaining their condition during a long voyage required captive trials on Nihoa (conducted in 2009 and 2010) to develop unique avicultural methods and equipment. The difficulty and danger of landing on Nihoa and Laysan - and moving endangered birds off and onto the islands - in rough seas or inclement weather limited the timeframe for translocation to June - September, when calm seas are most common. The timeframe was further truncated to August - September to avoid removing birds with dependent young. We contracted a research vessel with a flexible schedule, a cabin that could be modified to meet avicultural and veterinary specifications, and crew experienced in the NWHI and wildlife work. Intensive fund-raising was needed each year beginning in 2006 to support all phases of the project. Vessels and field teams in the NWHI must minimize disturbance to native species, including endangered species and vast seabird colonies; follow strict quarantine procedures to prevent introduction of alien species to the islands; and ensure that Nihoa's cultural and archaeological significance are respected and maintained. These considerations, and the Millerbird's status and small population on Nihoa, necessitated extensive project review and compliance under multiple federal and state laws and early involvement of native Hawaiian cultural monitors in all components of the project. We developed a detailed translocation plan that was widely peer-reviewed, and translocated a total of 50 Millerbirds from Nihoa to Laysan in 2011 and 2012.

Post-release monitoring: Based on breeding behavior observed on Laysan, the sex of all but six translocated Millerbirds was correctly identified. Survival, nest success, and habitat use were monitored on Laysan following the translocations. Survival was monitored using VHF radio-transmitters placed on half of the first release cohort (2011) and all of the second (2012), and by re-sighting color bands placed on all birds (2011, 2012). One-year survival was 58% in the first cohort and 96% in the second. As of September 2014, 54% of the 2011 cohort and 92% of the 2012 cohort survive. When combined with birds produced on Laysan, the minimum population estimate is 164. Following several failed efforts, the first successful nesting attempt occurred in March 2012, approximately six months after the first translocation. The Millerbird population has remained largely confined to the naupaka (*Scaevola taccada*) shrubland on the northern end of Laysan, the location of the original release sites. The number of breeding territories (held by paired and unpaired singing males) in this area has increased steadily from 11 in 2011 to 75 in 2014.

Major difficulties faced

- Access to Nihoa is highly restricted by regulations to protect its native biota and cultural value, by the expense of getting there, and by weather and safety concerns (landing on and getting off the island is always dangerous and can be impossible).
- Planning ahead and securing commitments from key team members was a major challenge because, owing to the nature of our principal funding sources, obtaining committed funds for more than 1 year at a time was not possible, and some funding sources were unpredictable from year to year.

- Convincing decision-makers and funders to support a project with many inherent risks to the endangered species and people involved (and to scarce conservation resources invested) was difficult.
- Continuous year-round monitoring of the nascent population on Laysan ended in 2013, when the field camp on Laysan was closed (after more than 20 years). Seasonal monitoring of the Millerbird population was interrupted by tropical storms and evacuation of team members from Laysan in 2014. Monitoring is likely to be seasonal and limited for the foreseeable future.

Major lessons learned

- Invest in answering as many key scientific and logistical questions as possible ahead of time with research and trials that produce data and direct experience.
- Identify and attract specific expertise and cultivate long-term commitments to project implementation.
- Identify and involve stakeholders and decision-makers as early as possible and ensure that concerns are aired and addressed. Share project news and milestones often and proactively and often and do not stint on attractive outreach and publicity that portrays the project as courageous and pioneering (not dangerous and liable to fail).
- Our original criteria for gauging the project's success included the Millerbirds using multiple vegetation types on Laysan (Indicator 4, above), but 3 years after the second translocation, foraging and breeding are still concentrated to the large expanse of shrubland where the birds were released. In hindsight, we do not believe this was a realistic or necessary criterion for a thriving Millerbird population on Laysan. Millerbirds are highly territorial, and have small territories in prey-rich habitat. We anticipate that their use of other types of vegetation, or other parts of the island, likely will be a density-dependent occurrence.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- We invested years in background research and field trials to fill information gaps and develop a detailed translocation plan, and in the process built a distinguished and committed team representing all requisite expertise for the project (field ornithology and avian ecology, avian husbandry and veterinary care, endangered species translocation and monitoring, and expert vessel support for wildlife research and conservation).
- The strong partnerships among public agencies and private organizations that characterized this project ensured that we had: 1) the support and participation of the native Hawaiian community in all aspects of the work, 2) support from agencies that facilitated obtaining permits to access the islands and work with endangered species, and 3) fundraising capacity to support extremely expensive vessel charters and field camps each year from 2006 to 2014.

Millerbird release on Laysan © L. Greig

- Millerbirds became established on Laysan because they are tough, adaptable island generalists and, owing to decades of restoration, the island's vegetation structure and abundant insect prey are similar to Nihoa's. The birds settled into their new habitat very rapidly and began breeding successfully.
- The two translocation events each were successful owing to: 1) the birds' ready acceptance of captivity and a novel diet, 2) aviculture techniques and transport equipment designed and field-tested specifically for this project, 3) meticulous planning, 4) a field team that was well organized, highly skilled, and passionately committed, and 5) cooperative weather and seas.

Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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A trial of release protocols for re-introduction of the bush stone-curlew to southern Australia

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Introduction

The bush stone-curlew (*Burhinus grallarius*) is a ground-dwelling non-passerine endemic to Australia. The total population is estimated at 15,000 birds (Garnett & Crowley, 2000). The species is listed as 'Least Concern' under IUCN criteria. Nevertheless, populations in southern Australia have suffered a marked decline over the past century (Marchant & Higgins 1993; Schodde & Tidemann, 1997). The species is listed as Endangered in the states of New South Wales and Victoria, where populations are estimated at around 1,000 breeding pairs. The key threatening processes are identified as poor recruitment due to predation by feral cats (*Felis catus*) and foxes (*Vulpes vulpes*), exacerbated by land clearing and loss of woody debris utilized for camouflage (Schodde & Tidemann, 1997; DEC, 2006).

Australian Wildlife Conservancy (AWC), a not-for-profit private conservation organization, is a leading exponent of re-introductions in Australia. Most re-introductions by AWC to date have been native mammals. In 2013, AWC conducted a trial re-introduction of bush stone-curlews to Scotia Sanctuary, south-west New South Wales. Birds were released inside a 4,000 ha fenced enclosure free of feral predators, into which a number of native marsupials had already been re-introduced, and to an adjacent area where foxes and cats were present, but controlled.

Bush stone-curlew
© David Roshier

Goals

- Goal 1: Establish a population of bush stone-curlews on Scotia Sanctuary from mixed genetic origin, whereby a breeding cohort is established and young are successfully recruited into the population.
- Goal 2: Assess whether re-introduction of bush stone-curlews in semi-arid southern Australia requires

complete exclusion of feral predators, or whether suppression of feral predators is sufficient.
- Goal 3: Trial delayed release protocol to encourage site fidelity post-release.
- Goal 4: Trial delayed release protocol to facilitate juvenile flocking behavior post-release.
- Goal 5: Trial provision of supplemental food post-release to encourage site fidelity and improve survivorship of captive-reared birds post-release.

Success Indicators

- Indicator 1: Short term (3 months)
  - ⇒ Success in the trial release methodology, resulting in individuals remaining as a flocking group, remaining in the local area, and >75% of released birds surviving 3 months post-release.
- Indicator 2: Medium term (3 - 12 months)
  - ⇒ Continued presence of birds in the local area with >50% survivorship at 12 months (or until transmitters stop functioning, a maximum of 12 months).
  - ⇒ Establishment and evidence of birds at known roosts (on camera traps).
- Indicator 3: Medium/long-term (1 - 5 years)
  - ⇒ Annual detection of birds via call play-back.
  - ⇒ Evidence of breeding.
- Indicator 4: Long term (>5 years)
  - ⇒ Evidence of breeding.
  - ⇒ Estimated numbers match or exceed numbers released.

Project Summary

Feasibility: Scotia Sanctuary is a 64,653 ha property located in south-west New South Wales, Australia. It has a semi-arid climate (250 mm rainfall/annum) and the dominant vegetation is 'mallee' (*Eucalyptus spp.*) on sand dunes and belah (*Casuarina pauper*) in swales (inter-dune area in a dunefield). Within Scotia, two 4,000 ha areas are enclosed by conservation fencing. Introduced predators (foxes & cats) and herbivores (goats, rabbits) have been eradicated from the fenced area, facilitating the re-introduction of five species of regionally extinct marsupials. Outside the fence, feral predator control (primarily targeting foxes) is undertaken across 37,000 ha, with the aim of reducing the density of feral predators sufficiently to conserve native fauna.

The bush stone-curlew is a nocturnal ground-nesting bird once present over much of Australia. Outside the breeding season, birds form groups of 10 to 20 individuals that walk or fly to foraging grounds within 20 km of roosting sites (Schodde & Tidemann, 1997). Given its vast range, the bush stone-curlew is not reliant upon particular habitats. In western NSW, the bush stone-curlew utilises chenopod shrublands, spinifex hummock grasslands and semi-arid woodlands dominated by belah with leaf litter, a grassy understorey and fallen timber (OEH 2015). Bush stone-curlews previously occurred across the 'mallee' landscapes of

southern Australia. Extant populations occur along the Murray River, 180 km south of Scotia.

Belah woodland habitat © W Lawler - courtesy of Australian Wildlife Conservancy

Implementation: Twenty birds were sourced from five different captive-breeding facilities across three Australia states. Birds underwent health screening and were sexed via DNA analysis prior to arrival at Scotia. Birds were divided into two release groups of equal sex ratio and mixed genetic origin then held in their release groups in aviaries constructed 1) inside and 2) outside the conservation fence (at the core of the feral predator control area), for a minimum of 30 days before release. The delay served as a quarantine period and was expected to facilitate acclimatization, encourage juvenile flocking behavior and improve site fidelity post-release. Water and supplemental food were provided daily, with the proportion of live prey increased gradually to improve foraging ability.

During the animals' final week in the aviaries, they were captured and fitted with unique individually numbered metal Australian Bird and Bat Banding Scheme (ABBBS) bands on the tarsus, a numbered coloured leg band on the tibia (for visual identification), and a small leg-mounted VHF radio transmitter on the tibia (typical range of 500 m and 1 year battery life). While in hand, all birds underwent post-quarantine health screening. Birds remained in aviaries for an additional week to recover from the handling process before being released. Aviary gates were opened in September 2013 to coincide with the seasonal increase in invertebrate activity. Supplementary water was provided continually and food was provided daily for 2 weeks after release, then weekly for the next month.

Post-release monitoring: Camera traps were established at aviary gates, feed stations and water points to monitor usage for 2 months post-release. Radio-tracking provided information on dispersal, group behavior and survivorship. Each bird was located daily for the first two weeks post-release, 2 - 3 times a week for the following month, and weekly thereafter, until they were no longer detectable. Radio-tracking was first done from a vehicle driving along a network of tracks using an omni-directional antenna and scanning receiver. Once birds were detected, directional antennae were used on foot to get a sighting (transmitters did not have 'mortality mode') or triangulation of the bird. Once birds were no

longer detectable, call play-back surveys were carried out. Nine months post-release, 53 sites were surveyed across Scotia with no responses heard. Survivorship was lower for birds inside the conservation fence, with five of the 10 birds dying 4 - 6 weeks post-release compared to one bird outside the fence. Post mortems attributed most deaths to starvation, suggesting that food access or availability was a more significant factor than predator densities during establishment in the re-introduction. Radio-tracking and camera trap data showed that birds inside the fence were further from their group mates, had lower site fidelity, and returned to the aviary less frequently during the first 2 weeks after release (while free feed was provided) compared with birds outside the fence. The lower frequency of aviary visitation and use of supplementary feed by birds inside the fence could be explained by the presence of re-introduced marsupials which were utilising the supplementary feed and excluding or disrupting feeding by the bush stone-curlews. In contrast, birds outside the fence maintained a high rate of aviary visitation until the daily feeding ceased. These outcomes suggested that unhindered access to supplementary food was critical during the first 2 weeks post-release.

Aviary screened from the potential approach of external animals

Major difficulties faced

- During planning, predation by introduced predators was considered the major risk to the re-introduction. However, the major actual cause of mortality was starvation. Furthermore, birds released inside the fenced area unexpectedly faced high levels of competition for supplementary food from re-introduced marsupials. This competition confounded our ability to compare outcomes of complete exclusion of introduced predators with suppression of introduced predators on the survival and establishment of bush stone-curlews.
- Leg-mounted VHF transmitters did not work well in this landscape for this study. The actual range was far shorter than expected, meaning that the birds could not easily be detected by the vehicle mounted omni-directional antenna from the network of tracks. Fifty percent of birds from each release group were detected for the first month post-

release, however the rate of detection declined quickly. Detectability declined substantially between 4 and 7 weeks post-release, with only two of the remaining birds reliably located beyond this time.

Major lessons learned

- Food availability was more important for survival of bush stone-curlews than predation during establishment. Birds inside the fence had a higher mortality rate than those outside the fence where predators were controlled but still present. The majority of detected mortalities occurred 4 - 6 weeks post-release and most were due to starvation. The release was conducted during a dry year; future releases of bush stone-curlews in semi-arid landscapes may need to be restricted to relatively wet years.
- Post-release daily supplementary feed was provided to all birds. While this food was utilized by birds released outside the fence and encouraged site fidelity, birds released inside the fence were outcompeted for the food by re-introduced marsupials. Future releases inside fenced areas may need to exclude re-introduced marsupials from the vicinity of the release site, to reduce such competition.
- The trial revealed issues previously not considered in the release protocol. For example, birds housed in the aviary inside the fence were markedly more “flighty” than those outside the fence during the quarantine period, and this may have affected the flocking behavior of juvenile birds and site fidelity post-release. The aviary within the fenced area was approachable by the re-introduced mammals, whereas the aviary outside the fence was screened from the potential approach of animals such as foxes and cats. In future, it may be useful to exclude other animals from the vicinity of aviaries to minimize disturbance to birds.
- In this trial, re-introduced bush stone-curlews were reliant on supplementary feed for survival following release. These results suggest it may be useful to incorporate live prey in the birds’ diet for a longer period whilst in the aviary to improve conditioning for foraging in the wild, and provide supplementary food for a longer period post-release.

Success of project

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Supplemental food provision post-release was critical for establishment of released birds. Birds released inside the fence were unexpectedly deterred from feeding by re-introduced marsupials. Additional (and possibly cumulative) stressors may have been that the natural food resources within the fence were not as abundant as outside the conservation fence, also due to competition from re-introduced marsupials, and/or that captive-bred birds were not sufficiently conditioned for foraging in the wild. These factors were exacerbated by the dry conditions prevailing at the time of the release.

- The delayed release protocol to encourage site fidelity and juvenile flocking behavior appears to have been compromised by the presence of re-introduced animals inside the fenced area. Birds outside the fence were calmer and less “flighty” than birds released inside the fence in the presence of numerous medium-sized mammals. On release, birds in the fenced area immediately flew from the aviary, remained further from conspecifics, had lower site fidelity, and did not utilize the supplementary feed as readily as birds outside the fence.

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Re-introducing captive-bred juvenile northern aplomado falcons to south-central New Mexico, USA

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Introduction

The northern aplomado falcon (*Falco femoralis septentrionalis*) is endemic to Mexico and the southwestern United States. The species is currently listed as endangered under the U.S. Endangered Species Act. The aplomado is listed as a Species of Least Concern on the IUCN Red List and is on Appendix II of CITES. The re-introduction project took place on the privately owned Armendaris Ranch and environs. The Ranch consists of approximately 1,439 km² in south-central New Mexico, east of the Rio Grande River. The ranch is located at the northernmost edge of the aplomado falcons' known historical range, within the Jornada del Muerto basin of the Chihuahuan Desert. Topography consists mostly of an open valley plain with primary habitats of Chihuahuan Desert scrub and desert grassland.

Goals

- Goal 1: Re-introduce captive-born aplomado falcons to suitable habitat.
- Goal 2: Increase survival of recently released falcons through the provisioning of food to maximize free-flying experience in the absence of food stress.
- Goal 3: Restore a viable population.

Success Indicators

- Indicator 1: Numerous sightings of re-introduced aplomado falcons during supplemental feedings and monitoring surveys.

Stooping aplomado falcon at the Armendaris Ranch, New Mexico

Aplomado falcon being readied for release

- Indicator 2: Aplomados thrive and stay in the release area by finding sufficient prey, avoiding predators, and reproducing.
- Indicator 3: Wild-born falcons survive and reproduce.

Project Summary

Feasibility: The aplomado falcon inhabits open grassland savannas scattered with tall soap tree yuccas (principally *Yucca treculeana*), in the Chihuahuan Desert and eastern Mexico. Aplomados do not build their own nests but depend on the presence of abandoned nests of similarly sized birds. Aplomados hunt via direct flights, sometimes cooperatively, and also utilize kleptoparasitism. Avian prey is the primary source of dietary biomass followed by insects. In all habitats, aplomados are indirectly dependent on nearby woodland, shrubland, and wetland bird communities for regularly abundant prey. Our project aimed to restore a viable population of aplomado falcons by re-introducing captive-born birds to the Chihuahuan grasslands of the Armendaris Ranch and environs. The Armendaris is privately owned and managed by Turner Enterprises, Inc. for ecological restoration including livestock production of native plains bison and high quality hunting of several quail species.

The aplomado was once considered a common resident in south-central New Mexico until about 1930 when sightings of the species began to decline. Potential reasons for the decline include pesticides, specimen collection, lead ingestion, electrocution, collisions with fences and power lines, drowning in livestock watering tanks, drought, disease, genetic disorders, prairie dog extirpation, loss of suitable habitat, a lack of abandoned available stick nests, and a decrease in available prey. In 1986, the aplomado was listed as endangered under the U.S. Endangered Species Act. In 1990 a recovery plan was authorized and called for restoring at least a population of 60 breeding pairs. In 2006, the Armendaris was chosen as the first release site in New Mexico because it had historically supported the species and offered secure and extensive seemingly suitable habitat. The re-introduction project was a collaborative effort involving the Peregrine Fund, the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, Turner Enterprises, Inc., and the Turner Endangered Species Fund.

Implementation: From 2006 through 2011, 102 captive-born aplomado falcons were released on the Armendaris. Standard raptor hacking procedures for

releasing the birds were used and involved holding the animals in a hack box for 7 - 10 days on an elevated platform erected in suitable habitat, and then releasing them at an age that corresponded with natural fledging. To promote survival and encourage the aplomados to establish residency near the release sites, hack site attendants provided supplemental food in the form of freshly thawed Japanese quail (*Coturnix japonica*), twice a day for approximately 40 days. To further improve survival, an extended supplemental feeding program was implemented after the standard 40-day period for all release years. Additionally, to improve habitat for the released aplomados on the Armendaris, in 2007, 20 artificial nest platforms were placed in areas lacking suitable nesting structures.

Post-release monitoring: In all years aplomado falcons were monitored throughout the year on and around the Armendaris via driving surveys. During the supplemental feeding program, observations of birds were recorded while food was available. Aerial surveys were also conducted strategically. In 2010, eight motion-activated trail cameras were deployed in locations frequented by aplomado falcons. In 2011, 10 falcons were equipped with VHF radio transmitters to document movements and mortality as part of a larger study by The Peregrine Fund. Annual spring surveys revealed that releases at the Armendaris led to the formation of nesting pairs at the ranch in 2007, 2009, and 2011. The 2007 pair fledged two chicks, the 2009 nesting attempt failed, and the 2011 pair fledged three chicks. Because none of the fledglings were banded their fates are unknown. However, from 2007 to October 2010 an un-banded female aplomado falcon resided at the Armendaris and regularly attended extended supplemental feedings. Circumstantial evidence suggests that this female was one of the chicks fledged in 2007 and, as an adult, was a part of the failed nesting attempt in 2009. The extended supplemental feeding program seemed to promote the survival and retention of recently released falcons and their eventual reproduction. Unfortunately, these benefits did not translate into improved long-term survival or population establishment. Although most of the radio-telemetry units deployed in 2011 malfunctioned, three mortalities attributed to avian predators were confirmed. The final fates of the majority of released aplomados remains largely unknown. It seems likely that most, if not all, of the birds did not survive to reproduce. Because of this no falcons have been released at the Armendaris Ranch since 2012 and no releases are planned for the future.

Aplomado falcons on hacking platform

Major difficulties faced

- Poor survival and/or retention of re-

introduced aplomados likely due to drought, shrub encroachment, inadequate prey populations, and predators.
- Determining the status of recently released falcons.
- Gaining support from collaborators to test improvements to the re-introduction protocol by including an extended supplemental feeding program.
- Gaining support from collaborators to complete a comprehensive assessment of the re-introduction effort.

Major lessons learned

- Regularly assess assumptions about the suitability of the re-introduction location including habitat, sufficiency of prey populations, and abundance/ distribution of predators.
- Create local awareness of the project to promote reliable identification of birds to better determine the status of recently released aplomado falcons.
- Maintain clear communication between project collaborators about expected roles, on the ground experiences, and the need to test methods for improving re-introduction protocols.

Success of project

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Habitat, as defined by prey populations and the abundance/distribution of predators, was of insufficient quality.

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Re-introduction of the cirl bunting to Cornwall, UK

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Introduction

The UK is on the northern edge of the global range of cirl buntings (*Emberiza cirlus*), which is mainly found within Mediterranean countries in Europe, with the core of the population in France and Spain, and also Northwest Africa. During the 19th century, cirl buntings were recorded across England and Wales and were locally numerous, being most abundant in coastal areas (Holloway, 1996). The population subsequently went into steady decline sometime after the 1930s, and by the mid-1960s numbers had collapsed across the majority of its UK range. By 1989 there were 118 pairs (Evans, 1992) and birds were mainly found in one county, Devon (two pairs each were found in Cornwall and Somerset). Due to these declines the cirl bunting was the only farmland songbird to be included in the original list of Red Data Birds in Britain and has subsequently appeared on the 'Red List' of Birds of Conservation Concern in the UK since this was first published in 1996 (Eaton *et al.*, 2009).

A successful species recovery project has resulted in a substantial increase in the UK population (862 pairs in 2009 (Stanbury *et al.*, 2010)). This recovery has been hugely encouraging, both with the increase in population size and the modest expansion and consolidation of the current breeding range. However, due to the species' sedentary nature and a barrier of unsuitable habitat around its south Devon stronghold, significant range recovery into formerly occupied areas of southern UK would be unlikely to occur unaided, or at least would be very slow. It was felt that for the species to become secure, a geographically separate population was needed. RSPB and Natural England therefore assessed the feasibility of

Close-up view of male cirl bunting

establishing another self-sustaining population of cirl buntings through translocation to a new area.

Goals

- Goal 1: To help secure the UK cirl bunting population.
- Goal 2: To establish a geographically separate second secure breeding population in the UK outside its current range.
- Goal 3: To develop release techniques for potential implementation elsewhere.
- Goal 4: To ensure habitat suitability is maintained and improved.

Success Indicators

- Indicator 1: Rear and release at least 60 birds per year for 4 years.
- Indicator 2: Achieve post release survival of 33% (birds surviving to the following Spring).
- Indicator 3: No significant detrimental effect recorded on donor population.
- Indicator 4: Establish a self-sustaining breeding population of at least 30 pairs following releases.

Project Summary

Feasibility: Feasibility assessments began as early as 1997 and initially focused on release site suitability. Potentially suitable release areas across southern Britain were assessed by means of a desk based study and follow up site visits. The following factors were considered: suitability of farming systems, extent of suitable habitat (based on features of occupied territories in Devon), history of mild winter weather, recent history of cirl buntings, and proximity to the existing population. Site assessments were carried out at various points in the planning process and a final assessment in 2005 indicated that four sites were potentially suitable (Lock *et al.*, 2005). These were on the Isle of Wight, and in Dorset, Somerset and Cornwall. The current and potential extent of suitable habitat in each locality was mapped in order to be sure that a Minimum Viable Population of cirl buntings could be supported (estimated to be 40 breeding pairs in five contiguous tetrads). This assessment concluded that only the Roseland Peninsula in Cornwall was considered suitable to support cirl buntings immediately, with a good prospect of holding a sustainable population in the long-term.

Release techniques were also assessed during the planning phase and a number of possibilities were considered and trialed in partnership with Paignton Zoo. Following trials with birds in captivity in 2002 - 2003, the idea of setting up a captive population for the source of released birds was abandoned as the birds seemed prone to disease and stress in captivity. Rear and release trials therefore followed in 2004 - 2005. These trials, involving chicks being taken from nests in Devon, hand reared and released back into the population, proved successful with birds surviving the winter and going on to pair with wild birds and reproduce.

Veterinary staff of the Zoological Society of London (ZSL) carried out a detailed Disease Risk Analysis to guide the implementation of the planned translocation

project. Advice was sought to minimize disease risks and implement suitable health surveillance during hand rearing and prior to release. Population modeling suggested that releasing a minimum of 60 birds per year for 4 years into an optimal area would lead to the establishment of a self-sustaining population of 30 - 40 pairs.

Cirl bunting nesting site

Implementation: Following several years of planning, a translocation project began in 2006, with the RSPB, Natural England, The National Trust, and Paignton forming the project partnership, and Zoological Society of London acting as advisors. An exact release location was found by working with farmers and landowners, and release aviaries were constructed. Skilled nest finders were employed to locate nests within areas of healthy and productive cirl bunting populations. Young chicks were then translocated under license to hand rearing facilities near the release site in south Cornwall. To ensure that 60 birds could be released, the target number of chicks to be removed was 75 due to inevitable pre-release mortality. Skilled aviculturalists were employed by Paignton Zoo to carry out hand-rearing and soft release. RSPB staff carried out post release monitoring, worked with farmers on habitat provision, and provided supplementary feed.

Over the period of releases the protocol was adjusted and refined based on monitoring results and during this time 254 birds were released (average 63 per year). RSPB liaised closely with farmers to ensure optimal habitat at the release site and beyond. Although it had been hoped that 2009 would be the final of 4 years of releases, only 13 breeding pairs were recorded at this stage. It was thought that poor weather conditions during 2007 and 2008, combined with a predominance of inexperienced birds within the breeding population, had inhibited breeding productivity and, hence, population development. It was decided that two more years of releases would be carried out in 2010 and 2011 to give the population a chance of success. To improve post release survival, improvements to the release strategy included using different release sites to prevent predators becoming habituated to a site with naive released birds.

Post-release monitoring: Post-release monitoring has shown that the project is now doing well. Following the two additional years of releases, in 2011 the population had increased to 28 breeding pairs. Significantly, the proportion of wild birds within the population had increased to 57%, and monitoring had showed that productivity of wild bred pairs was far greater than that of hand reared birds.

This meant that as wild birds were making up a higher proportion of the population, so the productivity of the whole population increased. This was proven in 2012 when the number of pairs increased to 44. In 2013 this had decreased to 28 pairs, but this has increased again to 39 pairs in 2014. A significant milestone has been reached in 2015 with 52 pairs being recorded. Monitoring effort will continue at a reduced level from 2016. It is hoped that the population will continue to follow this positive trend.

Major difficulties faced

- Hand-reared released birds were found to be less productive than their wild counterparts. This lower productivity level could be because wild bred birds benefit from the extra parental care they receive and are more aware of danger. This was not taken into account during planning stages.
- Funding for post release work was more difficult to secure than during the release phase.
- Adverse weather can have a very significant effect on breeding productivity and also the quality of chicks being harvested for release. This is unavoidable but the effect needs to be factored into models. A run of poor summers (something which could not be predicted) had a major effect on the project.
- Making a partnership work can be challenging. There can be conflicts about what is essential and what is practical.

Cirl bunting re-introduction project staff discussing habitat & farm management with a local farmer

Major lessons learned

- Making sure the plan was adaptable saved the project. The initial plan was well informed but flawed in some places. By making some adjustments, difficulties which could have meant the failure of the project were overcome.
- Trialing techniques can be vital in developing strategies. The initial release strategy involved captive rearing which was found to be too difficult during trials.
- Understanding the ecology of cirl buntings was invaluable in developing and adapting the project plan, as was employing dedicated and specialist staff.
- Robust management and faith in the project when things were going wrong helped keep the project on track.
- Habitat management and close liaison with the farmers providing the habitat was fundamental to the success of project.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- There was a good initial plan, with evidence based understanding of the species.
- The project was well resourced, with dedicated and highly skilled staff.
- The release strategy, once developed, was highly successful, with release targets being met in most years.
- Continued monitoring and results were able to be fed back and the project plan could be reviewed and adapted accordingly.
- Although the population is becoming sustainable, continued success is dependent on habitat provision and good breeding weather (warm, mainly dry summers). Habitat provision is dependent on farmers putting the right management in place. Government funding schemes to support the low intensity farming systems continue to be required.

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First attempt to restore a red-cockaded woodpecker population via re-introductions to unoccupied habitat at the Avalon Plantation, Florida, USA

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Introduction

The red-cockaded woodpecker (*Picoides borealis*), is endemic to the Southeastern United States southern pine ecosystem, which historically covered approximately 90 million acres from Virginia to Texas, USA. Today, this ecosystem has been reduced by over 95% from its original extent. The red-cockaded woodpecker (RCW) is a habitat specialist, being the only woodpecker in North America to excavate cavities in mature living pine trees and is dependent upon these cavities for roosting and nesting. The RCW is a territorial, non-migratory, cooperative breeding species with a complex social system; individuals normally live in groups with a breeding pair and up to 4 male offspring (known as helpers) from previous years. The aggregate of cavity trees is known as a cluster and the group on average, forages and defends a territory of about 200 acres. The red-cockaded woodpecker was listed as endangered in 1970 and received federal protection under the passage of the Endangered Species Act in 1973.

Red-cockaded woodpecker

Goals

- Goal 1: Restore a population of red-cockaded woodpeckers that includes 25 to 30 clusters (~100 birds) and persists with minimal management.

- Goal 2: Develop re-introduction techniques that could be used to promote recovery of the species elsewhere.
- Goal 3: Become a donor site, once the population goal is achieved.

Success Indicators

- Indicator 1: Re-introduced woodpeckers and their offspring breed and excavate their own cavities.
- Indicator 2: Re-introduction techniques developed are used to further recovery of the species elsewhere.
- Indicator 3: Red-cockaded woodpeckers are translocated to other recipient sites.

Project Summary

Feasibility: Beginning in 1998, the Turner Endangered Species Fund in cooperation with the U.S. Fish and Wildlife Service (USFWS) initiated an effort to re-introduce the red-cockaded woodpecker (RCW) to the Avalon Plantation (Avalon) in north Florida, USA. This effort was the first attempt by a private landowner, state or federal agency to re-introduce a population of RCWs where no founder population existed or into a pine forest that previously did not support the species. Although Avalon is within the historic range of the species and contains excellent RCW habitat, there is no evidence that the existing pine forest ever supported the species. As previously mentioned, there has been no other attempt to establish a population of RCWs *de novo*.

Therefore, it was difficult to generate a realistic population objective and timeframe required to achieve said objective. However, based on the characteristics of the pine forest at Avalon, we determined 25 - 30 potential breeding groups that persist with minimal management was a realistic population objective. Moreover, it seemed reasonable to expect that 10 years of active management would be required to reach this objective.

Implementation: Since RCWs never inhabited Avalon's existing forest, installation of artificial cavities and translocations of sub-adult birds from a secure donor population were essential components of this project. After careful evaluation of the two approved artificial cavity techniques, drilled cavities (Copeyon, 1990) and artificial inserts (Allen, 1991), we concluded artificial inserts were most

Banding a seven day-old chick

Red-cockaded woodpecker habitat at Avalon

suitable for our situation, because pine trees on Avalon were relatively young (60 - 70 years), vigorous growers (>8 cm sapwood), and large size (>76 cm dbh). Installation of artificial cavities began in early fall 1998 with the creation of five release clusters and five recruitment clusters. Release clusters were selected based on presence of adequate foraging habitat and its spatial relationship to other release clusters. All release clusters were located within 0.5 km of one another (Hagan *et al.*, 2003). Because RCWs typically disperse after release, and to maximize retention of released birds, at least one additional recruitment cluster was provided within 0.4 - 1 km of each release cluster. A minimum of 4 artificial inserts was provided in each release and recruitment cluster.

We conducted translocations from 1998 - 2002 (Hagan *et al.*, 2004). The Apalachicola National Forest, Apalachicola Ranger District was used as the donor population in 1998 and 1999. Private Lands in the Red Hills region in southern Georgia was used as the donor population in 2000 - 2003. Following the USFWS translocation policy (U.S. Fish and Wildlife Service, 2003), only sub-adult males that fledged from groups with at least one helper were removed for translocation. All sub-adult female fledglings were available for translocation. Individuals selected for translocation were removed during October - November each year. During the 5 years of translocations, 10 birds (five pairs of unrelated sub-adult males and females) were trapped on the same night and transported to release clusters on Avalon. All birds were released as pairs in individual clusters simultaneously at dawn the following morning. Fifty (25 males:25 females) sub-adult RCWs were released during the project period.

Post-release monitoring: An intensive and extensive monitoring program was implemented to document the results of the re-introductions. Following release, birds were left unmonitored for the first week to allow them some time to adjust to new surroundings without human interaction. After the adjustment period, each release and recruitment cluster was monitored daily for signs of cavity tree activity. We conducted daily visits for 1 month post-release, at which time weekly visits were initiated. All released individuals underwent an adjustment period in which we observed considerable movement and exploration of adjacent clusters. Of the 50 birds released, 36 (21 males:15 females) established residency on the property. We experienced a 50% retention rate after the first year of release, a

70% retention rate after the second year, and a 80% retention rate in years 3 - 5. Breeding success was documented in 1999, the first breeding season after re-introductions. Moreover, in all the following years, breeding success was also documented from birds released the prior fall. Currently, the Avalon Plantation supports 15 active clusters of RCWs that include 15 potential breeding pairs.

Cavity installation on tree

Major difficulties faced

- Locating, capturing, and translocating 10 individuals on a single night.
- Maintaining sufficient funding for adequate monitoring after the first few years of the project.

Major lessons learned

- Released individuals were wide-ranging. Not a single re-introduced bird was retained within its release cluster.
- We underestimated the number of years required to establish a population of 25 - 30 potential breeding pairs.
- While the groups on Avalon were prolific breeders, offspring were reluctant to disperse into unoccupied territory. This created very large groups, with up to four helpers. As a result, we began to only provide enough cavities for a breeding pair and two helpers (maximum of four usable cavities).

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The importance of releasing individuals into high quality habitat.
- Releasing numerous birds (5 pairs) simultaneously into the population over multiple years.
- Releasing multiple pairs in close proximity to one another apparently provided the necessary social interaction with other individuals to reduce post-release movements and facilitate establishment of breeding groups.

- Establishing recruitment clusters within 0.4 - 1 km of release clusters. Such an array allowed wide-ranging birds an opportunity to discover other clusters as well as interact with other birds.

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Trialing captive-releases of the critically endangered regent honeyeater in NE Victoria, Australia

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Introduction

Formerly ranging across south-eastern Australia from southern Queensland to South Australia, the range and population of the regent honeyeater (*Anthochaera phrygia*) has diminished substantially due to habitat loss, degradation and competition. Once estimated as occurring in the thousands the current population is considered to be as low as 400 birds, and as a result it is now listed by the IUCN as Critically Endangered. A national Regent Honeyeater Recovery Team coordinates a broad range of initiatives as part of the national Recovery Plan to address the species decline. Detailed studies of habitat requirements, breeding biology and genetics have been undertaken, while studies of distribution and movement patterns are ongoing. These results have informed habitat management, including the protection and restoration of key habitat throughout the species range. A captive population is now well established with Taronga Zoo the key 'breeding for release' institution and manager of the species' studbook and breeding program. The recovery team has recently trialed releasing captive-bred birds into the wild in north-east Victoria, in an effort to evaluate the effectiveness of the technique in producing birds fit for survival in the wild, and ultimately as a step to arrest the decline of the species.

Regent honeyeater

Goals

- Goal 1: To evaluate gross survival of captive-bred regent honeyeaters released into the wild.
- Goal 2: To evaluate survival of different cohorts of captive-bred regent honeyeaters released into the wild (e.g. young cf. old, male cf. female).
- Goal 3: To determine if captive-released birds are able to integrate into the wild population.

- Goal 4: To develop a monitoring program using community member assistance to evaluate success of the captive releases.
- Goal 5: To restore a self-sustaining wild population of regent honeyeaters.

Success Indicators

- Indicator 1: Survival rate of birds is higher than 70% for each release at 10 weeks post-release.
- Indicator 2: There is no difference in survival for any factor evaluated (age & sex).
- Indicator 3: Captive-released birds integrate with wild birds; calling, foraging and moving around the landscape together.
- Indicator 4: Monitoring program is well instituted and allows for daily monitoring of all birds known to be in the vicinity of the release site.
- Indicator 5: The population decline of regent honeyeaters stops.

Project Summary

Feasibility: The regent honeyeater is a medium-sized black and yellow honeyeater now considered most closely related to Australasian wattlebirds, and is a charismatic bird of box and ironbark woodlands of south-eastern mainland Australia. It has declined substantially over the years, largely as the favored habitat has been selectively cleared from the most fertile parts of the landscape to make way for stock and crop production. A small trial release of regent honeyeaters was conducted in the Capertee Valley, NSW, in 2000. A total of nine birds were released into a fragmented rural landscape and most failed to either survive the initial post-release period, or moved beyond monitoring range. Husbandry and field techniques were altered subsequently, with a view to releasing birds into a more intact environment.

Three trial captive-releases have since been conducted in north-east Victoria, Australia, within the boundary of the Chiltern-Mt. Pilot National Park. The first release was conducted in 2008, with subsequent releases in 2010 and 2013. The 2008 project saw 27 birds released into the wild, with the aim of evaluating the survival of birds post-release, and also to investigate any potential differences in survival driven by the age or sex of an individual. Across all releases there has been no obvious effect of age or sex. Short-term survival (10 weeks post-release) has been higher than 70%.

Pre-release holding tents

Glen Johnson (Author) giving a pre-release briefing

Implementation: A national recovery effort for the regent honeyeater has been in effect since 1994, working to redress habitat loss and modification, increased competition with other species, and the impacts of low population size. The recovery team established a captive population within 2 years of initiation, at a time when the population was much more robust than it is currently. Over the years the captive population has been maintained at around 50 individuals, at the same time as key breeding locations have been subject to re-vegetation or protection. Breeding was increased ahead of each release (2008, 2010 & 2013) and a total of 109 birds were released over that time. Birds were flown from Taronga Zoo in Sydney to Albury in southern NSW, close to the release site. Once present they were put into holding aviaries and 'hardened' for release by provision of cut eucalypt flowers of key tree species. Permits from relevant state agencies were required, as well as import and export permits (as birds were being moved between states), and relevant ethics approvals were required.

Post-release monitoring: In 2008 all 27 birds were be fitted with radio transmitters prior to their release to facilitate monitoring of the birds. In both 2010 and 2013 a cohort of 25 birds were fitted with transmitters out of the total 44 and 38 released, respectively. Birds fitted with radio-tags were monitored daily over the first few weeks, and monitoring continued until (and after) the 3 month life of the transmitters. The radio tracking period was extended in 2013 following fitting of four more transmitters to captive release birds not used in the initial tracking period. Opportunistic monitoring of birds that were not fitted with transmitters was also be undertaken during the radio-tracking period. Each captive-bred bird released was fitted with a unique color leg band combination which enabled identification of individuals, enabling observations to be recorded of any banded bird observed during the monitoring period.

In each year at least five months of intensive post-release monitoring has been achieved, after which time the birds appear to move out of the forest and into the surrounding landscape. Monitoring in following years is undertaken on selected weekends when volunteers are able to assist with a park-wide search for the birds. As a result of this, and numerous opportunistic sightings by birders and community members, over 25% of the 2010 release cohort has been sighted at least 12 months post-release, which is well above the average for re-sighting of color-banded wild birds. Over 10% of the 2013 release cohort has been similarly re-sighted at least one year later.

Major difficulties faced

- Several harness designs were trialed and field deployed, one of which unexpectedly injured several birds post-release. Aviary trials between releases allowed a safe design to be redeveloped.
- Predation: Up to 10% of each release cohort was preyed upon, attributed mainly to avian predators such as brown goshawks (*Accipiter fasciatus*).
- Nest failure post-release: Over all three releases there has been a >90% nest failure rate for birds breeding immediately post-release, with causes of failure including naïve birds, weather, and predation.
- Volunteer attrition requires management, as each release period involves monitoring for up to 6 months. This influences the ability to monitor birds.
- Competition with other highly aggressive native species is an ongoing issue. Noisy miners (*Manorina melanocephala*) outcompete species like regent honeyeaters, so a trial control of that population was planned in the lead up to the 2015 captive release.

Major lessons learned

- Conditions of the release site are paramount to the success of the release; birds must have access to nectar from flowering eucalypts and insects for feeding on and raising chicks with.

Volunteers band reading released honeyeaters

- Regent honeyeaters are an extremely mobile species, and at times become very cryptic. The use of radio tracking technology is imperative to good post-release monitoring.
- Extensive experience with handling and breeding regent honeyeaters in captivity allowed for refinement of release procedures.
- Post-release monitoring at the level undertaken is not possible

without citizen scientists assisting project staff in tracking, band reading and behavioral observations.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Regent honeyeaters are a fecund species in a captive environment, making breeding-for-release easier than in many other species.
- Choice of release site has been well researched, with suitable alternatives studied and compared each year. Birds are released at peak flowering of key feed trees which provides ample nectar flows.
- Intensive monitoring, well supported by an eager and highly skilled citizen science component, has allowed great evaluation to be undertaken. Use of radio transmitters has been a great asset to facilitate sightings of 'banded only' individuals.
- The logistics of the release site and region allow for generally smooth operations. The site surrounds a small regional town and is in close proximity to larger towns, allowing access to supplies and resources.
- In spite of their critically endangered status, regent honeyeaters appear to be relatively robust - they cope well in captivity, no adverse effects have been evident from transportation to the release site, and they adapt well to the local environment.

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Re-introduction of the threatened Cocos buff-banded rail to the southern atoll of the Cocos (Keeling) islands, Australia

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Introduction

A subspecies of the widespread Cocos buff-banded rail (*Gallirallus philippensis*) is restricted to the very isolated Cocos (Keeling) island group, an Australian external territory in the north-eastern Indian Ocean. This subspecies, *G. p. andrewsi*, declined catastrophically following human settlement of the islands in the early 19th century, largely due to extensive conversion of native forest to coconut palm plantation and predation by the introduced black rats (*Rattus rattus*) and feral cats. By the 1990s, it was restricted to a population of about 800 birds occupying a single uninhabited 1 km^2 island, Pulu Keeling (North Keeling Island), lying 24 km north of the Cocos southern atoll (a set of about 26 small islands with a total area of about 14 km^2). Given this very small population and area of

Released rail with legbands © Neil Hamilton

occupancy, this subspecies is listed as endangered under Australian legislation. A Recovery Plan for the Cocos Buff-banded Rail recommended that the highest priority conservation management action was to attempt to establish a second population, on at least one island in its former range of the southern atoll of the Cocos (Keeling) group.

Goals

- Goal 1: Identification of one or more islands in the southern atoll that may be suitable for re-introduction, notably ensuring that these are free of the primary threats (black rats & feral cats)
- Goal 2: Support for re-introduction from the Cocos islands community, and their involvement in this program.
- Goal 3: Translocation of rails from Pulu Keeling to a suitable island in the southern atoll, with subsequent breeding, population increase, and establishment of a viable re-introduced population.
- Goal 4: Long-term enhancement of habitat suitability (and control of predators) on multiple islands in the southern atoll, allowing for recolonization of multiple islands.
- Goal 5: Reduction in extinction risk and down-listing of conservation status.

Success Indicators

- Indicator 1: Suitable destination island identified and managed, with support of local community.
- Indicator 2: Monitoring demonstrates breeding and population increase for population on island to which it was re-introduced.
- Indicator 3: Monitoring demonstrates no significant reduction in population of source island (Pulu Keeling).
- Indicator 4: Increase in numbers of islands in southern atoll from which rats and cats have been eradicated.
- Indicator 5: Natural spread of re-introduced population to other islands in the southern atoll.

Project Summary

Feasibility: The project had several major challenges: 1) seeking support, involvement and endorsement of the Cocos (Keeling) community, who collectively own all islands potentially suitable for translocation; 2) identifying one or more islands in the southern atoll of the Cocos group that was suitable (i.e. with adequate habitat and absence of threats) as a re-introduction site; 3) ensuring that individuals taken from the source island (Pulu Keeling) for re-introduction did not jeopardize the viability of that population; 4) ability to monitor the population trends of the re-introduced population, given limitations posed by very dense vegetation and 5) over the longer term, seeking effective control of the introduced black rats and cats across islands in the southern atoll, to allow the natural re-colonization to other islands from the initial re-introduction island. The project also had some significant logistical constraints. The source island (Pulu Keeling) is remote from the main inhabited atoll of the Cocos (Keeling) group. Furthermore, fringing reefs around Pulu Keeling dictate that boats cannot land on it, so

Rails have to be transported in boxes to boats by swimming as boats cannot dock © Tanya Detto

visitation to and from the island involves swimming through surf. Hence, rails taken from the island for re-introduction to the southern atoll needed to be placed in watertight containers and guided by swimmers through breaking surf.

Implementation: Pulu Keeling is a national park managed by the Australian government's Parks Australia. Rangers for this park include members of the Cocos (Keeling) community. Over several years prior to the re-introduction attempt Parks staff engaged the Cocos (Keeling) community and its representative governance body, and the project was enthusiastically supported, with landholders endorsing use of nominated islands as potential re-introduction sites. Based on assessment of the extent of remaining native vegetation, and particularly the absence of black rats and cats, one island in the southern atoll, the 1 km^2 Horsburgh Island, was selected as the preferred site for re-introduction.

In April 2013, 39 rails were captured on Pulu Keeling, using mist nets and small cage traps. These were all individually colour-banded and transported to Horsburgh Island. All individuals survived this transport.

Post-release monitoring: The fate of the re-introduced birds has been monitored with three techniques: 1) radio-tracking of a subset of birds to assess short-term (1 - 2 weeks) survival; 2) camera-trapping to assess the medium term (2 weeks to 18 months) survival of the color-banded birds moved from Pulu Keeling, and to assess any influx to the population of un-banded birds (assumed to represent increase due to breeding) and 3) transect sampling and density estimates, using the program DISTANCE, to assess medium and longer term trends of the re-introduced population.

Radio transmitters were attached to 10 of the re-introduced individuals, and radio-tracking immediately post-release and for 2 weeks thereafter showed no short-term mortality. A set of 20 remote cameras placed around Horsburgh Island provided more than 2,000 images of rails. These cameras first detected chicks in September 2013, five months after the re-introduction, and thereafter an increasing proportion of un-banded birds (i.e. individuals resulting from successful breeding of the re-introduced population). Nonetheless, some color-banded (i.e.

re-introduced) individuals were shown to have persisted at the re-introduction site across the entire period (18 months post-release) covered by camera trapping.

Estimates of the re-introduced population, derived from analysis of transect censuses, indicated that the population initially declined from the 39 re-introduced individuals (April 2013) to 23 in February - March 2014, but subsequently increased to 54 in October 2014, and increased further to 122 individuals in May - June 2015, a 300% increase from the initial number of re-introduced individuals over a 26 month period. This monitoring program will continue.

Not all re-introduced individuals (or their descendants) remained on Horsburgh Island, with one banded individual (i.e. one of the re-introduced birds) subsequently recorded on West Island (~6 km distant from Horsburgh Island) in May 2014, and an initial record in June 2014 and then increasing number of individuals on the nearby (~4 km distant) Direction Island. It is likely that this natural spread to Direction Island will be successful, because black rats have been at least temporarily eradicated from it, and it does not have feral cats. However, further natural spread to return to other islands in the southern atoll is unlikely to be successful until rats and cats have been eradicated from those other islands.

Monitoring is also continuing on Pulu Keeling and this has indicated no reduction in population size since the removal of individuals for the re-introduction project. The area of occupancy of this threatened subspecies has now been doubled, and extinction risk substantially reduced because it no longer is restricted to a single small site. However, its total population size (~920 individuals) and area of occupancy (2 km^2) remain very limited.

Major difficulties faced

- Logistic constraints on access to and transport of rails from the source island, Pulu Keeling.
- (For the future of the program) eradication of black rats and feral cats from all islands in the southern atoll, in order to allow the natural spread and return of (and increase in) the re-introduced rail population.
- The small size (total area of 15 km^2) and biosecurity challenges of the Cocos (Keeling) island group may mean that this subspecies may

Releasing rails on Horsburgh Island
© Caitlyn Pink

always be susceptible to extinction, no matter how successful this conservation project is.

Major lessons learned

- Given the control of threats (in this case especially predation by black rats and feral cats), this threatened subspecies responded very positively and rapidly to re-introduction.
- Support of the local land-holding community was vital to achieve this success.
- Investment in different types of monitoring was important to document post re-introduction trends.
- The re-introduction program was guided by a recovery team that included a range of independent experts and community representatives, and this collaborative network was important for the project's success.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The re-introduction program was strategically developed through an approved recovery plan process.
- A substantial consultation process helped engender community support.
- Resourcing was adequate to allow the translocation project and subsequent monitoring.
- (For the future) further increase through natural spread of the rail to other islands in the southern atoll will be dependent upon ongoing support of the Cocos (Keeling) community and the eradication of black rats and effective control of cats.

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Trial re-introduction of the Eurasian beaver after an absence of 400 years to Scotland, UK

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Introduction

Eurasian beaver (*Castor fiber*) is a large, semi-aquatic, herbivorous rodent that was once found in freshwater habitats from the Chinese-Mongolian border across to its most western distribution in Britain. By the beginning of the 20th century, the species had been driven to near-extinction, largely as a result of over-exploitation by humans, who hunted beavers largely for their fur but also for meat and the glandular secretion castoreum, which was used for medicinal and perfumery purposes. The species is thought to have become largely extinct in England and Wales between the 12th and 13th centuries and in Scotland by the 16th century. By the end of the 20th century, the species had shown a remarkable recovery across Europe due to relaxation of hunting pressure, followed by natural recolonization in some areas and, latterly, artificial re-introduction programs which led to a sharp rise in the population and distribution of the species in Europe. The Eurasian beaver is currently listed as Least Concern by IUCN, but, under the EU's Directive 92/43/EEC Conservation of Natural Habitats and Wild Flora and Fauna (the 'Habitats Directive') Article 22, there is responsibility for member states to consider its re-introduction.

Eurasian beaver (released adult female)
© Philip Price

Goals

- Goal 1: The overall goal to collate and provide information that will support Scottish ministers in making a decision on the future of beavers in Scotland.
- Goal 2: To study the ecology and biology of

the Eurasian beaver in the Scottish environment and to assess the effects of beaver activities on the natural and socio-economic environments.
- Goal 3: To generate information during the proposed trial release that will inform a potential further release of beavers at other sites with different habitat characteristics.
- Goal 4: To determine the extent and impact of any increased tourism generated through the presence of beavers.
- Goal 5: To explore the environmental education opportunities that may arise from the Trial itself and the scope for a wider program should the Trial be successful.

Success Indicators

- Indicator 1: Survival of released individuals and evidence of breeding in a Scottish environment.
- Indicator 2: Delivery of scientific monitoring program and ongoing fulfillment of Scottish Government licence conditions over a 5 year period.
- Indicator 3: Changes in public support during the duration of the trial period.
- Indicator 4: Positive socio-economic impacts in the local community.

Project Summary

Feasibility: Beavers are widely considered to be 'ecosystem engineers' of freshwater and associated riparian habitats, having demonstrable positive influences on biodiversity. Beavers can provide a range of ecosystem services including water storage, flood alleviation, sediment retention and water quality improvement. The Eurasian beaver has now recovered across most of its natural range, and been successfully re-introduced to over 24 European countries. The issues surrounding beaver re-introduction to Scotland have been the subject of intense investigation and discussion over the last 20 years. In 2007, no standard format existed for making a licence application to the Scottish Government for the release of a species not resident in Scotland. Due to concerns about beaver re-introduction by some stakeholders, a time-limited, scientific trial re-introduction was agreed. Therefore, a document containing all the required information was written and submitted on behalf of the Scottish Beaver Trial partnership by the Royal Zoological Society of Scotland and Scottish Wildlife Trust, drawing upon content from the previous application and supporting information prepared by Scottish Natural Heritage (SNH).

Included with the licence request was essential additional information in support of the application to the Scottish Government. These included sections on: legal matters, the public consultation summary report, the proposed release area and sites, budgets, public-health issues, education initiatives, socio-economic impacts, source population and animal health, quarantine methods, post-release management methods, exit strategy, research and monitoring methods, risk assessment and dealing with potentially damaging effects, success and failure criteria, and project-management structure.

Implementation: The Scottish Beaver Trial was a relatively large-scale project involving several organizations over a number of years, with considerable resource implications for all of the main partners and SNH. There was consensus by all involved that it would be necessary to draw up legal agreements or Memoranda of Agreement between the various parties in order to clarify roles and responsibilities and to protect individual organizations' interests. In May 2008, a license was granted for the SBT on behalf of the Scottish Government, to release up to four families of beavers. The licence was subject to 31 conditions relating to animal and project management, research and monitoring, and mitigation measures. No template existed for a species re-introduction license application prior to the SBT. More recently, Scotland's National Species Re-introduction Forum has - partly based on the experience of beaver releases in Scotland - produced 'The Scottish Code for Conservation Translocations' and the accompanying 'Best Practice Guidelines for Conservation Translocations in Scotland', both based on the IUCN 'Guidelines for Re-introduction and Other Conservation Translocations'. These documents provide greater clarity to the re-introduction process and help to provide a checklist of actions for applicants to consider, including aspects of planning, legal status, permissions, consultation, resources and monitoring.

Knapdale Forest, a working forest owned and managed by the Forestry Commission Scotland, in mid-Argyll, was selected as the trial site (~44 km^2). This was specifically chosen as it was ecologically suitable for beavers, had a range of features that could be evaluated for beaver impact, it was considered to be naturally contained but with good access for field workers and visitors, local people were generally supportive and as a working forest the impacts of beavers on forestry could be assessed. This site includes a 'Special Protection Area', 'Site of Special Scientific Interest' and 'Special Area of Conservation', designated for their natural heritage interests. In collaboration with Telemark University College, Norway was identified as the most suitable donor country and source population for animals to be used as part of the Trial. Sixteen beavers were released in family units in individual lochs over 2009 - 2010. This was accompanied by a 5 year post-release scientific trial period and monitoring program involving 13 independent scientific partners specifically designed to test the main aims of the trial.

Post-release monitoring: Coordination of the independent monitoring of the Scottish Beaver Trial was the responsibility of Scottish Natural Heritage, in collaboration with the project partners. The delivery of the program, which by necessity was varied and complex, involved many organizations and individuals including SNH staff, SBT field staff and volunteers, independent field scientists and other governmental agencies. Post-release monitoring investigated a range of impacts including beaver ecology and health, freshwater and woodland habitat, fish communities, public health, archaeology, water chemistry and socio-economics. Prior to the first release of beavers in May 2009, independent baseline survey work was carried out on the majority of monitoring program areas so that comparisons could be made. The post-release monitoring program included a wide range of survey techniques including animal observations, animal

Beaver release loch, Knapdale forest, mid-Argyll
© SBT

trapping and sample collection (e.g. blood sampling for health assessment), field sign mapping via GIS, water sampling for chemistry testing, remote camera trapping, invertebrate surveys, vegetation transects, fluvial geomorphology assessment, and local business surveys.

The Trial provided an opportunity to undertake beaver-related research outside the implementation of the official scientific monitoring program. A number of peer-reviewed publications and academic conference proceedings were produced, addressing research questions and topics requiring further examination, specifically in relation to animal health, welfare and genetic research.

The information derived from the Trial is currently being considered by Scottish ministers, and will support a decision on the future of beavers in Scotland.

Major difficulties faced

- The overall cost of the project, including the delivery of the monitoring program, and the need for ongoing fundraising.
- The mortality of animals in quarantine and their dispersal from the trial site.
- The viability of such a small number of released animals, especially the initially limitation of moving whole family units.
- The unofficial release of beavers in the east of Scotland.

Major lessons learned

- The provenance and sourcing of beavers for re-introduction projects should be discussed and agreed at a national level, including a pragmatic discussion on the latest genetic and veterinary information, IUCN guidelines, the status of beavers already present both in the wild and in captive collections, and the need for further beaver importation.
- Inevitably, any project of the scale and profile of the Scottish Beaver Trial will always involve many different organizations and individuals, sometimes with differing objectives - and this can be a challenging process to manage. Such roles and responsibilities should be captured in specific Memoranda of Agreement between the relevant partners. Through the planning and implementation phase of the Trial, it was considered essential to focus on the

core objectives of the release process to successfully launch a scientifically monitored re-introduction trial. This would also help to ensure that the welfare of the animals came above any other considerations such as media coverage or funder care.

- Trapping of wild animals, particularly as whole family units, is a stressful experience for these individuals, and the subsequent health effects of this stress should not be underestimated. Careful consideration of trapping, handling and transportation procedures, and temporary holding methods used should be carefully managed, and best practice employed at all times. Capture of entire beaver families can be problematic and resource-heavy. The selection of young pairs or single animals of dispersal age is recommended. Health screening and body condition scoring should ensure individuals are fit for release and in best physical condition. If beaver families are imported, it is important to consider the family-group structure, including age, sex and potential reproductive status of all individuals, as this may create various constraints upon their use and placement. The welfare of any unpaired and unused animals must be considered, including appropriate provisions for a life in captivity if they cannot be released.
- With a fixed-term, high-profile project, there is always the temptation for (and demand from) external institutions to consider numerous research outputs. Being selective about any studies, setting SMART aims and ensuring publication of findings at the onset of the project, is essential in order to ensure successful completion and to produce projects of higher scientific value. Health screening methodology and veterinary care was a relatively under investigated area requiring research investment for this project. Quarantine and health screening requirements for wild caught mammals imported to Britain requires stringent procedures. Further research should be undertaken to develop captive husbandry and investigate mortality rates for beaver quarantine and captive holding facilities.
- Experience suggests accurately forecasting an outline budget for such a project can be a challenge, and it should be recognized that significant contingencies and flexibility should be built in from the start to adapt to changing circumstances, particularly with regard to animal costs. As with all major project budgets, sufficient lead -in time is required to cost out detailed tasks and capital items. A

Beaver tail measurements as part of body condition post-release monitoring program © SBT

simple yet key point to make when considering the budget and fundraising for such a nationally important, groundbreaking initiative is that scientifically monitored trial projects cannot be done on the cheap and need to be well resourced and very carefully costed to ensure the best chances of success.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The project was a milestone in UK conservation history, being the first official mammal re-introduction.
- The multidisciplinary approach and wide organizational collaboration to delivery of a robust scientific monitoring program.
- Majority public support, media interest and popular education outreach program.
- The flexibility to trial and develop animal management techniques.
- The ability of Eurasian beavers to survive in the Scottish environment.

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Re-introduction of the African lion from a captive origin: Zambia & Zimbabwe

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Introduction

The African lion (*Panthera leo*) is found in most countries of sub-Saharan Africa, although numbers have declined in recent times. Lion numbers in Africa were estimated at 200,000 in 1975 (Myers, 1975). Estimates published at the end of 2012 by a team at the Nicholas School of the Environment suggested that between 32,000 and 35,000 lions remain in Africa and that there is "*abundant evidence of widespread decline and local extinctions*" even in protected areas (Riggio, 2013). The African Lion is currently listed as "Vulnerable" on the IUCN Red List based on "A species population reduction of approximately 30% is suspected over the past two decades (= approximately three lion generations). The causes of this reduction (primarily indiscriminate killing in defense of life and livestock, coupled with prey base depletion: Bauer 2008), are unlikely to have ceased." (Bauer, Nowell & Packer, 2012). Loss of habitat due to human population growth is also a significant cause of population loss.

Goals

- Goal 1: Release of prides of captive bred lions into fenced-wild areas.
- Goal 2: Release of second generation lions into wild areas.
- Goal 3: Mitigation of reasons for the original loss of lions in proposed release areas.

African lion male

Success Indicators

- Indicator 1: Creation of socially stable and self-sustaining captive-bred lion prides in fenced wild areas.
- Indicator 2: Raising of second generation cubs to sub-adulthood by the captive -bred lions.
- Indicator 3: Survival of released second generation cubs.
- Indicator 4: Integration of released second generation cubs into local lion populations, including inter-breeding with native lions.
- Indicator 5: Identification of reasons for the loss of lions in proposed release areas, and success in mitigating those reasons through targeted programs.

Project Summary

Feasibility: *In-situ* conservation programs must continue to be the mainstay of efforts to protect habitat for lions to survive. However, there is a concern with a lack of empirical evidence that current conservation solutions for lions are, or can, work, in the long term. Given the speed of decline in lion populations, and the IUCN's Red List classification assessment that "… the reduction or its causes may not have ceased OR may not be understood OR may not be reversible", it is suggested that it is necessary to ensure that there is a back-up plan to complement *in-situ* efforts.

The IUCN technical guidelines for *ex-situ* management are based on fulfillment of one or more of the following Red List criteria: "When the taxa/population is prone to effects of human activities or stochastic events or When the taxa/population is likely to become Critically Endangered, Extinct in the Wild, or Extinct in a very short time. Additional criteria may need to be considered in some cases where taxa or populations of cultural importance, and significant economic or scientific importance, are threatened" (IUCN, 2002). It is argued that for the African lion, both of these criteria apply (Abell, Kokés & Youldon, 2013).

Implementation: During the initial stages captive-bred lions were given the opportunity to develop their natural instincts on human-led walks into a natural area, prior to being bonded together in prides. The first release of a pride of 2 males and 5 females into a fenced-wild area at the Dollar Block reserve in central Zimbabwe in August 2007 showed that the pride was able to feed itself, but that the social structure of the group was not stable, resulting in the death of 2 females; killed by the 2 males. It was considered that the males were too young and failed to establish dominance over the 2 females resulting in fatal fights, whilst the females of the pride were insufficiently bonded. The 2 males were removed and 3 additional females introduced. The female only pride proved to be self-sustaining and socially stable. Due to local land security problems the release site had to be moved. The female lions were placed back in captivity, adjacent to a new, older male for a period of 1 year whilst the site was moved to a new location in Gweru, central Zimbabwe. In September 2010 the females were released into the Ngamo release site, with the male released 2 weeks later.
A second pride of 6 females was released in August 2011 into a fenced - wild area in the Dambwa Forest, Livingstone, Zambia, with a male released into the same area in December 2011.

To date the program has yet to move to the next stage of releasing the second generation cubs into the wild.

Lion family group

Post-release monitoring: Between January 2011 and February 2012, a total of 19 cubs were born to the Ngamo pride in 7 litters. Four cubs failed to thrive, whilst 10 were killed by pride members. As a result 1 adult female was removed from the release site. The remaining 5 cubs, which have never had any human contact, have been successfully raised by the released lions to sub-adulthood. A further adult female was removed from the site for treatment in June 2013 having been discovered in the site, paralyzed from a prolapsed disc. The Dambwa pride have given birth to 6 cubs in 2 litters in June 2013 and January 2014. The integration of the cubs into the pride has resulted in the expulsion of 1 adult female by the pride, leading to her removal from the site. Social network analysis has shown that both prides are now socially stable (Abell *et al.*, 2013), whilst hunting analysis shows that both prides are capable of sustaining themselves. The sub-adults within the Ngamo release area are also now capable of hunting.

Major difficulties faced

- Ensuring land security.
- Obtaining sufficient funding to build adequately sized release areas.
- Sufficiently bonding the pride prior to release to ensure social stability.
- Understanding the reasons for the killing of cubs in the Ngamo release area by pride members.

Major lessons learned

- Male lions should be mature when introduced to the females, or raised with the females from an early age to ensure social stability.
- Release site sizes need to be as large as possible, with the aim of ensuring natural predator - prey relations are possible, and that prey populations can be naturally regenerating to offset the rate of predation and therefore reduce costs.
- Ensuring cooperation from national wildlife authorities is necessary to gain the necessary permits to proceed with implementation.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Insufficient funding to create appropriately large fenced-release areas.
- Insufficient evidence of the merits of *ex-situ* management for lions has been presented.

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Swift fox re-introduction at Bad River Ranches, South Dakota, USA

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Introduction

The swift fox (*Vulpes velox*), once abundant throughout the short and mixed grass prairies of the Great Plains of North America, has disappeared from 60% - 90% of its historical range since settlement (Kahn, 1997). Much of this decline is due to conversion of native prairie to agriculture and associated decline in prey species, unregulated hunting and trapping, and predator control programs focused on larger carnivores. The state of South Dakota lists this small fox (~2 kg) as threatened and is thus mandated to "manage, protect, and restore" the species (South Dakota Codified Law 34A-8).

From 2002 through spring 2008 the Turner Endangered Species Fund (TESF) implemented a cooperative project with state, federal, and other private entities to use re-introductions of wild caught foxes from Wyoming and Colorado to restore a population to the privately owned Bad River Ranches (BRR) and environs in west -central South Dakota, USA. Re-introductions to suitable habitat that are now depauperate of the species may offer a viable approach for maintaining, re-establishing, or facilitating range-expansion of imperiled wildlife populations by helping mitigate the effects of habitat loss, habitat fragmentation with localized surplus, and extirpations.

Goals

- Goal 1: Establish a self-sustaining population of swift foxes on and around the Bad River Ranch (BRR) in western South Dakota.
- Goal 2: Contribute to the viability of a regional population that serves as a source for swift fox recovery and expansion in South Dakota and

Adult radio-collared swift fox

neighboring states and assists in removing foxes from threatened status in South Dakota.

- Goal 3: Establish a population that enhances the long-term survival of the species, restores natural biodiversity to the area (part of restoration of full array of native species to the area), and promotes prairie conservation awareness.
- Goal 4: Collect and disseminate scientific information on re-introduction techniques and the ecological requirements for successful swift fox restoration.

Success Indicators

- Indicator 1: Initial success (1 - 3 years)
  - ⇒ This is reached when we achieve breeding of the first wild-born generation of foxes in the release area.
- Indicator 2: Short-term criteria (3 - 5 years)
  - ⇒ For success include survival and recruitment rates similar to other wild self-sustaining populations and population growth or $r > 0$.
- Indicator 3: Long-term success (>10 years)
  - ⇒ This is reached when fox populations expand and connect with other populations in the region.

Project Summary

Feasibility: As a charismatic species that generates little socio-political or economic controversy, the swift fox is an ideal flagship species for conservation of prairie ecosystems. Nonetheless, obtaining a permit to import foxes to South Dakota was difficult. The Animal Industry Board (AIB) denied our first request for an importation permit over concerns that our fox project would lead to the re-introduction of other larger carnivores like the gray wolf. After the denial we launched an 12 month public relations campaign to dispel erroneous notions about the project. During our second hearing for an importation permit 25 attendees testified in favor of our request, whereas only five testified in opposition. Four of the five agricultural groups that had opposed our initial request supported our second request. At the conclusion of the second hearing the AIB voted unanimously to issue us an importation permit. Our Swift Fox Restoration Area (SFRA) included about 10,000 km² in west-central South Dakota and included the BRR, Ft. Pierre National Grasslands, and Lower Brule Indian Reservation. From a habitat suitability model we estimated that 82% (437 km^2) of the BRR and 77% (7,848 km^2) of the restoration area was suitable for foxes. Road density within the project area was <3.5 km/km^2. Our feasibility study indicated that SFRA could support >200 foxes, the minimum recommended by Ginsberg (1994) to maintain genetic integrity.

Implementation: After we captured swift foxes in Wyoming (2002 - 2006) and Colorado (2006 - 2007), we assessed physical condition, determined body weight and then ear-tagged, micro-chipped, and radio-collared (ATS and Telonics collars weighing 42 - 50 g) each individual. To minimize disease risk during translocation we dusted foxes for fleas with carbaryl powder (SEVIN Dust) (Miller *et al.*, 2000, Pybus &Williams, 2003). We used four different types of release methods: hard-release, short-duration-soft-release (short-soft-release), extended-duration-soft-

release (long-soft-release), and captive born. We defined hard-releases as those in which foxes were held for less than 45 days between capture date and release date, where they were released directly from a transport kennel. Short-soft-release foxes were held for more than 50 days and released from soft-release pens by opening the door and allowing the foxes to leave voluntarily. Foxes in extended-duration-soft-release treatment group were held for more than 250 days on-site in soft-release pens through the winter and released the following year in early summer. Pups born to fox pairs in the long-soft-release category formed the "captive born" release cohort.

Swift fox kit and prairie vole © Georg Joutras

We translocated and released 179 foxes (85 males, 94 females, 91 adults & 88 sub-adults) onto the SFRA. Additionally, we released 43 pups (26 males & 17 females) born in long-soft-release pens. Because coyote predation is a factor limiting fox population growth (Kunkel *et al.*, 2001*b*), we initiated a coyote population reduction effort. Our coyote control program was aimed at short-term reductions timed to coincide with early summer and fall releases of foxes. Our primary method of control was aerial shooting from a fixed-winged aircraft combined with targeted use of recreational coyote callers and opportunistic shooting.

Post-release monitoring: Our protocol included 60-day initial post-release monitoring from October - December, maintenance monitoring and re-collaring from January - April, daily den observations from May - June, and 60-day post-release monitoring for soft-released foxes from July - September. Monitoring was accomplished by combining of aerial- and ground-based telemetry supplemented by direct observations at den sites. Tracking utilized triangulation using a mobile 3 -element null-peak systems mounted in 4x4 vehicles where roads and landscape characteristics allowed. Aerial telemetry typically was used once weekly to locate wide-ranging foxes. All radio collars contained a mortality sensor.

The short-duration-soft-releases resulted in the highest 60-day post-release survival (0.757 survival probability, SE=0.04) compared to long-soft-releases (0.659 survival probability, SE=0.07), hard-releases (0.609 survival probability, SE=0.1), and captive born releases (0.484 survival probability, SE=0.09). From 2003 through 2007 we documented 25 wild-born litters with a total of 102 pups and 12 captive-born litters with a total of 48 pups. We documented a population

growth of 26 foxes (λ=1.47), 16 foxes (λ=1.67), 23 foxes (λ=1.88), 12 foxes (λ =1.36), and 40 foxes (λ =2.05) in 2003, 2004, 2005, 2006 and 2007 respectively. We documented a decreased coyote population in 2003, 2005 and 2007, whereas an increased coyote population in 2004 and 2006. In 2005 the coyote population was at an all time low since 1999 due to the outbreak of mange. Our findings suggested that low coyote abundance along with high prey availability were necessary for higher population growth rate. The release area was found to be marginally suitable habitat for swift fox which resulted in long distance dispersal of both released and resident foxes hindering the long-term viability of the population. By 2010, two years after the restoration effort ended due to the tragic death of the project leader (Kevin Honness), there was scant evidence of swift foxes on BRR and environs.

Major difficulties faced

- Obtaining permits to translocate foxes from Wyoming to South Dakota from South Dakota Game, Fish, and Parks (SDGFP) and Wyoming Department of Fish and Game (WDFG), and Colorado Division of Wildlife.
- Low trapping success and high levels of plague in the Wyoming population made it difficult to translocate as many fox individuals as permitted.
- Aerial control of coyote population could not be done in 2004 and 2005 due to pilot availability prior to soft-release.
- Tragic death of the project leader resulted in termination of the restoration effort before a population could be established.

Major lessons learned

- Release of sub-adult swift foxes comprised of a balanced ratio of male and female foxes using short-soft-release methods is useful to enhance post-release survival and hence, short-term survival of translocated swift foxes.
- Periodic long term food supplementation as well as monitoring and management of the re-introduced population is necessary for long-term success of re-introduction.
- Given the difficulty of swift foxes surviving in areas with a limited view shed, habitat management to reduce the height of vegetation (e.g. through prescribed fire or livestock grazing) is crucial for re-introduction success and population viability.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Local support was crucial to this re-introduction effort. By far, the most important and effective method of promoting our work was from one-on-one contacts with area residents and adjoining landowners while conducting daily field activities. By the conclusion of the project nearly 100 neighboring private landowners had signaled support for the restoration effort. This level of support

is unequivocal evidence that the swift fox in a outstanding flagship species for the conservation of the grasslands of the Great Plains of the US and Canada.

- We documented some unusual long distance dispersal of some individuals from the release site areas eliminating them form contributing to the productivity of the re-introduced population, which might have been due to availability of marginally suitable habitat of the release site disproving our previous assessment of suitable habitat at the release site.

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Antillean manatee release program in Brazil

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Introduction

The Antillean manatee (*Trichechus manatus manatus*) (SIRENIA: TRICHECHIDAE) were widespread along the coast of Brazil as far as the southern state of Espírito Santo. However, they have disappeared from many localities due to over-hunting, habitat modification and a very low rate of natural reproduction (ICMBio, 2011). Estimates suggest that there are only about 500 - 1,000 individuals in scattered populations from Amapá State in the far north to the northeastern state of Alagoas (Luna, 2013). Thus, although the manatee is only classified as globally "Vulnerable" by the IUCN, it is regarded as "Critically Endangered" on the Brazilian Red List and is listed in Appendix II of CITES. There is low genetic connectivity between Brazilian manatees and neighboring populations in French Guiana and Guyana, suggesting that the Brazilian population may represent an evolutionarily distinct lineage. Moreover, Brazilian manatees show marked phylogeographic divisions and low haplotype diversity (Luna, 2013). In response to population fragmentation and widespread coastal development, in 1994 the Brazilian government initiated a manatee translocation and re-introduction program using rehabilitated calves.

Antillean manatee © Edson Acioli

Goals

- Goal 1: Link isolated populations producing a continuous distribution.
- Goal 2: Minimize negative genetic effects.
- Goal 3: Re-colonize parts of the historical distribution.

Success Indicators

- Indicator 1: Adaptation and survive of released individuals.

- Indicator 2: Reproductive success of released individuals.
- Indicator 3: Actual distribution increased.

Boat capture at Alagoas release site
© Ana Emília Alencar

Project Summary

Feasibility: Three release sites were used over the 20 years of the study, two in Alagoas and one in Paraíba State, northeastern Brazil. The two Alagoas sites are Porto de Pedras and Paripueira, inside the Costa dos Corais MPA. The region has inshore reefs, sea grass beds, algae and mangrove areas (ICMBio, 2011). Paripueira was the first release site. However, because of its close proximity (25 km north) to the state capital Maceió, translocations were stopped after only two releases. A new site (Porto de Pedras) 70 km north of Paripueira was subsequently chosen and has been used since 1998. This site is in the middle of two disjunct populations and had no extant population of manatees. The Paraíba site is in Barra do Rio Mamanguape MPA, an estuarine complex close to sea grass beds and inshore reefs (ICMBio, 2011).

Implementation: Stranding of newborn calves is one of the greatest threats to manatees in Brazil as a result of their habitat degradation (Parente *et al.*, 2004; ICMBio, 2011). Government agencies and partner institutions, as members of the Brazilian Stranding Network, rescue stranded calves and transfer them to a rehabilitation facility on Itamaracá Island at CMA/ICMBio facility. After a health assessment the rescued animals are kept in individual pools for a quarantine period, after which they are moved to bigger pools with other calves. They are fed on soy milk compounds, algae and sea grass. At the age of 1 year, they are put in a re-introduction oceanarium' where they have a more natural diet of sea grass and algae supplemented with vegetables (carrots and lettuce) and vitamins. After rehabilitation, selected individuals are moved by trucks and boats to staging areas. The manatees spend some time (15 days at the start of the Project, but increasing to 3 - 12 months later in the Project to facilitate acclimatization) in these areas to adapt to local environmental conditions.

Post-release monitoring: After release, the manatees were monitored using Very High Frequency (VHF) and satellite radio tags. A belt was attached around the caudal peduncle and a floating transmitter was connected with a flexible cable. Three different transmitter models were used (all produced by Telonics, INC.): The MOD-550 is a VHF only transmitter; ST-03 is a platform type transmitter (PTT) that uses an ARGOS link; The TMT-462 and TMT-464-2 are

Global Positioning System (GPS) transmitters that also have an ARGOS link. All satellite transmitters had built-in VHF transmitters, making it possible to track the target manatee in the field. The VHF signal is typically monitored until the researcher has observed the target manatee. Behavioral data were also recorded during field tracking, focusing on behavior relating to acclimatization or breeding. Satellite data were obtained through the ARGOS service and, when the radio tag could be recovered, data were downloaded directly from transmitters. From 2004 to 2012, all released manatees received passive integrate transponder (PIT) tags.

To facilitate comparison, the criteria used to determine success or failure was similar to those used by the Florida Manatee Rescue, Rehabilitation and Release Program. If an individual manatee lives at least 1 year after release without intervention it is considered as a successful. If the manatee dies, during the first year after release, it is considered as a failure. Due to problems with acclimatization or other issues some manatees were released more than once. Missing manatees are considered success if the carcass was not recovered - there is a marine mammal stranding network across the region and systematic campaigns to encourage people to report stranding. Moreover, the rarity of manatees means that sightings and strandings are normally widely publicized.

To measure the effectiveness of the Project in terms of breeding, seven released manatees (4 males and 3 females) were monitored by radio tags over a longer time period (average of 2,700 days). Breeding success was assessed through pregnancy diagnosis for females and breeding behavior observations for males. Breeding behavior was defined as seeing the male manatee in a typical embracing position with another individual. However, male manatees frequently engage in homosexual couplings and embracing behavior therefore does not necessarily signify male-female coupling.

Health assessment and tagging

© Ana Emília Alencar

Major difficulties faced

- The high costs involved and the necessity to keep long-term financial support.
- Logistical difficulties related to keeping manatees in captivity and to manage then in natural conditions.
- The shortage of pristine habitats along the coast of northeast Brazil.

Major lessons learned

- Soft-release facilitates the acclimatization process.
- Close monitoring, health assessments and rescues can significantly increase the success of release.
- Combining different monitoring techniques can improve data quality and reduce tracking costs.
- Long-term studies (15 - 20 years) are needed to effectively evaluate results.
- Releasing animals at approximately 5 years of age increases re-introduction success.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The combination of long-term investment from the Federal Government, NGOs and private sources.
- The creation and refine of re-introduction protocols over a 20 year period.
- Awareness-raising and the engagement of local populations.

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The conservation introduction of Tasmanian Devils to Maria Island National Park: A response to Devil Facial Tumor Disease (DFTD)

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Introduction

The Tasmanian devil (*Sarcophilus harrisii,* Boitard, 1841) once occurred across many areas of mainland Australia, but is now restricted to the State of Tasmania. Tasmanian devils are the largest extant carnivorous marsupial in the world. The species is under threat from a contagious, transmissible tumor known as Devil Facial Tumor Disease (DFTD) (Hawkins *et al.*, 2006). Since 1996 where it was first discovered in the North East of Tasmania, DFTD has spread across much of the species natural range. Long-term statewide spotlighting data indicates a decline in sightings of around 80% with long-term trapping data from some affected areas indicating declines of over 90%. It is listed as Endangered on State and Federal legislation, and also on the IUCN Red List. In

Tasmanian devil © Simon DeSalis

November 2012, fifteen devils (7 males & 8 females) were released from quarantine facilities onto Maria Island National Park on Tasmania's east coast. This was followed up by the release of another 13 animals (8 males & 5 females) in October/November 2013. The Conservation Introduction occurred as part of the Insurance Meta-population strategy for the species (CBSG, DPIPWE and ARAZPA, 2009), to establish a managed, disease free population of wild animals. Monitoring of Maria Island devils and their potential impacts has been ongoing.

Goals

- Goal 1: To establish a wild free-living and DFTD-free population of Tasmanian devils that requires the minimum level of management for its persistence as part of the insurance meta-population for this threatened species.
- Goal 2: To maintain the wild attributes and behaviors of the species as part of the long-term insurance population strategy for the species, including the maintenance of a suite of associated flora and fauna (commensal, symbiotic and parasitic) including an endemic tapeworm *Dasyurotaenia robusta* (Beddard, 1912).

Success Indicators

- Indicator 1: The introduced population's mean body condition score is within acceptable limits (using criteria for a subjective condition scoring system) post release. Weight fluctuations should not significantly vary from those observed in wild populations over time.
- Indicator 2: Greater than 50% of the founders survive after 12 months.
- Indicator 3: Greater than 30% of 2+ year old females breed successfully in the first breeding season post release.
- Indicator 4: F1 breed to produce viable offspring.
- Indicator 5: Establishment of a stable, genetically diverse (95%+ heterozygosity) population at least as large as the initial founding population, requiring minimal management intervention.

Project Summary

Feasibility: Maria Island (9,672 ha) has been a National Park since 1972. Numerous native mammal and bird conservation introductions have occurred particularly in the late 1960s to early 1970s. It is now one of the most bio-diverse islands in Tasmania in terms of mammal species. Maria Island ranked highly as a Tasmanian devil introduction site due to its biosecurity, large size, land tenure, prey and water availability, and presence of Parks and Wildlife Rangers. The island has appropriate denning substrate and habitat in the form of old fallen trees, sand dunes and dolerite boulder fields and an abundance of wombat burrows, commonly used by devils. It also lacks other threats such as dogs and public vehicles. Some ongoing management will be required on Maria Island to maintain a genetically viable devil population in the long term.

Previous land uses including farming converted some areas to pasture, which is now used by a variety of introduced and previously extant herbivores. Forester kangaroo (*Macropus giganteus*), Bennett's wallaby (*Macropus rufogriseus*), Tasmanian pademelon (*Thylogale billiadierii*), brushtail possum (*Trichosurus*

Staff releasing collared devil © Tom Waugh

vulpecula) and the common wombat (*Vombatus ursinus*) have bred to large numbers partly due to the lack of a terrestrial predator. This has resulted in a requirement for macropod population control programs to prevent poor overall population health in the three species. Potential impacts to ground nesting birds such as little penguins (*Eudyptula minor*), short-tailed shearwaters *(Puffinus tenuirostris)* shorebirds and also endangered species such as the forty-spotted pardalote (*Pardalotus quadragintus*), swift parrot ***(****Lathamus discolor****)*** and wedge-tailed eagle *(Aquila audax fleayi)* were considered in risk assessments.

Implementation:

Animal selection and preparation - genetics, health checks, behavior tests: Founding animals were initially selected with consideration to genetic suitability, and availability within the Tasmanian devil insurance meta-population. Breeding recommendations were coordinated by the Zoo and Aquarium Association of Australia (ZAA). Shortlisted animals were then subjected to health checks and behavior tests. The health checks were designed to address major issues raised in a Disease Risk Assessment, developed as part of the project proposal. Behavior tests were developed to: 1) Determine whether behavioral phenotype affects post-translocation survival and reproduction of Tasmanian devils and to 2) Ensure, by assessing responses of individual devils to human presence, that only those posing a minimal risk of becoming a public nuisance were introduced.

Establishment phase - timing of release, site selection, release method, early intervention: The timing of the release (November - Austral spring) was intended to allow establishment on island prior to a typical breeding season which begins around February. Release sites were chosen based on appropriate habitat, distance from the main tourist precinct and the presence of both prey items and fresh water. Animals were released directly into the island environment and provided with supplementary food. This was adjusted according to devil body condition assessment during post-release monitoring. Supplementary feeding was ceased within approximately 2 months of each release once the individuals were established. A public education/reporting campaign was also established to gain information about dispersal and sightings as well as create awareness of the program.

Post-release monitoring:
Collars: Five devils were released with GPS/VHF tracking collars (Thalmann, 2013). This provided information on survival (one devil was found dead in a wombat burrow). It also recorded initial dispersal of the collared animals across the island including some early home range information.

Trapping: Trapping of released devils occurred initially at 2 weeks, then at monthly intervals post 2012. Trapping to monitor general welfare of animals during the establishment phase as well as GPS collar fit. Collars were removed from all devils after 5 months and trapping was then timed to gather important information around breeding success and general body condition of animals. Trapping was frequent post-2013 release during the establishment phase and is now approximately quarterly, timed for important stages of the devil life cycle.

Post release survival has been high (87% for 2012 release and 100% for 2013 release as of August 2014). Breeding has successfully occurred in both 2013 and 2014 with greater than 75% of females observed with pouch young, including three F1 females. In general, weight and condition of animals post release has been within or above expectations.

Cameras at feed stations: Video and still cameras have been used almost constantly since the 2012 release. Animals were photographed during pre-release health checks allowing for remote monitoring of individuals. Camera monitoring has been a highly successful technique post release, especially where individual animals were not captured during trapping trips.

Diet: This was monitored via scat analysis (Rogers, in prep). The Tasmanian pademelon, brushtail possum, and the common wombat, problematic over-grazing species, collectively are making up the bulk (73% of the composition of the devils scat and their remains are found in 86% of scats) of the devils diet. Birds are also common and include cape barren geese, little penguins, shearwaters and unknown other species.

Major difficulties faced

- There was a paucity of recent fauna survey data for Maria Island, and therefore several years of survey work was required to build information into the initial proposal.
- Due to the National Park status of the island, the approval process involved both

First release at French's farm © Simon DeSalis

State and Federal legislation at the highest level resulting in a lengthy approval process.
- The introduction of a mammalian predator to an offshore island outside its range was a controversial concept and involved much debate - particularly whilst animals were still in reasonable numbers across their natural range in the wild (albeit severely declined and in the presence of DFTD spreading).
- There was a need to develop a Translocation Policy for the State concurrently, and also highlighted challenges within existing internal approval processes.
- This proposal highlighted the need to have a better understanding of the context of pathogens within the selected founders, and those extant in the chosen release site. Without a full understanding of potential impacts, e.g. the precautionary principle was applied to founders that tested positive to *Salmonella* and in some instances resulted in exclusion of otherwise suitable animals.

Major lessons learned

- A management regime for captive animals (both intensively managed and free range), aimed at maximizing wild behavior and minimizing human interaction with devils was very effective preparation for the released animals. Wherever possible, free-range captive animals should be given highest priority for selection due to their further removal from daily interactions with humans. When multiple institutions (i.e. zoos, government facilities & wildlife parks) are managing captive animals as a meta-population, every effort should be made to ensure a consistent approach with the ultimate aim being preparation for wild release.
- A strong partnership with the landholder (in this case Parks and Wildlife Service Tasmania) and the Save the Tasmanian Devil Program has been essential in every step of the project. Outlining key responsibilities of each party through Memorandum of Understanding (MoU) provides a clear framework for such partnerships.
- Much thought went into stress minimization for the animals selected for release. Considerations included: use of familiar traps as transport containers; releasing animals in familiar groups (i.e. animals that were housed together prior to release) at separate sites for each group. Release of less dominant, smaller animals in each group first; allowing animals to leave the traps in their own time; separation of media from animals with the use of hides; minimal scat removal (for diet analysis) in the first few weeks after release to allow natural social interactions to develop through the establishment of latrine sites and provision of easily accessed food and water. Whilst difficult to measure, the project success to date is likely to be a combination of many factors including these and other strategies implemented in the establishment phase.
- The development of a captive insurance population as one of the first measures in response to the threat of DFTD was valuable in allowing for suitable release animals to be selected in a timely manner, with suitable quarantine status.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Tasmanian devils are a highly adaptable, generalist species which appear to maintain wild instincts through several generations of captivity. Devils appear to cope well with transportation and translocation into both captive and wild situations using a variety of transport methods, when appropriate stress reduction measures are incorporated.
- Use of the IUCN Guidelines for Re-introductions (IUCN, 1998), a multi-disciplinary team and consultation with experts who had conducted translocations of other Dasyurid species proved very useful in developing the original proposal and post release monitoring plans.
- Careful management of animals in captive facilities to maintain wild traits and minimize human interactions proved to be invaluable preparation for the animals. Good communications between institutions and co-ordination at a meta-population level by the Zoological Association of Australia (ZAA) was essential to success.
- Island selection - Maria Island has met the ecological requirements of Tasmanian devils well to date - however in the long-term the population will require genetic management, and the impact of the devil on the ecology and park users of Maria Island will need to be monitored.
- Appropriate funding during the first 5 years of the Save the Tasmanian devil program allowed many aspects of the project to occur simultaneously in preparation for a successful release - for example project proposal development and baseline monitoring on Maria Island, establishment, development and maintenance of an insurance population, research into the mechanisms and vector of spread for DFTD as well as ongoing wild monitoring on the “disease front” and long-term monitoring sites.

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Re-introduction of eastern bettong to a critically endangered woodland habitat in the Australian Capital Territory, Australia

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Introduction

The eastern (or Tasmanian) bettong (*Bettongia gaimardi*) is a 1 - 2 kg mycophagous marsupial. Once common throughout south-eastern Australia, the species went extinct on the mainland by the 1930s due to fox (*Vulpes vulpes*) and cat (*Felis catus*) predation, habitat modification and human persecution (Short, 1998). Wild populations are now restricted to eastern Tasmania, and the species is listed as 'Near Threatened' by the IUCN (Menkhorst, 2008). This re-introduction was intended to re-establish bettongs on mainland Australia to stock future re-introductions. Two populations were established in the Australian Capital Territory (ACT), one as part of a captive-breeding program at Tidbinbilla Nature Reserve (TNR) (http://www.tidbinbilla.act.gov.au), and one as a wild population within the fox and cat free Mulligans Flat Woodland Sanctuary (MFWS) (http://www.mulligansflat.org.au). The MFWS is part of a larger woodland restoration project which aims to restore ecological function to a critically endangered woodland ecosystem, including research focused on the species' role as an 'ecosystem engineer' (Manning *et al.*, 2011 & Shorthouse *et al.*, 2012 http://www.mfgowoodlandexperiment.org.au).

The re-introduction was undertaken through a partnership between the ACT Government, the Australian National University, CSIRO, and the James Hutton Institute; with support from the Tasmanian Government, the Australian Research Council and the Woodland and Wetlands Conservation Trust.

Goals

- Goal 1: Establish two geographically isolated, healthy and genetically diverse populations in the ACT to provide a sustainable source for future re-introductions on the mainland, and provide insurance in case of further declines in Tasmania.
- Goal 2: Develop trapping and translocation protocols that minimize the risks to source population, and maximizes the probability of long-term persistence in re-introduced populations.
- Goal 3: Research the behavioral and biological responses to different re-introduction techniques and environmental conditions.
- Goal 4: Research the species' ecological function as an ecosystem engineer derived through its foraging and digging behaviors.
- Goal 5: Capture and maintain the genetic diversity present in the wild Tasmanian populations, whilst maintaining wild behaviors.

Success Indicators

- Indicator 1: A 75% survival rate of adults and pouch-young from acquisition in Tasmania to their arrival in the ACT.
- Indicator 2: A 75% survival rate during the initial 3 months post-release, and 80% per annum thereafter.
- Indicator 3: Reproductive activity in all surviving females within 6 months of release.
- Indicator 4: Population growth within both populations (no time limit placed on this due to the use of multiple translocation events over a prolonged period).
- Indicator 5: Maintenance of 95% of the genetic diversity present in founder population in both re-introduced populations after 2 generations.

Project Summary

Feasibility: As predation was recognized as the primary threat to re-introduction success, this project was initiated following the construction of the fox, cat and rabbit proof fence, and the eradication of foxes and cats from MFWS in 2009. The eastern bettong was selected as a priority species, due to its function as an ecosystem engineer, and the environmental suitability of habitat. The subfossil record confirmed historic accounts

Bettong © Stephen Corey, The Woodlands and Wetlands Conservation Trust

Box-gum grassy woodland © Philip Barton

that this species was previously present in the ACT. Environmental suitability was assessed through bioclimatic modeling and expert opinion. The arrangements for the project commenced in August 2010 when contact was established between the ACT's Conservation Research Unit, and the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE). A license to undertake a sedation trial was granted in April 2011, then successive licenses for a trial translocation, and each collection trip until a total of 60 adults were translocated from Tasmania. Suitable source populations were selected from outside nature reserves and national parks.

To minimize the impact on source populations, the number of bettongs taken from any site was never more than one third of the number trapped. The trapping was targeted in 5 regions separated by geographic barriers. This protocol was based on a previous genetic study by DPIPWE that indicated some genetic differentiation either side of major rivers and between northern and southern Tasmania.

Implementation: In May 2011, a sedation trial was undertaken with four individuals to determine an appropriate dosage of the benzodiazepine diazepam for transportation. The aim was to establish a level of sedation that calmed the animal to reduce its flight response, whilst avoiding excessive sedation e.g. unconsciousness and the risk of an occluded airway. The bettongs used in the sedation trial were returned to the point of capture. In July 2011 three bettongs were translocated from Tasmania to the ACT to trial the translocation protocols. Once the translocation protocols were approved, an additional 57 individuals were translocated over three events between October 2011 and September 2012. In total, 60 adults (19 Male:41 Female) and 28 pouch-young were translocated to the ACT.

As this species is known to readily throw large pouch young when stressed, females observed to be carrying furred pouch young were excluded from the translocation. Females with an elongated teat were also excluded due to the likelihood that they had a dependent young-at-foot which was not trapped. Twenty -eight of the adults were housed permanently at TNR (captive group), 16 were temporarily housed at TNR for between 3 - 12 months before being transferred to

MFWS (delayed-release group), and 16 were released directly into MFWS within 24 hours of initial capture (immediate-release group). Twenty adults were also transferred from the captive group to MFWS during 2013 to manage the population density at TNR, and increase population growth at MFWS. The captive group and the delayed-release group underwent a 30 day quarantine period at TNR remote from other animals. All individuals underwent anaesthesia for complete health evaluation and disease screening upon arrival in the ACT. At TNR, all individuals were provided with their daily requirements of food and water, and mating interactions are controlled to ensure genetic mixing among individuals from the five collection areas. At MFWS the population received no supplementary resources, and mating interactions were not controlled.

Post-release monitoring: At TNR, capture events are scheduled every 3 months for each individual to conduct full health and physiological assessments. All founders were monitored using remote cameras when released at TNR to conduct behavioral assessments and to test protocols and equipment. Any new animals encountered are pit-tagged, and DNA samples are taken for genetic analysis. In November, 2014 the population at TNR was estimated to be 51 individuals. At MFWS, with the exception of one individual, every founder was fitted with a VHF or GPS/VHF radio-collar when released, and these were removed at approximately 1 year post-release. The remaining individual was not collared due to a neck injury. Each founder was monitored daily for the first 30 days, and then at least weekly until the collar was removed to evaluate survival using the radio-collar's mortality function. Each founder was scheduled to be trapped a 1, 3, 6, 9 and 12 months post-release and given full health and physiological assessments; however, the actual timing of these events varied due to logistic constraints. Fecal and hair samples were collected during health assessments for dietary and hormonal analyses (e.g. cortisol). Following the removal of all of the collars the population will be monitored at least annually using Capture-Mark-Recapture. Any new animals encountered are pit-tagged, and DNA samples are taken for genetic analysis. In November, 2014 the population at MFWS was estimated to be 179 individuals. The DNA samples taken from both populations are being analyzed to assess genetic diversity and genetic progression.

Major difficulties faced

- Two pouch-young died after being evicted from the pouch either in the trap, or during trapside handling in Tasmania. The risk to the pouch-young was significantly reduced through changes to trapping protocols such as clearing traps before midnight, and approaching the trap rapidly. Four additional adults died within 1 month of release at MFWS due to pre-existing health conditions or misadventure with radio collars. The design of the collars was modified in-house to reduce the risk of future collar in response to these incidences of misadventure.
- Lower than expected capture rates at certain locations in Tasmania. This was attributed to lower than expected population densities at these locations. This impacted on the ability to obtain the desired number of founders especially given one-third harvesting rule, the exclusion of females with large pouch-

Staff undertaking fieldwork © Stephen Corey, The Woodlands and Wetlands Conservation Trust

young and young-at-foot, and the desired 2:1 sex-ratio. We improved the efficiency of subsequent events by undertaking prospective surveys.

- Difficulty designing and fitting radio-collars that did not cause injury or interfere with foraging ability. Multiple prototypes were tested at TNR to identify a suitable design and fitting method.
- Logistic difficulties relating to the translocation of wildlife interstate. Obtaining the relevant approvals and licenses was a lengthy process and required a long lead-in time for the project.
- Releasing bettongs at MFWS impacted on other on-site management activities at MFWS. For example, the presence of bettongs made broad-scale poisoning and trapping unacceptable options for controlling rabbits and resulted in the use of less cost efficient methods.

Major lessons learned

- Baseline health and disease data were determined for this species and can be used for the conservation management of the source and translocated populations. Administration of diazepam at 1 mg/kg appeared to effectively mitigate the effects of capture myopathy.
- Trapping, transport and monitoring protocols must be specifically designed, and tested within an adaptive and experimental frameworks. Without pre-release trials the probability of success would have been substantially reduced. Many of these trials would not have been possible without access to the captive facilities at TNR. All individuals fitted with radio collars must be regularly captured to reduce the risk of injury.
- The probability of successful establishment is high when this species is released into suitable, fenced and predator-free environments following the protocols developed during this project. The risk of inbreeding can be considered low given the high rates of pouch-occupancy, and lack of genetic assortment at MFWS.
- Uninjured pouch-young can be successfully taped back into the pouch, or alternatively hand-raised and returned to the wild following a pouch-eviction.

Wild founders can also perform favorably when released after a temporary period in captivity for quarantine.

- Wild-sourced bettongs assimilate well into captivity, but with supplementary feeding captive bettongs have shown a tendency to become overweight. Quantity of food, animal condition and stress needs to be monitored as it may impact on the breeding success.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- All indicators of success relating to survival and reproduction were met or exceeded in both populations. This can be attributed to the development and testing of management protocols with adaptive and experimental frameworks. As of November 2014 the ACT population was estimated to be 230.
- The successful establishment of population at MFWS indicates that the habitat at the site can be considered as high quality for this species. The environmental characteristics that are assumed to have contributed to success include the absence of foxes and cats, and the abundance and diversity of vegetation and mycorrhiza.
- The successful collaboration of multiple stakeholders including government, academic and community organizations. The group also included experts from diverse array of disciplines including scientist, wildlife veterinarians, captive breeders, and environmental practitioners. Those involved shared a willingness to adopt adaptive approaches to problem-solving which was critical to success.
- Housing animals in specialized captive facilities enabled quarantine, and equipment trials to be conducted within a controlled environment before conducting large translocations and releases into the unmanaged site. This reduced the risk of post-release mortality and disease/pathogen/parasite co-introductions.

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Supplementation of eastern swamp deer in Manas National Park, Assam, India

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Introduction

The swamp deer (*Rucervus duvauceli*) has three sub-species - northern swamp deer (*R. d. duvauceli*) inhabiting flooded tall grasslands of the Indo-gangetic plain (Dudhwa Tiger Reserve and some terai forests of UP and Uttarakhand), central swamp deer (*R. d. branderi*) or the hard ground barasingha found in Kahna National Park in Madhya Pradesh and the eastern swamp deer (*R. d. ranjitsinhi*), found largely in Kaziranga National Park of Assam. The species is listed in the IUCN Red List as Vulnerable and the population is noted to be decreasing. The eastern swamp deer was listed as having 300 - 500 animals in 1994 (Qureshi & Sawarkar, 1994). The major part of this population is in Kaziranga NP while its numbers have considerably dwindled in Manas National Park, where once they used to be relatively common. Reportedly there is a small population of swamp deer surviving in Manas but no estimates are available. Thus a project was conceived to re-populate Manas to create a viable second home for swamp deer, especially with the high threats posed to swamp deer in Kaziranga because of floods. This would also fulfil part of India's commitments to UNESCO towards restoring the past glory of Manas and further strengthening the UNESCO World Heritage Site.

Eastern swamp deer © Aftab Ahmed/WTI

Goals

- Goal 1: To repopulate eastern swamp deer in Manas National Park and other suitable areas in its former distribution range.
- Goal 2: To restore key flagship species to a World Heritage Site that had been placed in danger due to local habitat and species exterminations.

Success Indicators

- Indicator 1: Consent from all stakeholders involved in the eastern swamp deer conservation.
- Indicator 2: Development of a nationally recognized translocation protocol in order to guide the project.
- Indicator 3: Mortality free capture and transportation of at least 20 individuals from Kaziranga National Park to Manas National Park and release into a soft-release boma.
- Indicator 4: Release of at least 75% of acclimatized deer into the wild and monitoring.
- Indicator 5: Breeding of released population within two seasons.

Project Summary

Feasibility: With the only viable population of the eastern swamp deer in Kaziranga National Park, there was a need to build up remnant populations to secure the future of the species. The main stakeholders - the government of Assam, the local communities around Kaziranga and Manas and the Bodoland Territorial Council, all came together in support of this re-stocking project. An initial concern was to use a safe capture and transportation processes in view of the susceptibility of deer to capture myopathy. A two day consultative meeting was held in Guwahati with the aim of producing a translocation protocol to give direction to this endeavor. The workshop was attended by national and international ecological, veterinary and forestry experts The protocol addressed the three main aspects of the translocation: 1) the capture, transportation, veterinary and welfare concerns, 2) the release site suitability and *boma* considerations, and 3) monitoring and risk management. Communities living on the periphery of Kaziranga were involved and kept informed of the project to avoid any political protests. A passive mass capture was preferred over conventional chemical immobilization. The capture boma was screened by tarpaulin sheets mounted on taut steel wires supported by steel and bamboo poles such that they could be used as curtain-like barriers. The advantage with this was that any segment of the boma could be opened and shut as per on-site requirement. A group of swamp deer at Mihimkuh, which were habituated to elephant-riding visitors and thus could be approached very closely was chosen as the donor population.

Implementation: In December 2014, a capture boma was erected in Mihimukh. Attempts using elephants to drive the deer into the capture funnel were unsuccessful as the deer, instead of moving into the mouth of the funnel shaped capture boma, ran elsewhere. This method was abandoned in favor of a more passive approach of allowing the deer herd to move into the boma on their own before closing the openings and securing them within. On 25th December at around midday, when about 60 deer were inside the boma, the curtains on the wide entrance portion of the boma was closed and secured the deer inside. Once inside, the deer were driven into a tunnel leading to a transport vehicle using a wide screen made out of people holding tarpaulin sheets. In all 19 deer were captured and guided into two specially modified transportation trucks in groups of eight (two males and six females) and 11 (three males and eight females). This is

Eastern swamp deer release boma
© Subhamoy Bhattacharjee

after the veterinarians pronounced them fit for travel after a visual examination in the tunnel. The capture of swamp deer had thus been completed. The surplus animals that got trapped inside the tunnel were let out once the capture operation was over. Only males with antlers and spikes were injected with Azaperone @ 60-100 mg/animal in the tunnel before allowing them inside the transport vehicle. Adult females and yearlings were not injected with any drug.

The transportation to Manas National Park, located about 400 km west took over 10 hours. The two vehicles that transported the deer had been specially modified with paddings on the inner walls and anti-skid flooring. Adequate provisions had been kept for ventilation. Periodic checks, after every 2 - 3 hours, were conducted from the hatches provided for inspection and all swamp deer appeared to be calm and resting on the floor of the vehicle. The swamp deer were eventually released into the 15 ha release boma at daytime on 26th December. All 19 deer had survived the long travel.

Post-release monitoring: By May 2015, five fawns were born within the boma. However, the prolonged stay within the boma took their toll on the deer in that their health deteriorated as natural forage within the enclosure became scarce and they did not take to any other supplementary forage. The deer also had developed a moderate level of endoparasitic load. Two females succumbed in the boma before release and post-mortem revealed abscesses in the liver. This health condition precluded chemical capture to affix radio-collars and in June 2015, all the animals were released without any transmitters. However, it was possible to partially follow some deer by physical sightings or through camera traps. The deer have split in small groups, unlike in Kaziranga where they were part of a one large herd and are being sighted in the Kuribeel area of the park where suitable habitat exists. Two males strayed out of the park after release and got killed by people. One female got predated by a leopard soon after release and 19 deer are currently being monitored daily on elephant back.

Major difficulties faced

- Difficulty in establishing a much larger boma that would have self-sustained the population for a longer duration, without impacting the body condition

- Refusal to take the supplementary fodder provided to the deer within the boma. By the time the deer got habituated to natural fodder coming from outside, it was too late to retain them in the boma.
- Inability to restrain chemically due to poor health condition precluded procedures like radio-collar and biological sample collection and detail clinical evaluation/adaptation of the animals.

Major lessons learned

- Not to force swamp deer into capture enclosure by driving. Passive capture seems to be ideal for the species.
- Radio collaring of select animals in the capture tunnel itself before being loaded into the trucks.
- Release after a 2 months of temporary accommodation in the boma, to create some site fidelity.
- Reinforcing the power fence that already exist along the southern boundary of Manas National Park to prevent males from straying towards the village side.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Capture and translocation was a great success because most of the thought process and planning went into this, considering high mortality reported from previous capture operations done in Central India.
- Breeding success was also a good success indicator.
- Acclimatization and post-release monitoring did not go well because of the reasons mentioned above. It could have been easily overcome had the deer been collared at the source itself.

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Developing red squirrel re-introduction techniques for use during regional grey squirrel eradication programs in Europe

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Introduction

The red squirrel (*Sciurus vulgaris*) is an arboreal rodent of temperate forests across the Palaearctic. In the UK, Ireland and Italy it faces resource competition and lethal disease infection from the introduced north American eastern grey squirrel (*Sciurus carolinensis*). The red squirrel is of 'Least Concern' on the IUCN Red List, listed under Article III of the Berne Convention and protected under the UK Wildlife & Countryside Act 1981. In 1993, 14 radio-tagged red squirrels were translocated from the wild into a 580 ha pine woodland in Dorset, England to study survival and interactions with non-native grey squirrels. Re-introductions also took place on Anglesey, a 720 km^2 island linked by bridges to the adjacent northern coast of Wales. In 1998, the island contained 40 red squirrels and some 3,000 grey squirrels which were then subject to an eradication program. The Anglesey work was informed by the release in Dorset and another in broadleaved habitat in Conwy, Wales.

Adult red squirrel in Anglesey 2014
© Steve-Ransome

The first Anglesey re-introduction was successful and occurred in the Newborough pine plantation (Shuttleworth *et al.*, 2008). Subsequent releases occurred in broadleaved woodland. We describe how techniques evolved in the light of pathological disease and the presence of grey squirrels at release sites.

Goals

Dorset:

- Goal 1: To learn about release technique suitability, and behavior and survival of red squirrels in the presence of grey squirrels. This was done by experimental releases of radio-tagged red squirrels in pine woodland similar to that holding a dense island population nearby.

Conwy:

- Goal 2: To establish and co-ordinate a UK-wide red squirrel captive-breeding program. This would develop techniques for releasing captive-bred red squirrels to the wild from enclosures within a mixed conifer and broadleaved woodland.
- Goal 3: To educate the public about the natural history of the red squirrel and the threats faced by the species in the UK. Assessing the level of support needed to ensure the long-term viability of a newly-established re-introduced population of red squirrels in terms of control of grey squirrels, provisioning and artificial breeding sites.

Anglesey:

- Goal 4: To evolve re-introduction techniques to successfully re-introduce red squirrels to broadleaved woodlands, a habitat type where grey squirrels have a significant competitive advantage over their congener. This action would increase species distribution to an extent that would facilitate public participation in conservation, and increase community involvement in the latter stages of ongoing grey squirrel eradication.
- Goal 5: To restore a genetically rich and self sustaining red squirrel population within Anglesey bringing associated economic dividends through environmental tourism.

Success Indicators

Dorset:

- Indicator 1: The gathering of reproductive, survival and ranging behavior data from at least 10 released red squirrels for comparison with archive data from a natural population in similar Scots pine habitat nearby.

Conwy:

- Indicator 2: The establishment of a captive red squirrel breeding population in enclosures that would produce sufficient healthy and genetically diverse animals for release to the wild.
- Indicator 3: Establishment of a re-introduced red squirrel population with successful breeding in the wild; the resulting written protocols enabling re-introductions at other sites and raised public awareness of red squirrel conservation.

Anglesey:

- Indicator 4: The establishment and expansion of red squirrel populations in broadleaved woodland habitats especially within community parkland and wooded gardens.
- Indicator 5: Developing re-introduction techniques and management protocols for squirrelpox virus and adenovirus. These would reduce mortality rates and thus help facilitate an increase in the genetic variation within the wild red

Semi-natural broadleaved woodland on Anglesey

squirrel population following translocation. In 1998 the population had been monomorphic for Mitochondrial DNA.

Project Summary

Feasibility: Studies of competition between red and grey squirrels in the UK focussed upon feeding ecology during the 1980s. Such research preceded experimental re-introduction studies in the presence of grey squirrels, which started with Bertram & Moltu (1986). However, no released population persisted for longer than 18 months. The use of radio-tags on released red squirrels, on wild animals in a similar habitat nearby, and on 32 grey squirrels in the release area, enabled a later experiment on the Purbeck peninsula (Dorset) (Kenward & Hodder, 1998, as included here) to produce detailed data on inter-specific interactions and competition (and through much later repeated autopsy, on disease too). Subsequent trials in broadleaved woodland in Conwy (Shuttleworth *et al.*, 2014, also included here) were further key studies that particularly underpinned the final two projects on Anglesey that we report. A precursor to the Anglesey projects was a systematic grey squirrel eradication program initiated on the island in 1998 to facilitate natural recovery of the small remnant red squirrel population in a 244 ha forest (Shuttleworth, 2003). However, woodland fragmentation and geographical isolation of the initial red squirrel population precluded rapid re-colonization of wider landscapes. Project managers were aware of the public popularity of red squirrels (88% of UK adults would like to see red squirrels back in local parks and gardens) and that increased presence of this charismatic animal could be used as major driver in eradication of grey squirrels (Schuchert *et al.*, 2014).

In the first Anglesey translocation project, the successful re-introduction of red squirrels into 689 ha coastal pine plantation greatly benefitted from techniques evolved in the Dorset and Conwy releases. However, despite contingency planning, pathological adenovirus infection and difficulties in maintaining habitat free from grey squirrels were key lessons in a study which centered upon the release of young born to adults permanently housed within woodland enclosures following methods trialed in Conwy (Shuttleworth *et al.*, 2008). The remaining ~2,000 ha of island woodland habitat was predominantly broadleaved, and therefore was recognized as both a preferred grey squirrel habitat and also representative within the range of habitats naturally occupied by red squirrels in the absence of greys. Parkland and private garden woodland habitats offered the opportunity to bring red squirrels back into recreational locations and so

seamlessly create a learning and participation interface between local people and red squirrel conservation. The second Anglesey translocation project was into broadleaved habitat and is described below.

Implementation and monitoring: In the winter of 2006 - 2007 we initiated the first re-introduction of red squirrels into broadleaved woodland in the South East of Anglesey where grey squirrels were close to eradication. Captive-born red squirrels were housed in two separate 1.5 m x 3 m forest enclosures either as pairs or singularly. Animals were released after 4 - 12 weeks captivity into woodland containing supplemental food and nest boxes of a design identical to those within the enclosures. Red squirrels continued to have access to the enclosures for 3 months. Enclosures were thoroughly cleaned with Virkon S anti-viral disinfectant before other captive red squirrels were housed there. A total of 6 animals were released from 22nd January 2007 to 18th July 2008. Two other animals died whilst captive, one was confirmed as being infected by adenovirus. Within 3 years red squirrels had spread up to 4 km from the release site and populations established in local gardens where people began to put out supplemental foods. Local people joined a project Facebook group where they could post pictures and talk about the red squirrels. This dynamic platform also encouraged reporting of grey squirrel sightings.

Retrospective investigations have now revealed that adenovirus can be carried asymptomatically by red squirrels, grey squirrels and woodmice (Everest *et al.*, 2012, 2013), findings which only reinforce the need to design methodologies that reduce intra and inter-specific infection risks. Subsequent broadleaved habitat re-introductions on Anglesey therefore involved trapping and removal of woodmice from red squirrel enclosures and feeding stations. Red squirrels are also subjected to fecal screening to detect pathological cases of adenovirus infection but determining asymptomatic infections remains challenging as blood and fecal samples are suboptimal material to test (Everest *et al.*, 2012).

Integrated landscape management of squirrels Re-introductions of captive-bred animals into broadleaved habitats have been instrumental in the Anglesey red squirrel population increasing from 80 - 90 adults in 2002, to around 700 today making it the largest and most genetically diverse in Wales. There are now over 150 supplemental feeding stations in woodlands and gardens being managed by volunteers and community-based network is the basis of a framework of wider public monitoring of red squirrels. Annually we would now anticipate receiving 20 - 40 red squirrel carcasses collected from roads, gardens or woodlands by members of the public. This facilitates gross post mortem and histological population surveillance to be undertaken at a scale which would otherwise be beyond the scope of the project. Members of the community now act as ambassadors raising public awareness of red squirrel conservation and the impacts of non-native species. In 2009 the first red squirrels were found having dispersed across the sea channel to the mainland and establishing a population in parkland within the City of Bangor.

When the first Anglesey red squirrel re-introductions were undertaken the eradication of grey squirrels was well progressed but island-wide incomplete. Despite our best efforts grey squirrels were occasionally found sympatric with red squirrels and yet we did not record squirrelpox outbreaks. We now know that as the grey squirrel abundance decreased the prevalence of squirrelpox in remaining animals declined and the virus became extinct before grey eradication was complete (Schuchert *et al.*, 2014).

Major difficulties faced

DORSET:

- All squirrels survived translocation and 6 days of soft release, however 3 died in the next week, only 3 survived 3 months, and none for 4 months. Squirrels from Corsican pine (*Pinus nigra*) habitat dispersed from release within cone-rich Scots pine (*Pinus sylvestris*) woodland to the best Corsican pine stands, and 7 of 11 were eaten by foxes while dispersing. Behavior of three long-term survivors indicated competitive pressure from grey squirrels and the last surviving animal was infected with squirrelpox virus (SQPV).

CONWY:

- The development of a productive captive-breeding population in the Conwy project proved difficult. Protocols for successful births and rearing, including enclosure design, took several years to develop, as did the national network of breeding institutions who would make a long-term commitment to red squirrel captive management on sound genetic and demographic principles. Some private collections, although very successful at breeding squirrels, would not, or could not, conform to the basic principles of population management such as individual specimen identification, record keeping, and providing data to the studbook keeper/coordinator.
- Although the initial stages of the trial Conwy release project in the 1990s went well and a released female reared two litters of young in the wild, SQPV was a major factor in local extinction. At the planning stage, disease had been one of a number of risk factors considered, but as little was known about the impact of SQPV at that time, managers focused on reducing the competitive pressure from grey squirrels by controlling numbers rather than eradication to prevent transmission of pathogenic viral infection to the red squirrels. Tests for SQPV were not available at the start of the project, but as they became available and as released squirrels died, it was clear that eradication of grey squirrels would be essential for any future red squirrel releases.

ANGLESEY:

- Broadleaved woodlands are a habitat which gives grey squirrels a much greater competitive advantage over red squirrels than conifer plantations, and thus on Anglesey proved to require much more intensive levels of grey squirrel control. A series of strategic local re-introductions created opportunities for local communities to see foraging animals and so become involved in their conservation. However, grey squirrels were not eradicated from Anglesey before red squirrels were released locally, and this caused objections from some conservation agencies to our phased re-introduction strategy.
- There were no data available upon the impact of culling upon rates of

squirrelpox infection in residual grey squirrel populations, or on adenovirus epidemiology in red squirrels generally. Although the culling associated fall in SQPV infection benefitted re-introduction outcomes, lack of fore-knowledge hindered planning and lack of information on adenovirus epidemiology made efficient infection management difficult.

Children building squirrel feeding boxes

Major lessons learned

DORSET:

- For translocation of wild squirrels, release habitat should be as similar as possible to the habitat of origin. Radio-tagging was essential for indicating the advisability of removing grey squirrels, and possible predators from areas where red squirrels will be released.

CONWY:

- Successful management of captive red squirrel collections needs to be underpinned by research, perseverance, allocation of resources and the long-term commitment of a holding institution.
- Future attempts to re-introduce red squirrels to habitats with invasive grey squirrels not only have to address the issue of the grey squirrel competitive advantage, but also the infectious disease threat they pose.

ANGLESEY:

- Building on disease findings from Purbeck and Conwy, the development of measures to reduce pathogenic viral infection in both captive and released red squirrels was essential. Reducing adenovirus infection risk was achieved by shortening the captivity phase, using a low founder group size (6 - 8 animals) and introducing proactive fecal viral screening of animals within breeding institutions before transport to release sites. Long-term (5 - 10 years duration) post mortem monitoring of red squirrel mortality cases was also central to disease management. The study also demonstrated that culling of grey squirrels needs to have reduced their SQPV infection levels prior to red squirrel release.
- Releases into habitats which included wooded public parks and private gardens enabled people to see red squirrels regularly. This galvanized community support for regional grey squirrel eradication and was essential for securing the resources necessary for island wide eradication. However, the dispersal of red squirrels from Anglesey, across the Menai Straits into mainland Gwynedd was faster than anticipated. Although this increased the

geographical distribution of red squirrels it presents the challenge of managing potential disease risks from mainland grey squirrels. Contingency and management protocols to deal with this were consequently being produced reactively and without funding in place.

Success of project

Purbeck Peninsula (Dorset):

Highly Successful	Successful	Partially Successful	**Failure**
			√

Broadleaved woodland (Conwy):

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Newborough pine forest (Anglesey):

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Broadleaved sites (Anglesey):

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

DORSET:

- Release of wild-born translocated squirrels into habitat not exactly matching their original appeared to promote dispersal, during which predation was a problem; range sizes and trap response of settled survivors indicated possible competition effects from grey squirrels and the longest surviving animal became infected with SQPV.

CONWY:

- Successful long-term maintenance of a captive-breeding population at Conwy depended upon a long-term commitment to the program and the availability of animals from other co-operating breeders. The ability to adapt and redesign holding facilities and husbandry practice in the light of experience has also been important.
- The trial re-introduction in the late 1990s was a partial success in that protocols for on-site breeding and release were developed and later used on Anglesey, but the aim to establish a re-introduced population at the Conwy site failed due to infectious disease from grey squirrels.

ANGLESEY:

- During the progressive eradication of grey squirrels the rates of asymptomatic SQPV infection within residual populations declined dramatically. This decreased the risk of inter-specific infection, whilst in parallel soft-release protocols also evolved to minimize risk of pathogenic adenovirus infection.
- The series of releases progressively increased the geographical distribution of red squirrels, enhancing opportunities for local people to see animals and participate in their conservation by providing supplemental foods in gardens and woodlands. This reinforced political support for red squirrel conservation and was fundamental in obtaining the financial resources required to eradicate invasive grey squirrels. Anglesey now contains the largest (700 adults) and most genetically diverse red squirrel population in Wales. In 2009, red squirrel dispersed across the narrow sea channel and re-colonized the mainland county of Gwynedd.

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Re-introduction of the Mexican Wolf in Arizona and New Mexico, USA

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Introduction

Mexican wolf (*Canis lupus baileyi*) re-introduction in the United States has been ongoing since 1998 as part of our recovery program for this endangered subspecies. Mexican wolves historically ranged from the southwestern United States through central Mexico, but were extirpated from the wild by the 1980s. Mexican wolves are listed as endangered under the Endangered Species Act (ESA), and are protected as a subspecies at risk by Mexico. Mexican wolves are included in the gray wolf entry on the IUCN Red List (categorized as Least Concern due to the status of gray wolves worldwide). Mexican wolves are the rarest, most unique subspecies of gray wolf in North America.

The U.S.-Mexico bi-national captive-breeding program established for the Mexican wolf in the early 1970s was founded with only seven Mexican wolves. In the United States, we are re-introducing Mexican wolves in Arizona and New Mexico within the Mexican Wolf Experimental Population Area (MWEPA). This designation, under section 10(j) of the ESA, allows flexibility in our management of Mexican wolves. Mexican wolves are not present in the wild in the United States outside of the MWEPA. Mexico is conducting an independent re-introduction of Mexican wolves in Mexico.

Mexican wolf © George Andrejko

Goals

- Goal 1: Establish a population of 300 - 325 Mexican wolves in the Mexican Wolf Experimental Population Area.
- Goal 2: Decrease genetic risks to the population, including reducing mean kinship, inbreeding, and loss of heterozygosity.
- Goal 3: Minimize negative impacts to livestock producers and communities from Mexican wolf re-introduction, including seeking funding for the Mexican Wolf/Livestock Coexistence Council, which provides funding to livestock producers for proactive measures to decrease the likelihood of livestock depredation, payments for presence to offset indirect costs, and depredation compensation for direct costs.
- Goal 4: Develop a revised recovery plan to guide the Mexican wolf recovery program.
- Goal 5: Maintain and strengthen interagency partnerships and relationships with local communities and tribes.

Success Indicators

- Indicator 1: Mexican wolf population is growing by approximately 10% annually, including reaching a population size of approximately 150 within the next five years, 200 within the next eight years, and 300 - 325 within 13 years.
- Indicator 2: An adequate number of effective migrants are added to the experimental population over several generations to decrease genetic risks for the population via the release of Mexican wolves from captivity to the wild.
- Indicator 3: The Coexistence Council is able to provide adequate funding to livestock producers to conduct proactive management actions that will decrease livestock depredations, compensate for depredations, and provide payments for presence of Mexican wolves.
- Indicator 4: A recovery plan is finalized during 2016 - 2017.
- Indicator 5: Working relationships with partner agencies, local communities, and tribes are effective in moving recovery forward.

Project Summary

Feasibility: The current focus of this project is to establish a population of 300 - 325 Mexican wolves in the MWEPA. We expect this population to contribute to recovery of the Mexican wolf under the ESA, which will likely require several populations and considerably more than 300 Mexican wolves in the United States and Mexico. The MWEPA contains adequate suitable habitat to support our population objective at a density that we expect will not negatively impact native ungulate populations. (Mexican wolves' primary prey is currently elk. Deer, other ungulates, and small mammals are also preyed upon, as well as livestock.) Therefore, from an ecological perspective, the feasibility of the project is high. Although the re-introduction and recovery of the Mexican wolf is strongly supported by the public at large, it is highly controversial with local communities, who have concerns about human safety and economic impacts on the livestock and hunting industries. In addition, the MWEPA spans tribal lands of two dozen Native American tribes, who have varying levels of support for, or concern about,

Mexican wolf occupancy on their land. Therefore, the socio-political landscape of Mexican wolf re-introduction is very complex.

Implementation: We have been re-introducing the Mexican wolf in the United States with our partner agencies since 1998. Currently, our partner agencies include Arizona Game and Fish Department, White Mountain Apache Tribe, U.S. Forest Service, USDA Wildlife Services, and Gila, Greenlee, Navajo, Graham, and Eastern Arizona Counties Organization. Over the 17 years of the re-introduction project, we have improved our techniques for conducting successful management actions such as the release of wolves from captivity, translocating wolves from one area to another, conducting management actions in response to depredation or nuisance behavior, and most recently, cross-fostering Mexican wolves in the wild (offspring that are removed from their biological parents and raised by surrogate parents). In January 2015, we revised the regulations established in 1998 for the MWEPA in order to improve our conservation of the Mexican wolf and our management flexibility of the experimental population. Our revised regulations expand the area where the experimental population can occur from of 18,679 km^2 to over 398,477 km^2 (including 81,229 km^2 of suitable habitat). The revised regulations also expand the area in which we can release Mexican wolves from captivity into the wild from 2,986 km^2 to 32,392 km^2. We will be working with our partner agencies in 2015 to implement these new regulations and adjust our management over this larger area.

Post-release monitoring: Routine (weekly) monitoring of Mexican wolves is conducted. Mexican wolves captured in, or released to, the wild are fitted with radio-collars, with a goal to maintain two radio-collared wolves per pack. Locational data is recorded into a database to be correlated with specific incidents (e.g. depredations & nuisance reports), management actions (e.g. captures, translocations & initial releases) and pack activities (e.g. denning, predation & mortalities). The re-introduction project utilizes standard VHF radio collars as well as various types of GPS radio collars. We conduct an end-of-year population count every year. The minimum population count at the end of 2013 was 83 wolves; our 2014 population count will be announced in February 2015.

Major difficulties faced

- Local community opposition to Mexican wolf re-introduction and recovery.
- Communication with the public about our goals for Mexican wolf recovery.
- Regulatory constraints related to our 1998 experimental population regulations, especially as related to adequate habitat in which we could release Mexican wolves from captivity to the wild to address genetic issues.
- Unknown consequences of limited genetic diversity. Inbreeding depression has been documented in the captive and experimental populations. Active management of the captive population minimizes the risk of inbreeding depression to the extent possible, but inbreeding depression has the potential to decrease the fitness, growth rate, and genetic variation of the experimental population unless addressed by appropriate management actions (i.e. release of unrelated wolves from the captive population).

Major lessons learned

- We have successfully established a wild population of Mexican wolves in the MWEPA. In 2013, the minimum population count was 83 with all Mexican wolves wild born; some of these Mexican wolves are at least 4th generation wild wolves. This experimental population originated from 7 founders that were used to establish a bi-national captive-breeding program. Releasing naïve wolves from captivity into the wild is much more difficult and time intensive, due to management of nuisance behaviors, than translocation of wild wolves from one area to another. Releases continue to be necessary to augment the genetics of the wild population. Our preferred release methodology has been adult wolves with young pups, with the pups serving to "anchor" the adults to the release area, enabling the supplemental feeding of the pack until successful hunting is documented. We have found that the experience gained in the wild allows for these same animals to be more successful in subsequent release events. In the future, we are likely to transition to more cross fostering of captive pups into wild dens to assist in achieving the genetic variation desired, reducing the nuisance issues often associated with the release of captive wolves.
- Adaptive management is needed to balance the release of captive wolves and removal strategies to address livestock depredations and nuisance behavior to maintain a growing population. Overly restrictive and prescriptive rules and protocols requiring removal of Mexican wolves due to depredations or nuisance behaviors that do not allow for consideration of the status of the population will not allow for sustained population growth.
- Dispersal distance and suitable habitat should be considered when establishing areas of occupancy. Limiting the geography of where animals can be released and where animals can disperse to and occupy create a scenario of limited population growth and management flexibility.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The Mexican Wolf Recovery Program is often compared to wolf re-introduction efforts in the Northern Rocky Mountains. However, several important differences exist. In the Northern Rocky Mountains, wild wolves were captured in Canada and re-introduced into Yellowstone National Park and the central Idaho Wilderness - both large swaths of land largely absent of cattle. In the southwest, there are no other populations of Mexican wolves, so we have relied on captive raised wolves for release onto national forest service lands, most of which are grazed upon by cattle. In the face of these challenges, we have established a population of Mexican wolves, and at the end of 2013 all Mexican wolves documented in the wild were wild born, demonstrating that we were able to establish a wild population from captive-released animals.

Releasing Mexican wolves to the wild © USFWS

- The 1998 Final Rule restricted the area where Mexican wolves could be released from captivity and further restricted the area where wolves were allowed to disperse and occupy. A Final Rule published in 2015 greatly expands the area in which releases can occur, as well as the area wolves can disperse to and occupy. The changes provided in the 2015 Final Rule should allow for this population to grow to 300 - 325 Mexican wolves, better enabling it to contribute to the overall recovery of the Mexican wolf.
- The captive-breeding program has rigorously managed the captive population to minimize the loss of genes and produce animals for re-introduction. The wild population has fewer founder genome equivalents, less gene diversity, higher mean inbreeding coefficient, and greater population mean kinship when compared to that of the captive population. All of these genetic parameters can be positively affected by the re-introduction of captive wolves to the wild.
- The lack of an updated recovery plan results in difficulty communicating our objectives with the public and our partners. The 1982 Mexican Wolf Recovery Plan did not contain recovery criteria.
- The politics of wolves often causes difficulties in our partnerships.
- Predator re-introductions tend to be controversial with the public and local governments; the Mexican wolf program engenders strong pro- and anti-wolf sentiments that play out in the press, community meetings, and during one-on-one interactions with landowners. Litigation against the program has increased in recent years, which often impedes our ability to move forward with recovery implementation.

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Re-introduction of the Columbia Basin pygmy rabbit in central Washington, USA

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Introduction

The pygmy rabbit (*Brachylagus idahoensis*) is a small burrowing lagomorph, classified by the IUCN as a species of Least Concern across its range in the sagebrush steppe of the western United States. However, a geographically and genetically isolated population in the Columbia Basin of central Washington declined drastically in range and abundance by the 1990s. This population was listed as endangered by the state of Washington in 1993, and listed as an endangered distinct population segment under the federal Endangered Species Act in 2001. Pygmy rabbits are shrub-steppe obligates, depending on sagebrush (*Artemisia spp.*) for a large portion of their diet (Green & Flinders, 1980). The principle threat to the species in Washington is habitat loss due to land conversion, primarily for agriculture. In 2001, 16 adult pygmy rabbits from the last remnant population in Washington were captured and transferred to an *ex-situ* captive-breeding program, after which the wild population went extinct. In 2011, after limited breeding success in captivity, the Washington Department of Fish and Wildlife (WDFW) switched to *in-situ* breeding in large field enclosures, and supplemented the Washington founders with translocated pygmy rabbits from other states. Releases from these enclosures began in 2012.

Goals

- Goal 1: Develop methods to propagate large numbers of pygmy rabbits for release to the wild.
- Goal 2: Work with public and private landowners to ensure support for pygmy rabbit re-introductions across land ownership boundaries.
- Goal 3: Establish a meta-population of free-ranging pygmy rabbits within their historic

Pygmy rabbit © B. L. DeMay

range in central Washington, sustained with little or no supplemental introductions.
- Goal 4: Monitor the re-introduced population to study post-release survival, reproduction, and dispersal, and identify variables influencing long-term recovery success.

Success Indicators

- Indicator 1: Sufficient production of captive-born animals to initiate re-introduction.
- Indicator 2: High participation of landowners in Safe Harbor Agreements to support conservation on private land.
- Indicator 3: In the short-term, establishment of at least two subpopulations with a 5 year average population size of 125 individuals (USFWS Recovery Plan).
- Indicator 4: In the longer term, consider state delisting when Washington supports a minimum 5-year average of at least 1,400 adult pygmy rabbits in six populations; two populations with at least 500 adults each and four populations with at least 100 adult rabbits each (WA State Recovery Plan).

Project Summary

Feasibility: The first recovery emphasis area identified for re-introduction was the state-owned Sagebrush Flat Wildlife Area (1,515 ha), the location of the last known wild population of pygmy rabbits in Washington prior to extirpation. Land surrounding the wildlife area is a mosaic of private and publicly owned land. Over 90% of eligible lands within a 8.05 km radius of the re-introduction site are enrolled in Safe Harbor Agreements under Section 10 of the US Endangered Species Act, offering protections to land owners in return for their cooperation with conservation efforts. Additionally, several thousand acres surrounding the wildlife area are enrolled in federal Farm Bill programs like the Conservation Reserve Program and the State Acres for Wildlife Enhancement program. The second recovery emphasis area (3,390 ha), is managed by The Nature Conservancy and a private landowner, and is located 17 km away from the first site. The Nature Conservancy and Federal lands surrounding both sites are managed consistently with pygmy rabbit recovery efforts (USFWS, 2012), and additional private land owners have enrolled in the Safe Harbor program in the area. Prior to large-scale re-introductions, a population viability analysis and trial re-introductions of captive-bred pygmy rabbits in Washington and Idaho identified the needs to 1) release large numbers of animals (>100) annually to combat high post-release mortality rates, and 2) address behavioral adaptations to captivity that produce naïve rabbits unlikely to survive in the wild. This recovery program is administered by WDFW and the US Fish & Wildlife Service, and guided by a science advisory group made up of subject experts from numerous organizations and institutions.

Implementation: From 2001 - 2012, captive breeding took place at three separate facilities to buffer against loss of the entire population in one event (e.g. disease outbreak). Inbreeding depression limited production in captivity, so pygmy rabbits from Idaho were brought into the captive-breeding program to increase genetic diversity. However, juvenile survival remained low, disease was

a major cause of mortality, and the captive-breeding program was unable to produce and maintain the numbers of rabbits needed to support a large-scale re-introduction. In 2011, the recovery strategy was adapted to increase the chances of success. The captive-breeding program was phased out, and pygmy rabbits from captivity were moved to large outdoor enclosures (2.2 - 4.4 ha) in native sagebrush habitat within the species' historic range. The enclosures are resistant to avian and terrestrial predators, and outfitted with artificial and natural burrows, supplemental food, and free water during the hot summer months.

Tracking pygmy rabbit © D. J. DeMay

In addition to rabbits from the captive-breeding program, 110 wild pygmy rabbits were translocated from Oregon, Nevada, Utah, and Wyoming from 2011 - 2013 and held in the enclosures. The addition of these rabbits was deemed necessary to increase the genetic diversity of the founder population, and increase the number of individuals available for release. Rabbits from captivity and wild translocations interbreed freely inside the enclosures during the breeding season from late spring to early summer. In 2011, we released 64 captive-reared adult and juvenile pygmy rabbits into the wild. In 2012, after the first year of large-scale breeding in the enclosures, we released 104 juveniles (kits) from 2 enclosures using both soft and hard release methods. In 2013, we released 272 kits from 3 enclosures, using only hard release. While the releases were focused on kits because of concerns that adult rabbits born in captive facilities habituated to human presence would not survive well in the wild, it became necessary to release enclosure-born adults to make room for younger breeders. In 2014, we released 830 rabbits from 4 enclosures, including 113 adults. In 2015, we released 578 rabbits from 4 enclosures, including 51 adults. We collected a tissue sample from each handled rabbit to create a genetic and demographic database of all known rabbits in the recovery program. Each year, a subset of kits shown to have high amounts of Columbia Basin ancestry were retained for future breeding, and exchanged among enclosures to simulate gene flow.

Post-release monitoring: During 2012 and 2013, we tracked 82% and 18%, respectively, of released kits with glue-on VHF transmitters. Resulting data were limited by low transmitter retention times and tracking difficulties (DeMay *et al.*, 2015), but informed later survey efforts. For long-term monitoring, we conducted winter burrow surveys coupled with collection of fecal pellets for genetic analysis.

Monitoring animals non-invasively by their genotypes allowed us to study post-release dispersal, survival, and reproduction in the wild, as well as monitor the genetic diversity of the population over time. During the winters following the 2012 - 2014 releases, we detected 39%, 13%, and 11% of released rabbits surviving to winter. We have detected first and second generation wild-born rabbits born on the release area in 2013, but overall reproduction in the wild has remained low.

Major difficulties faced

- Reproductive output in captivity was low due to inbreeding depression and disease. Even with genetic rescue, low juvenile survival limited population growth and prevented large-scale re-introductions during the decade of captive breeding.
- Captive-reared adult pygmy rabbits were naïve and suffered high mortality in the wild.
- Monitoring the re-introduced population in the near and long-term has been challenging. Immediate post-release tracking with telemetry was limited by short retention time and the small size of transmitters. Long-term monitoring with genetic analysis offers detailed information on which individuals survive and reproduce, but laboratory analyses are costly. Rabbits not detected in winter surveys may have died or dispersed beyond the surveyed area, and it is not possible to separate these two mechanisms. The area surveyed each winter is limited by weather, available time and human resources (largely volunteers), and it is not possible to survey all potential habitat.
- Estimating and managing population sizes inside the breeding enclosures has proven difficult, and we tend to underestimate the amount of adults kept over winter for future breeding, leading to higher than anticipated adult and kit densities when breeding begins.
- Holding high densities of rabbits in enclosures for multiple years impacts the vegetation, and increases risk of disease transmission. Building new enclosures is costly in terms of time and money, so we are developing a rest-rotation strategy for enclosures to rehabilitate vegetation and lessen disease loads.

Major lessons learned

- Although captive-breeding has been a crucial part of recovery for many populations, not all species thrive in captivity. The recent successes for pygmy rabbit recovery have resulted from shifting away from breeding in *ex-situ* captive facilities, and breeding rabbits instead in large naturalized enclosures, where they exhibit natural mate choice and reproductive behaviors (DeMay *et al.* (in press)). Additionally, kits produced in the enclosures had limited exposure to humans, and a present (although significantly reduced) risk of predation, making them more suitable for life in the wild than naïve rabbits raised in captivity.
- Results from a trial in 2012 indicate that soft-release enclosures did not improve survival or residency of released kits compared to hard release.
- No pygmy rabbit kits released at <125 g have been detected surviving, but rabbits released between 125g - 150 g have survival rates similar to other weight ranges, leading to the adoption of a 125 g lower limit for release.

- Drip irrigation in the large enclosures extended the growth season of the vegetation and provided more forage for rabbits in the enclosures.
- While predators such as owls, harriers and weasels have killed several pygmy rabbits in the enclosures, this source of mortality has not limited the numbers produced for re-introduction. In fact, we expect that pressure from predators while in the enclosures better prepares the rabbits for release in the wild.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- This re-introduction program is relatively young, and it is difficult to gauge the success at this early point. Into the future, success will depend on continual assessment and adaptation of the recovery strategy, as was done in shifting from captive-breeding to field breeding.
- Community support has been paramount to the smooth operation of the recovery program. We have high participation from private landowners in Safe Harbor Agreements to support conservation on their land, and we have depended on volunteers to provide approximately 75% of the field work for both releases and winter surveys.
- The overall success to date is due to shifting to a strategy that allows this species, a species that was not doing particularly well in a captive-breeding setting, to exhibit more natural behaviors in a more natural setting.

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Re-introduction of the Persian fallow deer to the northern region of Israel

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Introduction

The Persian fallow deer (*Dama mesopotamica*), used to be abundant throughout the Middle East, ranging from today's Iran and Iraq, north-west into Syria and Turkey and down along the Mediterranean coast through Lebanon and northern Israel. Originally, the Persian and European fallow deer were considered two subspecies of *Dama dama*, but recent work has indicated them to be separate species. Hunting and loss of habitat have driven the decline of *Dama mesopotamica* and by mid 20th century it was considered extinct throughout it range. In 1956 two remnant populations (estimated at the time at two dozen) were found along the Dez and Karkeh rivers in Iran and the species changed its status to Critically Endangered. In 1976 the Israel Nature Reserves Authority (to be later named the Israel Nature and Parks Authority - INPA) established a captive-breeding core in the Hai-Bar Carmel in Israel from 2 males and 5 females, all descendants of individuals from the Irani populations.

Persian fallow deer © Eyal Bartov

The INPA started re-introducing the deer to the western Galilee region in 1996. The region, which used to be the south-

western part of the species range, is dominated by Mediterranean woodland habitat, with mild wet winters and hot dry summers.

Typical release site habitat

Goals

- Goal 1: A wild and sustainable population of at least 125 adult females.

Success Indicators

- Indicator 1: A stable or growing self-sustaining deer population.

Project Summary

Feasibility: A feasibility study was written and then scrutinized by a professional committee consisting of scientists from academic institutions and members of the INPA Science Division. The study concluded that the original causes of extinction had been removed, i.e. hunting laws now existed and were strictly enforced by the Israel Nature Reserves Authority, and the Mediterranean habitat in northern Israel had recovered. The existence of a relatively large breeding nucleus (by the mid 1990s it consisted of more than 50 adult females) and land availability made a re-introduction feasible. The release site was selected by requesting rangers from the northern region of the INPA to suggest potential sites for re-introduction. Six of these were selected and were then assessed according to 11 criteria such as water availability, distance to roads, accessibility for radio-tracking, etc. Based on these criteria the Nahal Kziv nature reserve was selected. Another smaller scaled release was later initiated in the Nahal Soreq reserve in the Judea Mountains but will not be discussed here.

The INPA adopted a long-term strategy with an adaptive management approach based on repeated releases. A computer simulation using a maximum sustained yield approach with demographic stochasticity indicated that it would be possible to remove ~28% of females aged 1 - 5 years (roughly 12 prime-aged females) annually from the breeding core without degrading it. Another demographic simulation model projecting the growth of the wild population estimated that if all releases to the wild will go as planned and reproductive success and survival will be as projected, the target population of 125 adult females can be reached within 7 - 9 years. The long-term multiple release approach necessitated the construction of a permanent habituation enclosure at the release site. The enclosure was constructed on a flat area at the bottom of the Kziv ravine, approximately 50 m from the stream, with open meadows, garigue, and Mediterranean maqui habitats.

Deer being released © Oded Berger-Tal

Implementation: During the first 5 years, releases were carried out twice a year with ~6 adult females and a similar number of males each time. All females were radio-collared and all radios had mortality sensors. Animals remained in the enclosure for up to 3 months. Prior to each release from the enclosure, jackals and feral dogs sighted in the area were culled. The process of animals exiting the enclosure to the wild took longer than expected, and often lasted days and even weeks. Efforts to herd the animals out of the enclosure were generally unsuccessful.

Mounting damage to agriculture (mostly damage to orchards) and budget cuts to the program meant that from the 6th to the 10th year after the project began, fewer animals were released (22 adult females as opposed to 57 during the first 5 years) and monitoring became irregular. Between the years 2006 and 2009 the release of animals has ceased, but was resumed in 2009. A spatially realistic model using demographic information taken from the wild population in the first years of the project indicated that the best re-introduction results, in terms of numerical growth and spatial expansion, would be obtained by repeated releases in two sites carried out sequentially. As a result, a new release site, located in the Sasa ridge, approximately 15 km from the Kziv site, was approved by the INPA, and release from that site commenced in 2013, with the goal of having the newly released population connect to the Kziv population within 10 years. By 2015, four releases have taken place in the Sasa site, and a total of approximately 40 individuals were released. Current plans are to release 20 individuals every year at this site. Additional smaller scale releases are conducted in two additional sites - Mt. Hermon and Mt. Carmel.

The current wild population of Persian fallow deer in the north of Israel is estimated to be 200 - 300 individuals.

Post-release monitoring: Post-release monitoring of the released animals was conducted by using radio-telemetry (VHF collars at first; GPS collars in recent years), direct observations (when possible), and infra-red camera traps. Home-range dynamics suggested that the re-introduced deer adapted space-use patterns similar to wild deer of other species, with males having larger home ranges during the rut than females, and mothers having larger home ranges than barren females. Re-introduced females established a home range within a year,

but exhibited shifts in the home range during the second and third years towards more moderate slopes and an overall home range consisting of roughly 50% woodland. Roads appeared to act as barriers, and did not traverse individual home ranges. Individuals from later releases established a home range quicker, supporting the notion that individuals from earlier releases serve as cues to the 'newcomers' as to where to establish a home range.

An individual-based spatially-realistic model was created to assess population performance under two scenarios: Current habitat versus future governmental development plans. The model parameters were based on data collected during the first 2.5 years of the re-introduction, and validated based on parameters generated after 5 years. Based on the results, bottlenecks in landscape connectivity that could dampen the numerical growth and spread of the population were identified on the governmental development plans, and recommendations were made to forgo development in these specific areas.

Major difficulties faced

- Damage to agriculture.
- Canid predation (feral dogs and wolves).
- Budget cuts.

Major lessons learned

- The long-term multiple releases approach which was enabled by the permanent breeding facilities enables flexibility and adaptive management.
- Long-term monitoring is a vital aspect of efficient adaptive management.
- The culling of canid predators in the vicinity of the release sites prior to major releases is necessary to ensure the survival of the deer in the weeks following the release.
- The use of models for the different stages of the project: feasibility study, release design, additional releases, enabled an efficient decisions-making process.
- Captive-breeding facilities for the purpose of re-introduction should minimize anthropogenic disturbances.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Computer simulations combined with a permanent breeding core enabled robust planning and an adaptive management approach.

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Re-introduction of the giant anteater in Iberá Nature Reserve, Corrientes, Argentina

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Introduction

The giant anteater (*Myrmecophaga tridactyla*) is a widely distributed neotropical species, listed as "Vulnerable" in both the IUCN Red List of Threatened Species and the Argentinean Red List. Across its range it occupies diverse habitat types including grasslands, savannas and forests, where it feeds on ants and termites. Several authors refer to the historical presence of giant anteaters in Corrientes Province and its extinction around the middle of the 20th century due to a combination of widespread commercial/subsistence hunting and a cattle ranching tradition based on the frequent use of fires and dogs. The Iberá Nature Reserve (INR) is a 13,000 km^2 multiple use protected area that includes a diverse mosaic of marshlands, open grasslands, savannas and small forests. When INR was established in 1983, provincial park-rangers started to enforce hunting prohibitions, remnant wildlife populations recovered, and several authors proposed the re-introduction of extirpated fauna. Following this recommendation, in 2006 the government of Corrientes and CLT started the first world-wide experience aimed to restore an extinct population of giant anteaters. Within the private properties included inside INR, The Conservation Land Trust (CLT) holds 1,500 km^2 of private reserves dedicated to nature conservation and ecological restoration.

Goals

The following goals were part of the Giant Anteater Recovery Plan presented by CLT and approved by the government of Corrientes (Jiménez-Pérez, 2006):

Re-introduced anteater with cub

- Goal 1: (Long-term)
  ⇒ Establishing a self-sustainable population of giant anteaters inside INR and neighboring areas.
- Goal 2: (5 year period)
  ⇒ Establishing a population nucleus of giant anteaters with, at least, 20 individuals, which through monitoring and evaluation will help to build the methods and organizational arrangements that will lead to our long -term goal.

Success Indicators

The following indicators were also included within the original Recovery Plan (Jiménez-Pérez, 2006):

- Indicator 1: Numbers of wild anteaters living in INR, with emphasis on animals that have breed in the area, have died, have been born and have been living for more than one year.
- Indicator 2: An organizational structure that supports the re-introduction project that brings external resources (information, people, technical and financial) and that promotes permanent evaluation and improvements.
- Indicator 3: Well developed protocols and methods that will help the efficient management of all aspects within the project.

Project Summary

Feasibility: To assess habitat suitability we invited two giant anteater experts to visit different areas within INR in order to see if there were enough good areas for the species in the reserve, and to identify the best locations regarding habitats. To design a recovery plan, a participatory workshop was carried out in INR, which included experts on anteater ecology, veterinary and genetic issues, local social issues, endangered species recovery and provincial authorities. As a result of this meeting, a recovery plan was drafted and agreed amongst the attendants. The plan identified Rincón del Socorro/Iberá (30,000 ha) and San Alonso (10,000 ha) reserves as the first and second sites to re-introduce the species. It also identified neighboring provinces in Northern Argentina as the source for releasable animals. Both areas belong to CLT and were chosen because of habitat availability, strict conservation policies and existent management facilities. Local attitudes and knowledge about anteaters from neighboring communities were assessed formally, and were found to be positive or neutral, though there was very little knowledge about the species (Delgado *et al.*, 2008). Since in Argentina wildlife is managed by the provinces, the plan was presented to the government of Corrientes for its final approval, which took more than 1 year. During this process, it helped that the National Wildlife Authority showed explicit support to the re-introduction initiative. Several specialists were consulted, management protocols were designed and published on the Internet, and quarantine and pre-release pens were built. Before the arrival of any animal, we gave several talks in the two neighboring villages (i.e. Carlos Pellegrini and Uguay) to explain the project and its implications.

Implementation: Due to the lack of tradition of re-introduction projects and of cooperation between provincial governments regarding the movement of fauna, at

Rescuing orphan anteater

the beginning it was very difficult to obtain animals for the project. In 2007 we were able to get authorization to move the first two animals: an adult female living on the backyard of a private house and an adult male from a zoo. The day when the first animal arrived to its pre-release pen in Rincón del Socorro there was a big public act attended by the governor of Corrientes and all authorities in charge of wildlife, plus children from the adjacent villages, representatives of conservation NGOs, neighbors, etc. This act helped to break the "political ice" around the project. By June 2015, the project has handled 72 individuals, of which 52 were wild-born orphan cubs, 10 adult captives, two adults translocated from the wild, 8 injured free-ranging adults, and one was captive-born. In the case of orphan cubs, we hand-reared them until they weighted around 20 kg and could be released in INR between late spring and early autumn. All the re-introduced animals came from the Dry Chaco Ecoregion, with the exception of two animals from neighboring Yungas and Wet Chaco ecoregions. Prior to their release, all animals were checked for nine infectious diseases, detecting titres for toxoplasmosis in 27% of the cases and canine distemper in 25%. All animals positive to distemper became negative to the virus before release. Between 2007 and 2015, 31 animals were released in Rincón del Socorro, and 16 animals have been released in San Alonso starting in 2013. Releases at San Alonso continue nowadays and in the near future. During their first two winters in the wild, most animals are supplemented with the same food liquid mixture used during the quarantine and hand-rearing phases.

Post-release monitoring: Re-introduced anteaters were fitted with VHF transmitters and then monitored through this method and camera traps. Radio-harnesses caused injuries in several occasions and had to be refitted often, which required regular recaptures of re-introduced anteaters (Di Blanco *et al.*, 2012). No anteater died as result of these 100 plus recaptures. By June 2015, of 47 released animals, 12 have been found dead, 10 females have given birth to 28 cubs and we estimate that there are between 35 and 45 animals in the first population and 18 in the second one. Since the animals started breeding in 2009, there have been 4 years with more births than deaths and one where mortality surpassed reproduction. Annual survival for the re-introduced animals and their offspring in Socorro is 92% (Zamboni *et al.*, 2015). This number rose to 100% during the 2 years of re-introductions in San Alonso and 53% of all females older

than 3 years gave birth in Socorro annually. However, once a female started giving birth, they tended to produce one cub per year.

Major difficulties faced

- Due to the lack of tradition of cooperation between provincial governments, at the beginning it was especially difficult to get permits to move anteaters from neighboring provinces to Corrientes. Permits were only granted for captive animals and it was not possible to get permits to translocate wild animals from healthy populations towards Iberá.
- Absence of precedents in re-introduction in the country, plus a conservative tradition of management from academia, governments and NGOs created an initial environment of opposition or skepticism towards the whole idea of re-introducing anteaters. However, once results (good and bad) were openly shared, this environment tended to change towards general support.
- Since there were no previous experiences of re-introducing anteaters, we had to learn our own protocols regarding hand-rearing cubs, radio-tagging, winter supplementation, regular recaptures, soft releases, etc. This was a main challenge during the first 5 years, though it has been solved nowadays.
- Radio-harnesses were difficult to adjust and it took much experience and several recaptures to find a way to attach and re-adjust them to avoid their loss or injuring the animals.
- The fact that CLT buys land for conservation and that its President is a rich philanthropist from USA, created a climate of distrust, since nobody could believe that someone would spend significant private funds into a public good. It took several years of proactive communication and public relations to convince the public that the conservation agenda was honest and sincere.

Major lessons learned

- Keep the authorities on the loop: This project was lead by an NGO, but governments have legal authority over wildlife. Therefore, for a project like this to be successful it is crucial to keep good relations with relevant authorities and, whenever they are interested, to allow for their participation. This will take lots of patience, empathy, respect and interpersonal skills, since NGOs and governments have different organizational values, incentives, resources, timing and world-views. Each animal should comply with legal and administrative permits for transportation and handling.
- Progress is incremental and takes time: At the beginning we had to start with very few, and less than ideal animals. This should be taken as part of a normal process. Nothing starts with perfection. Once we were able to show concrete results and establish trust with the many stake-holders, new doors opened and these led to more and better animals, which also led to better results and so on.
- Communicate widely: Anteaters as any wildlife species are a public good, not a private property. If these animals are considered endangered and are also charismatic, they even become more public, since more people care about them. This means that they are not *our* animals, but belong legally, psychologically and emotionally to a wide array of people. Therefore, if we want to get support, and ultimately, approval for translocation and release we

need to inform the public about the project results. The project was communicated in a highly proactive manner through newsletters, presentations in neighboring villages, scientific meetings, technical reports and scientific articles, brochures, posters, a major photo book (Jiménez-Pérez, 2013), a 30 minutes documentary, stickers, a website, Facebook, educational activities with children, etc. During all these years we reported both on the losses and successes related to the project. Honest and effective communication is crucial to achieve the incremental process described above.

Putting a radio-harness on a cub

- Monitor all released animals: Every animal released in the wild has to be monitored for survival, general health and reproduction. This is the only way to assess if we are approaching our goal and if we need to make major changes. Results from monitoring are crucial for communication (see above), which is also crucial for building trust, which is the best way to get access to more and better animals for release.
- Be ready to adapt from reality: Our original plan was based on the availability of wild adult anteaters and a short period of quarantine. Once we started looking for animals it seemed obvious to us that the provincial authorities were not willing to pay the "political price" involved in allowing for wild animals to be captured and translocated to another province. Hence, we had to look for adult animals from zoos, which were politically sound but too scarce to establish a population. Finally we discovered that there was an unknown habit of having anteater cubs in family houses within the Chaco region. These animals were politically available, though they were far from ideal since they required about one year of hand-rearing before release. As result of this new reality, our original quarantine facilities were changed and expanded into a hand-rearing center for orphan giant anteater cubs.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Long-term commitment: CLT was ready to invest on this project for as many years as necessary.

- Stakeholder involvement: We were able to inform, show respect and leave space for participation to stakeholders from neighboring villages, anteater areas, landowners, public media, private companies, governments (at three levels), academia, and other NGOs.
- Team work: During these 10 years of work we have been able to establish a highly motivated team of professionals who share a common vision, are able to put aside personal agendas, take management decisions in a cooperative way, manage interpersonal conflicts in an educated and positive manner, and enjoy working with each other. This has been crucial to invest all our energy in getting results, learning fast and avoiding waste of energy in unproductive conflict, blaming each other or interpersonal fights.
- Giant anteaters are easy to work with: They can survive in natural environments in spite of having grown in non-natural settings, and they are also easy to capture and immobilize. This allowed us to work with suboptimal animals (i.e. hand-reared orphan cubs and adults from zoos), to check on their status, readjust their harnesses or supplement them with food whenever it was needed.
- Organizational adaptability: Being a pioneer project, we needed to try and test new methods in order to respond to losses, or to improve our management techniques. In this regard it was critical to monitor the different stages of the re-introduction process: quarantine, hand-rearing, survival and reproduction in the wild. Every year we have discussed and implemented changes in our health screening protocols and veterinary treatments, diet, behavioral enrichment and management of cubs, population monitoring through radio-telemetry and trap cameras, supplementation in the wild, fire management and other practical issues. After 9 years of working with these animals and learning from them and ourselves as a team, we can say that we have reached a "plateau" in efficiency, expressed through high survival of hand-reared and released animals.

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Eurasian beaver re-introduction in Hungary

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Introduction

The Eurasian beaver (*Castor fiber*) is a large rodent species that lives on the banks of streams, rivers and ponds. Once widespread across Europe and Asia it was exterminated by man in most of its range and the beaver population was reduced to ~1,200 at the beginning of the 20th century (Nolet & Rosell, 1998). The last individual in Hungary was killed in 1865. Sweden started to re-introduce beavers in 1922 and later the example was followed by more than 20 European countries. These are among the world's most successful conservation projects (Haarberg, 2007). The population of the Eurasian beaver reached one million individuals around 2011 (Müller-Schwarze, 2011). Because of this success, the IUCN down-listed the species to Least Concern in 2008. Eurasian beavers are protected under the Bern Convention (Appendix III), the EU Habitats and Species Directive (Annex II and IV for the Hungarian populations) and Hungarian national law, but not included in CITES.

In our national legal system individuals of a species protected under law have a value in Hungarian currency, which is 50,000 HUF (US$ ~178) in the case of the beaver. In Hungary beavers were re-introduced in Hanság and Gemenc areas and by the rivers Tisza and Dráva.

Goals

- Goal 1: Choose suitable sites for the release of beavers in the catchments of the Tisza and Danube rivers in Hungary.

Release of a beaver © Balint Bajomi

- Goal 2: Re-introduction of 30 individuals at each of the two sites.
- Goal 3: Create a self-sustaining population in Hungary.
- Goal 4: Individuals should disperse to new sites in Hungary.
- Goal 5: Disseminate the results of the program in the media.

Success Indicators

- Indicator 1: Number of individuals estimated through monitoring.
- Indicator 2: Occupied areas recorded through monitoring.
- Indicator 3: A self sustaining Hungarian population of at least 500 individuals.

Project Summary

Feasibility: The Eurasian beaver is the biggest rodent in Europe. It lives in water and is an ecosystem engineer: it constructs dams on watercourses, cuts trees in winter and digs its home in the bank. After the extinction in the 19th century, the beaver was missing from the Hungarian fauna for 120 years, until 1985 - 1986, when it appeared again in the Szigetköz area. Those animals probably dispersed to Hungary from the population successfully re-introduced to Austria. Nowadays Szigetköz population is the biggest in Hungary counting several hundreds of animals. In 1988, experts also found beavers near Lake Tisza, this small population was augmented with seven more animals by the staff of the Hortobágy National Park. Later they realized that the released individuals were North American beavers (*Castor canadensis*). Because of this, they captured the last living specimen, so this small population probably disappeared.

The idea of the Hungarian Beaver Re-introduction Program arose in 1994. The feasibility study was prepared by László Haraszthy (the director of WWF Hungary at that period) with the support of Günther Lutshinger, the director of WWF Austria (Haraszthy, 1996; Bozsér, 2001). During the course of the program over 25 persons got involved, forming a multidisciplinary team made up by, among others, conservation specialists, biologists, communication experts and water engineers. DIY retailer firm OBI - the main sponsor of the project, gave US$ 344,212 for this program. The potential habitats were surveyed before each release on the basis of a habitat suitability model developed originally in America, adopted in Switzerland and rewritten by Orsolya Bozsér to suit the Hungarian situation. The re-introduction sites were chosen with the help of habitat monitoring specialists. The opinion of National Park Directorates was taken into consideration. Almost all localities are protected by law, except 2 - 3 sites.

Implementation: Between 1996 and 2008, 234 beavers were re-introduced in the areas of Gemenc in the south of the country, Hanság in the west, and next to the rivers Tisza and Dráva, the latter being the boundary river with Slovenia and Croatia. Most of these wild born beavers came from Bavaria, Germany, and some animals came from Austria. The Bavarian population was established also as a result of a re-introduction program, thus the Hungarian re-introduction was a serial translocation. The transportation took place in metal boxes lined with straw. The travelled distance was 500 to 1,000 km, and took 5 to 10 hours by car. The sexes of beavers are not detectable morphologically; therefore the sexes of the re-introduced animals were unknown. The German scientists informed the

Hungarian colleagues which specimens belonged to the same families. The age class of the individuals (adult, sub-adult or juvenile) was always recorded.
Since 2004, the re-introduced specimens were marked with microchip implants with ID numbers. Chips used for beavers were similar to dog chips, so all veterinarians and Budapest Zoo co-workers have the compatible equipment to handle them. The chips were not actually used during the monitoring, as the beavers were not recaptured after release. Only one case of finding a chip in a beaver corpse was reported.

Dávid Czabán with gnawed trees
© Balint Bajomi

Upon release, the beavers were subjected to a quick non-lab veterinary inspection. The beavers were always released from the carriage boxes on the day of arrival. The releases with media publicity were instantly released to the water, while at the rest of the releases the beavers were allowed more time to adapt. In some cases the cages were left open to set the beavers loose, then organizers returned for the empty cages. The beavers were not fed afterwards. During the re-introductions at Lake Tisza in 2005, at Mártély in 2006 and in Tiszatarján in 2008 organizers made artificial lodges, but the beavers did not use any of them. No control of predators or competitors was necessary in connection with the re-introductions.

Post-release monitoring: Since the beginning of the re-introduction experts have continuously monitored the Hungarian beaver population. Beavers are very difficult to observe because they are active during the night, so their monitoring consists of searching for signs of beaver presence: gnawed trees, dams and lodges. Monitoring shows that the Hungarian population is growing and currently stands at 2,500 - 3,000 individuals. As the re-established population persists, we can state that the Hungarian beaver re-introduction program is a success from the point of view of conservation biology. However beavers cause many economic problems (detailed in the next section), so many people in Hungary do not consider beaver re-introduction a success story.

Major difficulties faced

- It is very difficult to distinguish the Eurasian beaver from the North American beaver. The animals released between 1991 and 1994 in Hortobágy area were

later identified as North American beavers, so the last surviving individual was caught and transported to Budapest Zoo.

- In winter, beavers are cutting trees near watercourses. This activity is causing significant damage to forestry organizations and sometimes perceived as a forest conservation problem.
- Beavers sometimes construct dams on streams and occasionally dig burrows in dykes, causing problems to water management organizations.
- In recent years media coverage of the beaver in Hungary has mostly been negative because of the last two points.
- Theoretically the law permits the Hungarian state to pay compensation for the damages, but in practice this dos not happen. Translocation of problem animals started in late 2014, and probably will be more and more widespread using techniques already applied in Austria, the Czech Republic and Germany. It would make sense to have a sustainable harvest to the species that can be economically beneficial to compensate for the damage. But currently beavers are protected under European Union Natura 2000 law, so this is not feasible.
- The main threat for beavers are the fishing nets set up along the river banks. There is no data about the beavers died in the nets because the fishermen do not give any information about that phenomenon. Probably they are afraid of the penalty that can be given.

Major lessons learned

- The general public has to be informed prior to the releases about the potential economic damage caused by beavers.
- An action plan for the compensation of damages and the treatment of problem individuals should have been elaborated already in the planning phase of the re-introduction program.
- A well managed population monitoring is of utmost importance in the case of such a re-introduction program.
- The beavers adapt easily to their environment, so if the core reason of population declines, the hunt for beavers ceases, then the species can be the subject of successful re-introduction.
- Beavers tend to prefer habitats similar to their place of origin. In a number of cases the released animals left the supposed-to-be ideal areas and moved to small streams that resembled their place of birth.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The species has a large capacity of environmental adaptation.
- The reason for original extinction (hunting) does not exist any more as hunting is now illegal.
- Wild individuals were released instead of captive-bred animals.

- A large number (234) of individuals were released.
- Large quantities of beaver habitat exist in Hungary.

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Releasing confiscated Barbary macaques to improve national awareness of the illegal pet trade in Morocco

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Introduction

The Barbary macaque (*Macaca sylvanus*) is found in fragmented populations in Morocco and Algeria. Barbary macaques are unique within *Cercopithecidae* for their extensive non-maternal care *(*Kümmerli & Martin, 2008*)*. Infants are targets of interest for both sexes and all age classes, especially during the first weeks after birth. The promiscuity of the species makes it unlikely that infant handling is a paternal investment. In spite of that, infants may spend a high proportion of time in males' care and some males seem to have preferences for particular infants. The Barbary macaque is listed on Appendix II of CITES and Endangered on the IUCN Red List (Butynski *et al.*, 2008). The main cause of its decline is attributed to infant capture for the pet trade from the Middle Atlas population (Menard *et al.*, 2013) and, less intensively, from other populations over its distribution. The capture, keeping and selling of Barbary macaques is illegal in Morocco. In 2009, a conservation project inclusive of local people was initiated in Bouhachem forest in northern Morocco. The forest is in a remote mountainous area with non-habituated Barbary macaque groups and a supportive local human population (Waters, 2014).

Female with her adoptive male post-release
© B. Kubenova

Goals

- Goal 1: Implement confiscation protocols to discourage the open sale and exploitation of Endangered Barbary macaques in Tangier-Tétouan region, Northern Morocco
- Goal 2: Use social media to increase public awareness regarding the conservation and welfare implications of the illegal trade in Barbary macaques.
- Goal 3: Ensure the welfare of confiscated macaques within the limitations of the situation in Morocco, where there is only one officially recognized center to house all confiscated wildlife.
- Goal 4: To alleviate pressure on the above center, release confiscated infant macaques into wild Barbary macaque groups if they meet basic behavioral and psychological criteria.
- Goal 5: Communicate news of releases on social media.

Success Indicators

- Indicator 1: All Barbary macaques openly on sale or used as tourist photo props in Tangier-Tetouan region confiscated and owners fined.
- Indicator 2: Public awareness increased.
- Indicator 3: Adult and imprinted macaques transferred to the only officially recognised centre for confiscated wildlife in Morocco.
- Indicator 4: Confiscated macaques meeting physical and psychological criteria released into wild macaque groups.
- Indicator 5: Increased reporting of illegally held macaques by the Moroccan public using social media or a contact number provided on social media.

Project Summary

Feasibility: In 2013, the Moroccan conservation NGO, Barbary Macaque Awareness & Conservation (BMAC), signed an MOU with the Direction Rif Haut Commissariat Eaux et Foret et la Lutte contre la Desertification (DRHCEFLCD), to collaborate in the confiscation of Barbary macaques openly on sale or exploited for tourism in Tangier-Tétouan region. BMAC was given responsibility for the care of confiscated macaques whilst DRHCEFLCD prepared relevant permits and arranged a place for the confiscated individuals. This was the Rabat Zoo which was forced to close its doors to further confiscations in September 2013 due to being over capacity. The Moroccan public was responding to news of confiscations by reporting other illegally held macaques. Thus we believed it important to continue the momentum and decided to try releasing suitable confiscates into relatively undisturbed wild groups in Bouhachem.

Implementation: Five macaque confiscations took place with two adult females transferred to the Rabat zoo. Two female infants were confiscated by customs in Tangier and may have been infants reported as poached from a macaque group habituated for research in the Ifrane National Park (INP) in the Middle Atlas Mountains. BMAC staff transferred the infants to INP but, on release, the infants fled the scene due to their fear of the macaque males in close proximity. After extensive searching only one female was found. This female was rehydrated and fed and the following day placed in an improvised "howdy" cage, which was

Female infant in cage surrounded by wild macaques © BMAC

placed close to the study group. She could see and hear macaque group members but they could not touch her. The reaction of the males was particularly strong when they heard the infant and they also reacted against the researchers who were following the group. The researchers moved the cage when the group moved in order to maximize the familiarization period between it and the infant. This procedure continued for 4 days. To enable better communication between the infant and the group, the infant was placed in a larger wire cage. Various forms of communication between the infant and other group members - including greetings and reciprocal teeth chattering and invitations to follow - were observed. Moreover, the infant started reacting to the group's departures with distress calls. On the 4th day of the soft release, the decision to release the infant was made because the infant seemed used to the group and the group appeared to be losing interest in the infant. The next day, the cage door was opened. After ~30 seconds, the infant calmly left the cage and was picked up by a sub-adult female, who took her into the center of the group. Later, she started being handled by one male, who had had the strongest reaction to her when she was still in the cage. He became her main caretaker or "adoptive male".

To date, we have released two other confiscated macaques, a ~8-month male and an 18-month female into two different groups in Bouhachem, but without the use of a "howdy" cage because the individuals did not demonstrate fear of conspecifics. The male was immediately carried off into the forest by adult males who were very aggressive towards the BMAC team members trying to back away from the infant. We released this female and she immediately joined a wild group when she heard them vocalizing close to her release location. We saw this female with the wild group in October 2015.

Post-release monitoring: The infant in INP was monitored for a year post-release. The infant was handled most frequently by males, but levels of interest in her differed among individuals. The infant spent most time in the proximity and "care" of her "adoptive" male. His interest seemed to play a crucial role in the infant's survival, as he carried her when the group was travelling, protecting her

against potential danger and aggression and also staying with her overnight. Females' behavior towards the infant was mainly neutral or negative, but their aggression was mainly non-contact (display) and never led to serious injury. However, the infant was attacked three times by sub-adult males, when she was about 16 months. One sub-adult female was often observed providing the infant with positive care, including grooming. The rare interactions between the infants and other non-adults included negative, neutral and positive behavior. Play displays were observed very occasionally, never lasted long, and the released female never initiated play or played much with other infants.

The lack of play and low activity could be caused by earlier deprivation but also by lack of energy. The absence of milk seemed to result in the infant's dehydration during summer months, whereas malnutrition was obvious during winter, when the infant seemed unable to gain weight. This female was observed for ~18 months but, since the winter of 2014, we have no further information about her status.

Major difficulties faced

- We are unable to quarantine confiscated macaques due to a lack of suitable facilities.
- If infants have spent prolonged time in captivity, the behavior of the adult males inspires a fear and flight response from the infants on release.
- Behavioral backwardness - possibly caused by maternal deprivation causing retarded social development.
- Risk of undernourishment and dehydration. The possibility of supplemental provisioning is limited when wild groups are used.
- It is difficult to ascertain the fate of confiscated macaques released into non-habituated macaque groups due to lack of funding for post-release monitoring equipment.

Major lessons learned

- Due to the adult male Barbary macaques' caretaking behavior, it is possible to release confiscated infants into wild groups of the species even when it is not the infant's natal group.
- If infants demonstrate extreme fear of adult males then a soft release in a "howdy" cage which can be moved with an habituated macaque group enables the infants to gain confidence and initiate contact themselves with group males that may adopt the infant on its release.
- Adult males' enthusiasm for handling the infants decreases as the infants grow.
- The best candidates for release are infants that have not endured prolonged captivity and are more than 8 months old close to weaning.

Success of project

Highly Successful	**Successful***	Partially Successful	Failure
	√		

** - (in the case of the female released in Ifrane National Park and in terms of raising public awareness)*

Reason(s) for success/failure:

- The use of social media to publicize the confiscations increased public awareness in the region and beyond. For example, the second photo prop macaque was confiscated after BMAC received 20 calls in 30 minutes from the public reporting the first appearance of the animal and its handler at a coastal resort close to Tétouan. See Waters & El Harrad (2013) for further information.
- The success in releasing confiscated infants into wild macaque groups can be attributed to the alloparental behavior of adult male Barbary macaques.
- We are very aware that we are unable to adequately address all health and welfare concerns of released animals due to our lack of funding and facilities. We hope to rectify this situation in the near future.
- We are unable to confiscate adult macaques because they are habituated to humans and are unsuitable for release. A dedicated rescue center for Barbary macaques is needed in Morocco so that Moroccan nationals are trained in primate rehabilitation and release techniques.

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Re-introduction of the pampas deer in Iberá Nature Reserve, Corrientes, Argentina

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Introduction

The pampas deer (*Ozotoceros bezoarticus*) was the dominant ungulate over most of the vast plain areas of southern South America (González *et al.*, 2010). Originally distributed throughout the Argentinean grasslands, pampas deer suffered a dramatic decline within this country due to habitat loss and fragmentation, hunting, and the competition with livestock. It is considered internationally as a Nearly Threatened species and as Endangered in Argentina. Out of the pampas deer populations remaining in this country, one is located on the Aguapey grasslands (Corrientes province, north-eastern Argentina), which holds around 1,500 individuals living in private cattle ranches (Zamboni *et al.*, 2015). Many of these ranches are being transformed into pine plantations or intensive livestock production. Adjacent to the Aguapey grasslands, The Iberá Nature Reserve (INR) is a 13,000 km^2 multiple use protected area that includes significant grassland habitats. At least two pampas deer populations became extinct around INR during the late 20th century. When INR was established in 1983 remnant wildlife populations started to recover and several authors proposed the re-introduction of extirpated fauna. Thus, The Conservation Land Trust (CLT) started a project aimed to restore pampas deer within some of its own reserves sited inside INR.

Goals

The following goal was included within the Pampas Deer Recovery Plan presented by CLT and approved by the government of Corrientes (Jiménez-Pérez *et al.*, 2009a):

- Goal 1: Establishing, at least, one population of pampas deer inside Iberá Nature Reserve that will augment the

Released deer © Juan Ramon Diaz Colodrero

species distribution in Corrientes province and that will assure its long-term survival.

Success Indicators

The above plan did not include explicit indicators of performance. Therefore, we include basic demographic indicators related to our general goal:

- Indicator 1: Number of pampas deer present in the re-introduced populations.
- Indicator 2: Ratio between reproduction and mortality in the re-introduced populations.
- Indicator 3: Rate of increase in the re-introduced populations.

Project Summary

Feasibility: In 2001, a group of consultants presented to CLT a proposal to re-introduce pampas deer inside San Alonso 100 km^2 private reserve. In 2006, a technical team within CLT revised this proposal to turn it into a recovery plan that could be implemented by the foundation and approved by relevant authorities. First, we asked Argentinean and Brazilian experts to visit both the capture and release areas to review and plan translocation methods. All agreed that wild animals should be captured from the Aguapey population and then released into an acclimation pen at San Alonso before actual release. Pampas deer at the source population inhabit flooded grasslands that are impassable by truck and these animals could not be approached on foot or by horse. Hence, we had to dart the deer from a tractor carrying an especially designed platform on this rear. Since the CLT team did not have actual experience in darting, immobilizing and transporting pampas deer we had to look for an external expert to coordinate the first captures. Coordination was given to Dr. Mauricio Barbanti from Brazil, who was at that time the person with the most experience in capturing and handling pampas deer internationally. He helped us to design capture, transport, radio-tagging and pre-release methods.

A Population Viability Assessment (PVA) was carried out to choose different translocation strategies and to asses demographic and genetic impact on the source population (Jiménez-Pérez *et al.*, 2009b). Once we had chosen a translocation coordinator, we presented a recovery plan to provincial authorities for its approval. This plan included three potential re-introductions sites within INR in order of descending priority: San Alonso, San Nicolás (200 km^2) and Rincón del Socorro/Iberá (300 km^2). Explanatory meetings and personal visits where held with local landowners to explain the project rational, goals and methods. General response to the idea was unenthusiastic, since cattle ranches tended to be reluctant to cooperate with conservationists that “interfere” in the management of their properties. During this process we were in contact with national wildlife authorities that were coordinating a national recovery plan for the species. Simultaneously, a PhD thesis showed good genetic variability within the source population in Aguapey (Raimondi, 2013).

Implementation: Since all pampas deer live in private property and no landowner was willing to let us capture animals at their land, we purchased a 5 km^2 property sited in the best area for the species. Within this property cattle was excluded and

small burns were carried out to create optimum habitat for pampas deer. A park ranger watched the area and started habituating deer to the tractor that would be used in the captures. The first translocation campaign was coordinated by an external expert (i.e. Mauricio Barbanti) with assistance from our team, and supervision from provincial authorities on June 2009. During this campaign five animals were captured and translocated (3 females:1 male) to San Alonso. Two of the females died at the pre-release pen due to the translocation process. In July 2009, a second campaign was coordinated by our veterinarians who gained experience on the previous operation. On this occasion 4 females were captured and translocated, one of which died due to the impact of the dart on its hip (Jiménez-Pérez *et al.*, 2009b). During 2011, five more female deer were translocated San Alonso and all of them survived. During 2012, 10 more animals were translocated to the area (9 females:1 male) with zero casualties during the translocation and pre-release phases. During the following 2 months after their release 4 female deer died after drowning in the swamps that surround San Alonso Island.

Darting from a tractor © Gustavo Correa

On 2012, 6 animals (4 females:2 males) were translocated from Aguapey to San Nicolás on western INR. During the following months, 1 female drowned in a lagoon, 1 male swam to San Alonso and remains there, 2 moved to pine plantations outside INR and died there, and 2 were captured and translocated to San Alonso, one of which died after translocation. As a result of this, further re-introductions to San Nicolás reserve were halted. In 2015 a third population was started in Rincón del Socorro on south-eastern INR. Seven animals were translocated with zero casualties during the captures. One animal died at the pre-release pen from wounds unrelated to the captures, and the remaining 6 animals were released from the pen. Later a female deer died after leaving the protected area to move into private cattle ranches, while the remaining 5 animals seem to have settled in protected prime habitat. This incipient population will be reinforced with more animals during the following years.

Post-release monitoring: All translocated animals carried VHF collars and were monitored regularly. After settling in the area, pampas deer started breeding fast in San Alonso. By June 2015, 48 fawns have been identified in San Alonso and the estimated population was 55 - 60 animals. Annual pregnancy rate and annual survival were estimated at 86% and 90% respectively, which gave an estimated

intrinsic population growth rate (i.e. λ) of 1.67 and an annual rate of population increase of 33% (Zamboni *et al.*, 2015). With this information in hand the re-introduced population should grow and persist in the long term at San Alonso and, most likely, colonize other sites in western INR, like San Nicolás, from there.

Major difficulties faced

- Pampas deer are difficult to capture, immobilize and handle: These are small deer that can suffer from capture stress, and have a small muscular area for darting. We have lost several animals during captures. Even though we have been able to minimize losses through experience and changes in drugs and type of darts, there is still a significant chance that an animal could die in any capture. As a result of this, we decided to stop capturing animals in San Alonso to put radio-collars and we also stopped further releases once we saw that these were not essential. We also saw that putting new animals in well-established groups could promote migration that could end up in animals being lost or drowned.
- We did not have actual experience in capturing and translocating these animals: Solutions to this problem are explained below.
- Pampas deer is a high-profile species with a negative precedent regarding capture and translocation: This is one of the most popular endangered species in Argentina. As a result of this, many people get anxious when someone proposes proactive management, which could result in potential individual losses. There was also a precedent in the 1960s when the Argentinean Hunters Association and the Army carried out a large-scale operation aimed to capture and rescue an endangered population of this species in Buenos Aires province. The result of this operation was the eventual death of all animals involved. This created a very negative precedent within a national conservation culture that also lacked clear examples of successful re-introductions with other species.
- As a consequence of the previous challenges, it was difficult to get permits to capture and translocate pampas deer in order to establish a new population: Getting these permits took patience, getting the best external advice, establishing good methods and managing interpersonal relations.
- Relations with landowners at the source population were difficult: Local land-owners were very distrustful of conservationists, and especially of people working for CLT because they feared that we wanted to set limits to their land use or have some hidden agenda. The let us get into their properties to census pampas deer but did not let us get animals from their ranches. This forced us to buy a small property where we could work in a safe and predictable manner, which was an expensive alternative. After the translocations, some neighbors were outraged that we were taking away “their” deer, even though we had all legal permits, we worked inside our property, we did not tell them what to do in their land, they did not have any legal right on the animals, or carried out any activity with them. These complaints did not stop the authorities from authorizing several translocations, though they did complicate the whole process.

Major lessons learned

Darted pampas deer

- Bring the best practical available knowledge into your plans: It is important to identify those people with the best practical experience on the matter and learn from them. Listen but also be cautious from experts with much biological and theoretical knowledge who have no previous experience in actual re-introductions. If you want to learn about how to re-introduce a species, you should mostly look for people with experience on similar re-introductions, not so much for experts on the species biology. Instead of asking who of your friends knows the most about the subject, try to identify whoever in the World has the best practical knowledge about your case and turn him or her into your friend and collaborator. If the project is sensible they will probably come to your help without charging for it. It is important to gather the best available information and show that your plan and methods are sensible and well-grounded. Having good experts on your side and a professionally written plan also helps the authorities to grant the requested permits for capture and translocation.
- Listen to everybody's opinion but get ready to displease someone when you try to change the status quo: Working with high-profile species is a delicate matter and it is easy to get entangled in interpersonal and inter-institutional conflict. Quite often conservationists are conservative and feel more comfortable if things are left the way they are, (i.e. the present status quo) than if someone tries to change them. In these cases, benign neglect is seen with understanding, while proactive management is watched with skepticism, when not hostility. If something goes wrong someone should be blamed, you, scientists who supported the project or the authority that authorized it, and this makes some people highly defensive or critical, in order to avoid getting caught in an eventual public "cross-fire". Also, be aware of consultants that propose plans that are very costly to your institution in terms of limited resources (time, land, money or personnel) because they want to save face with their peers in case that something goes wrong. Though it is critical to get the best external advice, it is also key that final decisions are taken by the team and institution that, in any case, will have to pay the final price. Finally, while it is important to take in account everybody's opinions, if you try to make everybody happy, you may end up not doing anything substantial or just pretending that you did it.

- Be respectful and patient without stalling: Invest time and respect with all authorities, stakeholders and experts. We probably went too fast with national authorities without recognizing what they saw as their legitimate authority, and this created unnecessary tensions through the years. We could also have invested more time getting the landowners on our side, though it is possible that would not have changed what already was an excellent biological result (i.e. an established and growing re-introduced population).
- Get ready for losses but also be aware that progress is incremental and things improve when you persist, monitor, evaluate and learn from mistakes: During the first two captures we had significant mortality related to the translocation process. Whoever, these two operations were critical to establish a well-trained local team and to identify points for improvement. Subsequent translocations reduced animal losses to a minimum and allowed us to build a sustainable population. Hence, it is very important to understand that nothing starts with perfection, and that with these delicate animals this will imply initial deaths. However, if you persist and learn fast the overall result will be positive for the species conservation status as long as there is good habitat. If a good project is halted after the first setbacks you may loose the opportunity to learn and create significant improvements, while you may also establish a bad precedent for future similar initiatives.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Long-term commitment and high availability of optimal habitat: CLT was ready to invest on this project for as many years as necessary. Patience and persistence were critical for eventual success. It was also critical that CLT managed vast areas with good grasslands and no threats for the species, and that the area lacked large predators like puma or jaguar, which would have affected survival of re-introduced animals.
- Excellent advisors: Support and commitment from experienced external advisors helped us to design professional plans, to get them authorized and, most important, to train a local team that now has optimal experience in capturing, translocating, monitoring and managing pampas deer.
- Team work: During these years of work we have been able to establish a highly motivated team of professionals who share a common vision, are able to put aside personal agendas, take management decisions in a cooperative way, manage interpersonal conflicts in an educated and positive manner, and enjoy working with each other. This has been crucial to invest all our energy in getting results, learning fast and avoiding waste of energy in unproductive conflict, blaming each other or interpersonal fights.
- Establishing a learning culture: Being a pioneer project, we needed to try and test new methods in order to respond to losses, or to improve our management techniques. In this regard it was critical to monitor the different stages of the re-introduction process: immobilization, transport, acclimation,

release, survival and reproduction in the wild. Every translocation operation and regular monitoring of re-introduced animals has helped us to improve our knowledge on the species needs and how to manage it. After 7 years of working with these animals we still have much to learn about them (e.g. we still do not know why the deer chose to leave San Nicolás reserve) but we have been able to improve our techniques to achieve high survival of captured and, especially, released animals.

- Proactive communication and transparency: The project was quick to communicate to authorities, neighbors, academics, conservationists and the general public both the good and the bad news. For some time this gave "fuel" to some groups that had a negative predisposition towards the project. However, on the long run, once it was clear that the re-introduced population was closely monitored and growing quickly, there was general acceptance that gains surpassed any losses, and that it was a good opportunity to establish a new population of this cervid inside what is presently its largest strictly protected area in Argentina.

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A trial re-introduction of the western quoll into the Flinders Ranges National Park, South Australia

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Introduction

The western quoll (*Dasyurus geoffroii*) is a carnivorous marsupial that formerly occupied nearly 70% of the Australian mainland (Morris *et al.*, 2003). The species has declined significantly since European settlement and is now only found in south-west Western Australia, having become extinct from all other states. Reasons for decline include habitat clearance, disease and predation by introduced red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*). It is internationally listed as Near Threatened (IUCN Red List, 2009) and nationally listed as Vulnerable under the Australian *Environment Protection and Biodiversity Conservation Act* 1999. Males attain an average weight of 1.3 kg and females 0.9 kg. Western quolls are a distinctive animal, with up to 60 white body spots covering their brown fur and a black brush on the tail. They are seasonal breeders with females entering oestrus in late April/May and births occurring between May and September.

Western quoll

The re-introduction site is the Flinders Ranges National Park in South Australia, a 91,840 ha arid zone conservation reserve jointly managed by the South Australian Government and Adnyamathanha traditional owners. The Flinders Ranges National Park is characterized by rugged hills and scree

slopes with *Eucalyptus* lined creeklines, open grasslands and shrublands, and *Callitris* pine woodlands.

Goals

- Goal 1: To establish a self-sustaining population of western quolls within the central Flinders Ranges that requires minimal long-term management intervention.

Success Indicators

- Indicator 1: Survival of at least 50% of each of the release populations during the first 3 months after release. This will indicate that food availability is high enough and predation levels are low enough for the majority of individuals to survive - *Achieved*.
- Indicator 2: About 20% - 30% of females with young (F1) surviving to pouch exit in their second year. This will indicate that food and shelter resources are adequate for successful breeding - *Achieved*.
- Indicator 3: A population increase of at least 10% as measured by trapping and the minimum number of individuals known to be alive (MKTBA), with F2 generation individuals recruited into the population within 3 years. Baseline population size will be measured at 3 months post-release - *Achieved*.
- Indicator 4: No long-term decline in extent of occurrence. A baseline extent of occurrence should be estimated at 5 years after release, measured through camera traps, trapping and/or presence of sign (scats, sightings, occupied den sites). This baseline should be maintained (hopefully increased) and monitored every 3 - 5 years after release.
- Indicator 5: Population persistence during drought. Droughts are common in the arid zone, characterized by food shortage and low reproductive rates. If the population of western quolls is able to survive drought periods and bounce back to pre-drought levels afterwards then this is a strong indication that the re-introduction has been successful.

Project Summary

Feasibility: The western quoll re-introduction is a partnership project between the South Australian Department for Environment, Water and Natural Resources (DEWNR), the Foundation for Australia's Most Endangered species (FAME) and the Western Australian Department of Parks and Wildlife (DPaW). This unique partnership has combined private fundraising with conservation on public lands and has drawn on the strengths of each partner organization. A re-introduction project team is comprised of members from each organization. The Flinders Ranges National Park is jointly managed by DEWNR and the Adnyamathanha people and an important step was gaining support from the co-management committee. Once this support was obtained the major focus was on raising enough private funds to implement the project.

A translocation proposal was prepared (Moseby & Peacock, 2013) which included an assessment of the release site for suitability. A visit from two DPaW staff members experienced in western quolls was conducted and habitat assessments (particularly den site abundance) were implemented. A critical factor enabling the

Overview of release site

re-introduction to proceed was the extensive fox (1080 baiting four times per year) and feral goat (ground and aerial shooting) control already conducted in the park by DEWNR through their Bounceback program (de Preu, 2006). Foxes were considered to be the primary threat to a quoll re-introduction. Remote cameras were set throughout the release area to determine the level of feral predators present and results suggested foxes were all but absent and cat abundance was similar to sites in Western Australia where quolls were extant. Based on these factors the release was approved by DEWNR.

Implementation: A contractor with extensive re-introduction experience (Ecological Horizons) was hired to coordinate and implement the program. Quolls were captured by DPaW over a 3 week period in Western Australia and housed at the Native Animal Rescue center in individual pens. When sufficient quolls were captured they were flown to the Flinders Ranges National Park, a distance of several thousand kilometres. A total of 41 quolls were released in April/May 2014 and 37 in May 2015. A “welcome to country” ceremony was held on the release night with important donors, DEWNR staff and Adnyamathanha attending. This event was important as it helped strengthen the project partnership. A number of different release methods were trialed including soft release pens, releasing males before females to reduce male dispersal and release into different habitats. The trial re-introduction was conducted as an adaptive management project in order to understand the reasons for success or failure.

Post-release monitoring: All western quolls were radio-collared before release with VHF/mortality sensor collars and radio-tracked for up to 6 months after release. A light aircraft with wing mounted antennas was used to track animals from the air due to the rugged terrain. Once located from the air, personnel walked in on radio-collared animals to record information on den sites and habitat choice. All animals were captured in cage traps after 2 months to check their condition and collars. Any animals found dead were sent off for autopsy and DNA swabs taken from their collars to ascertain cause of death. A comprehensive

trapping program was conducted twice a year throughout the release areas to capture new individuals. Feral predators and quolls were also monitored using detection rates on 24 remote cameras set throughout the release areas.

Major difficulties faced

- Getting support and approval for the re-introduction, and sourcing the required funds. The proposal was initially conceived in 2007 and raised for discussion at the 2008 WWF Quoll Workshop. FAME agreed in 2012 to source required funds, and all project approvals were signed by early 2014.
- Effective and affordable landscape scale control of feral cats. The major threat to success has been predation by feral cats. Approximately 33% of released quolls were lost to cats within the first 6 months after release. Cat control is difficult to conduct on a broad scale and very labor intensive. Although fox control is regularly conducted, cat control was not part of the existing Bounceback predator control program so additional control needed to be subsidized through the project budget.
- Raising sufficient funds to ensure adequate post release monitoring and pre/post-release feral cat control. The project has been funded almost entirely by private donations through FAME. This meant that funding was not always available as planned, causing some activities to be delayed or revised.
- Logistic and regulatory hurdles that need to be negotiated when attempting to control problem predators on public lands that are also a major tourism location.

Major lessons learned

- Quolls are very adaptable animals and will find food and den sites in a new region outside our knowledge base. In an effectively fox-free habitat, controlling feral cats becomes the primary management requirement.
- Aspirations and expectations of all partners should be clearly acknowledged at the start of the project and reviewed regularly. This should include both management and on ground staff involved in the project.
- Contingency funds need to be set aside to cover unforeseen circumstances (e.g. additional feral cat control).
- Re-introductions require significant funds and commitment. Fortunately, the quoll re-introduction project combined private and

Western quoll project team

public organizations and all involved were extremely committed to project outcomes.
- Procedures and operation plans required to obtain high level approvals for extraordinary activities on public lands need to be sought prior to re-introduction. These include the use of firearms by private contractors to control feral pests.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
- Passionate, committed and skilled people willing and able to overcome the many obstacles encountered in researching, progressing, funding, planning and then undertaking a successful re-introduction project.
- The species being re-introduced has a broad dietary and habitat niche, and is somewhat arboreal to assist predator avoidance.
- Having been previously successfully (and unsuccessfully) translocated over ~20 years there is already a substantial accrued knowledge base from which to borrow.
- Cats remains the most likely threat to long-term establishment but initial results suggest that quolls can avoid cat predation in some instances. Additional cat control has assisted with early population establishment but may need to be continued to ensure long term success

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Successful re-introduction of *Rhizophora mucronata* - an extinct mangrove species on Sir Bani Yas Island, Abu Dhabi emirate, United Arab Emirates

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Introduction

Mangroves are the most important ecosystems of UAE both ecologically and economically. Mangroves sequester carbon more effectively and permanently about 100 times faster than terrestrial forests. They support a complex aquatic food web and provide a unique habitat for a variety of bird, marine fauna and have a high aesthetic value for developing eco-tourism. Mangroves are most important spawning areas for fish and shellfish. The presence of mangroves, act as a stabilization force to protect coastline from erosion and the devastations of cyclones. Sir Bani Yas is surrounded by beautiful *Avicennia marina* forests which are a major attraction for the tourist to relax and watch variety of birds or enjoying kayaking through the dense mangroves.

18-month old *Rhizophora mucronata*

Rhizophora mucronata is an extinct heritage mangrove species of the UAE and is included in the "IUCN Red List of Threatened Species". It was successfully re-introduced to Arabian Gulf waters after 100 years at Ras Ghanada Island, Abu Dhabi, UAE through a joint initiative by the "Department of the President Affairs, Abu Dhabi" and Environment Agency Abu Dhabi (EAD) during the year 2004 (Vistro, 2013). After 2004, no further re-introduction trials or experimental plantations of *R. mucronata* were established in the UAE. In 2008, Barari Forest Management (BFM), Abu Dhabi initiated a mangrove nursery and plantations development project focusing on 2 mangrove species; *R. mucronata* and *A. marina*. On 8th December 2013, H.H. Sheikh Mohammed Bin Rashid Al Maktoum, Prime Minister of UAE and Ruler of

Mangroves planted on Sir Bani Yas Island

Dubai along with Federal Cabinet Ministers planted 21 *R. mucronata* and 15 *Avicennia marina* seedlings on Sir Bani Yas Island. This unique event was organized by the Tourism Development & Investment Company (TDIC) in collaboration with Barari Forest Management (BFM). The Island is an award-wining eco-tourism destination that features over 28 different species of free-roaming animals, including one of the world's largest herds of endangered Arabian Oryx, in its 1,400 hectare Arabian Wildlife Park (AWP).

To have a comparative study, another experimental plantation comprising of 19 *R. mucronata* seedlings was established at the island's Da'asha site on 10th March 2014. The plantations were established in the natural coastal environment at both sites to evaluate the species' survival and growth potential in the natural habitat at Sir Bani Yas Island. To protect the seedlings from free-roaming animals, high summer temperatures and dusty desiccating winds, the plants were fenced with green shade nets. The plantations were regularly monitored with survival and growth data recorded in June 2014, December 2014 and June 2015. New seedlings were replanted at failure pits after every survival assessment. In June 2015, a 100% seedling survival was recorded, which is an indication that the *R. mucronata* seedlings have adapted to environmental conditions and became a part of the island's ecosystem.

Goals

- Goal 1: Establish *R. mucronata* plantations to preserve this extinct natural mangrove heritage species at Sir Bani Yas Island.
- Goal 2: Increase biodiversity of mangrove species on Sir Bani Yas Island.
- Goal 3: Standardize plantation techniques for establishing successful plantations.

Success indicators

- Indicator 1: Grow healthy *R. mucronata* seedlings in the nursery.
- Indicator 2: Establish successful *R. mucronata* plantations.

Project summary

Feasibility: *R. mucronata* was successfully re-introduced back to Ras Ghanada Island, Abu Dhabi in 2004. Afterwards, no other experimental plantation or re-

introduction work was carried out. On 8th December 2013, H.H. Sheikh Mohammed Bin Rashid Al-Maktoom, along with Federal Cabinet members visited Sir Bani Yas Island. During their stay on the Island, they planted *R. mucronata* seedlings in a special ceremony organized by TDIC's Senior Management. The plantation site was selected in consultation with the TDIC's Senior Management in the Habari area near Al Yamm Villa Resort. As a conservation strategy, another, plantation site was selected in the Da'asha area. *R. mucronata* seedlings were supplied by the Barari Forest Management, Abu Dhabi.

Implementation:

Seedlings procurement: Mature propagules were procured by Barari Forest Management from the Shah Bundar Forest Block of Sindh Province, Pakistan with the cooperation and assistance of Sindh Forest and Wildlife Department, Karachi, Pakistan and Environment Agency Abu Dhabi, UAE. The propagules were planted in the Barari Forest Management's mangrove nursery. Barari Forest Management supplied *R. mucronata* seedlings for planting at Sir Bani Yas Island. Before shifting the plants from the nursery to planting site, each plant was evaluated. Only healthy seedlings that had a height of 60 cm. and above were selected for planting. The average size of seedlings at planting time was 65 cm.

Plantation Establishment:

Habari site: H. H. Sheikh Mohammed Bin Rashid Al Maktoum, Sheikh Hamdan Bin Rashid Al Maktoum, Deputy Ruler of Dubai, Lieutenant General Sheikh Saif Bin Zayed Al Nahyan, Deputy Prime Minister and Minister of Interior, Sheikh Mansoor Bin Zayed Al Nahyan, Deputy Prime Minister and Minister of Presidential Affairs, Sheikh Abdullah Bin Zayed Al Nahyan, Minister of Foreign Affairs and other cabinet ministers planted 21 *R. mucronata* seedlings on 8th December 2013 in a special ceremony. The selected area was blank, characterized with predominantly sandy loam soil. Immediately after planting, the area was fenced to protect the seedlings from free-roaming sand gazelles and other animals.

Author measuring *R. mucronata* seedling

Da'asha site: In contrast with the Habari site, the soil of Da'asha features clay loam soil with scattered natural growth of *A. marina* mature trees. This is an ideal situation to compare the survival and growth behavior of *R. mucronata* seedlings in different soil types and

environmental conditions; blank area verses partially *A. marina* natural growth area. A total of 19 *R. mucronata* seedlings were planted at this site on 10th March 2014 and the plantation operations were carried out during the low tide period in the day time.

Post-Plantation Monitoring

Habari site: The newly established plantation comprised of 21 *R. mucronata* plants was regularly monitored. First survival evaluation was done in June 2014; it was observed that out of 21 seedlings planted, 15 seedlings survived. Six seedlings were replanted at the failure sites. The second evaluation was done in December 2014, with 18 seedlings recorded as surviving and only 3 dead seedlings. Those seedlings were replaced with new ones. The third survival evaluation was done in June 2015 when a 100% seedling survival was recorded. The details of survival and height growth data is given in Table 1.

Table 1. Survival and Height Growth Data at Habari Site

Period	Seedlings Planted (Nos.)	Seedling Survival (Nos.)	Average Size	Maximum Size
June 2014	21	15 (71%)	74 cm	89 cm
December 2014	21	18 (86%)	79 cm	100 cm
June 2015	21	21 (100%)	85 cm	110 cm

Da'asha site: A total of 19 seedlings were planted at this site and 3 seedlings were recorded dead during the first survival evaluation in June 2014. Consequently, 3 seedlings were replanted at the failure sites. The second evaluation was done in December 2014, and 1 seedling was observed as dead. A new seedling was replanted at the failure pit. The third survival evaluation was done in June 2015, and a 100% seedling survival was recorded. The details of survival and height growth data is given in Table 2.

Table 2. Survival and Height Growth Data at Da'asha Site

Period	Seedlings Planted (Nos.)	Seedlings Survival (Nos.)	Average Size	Maximum Size
June 2014	19	16 (84%)	75 cm	92
December 2014	19	18 (95%)	81cm	101
June 2015	19	19 (100%)	86 cm	113

The survival rate data shows that at both sites, there were few seedling mortalities. However, a 100% success rate was achieved only through close monitoring and replanting at failure locations within a period of 1 year. It is pleasant to see that "*R. mucronata* plants have adapted to the local site conditions and are growing in the natural environment in the shape of pure stand

and mix stand side by side with natural *A. marina* trees". It is also interesting to observe that *A. marina* trees performing a "motherly role" and are protecting *R. mucronata* seedlings from hot dusty winds, direct sunshine and high temperatures.

Major difficulties faced

- Procurement of propagules from Pakistan.
- Harsh summer temperatures with dusty winds.
- Barnacles attaching on stems.

Major lessons learned

- Site selection for *R. mucronata* plantations is most critical and survival and growth of plants depends on proper site selection.
- Predominantly bare sandy soils should not be selected for plantations. Clay-loam soils are best suited for *R. mucronata*.
- Plantations should not be established on low tidal sites.
- Healthy and appropriate sized planting stock is one of the major factors for success of *R. mucronata* re-introduction program.
- Survival rate is higher when planted in the shelter of *A. marina* trees.
- *A. marina* is performing "motherly role" and protecting *R. mucronata* seedlings from direct sunshine, high temperatures and dusty winds.

Success of Project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure

- Selection of suitable plantation sites.
- Selection of healthy and proper-sized planting stock.
- Planting operations at the proper time and planting season.
- Care in handling and transportation of plants from nursery to plantation sites.
- Planting in conjunction with the natural *A. marina* young stands.
- Effective technical guidance and supervision.

Acknowledgements:
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Re-introduction of the four leaf clover in the agricultural context of the Po River Plain, Italy

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Introduction

The four leaf clover (*Marsilea quadrifolia* L.), is a circumboreal aquatic pteridophyte bearing four-parted leaf, floating in the water or erected in shallow water and land. It occurs in central and southern Europe, Asia and North America. It is listed in the annex II and IV of the European Directive 92/43/EEC among the species requiring special areas of conservation and it is listed in the annex I of the Bern Convention. Following (Bruni *et al.*, 2013) *M. quadrifolia* was classified as Vulnerable at the European level, where it has been facing a strong population decline at the southern edge of its distribution. For instance, in Italy where it has recently disappeared from the southern regions is classified as Endangered (Rossi *et al.*, 2013). According to Gentili *et al.* (2010), reasons for decline were identified in agricultural practices (it is currently considered a weed of rice crop), competition with invasive species (e.g. *Heteranthera reniformis*) and non-native predators like the Louisiana crayfish (*Procambarus clarkii*) and the nutria (*Myocastor coypus*). The re-introduction of *M. quadrifolia* at different sites in the Po Plain was one of the major goals of three conservation projects carried out from 2010 to 2012 (CORINAT, Life “Pianura Parmense”, RIVIVRO’).

Four leaf clover © Rodolfo Gentili

Goals

- Goal 1: Establish viable and self-sustaining populations of the four leaf clover in suitable areas of the Po Plain.
- Goal 2: Understand the threats affecting the target species and assess the impact of agricultural activity of *M. quadrifolia*.

- Goal 3: Define suitable methods of *ex-situ* propagation to increase the number of propagules for re-introduction.

Success Indicators

- Indicator 1: Long-term survival (>3 years) of the established populations.
- Indicator 2: Definition of the factors linked to the rice cultivation affecting the species survival.
- Indicator 3: Obtain enough individuals to be re-introduced, through *ex-situ* cultivation

Preparing *ex-situ* material for re-introduction
© Paolo Cauzzi

Project Summary

Feasibility: The aim of the re-introduction of *M. quadrifolia* in the context of the above mentioned projects was to establish a number of viable populations of the target species in some Special Areas of Conservation belonging to the Natura 2000 network. The alarming rate of decline of *M. quadrifolia* in Italy made the scientific community aware of the need of urgent conservation actions, to avoid the fate of other aquatic species that become extinct in the past decade, like *Stratiotes aloides* and *Aldrovanda vesiculosa*. Additionally, the conservation of this species is made mandatory by European Union legislation. However, *M. quadrifolia* is considered as a weed of rice fields, so the use of herbicide strongly reduced the possibility of natural recolonization of the historic range by the species. The degradation of habitat quality also affected the possibility to re-introduce the species in areas characterized by intensive rice cultivation. This made it necessary to highlight sites within protected areas less affected by the agricultural activity, to guarantee the persistence of re-introduced population. In one case (Bagnacavallo, Ravenna) a pond was excavated *ex-novo* to exclude alien predators like the Louisiana crayfish and to allow the regulation of the water flow.

Implementation: The main issues concerning the implementation of the re-introduction plan were the choice of the source population, the propagation of plant material and the tolerance to herbicides. Molecular analysis using AFLP markers was employed to identify the most suitable source population to obtain plant material. Both the within-population and between-population genetic diversity of *M. quadrifolia* in Italy was very low. In fact, no private alleles were identified in the analyzed populations. This, on one side, did not raise concerns about the choice of the source population, but on the other side revealed that

populations may suffer for inbreeding depression (Bruni *et al.*, 2013). Small portions of rhizoma were collected from several ramets from two source populations located in relict sites of occurrence in Northern Italy. Proven very difficult to obtain plant individuals from *in-vitro* crossing of male and female spores, plants were vegetatively propagated from rhizomas for 2 years, with excellent results. At each release site, a meta-population structure made by several sub-populations was established, to reduce the negative impact of stochastic events and to differentiate the characteristic of the microsite conditions. Such a solution was successful, as some of the subpopulations disappeared, but the population as a whole had minor damages. Tolerance tests to herbicide demonstrated the *M. quadrifolia* was quite sensitive to many common herbicides used in the cultivation of rice, thus the release sites had to be chosen within areas less impacted by the agricultural activity (Natural habitats in protected areas). Artificial floating islands were effectively used in a site with high fluctuation of the water level, that often negatively affect the species survival in artificial ponds.

Post-plantation monitoring: After 6 months from planting the species cover increased by 100%, that fell to 50% the year after the re-introduction. Such variability is an intrinsic characteristic of the species which is affected by the water level that may strongly fluctuate from year to year and by the precipitation regime, also highly variable. However, some of these fluctuation may also be due to unknown factors. After 3 years some of the sub-populations become extinct mainly as a consequence of the selection of wrong microsites (especially concerning the water level fluctuation) and predation. For instance, at the Bagnacavallo site the only population still alive is the one in the artificial pond. However, the meta-population structure buffered the damages to the single sub-populations.

Major difficulties faced

- Scarcity of suitable release sites: The use of herbicides strongly affect the species, thus release sites for the re-introduced populations were identified in small areas less affected by the cultivation of rice, or where the cultivation of rice follows practices more compatible with the species persistence, which however are very few in the whole Po Plain.
- Remove or mitigate the impact of alien species: Currently this is an unsolved problem, especially for the Louisiana crayfish, that is very difficult to eradicate or control.
- Increase the genetic variation of the re-introduced populations: The choice of different source populations partially solved this problem, leaving the remnant populations highly inbred.
- Interpretation of the re-introduced population fluctuations: Strong fluctuation was recorded during the post-release period, but reasons for strong fluctuations in the surface covered by the species at the release sites can only be hypothesized.

Major lessons learned

- When between-population genetic diversity is low, there are few concerns in the choice of the source population, but the mix of different populations may

enhance the within-population generic variation of the re-introduced populations.
- The use of herbicides is the main threat factor affecting *M. quadrifolia* as well as other aquatic species in an agricultural context.
- The meta-population approach allows to minimize the damages to the whole population even when some sub-populations disappeared.
- The use of artificial floating islands was very successful in water bodies with a high variation in the water level.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:
- Complete analysis of the threats affecting the species at a local scale.
- Understanding the ecological requirements of the species through long-term ecological studies of the remnant wild populations.
- Understanding of the tolerance to dose and types of herbicides used in the rice cultivation, allowed for the selection of suitable release sites.
- Intrinsic ability of the species for rapid growth and vegetative propagation when conditions are suitable.
- Meta-population approach.

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Moris's pink re-introduction project in Sardinia, Italy

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Introduction

The Moris's pink (*Dianthus morisianus* Vals.) (Caryophyllaceae) was listed in the National Red List as Endangered and in the Regional Red List as Vulnerable; the small size of the population and the limited seedling recruitment make *D. morisianus* potentially prone to extinction, and, more recently, it is categorized as Critically Endangered on the European and Global Red Lists (Cogoni *et al.*, 2013 and references therein). Preliminary research focused on the ecology of *D. morisianus* and the level of human disturbance in its habitat. These surveys facilitated the identification of a suitable area ~150 m from the natural population, in a protected site, managed by public administration (EFS, Ente Foreste della Sardegna - Regione Sardegna); the chosen site was most likely a part of the species' former range and had not been greatly altered by human activities.

Goals

- Goal 1: To contribute to the recovery of threatened species.
- Goal 2: To increase the population size.
- Goal 3: To determine the conditions under which we might expect plant species re-introductions to be most successful.
- Goal 4: To make the results of this project available for future plant re-introduction trials.

Moris's pink

Success Indicators

- Indicator 1: Survival rates.
- Indicator 2: Number of established seedlings.
- Indicator 3: Number of seedlings becoming reproductive.
- Indicator 4: Flowering and fruiting rates per plant.
- Indicator 5: Mean number of fruits/seeds per plant.

Project Summary

Planting Moris's Pink at the release site

Feasibility: *Dianthus morisianus*, is the only psammophilous species of the genus in the Mediterranean basin and with only one population located on the Portixeddu coastal dune system (Buggerru, South-West Sardinia). The natural habitat of *D. morisianus* has been strongly modified by human activities, causing habitat loss and fragmentation: there are several settlements in the species' habitat and since 1950 much of the dune system has been afforested to stabilize the dunes and halt the movement of sand inland (Cogoni *et al.*, 2013).

Implementation: Seedling emergence and establishment are the most critical stages in the life cycle of *D. morisianus* (Cogoni *et al.*, 2012) and therefore juvenile plants were used for the re-introduction. Seedlings germinated from seeds collected in different years were used to facilitate the inclusion of some genetic diversity. Fruits were collected from the wild population in 2008 and 2009, by sampling 50 mature plants in each year. In a laboratory, 200 seeds (100 per collection) were sown and incubated at the optimal germination temperature (15° C; Cogoni *et al.*, 2012). Subsequently, all the seedlings were placed in pots with sand collected in the species' habitat. Successful growth requires adaptation to environmental conditions and thus propagation requires hardening, to decrease the stress of planting out and increase survival; accordingly, no horticultural treatments were adopted.

In November 2010, the 113 surviving plants (50 and 63 from the first and the second sowing, respectively) were re-introduced to the chosen site. The plants were placed in nine groups at a mean distance of ~15 m from each other; the location of each group was determined by the availability of suitable microhabitats (Cogoni *et al.*, 2013). A second re-introduction was done during 2011, on an unprotected site (Fenu *et al.*, 2015).

Post-plantation monitoring: The transplanted plants were marked and monitored monthly recording the following parameters: 1) number of plants surviving, 2) number flowered, 3) fructified plants, 4) number of flowers and fruits/ seeds per plant, and 5) number of new established seedlings.

The survival rate was high, with few plants dead in the first year (96%) and those remaining were alive after 24 months. About 40% and 65% of the plants became

Pots of Moris's pink placed in holes before being covered with soil at the release site

reproductive in the first and second years, respectively. The mean number of fruits per plant was 3.84 ± SE 2.48 and 7.97 ± SE 7.11 in the first and second years, respectively, higher than that in the natural population (2.60; Cogoni *et al.*, unpubl. data). The number of seedlings produced by the re-introduced plants (87) is higher than recorded in the natural population, where seedlings comprise 9.95% of the population (Cogoni *et al.*, 2013 and unpubl. data).

Major difficulties faced

- Site selection: Difficulties in finding suitable ecological patches considering the high level of human alteration of the coastal dune system.
- Grazing limitation: There is intensive grazing present in the area linked to domestic and wild animals that eat the stems and fruits.
- Summer drought: In the Mediterranean costal dune it represents a critical factor for plant persistence. In fact, the summer aridity in this coastal area, extends to late spring until autumn and often high-temperature peaks coincide with the lowest rainfall levels during the year. Given the role that some of these factors may play as selective pressures on flowering times.

Major lessons learned

- Select an appropriate microhabitat, something unique to each taxa, is a key feature for successful plant re-introduction.
- Successful re-introduction requires adaptation to environmental conditions and thus propagation requires hardening, to decrease the stress of planting out and increase survival; accordingly, no horticultural treatments were adopted.
- To select the appropriate season to carry out the re-introduction and in the Mediterranean costal dunes the best season is during autumn.
- Choice of an area managed by public administration (EFS, Forestry Agency of Sardinia) - conservation of threatened plants is more practicable on legally protected than on private land.
- To work in collaboration with public authorities and local stakeholders.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- High number of survived transplants.
- High number of seedlings established.
- High rate of reproductive plants.
- High rate of flowering and fruiting.
- High number of seeds per plant.

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Reinforcement of a population of chalky wattle on Eyre Peninsula, South Australia

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Introduction

The chalky wattle (*Acacia cretacea* Maslin & Whibley, Leguminosae) is a spindly, usually single-stemmed small tree with an open, straggly crown and chalky-white branchlets, inflorescences and legumes. The plant proliferates both from seed and vegetatively by root suckering or basal regrowth following disturbance or injury. It occurs in low shrubland and mallee scrub on deep red sand in gently undulating country with low sand ridges and is endemic to north-eastern Eyre Peninsula, South Australia (Jusaitis & Sorensen, 1994). Remnant populations are found along roadsides and on adjacent uncleared sand dunes in otherwise arable country near the northernmost limit of productive cropping. Surveys indicate a range of about 3 x 2 km with an extent of occurrence of 5.1 km^2 and an area of occupancy of 0.33 km^2 (Jusaitis *et al*., 2000). The population is threatened by its extremely small area of occupancy, and by grazing of young shoots of seedlings and root suckers by rabbits, kangaroos and domestic stock. The species does not occur in any conservation reserve and is listed as Endangered under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and assessed as Critically Endangered under IUCN (2001) criteria (CR B1&2ab(i)(iii)) (Pobke, 2007).

***Acacia cretacea* shoots in flower © M. Jusaitis**

Goals

- Goal 1: Safeguard the natural populations of *A. cretacea* by re-inforcing plant numbers in declining populations.
- Goal 2: Examine the influence of herbivore grazing on growth and survival of transplants.
- Goal 3: Examine the use of water storage crystals to improve translocation success.
- Goal 4: Examine the influence of founder propagule on translocation success.

Success Indicators

- Indicator 1: Survival, flowering, reproduction and recruitment of *A. cretacea* following translocation into natural populations.
- Indicator 2: The completion of an experimental translocation to evaluate the effect of herbivores on plant establishment.
- Indicator 3: The completion of an experimental translocation to evaluate the effect of water storage crystals on establishment success.
- Indicator 4: The completion of translocation trials to evaluate the establishment and survival of seed and seedling founders.

***Acacia cretacea* visible in the foreground and extending above the canopy of eucalypts as tall spindly trees**
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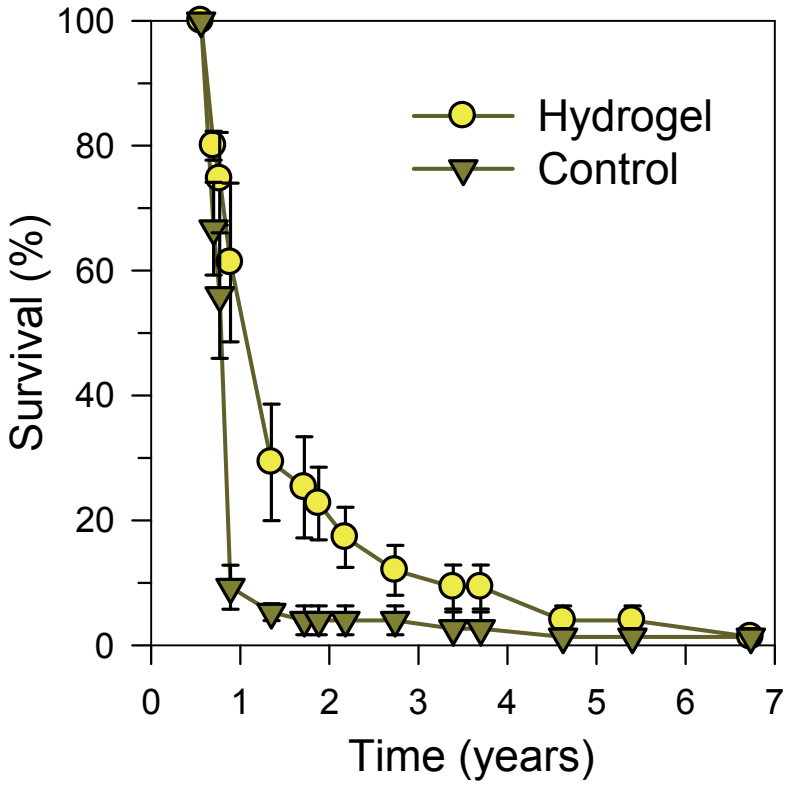
Project Summary

1992 translocation: This first translocation (36 seedlings, half of which were fenced) was planted during the winter of 1992, which proved to be a year of above average rainfall for the region (Jusaitis, 2005). The meteorological station at nearby Cowell recorded an annual rainfall of 552.6 mm that year, the highest on record for over 120 years (annual average 282.3 mm). The highest monthly rainfall for 1992 occurred during October and December, and more than likely contributed to the high survival and growth observed. After 7 years, transplants had reached average heights of 2.8 ± 0.3 m (fenced) and 1.3 ± 0.4 m (unfenced), survival had stabilized to 85% and 36% in each area respectively, and fenced plants had flowered and set fruit. Losses of unfenced seedlings were largely due to grazing damage, particularly during their first 2 years. These results demonstrated that with appropriate grazing protection, good survival and establishment of *A. cretacea* was possible if planted in a year of abundant rainfall.

Grazing effects: In 1996, a stock-proof fence (excluded stock but not kangaroos) was erected to enclose the largest remnant population (6 ha of over 400 *A. cretacea*). Inside this, a smaller (0.2 ha) rabbit-proof enclosure was constructed. Thirty four *A. cretacea* seedlings were planted into each of three areas (rabbit-proof enclosure, stock-proof enclosure and unfenced). The results of this trial are published elsewhere (Jusaitis, 2005) and revealed a 60% mortality due to dry conditions during the first summer, and 30 - 35% mortality due to herbivore grazing. No transplants survived their first summer without some form of grazing

Figure 1. Effect of hydrogel on survival of *Acacia cretacea* transplanted in 1997. Results are averaged over the three fencing treatments. Vertical bars represent ± SE Mean (*n* = 3).



protection, and the only plants to put on net growth were those protected by rabbit-proof fencing (Jusaitis *et al*., 2000).

Use of water storage crystals: Hydrogel is a synthetic hydrophilic acrylamide polymer that acts as a super-sponge, absorbing and storing hundreds of times its weight in plant available water. Commercially available as a potting-media amendment to reduce watering requirements, in this trial it was tested as a potential tool to improve establishment and survival of translocated *A. cretacea*. In July 1997, 50 seedlings were transplanted in pairs (~1 m apart), in each of the three areas established above (rabbit-proof, stock-proof, and unfenced). One of each pair was planted with about 200 ml of hydrated hydrogel placed at the bottom of the planting hole, the other was given no hydrogel. Treatment seedlings were planted with their lower roots in contact with the wet hydrogel. Soil conditions were very dry at planting and no rain fell for nearly 2 weeks after planting.

Hydrogel had a dramatic effect on early survival of transplants (Figure 1). Within 6 months of transplanting, most control plants had died, regardless of which grazing treatment they were in. However, plants treated with hydrogel had over 70% survival in both enclosures, and 36% survival when unfenced (Jusaitis *et al*., 2000). Although an unseasonably dry autumn and winter in 1999 resulted in further plant losses through moisture stress and grazing damage, the overall survival of hydrogel-treated plants remained significantly higher than that of control plants until year four. By year six, only two plants remained in the rabbit-proof enclosure, one hydrogel-treated and one a control. Both survived until at least year 11. Hydrogel-treated plants also responded with increased growth (in height) over control plants in all grazing treatments. Generally, transplants in the rabbit-proof enclosure put on the most growth due to restricted grazing. However, during the unseasonably dry 1999, we observed evidence of kangaroos having entered the rabbit-proof enclosure and plants in all three fencing treatments received a similar amount of grazing that year.

Seed as a founder propagule: *A. cretacea* seed were pretreated the night before sowing by covering them with just-boiled water and allowing them to stand until the water had cooled to room temperature (Sorensen & Jusaitis, 1995). The next day (24th July 1997), the moist seeds were sown using a 1 m^2 (10 x 10) grid to facilitate subsequent monitoring. Fifty seeds were sown (1 cm deep) in each of three replicates, in each of three fenced areas (rabbit-proof, stock-proof and unfenced). The soil was dry at sowing and no water was applied. No seedlings emerged in the rabbit-proof enclosure and only three emerged in the stock-proof enclosure, all dying during their first summer. The only significant emergences were seen in one replicate in the unfenced area. This replicate was in a shady area beneath a mallee (a form of eucalypt species that grows with multiple stems emerging from a lignotuber), and therefore may have had a better moisture regime than some of the other more exposed sites. For this replicate, seedlings were first observed 2 months after sowing and a maximum of 16% of seeds emerged by 3 months. Thereafter their numbers declined as soil dried out over summer, and all had died by their third year.

Translocated *Acacia cretacea* showing grazing damage caused by kangaroos © M. Jusaitis

Further translocations: Between 1998 and 2000, nearly 400 more seedlings were translocated into existing populations, but none of these trials had the success rate of the original 1992 translocation. All these translocants died within 4 years of planting.

Major difficulties faced

- *A. cretacea* occurs in a region of low rainfall (282.3 mm/annum) and it proved very difficult to establish plants from seed or transplants in this environment without any supplementary watering. The hot and dry summers desiccated plants in their first year before roots were able to grow deep enough to tap into subsoil moisture.
- Grazing or damage by rabbits, kangaroos and stock was observed on plants of all ages, but particularly on younger plants and especially during periods of unseasonably dry weather.
- The remoteness of the population site and travelling distance from Adelaide made frequent visitation for watering and maintenance of trials difficult and expensive.

Major lessons learnt

- The condition of transplants was critical to successful establishment. Young transplants (1 - 2 phyllode stage) were preferable to older seedlings. Pot-bound seedlings were less likely to establish quickly, and more likely to result in an unstable plant with a poorly developed root system.
- Seeds were less effective founder propagules than transplants. Translocations using seed will require the use of pre-treated (scarified) seed, additional watering during the first summer (depending on seasonal conditions), and protection from grazing after the second year of establishment.
- The first summer after transplantation was the most critical period for plant establishment. Provision of adequate soil moisture and protection from grazers during this time were essential to ensure ongoing plant survival. Best results were obtained by transplanting in years of extremely high rainfall, although supplementary summer-watering may alleviate this requirement.
- Hydrogel water storage crystals were effective in improving early survival and growth of *A. cretacea,* particularly over the first 4 years of establishment. Favorable rainfall events following translocation should further improve long-term establishment.
- Transplants must be protected on an individual basis (e.g.., plant guard) or on a community basis (e.g.., fencing). The latter method is more economical, particularly if large numbers of plants are to be protected. Fencing has additional long-term benefits for the ecosystem, in that all plants (including natural regenerants) are protected, and soil disturbance is reduced.
- The spiny *Triodia irritans* was commonly associated with *A. cretacea*, and transplants placed within or near a clump of *T. irritans* were invariably protected from grazing, at least in their early growth stages.
- Herbivory was more significant on younger plants and declined as plants matured. Grazing damage was also more severe following unseasonably dry periods.
- Herbivore damage was also observed on mature *A. cretacea*. Bark stripping and ring-barking of mature plants by kangaroos usually resulted in death of affected plants.

Success of Project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reasons for success/failure:

- The first translocation trial planted in 1992 proved very successful as a result of extremely high rainfall events during that year, particularly in summer, allowing plants to quickly establish deep roots while soil remained moist.
- Translocations in other years proved difficult due to insufficient soil moisture to enable rapid deep root establishment.
- Grazing during early stages of growth hampered plant establishment and was particularly severe during unseasonably dry periods.

- In the direct seeding trial, rainfall during July when the seeds were sown was well below the average for the area, and the result may have been improved by sowing earlier in the season, or during a month/year of higher rainfall.

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Successful translocation of *Narcissus cavanillesii* in Portugal

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Introduction

Narcissus cavanillesii A. Barra & G. López (Amaryllidaceae) is an autumnal geophyte listed in the Annexes II and IV (as *N. humilis*) of Habitats Directive (92/43/EEC). The first approximation to its threat status suggests that it should be classified as Critically Endangered in Portugal according to IUCN criteria (2001). This species occurs in the Iberian Peninsula and North Africa and the only two localities recorded in Portugal were affected by the construction of the Alqueva dam (Alentejo region). One of the localities would have been completely flooded if no conservation action had been taken and the other would have been affected by changes in habitat and in human activities. The population that was going to be flooded was discovered in 1999 during preliminary works of the construction of the dam (Rosselló-Graell *et al.*, 2003). This is key since because the floodgates would be closed during the summer of 2001 leaving just one flowering season to determine the situation of the population.

Flower of *Narcissus cavanillesii* © D. Draper

A conservation program was planned with the main goal focused on to avoid the extinction of the species in Portugal as well as guaranteeing the survival of its populations. The translocation action was followed by 11 years of monitoring activities and punctual interventions when needed.

Goals

- Goal 1: Get a clear picture of the situation of the population and the dynamic of the species (baseline information).
- Goal 2: Identify the best receptor site within the area of influence of the reservoir and validate *in-situ* the species suitability before translocation.
- Goal 3: Develop *ex-situ* conservation protocols to face the risks of the translocation.
- Goal 4: Perform the translocation while maintaining the original conditions as much as possible: translocate not only the individuals but also the organisms in the rhizosphere, keeping as much as possible the population structure and the spatial relative location of the various patches and individuals that conformed the population.
- Goal 5: Monitor the translocated population over the next 11 years and implement corrective measures when required.

Success Indicators

- Indicator 1: Percentage of individuals translocated relative to the census of 2000.
- Indicator 2: Number of patches translocated.
- Indicator 3: Percentage of reproductive plants annually relative to the census of 2000.
- Indicator 4: Long-term efficient *ex-situ* conservation of seeds and *in-vitro* micropropagation and preservation of 50 bulbs from the two Portuguese populations during at least 5 years (medium-term).

Project Summary

Feasibility: The distribution range of *N. cavanillesii* extends from Algeria and Morocco to Portugal and Spain. In Portugal, *N. cavanillesii* is restricted to two localities, Ajuda and Montes Juntos, in the Alentejo region corresponding to the species' western range limit in the Iberian Peninsula. It can be found in forests clearings, scrublands, Mediterranean pastures, and riparian communities, and road edges in sub-humid Mediterranean climates from the sea level up to 1,000 m a.s.l. (Marques & Draper, 2012). *N. cavanillesii* is a small perennial geophyte less than 15 cm high. It has bright yellow flowers that bloom in early autumn and generally produce only one flower per individual. It has an open corolla exposing sexual structures with a virtual tube that improves cross-pollinations chance. The species is self-compatible although insects are needed to achieve a higher rate of fruit and seed set (Marques *et al.*, 2007). Major threats are habitat change and fragmentation of populations. Small populations are not attractive enough to pollinators (Marques *et al.*, 2007) and sexual reproduction often depends on the co-existence of congener species like *N. serotinus* and *N. miniatus*, although this also leads to hybridization in some cases (Marques *et al.*, 2012).

Implementation: After the discovery of the population of Monte Juntos in 1999 there was hardly time available to complete the phenological cycle and to know the dynamics and status of the population, because the closure of the floodgates was scheduled for August 2001. With this limitation, during that first year the

development of census of individuals (vegetative and reproductive) as well as a detailed log of the spatial distribution of individuals, phenological study, and characterization of predators, pollinators and dispersers was prioritized. A two-phase translocation was scheduled as the receptor site was not yet selected in 2001. A temporal translocation was made in 2001 (before blooming) taking the population above the flood level but as close as possible to the original population. The aim of this action was to keep the population in the same habitat but safe from water level rise caused by the closing of the gates.

Translocation was carried out cutting the rocks or soil patches in small blocks to be transported. This procedure had the advantage of moving the bulbs together with surrounding soil or rock and keeping the relative spatial structure. The translocated population had a total number of 1,200 mature individuals and it was structured in 11 small patches from 0.5 m^2 to 8 m^2. The final translocation site was determined by using predictive models integrating the niche and the characteristics of the original site (Draper *et al.*, 2006).

The model was stratified and validated by seed germination experiments in the field, so a relationship was established between the habitat suitability of the studied territory generated by the model and the germination rate. Several places were selected according to this workflow but the definitive receptor site should have the agreement of the land owner. A negotiation was carried out with the land owner to achieve the commitment to maintain the land use of the place over time. With the receptor site validated and selected and the commitment of the owner to maintain the land use, we proceeded to the final translocation. The receptor site was only 1.5 km north of the original site.

Post-plantation monitoring: Monitoring was performed during the following 11 years. This monitoring was divided into two phases: 1) The first 4 years had the financial support of EDIA S.A. and could implement corrective measures based on the observed results, 2) The second phase took place from year 5 to 11, where an annual census of reproductive plants and fruit set was performed. The second phase was performed with the logistical support of the Lisbon Botanical Gardens from the National Museum of Natural History and Science (Portugal).

Plants translocated with rock layer © I. Marques

Indicators showed a drop in percentage of reproductive plants during the first flowering season after translocation in all plots (average of 24%). To

reverse this trend, seed produced in each plot were planted in the plot for the next 4 years. The increase of cattle during the breeding season of 2004 forced to protect the plots with temporary exclusions which remained until 2010.

Overview of re-introduction site © I. Marques

After these corrective measures an increasing trend in the percentage of reproductive plants has been observed reaching the values before translocation. In 2010, about 5 m away from one of the translocation plots we found a reproductive individual. From this it follows that during all this time pollination, dispersal, germination and establishment processes effectively took place. *Narcissus cavanillesii* has managed to complete the life cycle in the new site. In the last census of 2011 the number of individuals was slightly above the reference value of 2000. Ten years after the translocation the number of breeding individuals was similar to that before the intervention.

Major difficulties faced

- Lack of knowledge of the species.
- Limited time to know the status of the original population.
- The scheduling of public works overrides biological processes and constrains our ability to act.

Major lessons learned

- The importance of a multidisciplinary team (botanists, entomologists, agronomists, geologists, etc.) is a first step to success.
- It is essential to understand as well as its relationships with the environment and other organisms.
- The process of identifying the receptor site must combine knowledge of the species with knowledge of space available for translocation.
- The *in-situ* germination can help validate the receptor sites.
- Dialogue between land-owners, researchers and decision makers must be continuous and fluid.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- We were able to identify the main factors governing population viability.
- The selection of the receptor site was made considering the ecology of the species and distance factors adding to the original population. Thus changes in soil, vegetation, wildlife or weather were minimized. The first ascertaining that in the receptor site the species would have a high germination rate reduced the risk that the new locality the species would be able to complete its life cycle.
- We translocated the community and not only the individuals. Cutting the soil blocks and rocky outcrops where individuals occurred and performing the translocation when the bulbs were dormant minimized the impact on the individuals.
- Having kept the spatial structure of individuals and plots helped ensure the genetic relationships between them. This is essential concerning future gene flow via both pollinators and dispersers.
- To summarize, we tried to maintain as much possible the original conditions.

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Setting up neopopulations of the endangered endemic sea lavender in Eastern Spain

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Introduction

The sea lavender *(Limonium perplexum)* Sáez & Rosselló (Plumbaginaceae) is one of the most endangered endemic species of the European continent, having a unique population, placed on a small outcrop ~40 m^2 of a low coastal limestone-cliff near Peñíscola, Mediterranean coast of Castellón province, Valencian Community, Spain (Aguilella *et al.*, 2010). This species is an herbaceous, rosulate annual or short-lived perennial plant, living on the crevices and sandbanks formed on the cliff platform. The site is affected by collapse risk, as an effect of continuous marine storms. The unique population of *L. perplexum* shows strong interannual fluctuations, from 19 to 383 individuals (Ferrando *et al.*, 2014). *L. perplexum* is a triploid, apomictic, self-incompatible species (Sáez & Rosselló, 1999) with no genetic diversity. It is theorically able to hybridize with other co-living and morphologically close sea lavenders (*Limonium* spp.). It is listed as Critically Endnagered in the Spanish Plant Data Book (Crespo, 2004), and protected within the major legal category, Imperiled of Extinction, in the Spanish and Valencian Catalogues of Threatened Species. Its conservation depends on the Valencian Wildlife Service, and the Valencian Government passed in 2015 a recovery plan for the species (http://www.agricultura.gva.es/web/biodiversidad/planes-de-recuperacion). The site is strictly protected as a Plant Micro-Reserve.

Goals

- Goal 1: To generate *ex-situ* annual pools of seed-producer plants, free from hybridization, and to obtain enough seed amounts to carry out the translocation project.

Sea lavender © Emilio Laguna

- Goal 2: To create neo-populations, planted and regularly monitored, placed on sites close to the unique native population known for the species.
- Goal 3: As additional useful information, to test the implantation techniques effectiveness as well as the site conditions or other relevant issues to ensure long-term conservation.
- Goal 4: To monitor the presence of spontaneous hybrids, obtaining an alternative strategy for those cases (removal of co-generic species and hybrids, if needed).
- Goal 5: To reduce other impacts or risk factors on the populations, if needed.

Success Indicators

- Indicator 1: Survival and long-term maintenance of the unique native population.
- Indicator 2: Six or more new populations (=neo-populations) planted in not less than five 1 km x 1 km quadrates*.
- Indicator 3: Self-maintenance of the established neo-populations for more than 5 years*.

**Target numbers have been proposed by the recovery plan, in order to obtain a mid-term re-evaluation as EN (Endangered) instead of CR (Critically endangered), using the current IUCN Red List Categories.*

Project Summary

Feasibility: The sites to set up neopopulations, as well as the native population, form a part of the sea shoreline, which is a national, public property in Spain, of the Nature Park 'Serra d'Irta'. The species produce enough seeds *ex-situ* up to 280 seeds per plant in nursery to carry out the conservation translocations. The seeds have high germination rates, over 95%, and the plantlets are well adapted to grow in nurseries under standard culture conditions and commercial substrata (Ferrando *et al.*, 2014). To avoid an extreme seed collection from the unique known population, artificial pools are regularly grown to provide new seeds, without genetic risk, due to the natural apomychtic reproduction, which does not generate genetic variability. Plant pools are maintained in nurseries without other co-living cultivated *Limonium* species. Due to the small surface where the species grows and its public property, no significant social conflicts are found. The recovery plan includes specific measures to forbid the use of the area as occasional site to practice angling. In addition the plan establishes specific regulations to avoid the effects of any future enlargement of a nearby coastal track.

Implementation: Since 2005, nine plantations (herein called 'P' sites) placed on seven 1 km x 1 km quadrats, using UTM coordinates system, datum ETRS89, have been made along 10 km of coastline over several kinds of limestone, close to the native population ('N'). The number of individuals planted has varied from 44 (plantation P1) to 1,347 (P7), upon availability of nursery production and plantation sites. The first five plantations (P1 to P5) involved small amounts of plants, less than 200, due that the initial lack of long-term monitoring results did not advice us to employ bigger numbers. Because of the natural high levels of air-moisture on the seacliffs, only some few initial water supplies are needed. All the

plantations have been made using young plants (3 - 6 months old). Due to the low availability of crevices and insufficient depth of soils on the cliff ledges, the plantation tasks face significant difficulties. In addition, the real underground depth or soil volume able for root growth in each microsite cannot be known in advance. Also a lack of experience in sowing seeds, which will be experimented in 2015 - 2016, could aid to solve this problem in the near future.

The original population N has not been reinforced, in order to avoid interferences to monitor its population dynamics, and only small seed collections have been made sporadically. Annual census of the original population is regularly made since 1995 (Gómez Serrano *et al*., 2005).

Post-plantation monitoring: All the plantation sites are annually monitored (Ferrando *et al*., 2014). In 2014, the total amount of adult plants reached 521 individuals, belonging 87 (16.70%) to "N", and 434 (83.30%) to the 8 plantations (P1 to P8) having being more than 1 year old and showing effective *in-situ* germination of new plants. Each neopopulation shows an initial erratic dynamics within 2 - 3 years during which enough seeds are being accumulated to form an effective seedbank. This initial dynamics can include the absolute lack of new emerged plants for 1 - 2 years after the plantation, during which the species only survives in form of seeds produced by the planted specimens, which die the same year as a result of a strong reproductive stress. Afterwards, each neopopulation "P" follows a similar fluctuating pattern to "N". Apparently, the dynamics of "N" and the oldest "P" populations could be due to climate parameters, but the specific effect of temperature and rainfall still need to be studied for more years, combined with the negative effect of strong marine storms. Although *L. perplexum* is co-living with 2 more triploid co-generic species in some "P" sites (*L. girardianum* and *L. virgatum*), no hybridization events have been detected.

After each plantation, carried out in winter or early spring, only 33% - 66% of the planted individuals survive to reach the reproductive time the following summer. The unpredictability on the microsite suitability is a major force to explain these failures, and no significant differences have been found between the different rock types forming the cliffs. Only a small proportion of the new individuals germinating each year, apparently less than 33% reach the hemicryptophyte or chamaephyte life form, living for 2 or more years. They preferably grow on the deepest crevices or

Planting sea lavender © Emilio Laguna

1 year post-planting © Emilio Laguna

sandbanks, acting as the main plants for seed production. The remainder amount is formed by annual individuals reaching smaller sizes and with lower production of seeds.

After very recent surveys, a new species of *Limonium* has been discovered, a few km north from the native population "N". This new species is still under scientific description and it could be able to hybridize with *L. perplexum*, so the available sites to carry out future plantations (from P10 onwards) is significantly reduced.

Major difficulties faced

- Finding good microsites to plant the species is a difficult issue. The effective soil depth/volume for root development cannot be predicted.
- The long term coexistence effects with other triploid co-living species of *Limonium* are unpredictable (although the experience shows that no apparent hybrids are formed living with the commonest local species *L. girardianum* and *L. virgatum*)
- The maintenance of *ex-situ* reproductive pools, as well as the production of new plants, must be made far from nurseries where other species of *Limonium* are cultivated.
- The long-term maintenance of the original site, where the unique native population is placed, is uncertain and unpredictable.

Major lessons learned

- Due to the unpredictability to find good plantation microsites, a big amount of plants should be produced and planted. However, small plantations i.e. the first ones made in 2005, also yield positive results.
- The complete disappearance of the species during 1 - 2 years cannot be interpreted as a translocation failure. Managers must wait for the recruitment of new individuals from seeds, which can be done within the following years.
- The species can grow on several kinds of cliff substrata such as massive limestones, conglomerates, etc.. No exact reproduction of the characteristics of the unique remnant native population is strictly needed.
- Due to a major proportion of new plants born *in-situ* are annual individuals, alternative techniques such as sowing seeds must be tested, in order to compare its effectiveness and costs in the near future.

- The results obtained with this species could implement the conservation plans for other Valencian *Limonium* endemic species also affected by similar problems, but being categorized in lower levels (as Endangered or Vulnerable).

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Success is apparently facilitated by the local conditions of coastal cliffs (high levels of air moisture) and the biological traits of the endangered species.
- The working framework for the conservation translocation is favorable (protected sites, public property, a recovery plan legally passed) and can ensure the continuity in a future.
- Long-term conservation of the site for the original population cannot be fully ensured, due to major nature forces such as collapse risks caused by big marine storms. This problem only can be counteracted ensuring new, close safe sites for the species housing artificial neopopulations.

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Creating new populations to conserve the endangered *Silene cambessedesii* in the Iberian Peninsula

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Introduction

Silene cambessedesii Boiss. & Reut. is a little annual plant, endemic to the coastal dunes of Ibiza and Formentera, Balearic Islands and the Eastern Iberian Peninsula, Spain (Aguilella *et al.*, 2010). Listed as Vulnerable in the Spanish Red List of Threatened Vascular Plants (Moreno, 2008). In late 1980s, the Iberian coast housed four populations, placed on the coastal dunes of southern Castellón province (Valencian Community), but three of them vanished as a result of massive dune movements caused by marine storms and human actions. At the end of the past century, only one population - called 'Platja d'Almenara'- remained. *S. cambessedesii* shows an ephemeral life cycle of 3 to 6 months and has strong interannual fluctuations from 99 to 8,935 individuals, throughout the period 2006 - 2015.

Flowering individual of *Silene cambessedesii*
© Emilio Laguna

The species is strictly protected by the Valencian Community government and the site 'Platja d'Almenara' is legally protected as a Plant Micro-Reserve. The conservation of this species is made by the Valencian Wildlife Service. No recovery plan has been formally drafted.

Goals

- Goal 1: To generate and to re-establish if needed *ex-situ* annual

pools of seed-producer plants, and to obtain enough seed amounts to carry out the translocation project.

- Goal 2: To create neo-populations, planted and regularly monitored, placed on sites close to the unique known native population for the species in the Iberian Peninsula.
- Goal 3: As additional useful information, to test the implantation techniques (planting, sowing) effectiveness as well as the site conditions or other relevant issues to ensure long-term conservation.

Success Indicators

- Indicator 1: Survival and long-term maintenance of the unique native population
- Indicator 2: Six or more new populations (=neo-populations) planted in not less than six 1 km x 1 km quadrates*.
- Indicator 3: Self-maintenance of the established neo-populations for more than five years*

**Target numbers have been proposed by recovery plans for similar species (i.e.* Limonium perplexum*), in order to obtain a mid-term re-evaluation as EN (Endangered) instead of CR (Critically Endangered), using the current IUCN Red List Categories.*

Project Summary

Feasibility: Although a unique population of *S. cambessedesii* remains, the coastline of southern Castellón and the neighbouring sites of the province of Valencia, all of them form a part of the Valencian Community. This is almost 35 km of sand and gravel dunes, containing similar plant communities and belonging to the same chorologic territory, Valencian-Tarraconensean vegetation sector. All the coastal dunes are a public property owned by the Spanish State and managed by the national Coasts Service. The nature conservation tasks are carried out by the regional (Valencian) Wildlife Service, under the Coasts Service permission. Several annual species of Campions (*Silene* spp.) had co-lived and still live together with *S. cambessedessii* i.e. *S. tridentata* and *S. ramosissima*- nevertheless, hybrids have not been found.

The germination rates of *S. cambessedesii* are low, not less than 40% under standard lab conditions, reaching 78.60% under

Plantation of *Silene cambessedesii* © Emilio Laguna

Second generation plants © Emilio Laguna

Lithium Chloride atmosphere in Petri dishes (Ferrer-Gallego *et al*., 2013). However the species yield a massive seed production *ex-situ*, so enough plants to carry out conservation translocations can be produced using single nursery techniques, such as traditional seedbeds. Plant culture in nurseries is easily performed using standard substrata for wild plants (Ferrer-Gallego *et al*., 2013). The site 'Platja d'Almenara' has been affected in the past by several beach management practices such as sand leveling, building of bath infrastructures, etc. progressively solved through agreements between the Valencian Wildlife Service and the Spanish Coasts Service.

Implementation: The conservation strategy is based on the creation of 'neopopulations', new populations which are set up for safety reasons, Laguna & Ferrer-Gallego (2012), near the unique remaining site Platja d'Almenara. The suitable sites must be free of the strong effects caused by marine storms. Since 2012, seven plantations and one sowing experience have been carried out by the Wildlife Service, along 30 km of coastline from Moncofa (Castellón) to Sagunto (Valencia). The plants amount varied from 52 to 816 individuals, depending on the *ex-situ* production availability (Navarro *et al.*, in press). Due to the dune microclimate, the night sea spray is ensured during the whole year, and only initial water supplies are needed.

The germination and culture of new plants are made in the nursery of the Centre for Forestry Research and Experimentation, Generalitat Valenciana (CIEF in Spanish). In order to avoid the extreme seed collection in Platja d'Almenara site, a part of them are obtained *ex-situ* every year are used to produce the next generation. However, it has been noticed that the vigor of new plants is reduced after 3 - 4 *ex-situ* generations. As a result of that, new culture lines must be started using the remaining part of the initial seed accessions, or picking up new seeds from the natural population.

Post-plantation monitoring: All the plantation sites are monitored annually and 4 plantations were established throughout 2012 - 2013 have yielded apparently stable neopopulations. As also noticed with other annual species planted by the Wildlife Service (i.e. *Limonium perplexum*, see the specific sheet in this book) each neopopulation shows a weak recruitment within the 1st and/or 2nd year,

followed by a quick increase after the 3rd year. This behavior can be related to the need to create and store a soil seedbank, able to ensure a regular recruitment for the next generations. For the oldest plantation, where only 52 plants were initially planted, 2,863 reproductive individuals have been censed in 2015. Summing the data for the four plantations carried out before 2014, a total amount of 1,105 individuals were planted, the census of 2015 yields 3,461 individuals, still far from the native site 'Platja d'Almenara' (7,487 individuals counted in 2015). More recent plantations are still too young to obtain reliable results. Reporting the initial population 'Platja d'Almenara', no relevant recent impacts have been recorded and its maintenance can be long-term ensured.

However, both natural and planted populations are placed on beaches intensively used in summer when *S. cambessedesii* only remains as seeds, for tourists and local bathers. The maintenance of some standards and quality labels –i.e. 'blue flags' granted to the European Commission to the best bath beaches, often forces the local and national authorities to carry out conditioning practices i.e. sand leveling, removing natural organic matter deposited by sea waves, etc. which can degrade the habitat quality of this species.

Major difficulties faced

- Recent plantations could contain plants obtained after 3 - 4 successive generations from *ex-situ* culture, so germination and vigor of the new plants born *in-situ* will need an accurate monitoring.
- Some plantation sites, where the plants live from winter to late spring, are placed on beaches which can be intensively used by bathers and other tourists in summer. To maintain the naturalness of these areas i.e. avoiding beach cleaning or other conditioning practices, a more intensive commitment must be obtained from the municipal and national authorities.
- The germination times can vary notably intra- and inter-populations, and between successive years. The species census often requires more than one visit to the plantation site.

Major lessons learned

- Plantations are self-maintained without further human intervention. No regular water supply, fencing or other common practices for plant conservation are needed.
- As for other annual endangered species, the complete disappearance of the species during 1 - 2 years after plantation cannot be interpreted as a translocation failure. Managers must wait for the recruitment of new individuals from seeds, which can be done within the next years.
- Alternative techniques such as sowing seeds must be tested, in order to compare its effectiveness and costs in the near future.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Success is apparently facilitated by the local conditions of coastal dunes (high levels of air moisture) and the biological traits of the endangered species.
- Long-term conservation of the site for the original population can be reasonably ensured, but a more effective cooperation between local, regional and national authorities should be established in the near future.
- Future failures in the more recent plantations could be explained by the lack of genetic renewal of the seed orchard. This issue must be monitored throughout the following years.

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First phase of conservation translocations of the Cartagena's rockrose in the Valencian Community, Spain

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Introduction

Cistus heterophyllus Desf. is an Iberian-North African rockrose species. The populations of the Iberian Peninsula are differentiated as subsp. *carthaginensis* (Pau) M.B. Crespo & Mateo, "Cartagena's Rockrose", which is one of the more threatened plants in Europe. This subspecies only lives in the regions of Valencian Community, where only a unique pure specimen in wild has been found and in Murcia where around 40 specimens, apparently showing traits of hybridization with the close relative white rockrose (*Cistus albidus* L.). The two Iberian populations are over 300 km far from each other. The Cartagena's rockrose has been categorized Critically Endangered (CR) by the Spanish Red List of Threatened Vascular Flora (Moreno, 2008). It is strictly protected with the maximum level of the Spanish laws (Imperiled of Extinction). It is also protected at the same level in the Valencian Community and Murcia throughout their regional laws, and both regions have passed a recovery plan. This plant is a calcicolous shrub up to 0.8 m tall living in semi-arid (rainfall amount between 200 - 350 mm/year) or dry-semiarid (350 - 450 mm/year) areas. The rockroses use to be self-incompatible for pollination and further seed production, and only scarce fruits containing very few seeds can be collected every year.

Flowering close-up of *Cistus heterophyllus subsp. carthaginensis* © Emilio Laguna

Goals

- Goal 1: Producing *ex-situ* new plants through vegetative propagation techniques, as a safety

measure (preventing the lack of sexual reproduction) and achieving a vegetative orchard.
- Goal 2: Obtaining seeds *ex-situ* from two or more generations. Getting an *ex-situ* pool of genetically diverse plants ('biodiverse plants').
- Goal 3: Making plantations able to produce new individuals.
- Goal 4: Obtaining at least one population with long-lived parental plants under 'suitable' ecological conditions, similar to those of the site where the unique wild specimen is found.

Success Indicators

- Indicator 1: A safety pool of at least 50 - 100 plants produced through vegetative methods i.e. *in-vitro*, cuttings to set up a plant orchard.
- Indicator 2: New plants grown *ex-situ* from seeds, taken from the original native wild individual, and/or the plant orchard.
- Indicator 3: One or more new populations established and self-maintained in 'suitable' ecological conditions similar to the native population.

Project Summary

Feasibility: Full recovery of the species in the Valencian Community region which holds the Northernmost population, with only one wild specimen should be expected for a very long-term, so its rescue has been planned following several phases. The first one includes the obtaining of new specimens and first experimental plantations in natural areas. The conservation of the Murcian population, bigger than the Valencian ones but apparently hybridized (Jiménez *et al.*, 2007; Aguilella *et al*., 2010) should be implemented in further phases. It will depend on the propagation success of the Valencian plant material which could be used to dilute the effect of hybridization noticed in the Murcian plants. The provision of new Valencian specimens has been performed through three different ways: 1) clonal, *in-vitro* specimens; 2) clonal plants grown after cuttings collected from the wild specimen; and 3) seeds from outstanding fruiting episodes, produced by the unique wild specimen or its clonal descendants obtained via 1 or 2 (Escribá *et al.*, 2007). At least the new plants obtained via 1 and 2, have shown a strong incompatibility to produce seeds in nursery, even after artificial pollination. The feasibility of the recovery in future phases will depend on several factors, for which there is no sufficient certainty: 1) the progressive obtaining of new generations of Cartagena's rockrose specimens from seeds - where a lower incompatibility could be expected; 2) the maintenance of enough vigour and/or the reduction of negative expected effects of endogamy; 3) the finding of available sites without *Cistus albidus* and the positive performance of *C. heterophyllus* subsp. *carthaginensis* after its implantation.

Implementation: The first phase consisted of 1) obtaining new Valencian clonal individuals, 2) to test the plantation of individuals using clonal Valencian plants in order to obtain a field protocol, to be used in the future using plants obtained from seeds and 3) the establishment of a seed orchard pool of Valencian 'pure' plants, not introgreded by *C. albidus*. Clonal *in-vitro* propagation was achieved in 1990 - 1991 (Arregui *et al.*, 1993) and more than 200 individuals have been produced. *In -vitro* plants have been the unique way to save the species from the extinction

throughout 1991 - 2011. It has been recently demonstrated - unpublished data that *in-vitro* plants could carry a little mutation in their rDNA chomosomic region. Its codability is unknown, but no apparent morphological changes have been noticed on the *in-vitro* plants, compared to the wild specimen. Clonal propagation using hormonated cuttings, were unsuccessfully attempted between 1987 and 2011. After good rainfall seasons in 2011 - 2012, enough plant material in good condition was collected from the unique wild plant and more than 50% of cuttings rooted, producing an initial pool of a dozen of new individuals. Their lack of chromosomic alterations has been tested.

Searching for new seedlings in the Plant Micro-reserve 'Tancat de Portaceli' © Emilio Laguna

An outstanding episode of seed production was recorded in the wild specimen in 2013, collecting up to 50 seeds. Twenty-five new individuals grown *ex-situ* have started to flower in 2015, and a few fruits with new seeds are being currently collected, in order to start a future second generation. Additionally, artificial crosses in isolation chambers have been made since 2013, using Valencian, Murcian and African plants, show a remarkable hybrid vigor (i.e. crossing the two subspecies) has been noticed. Up to seven plantations of 150 individuals were made from 1997 to 2010 on several kinds of soils, plant communities and altitudes. The plantations were made depending on the *ex-situ* plant production.

Post-plantation monitoring: Most part of the seven plantations failed and the planted individuals died without recruited new plants. The majority of those sites suited the theoretical good conditions similar to the site of the native individual. However a plantation of 25 *in-vitro* specimens made in 1997 in the Plant Micro-Reserve (PMR) 'Tancat de Portaceli' (Serra, province of Valencia) produced new individuals from 2011. The PMR was not a theoretical good site, because of its tree cover provided by Aleppo pine (*Pinus halepensis*) and the presence of *Cistus albidus*. In 2012 - 2013, 40% of the individuals planted in 1997 still survived, and four newly recruited plants of *C. heterophyllus* were found. The death of the remainder 60% was mainly caused by the strong competition of bigger shrubs such as *Pistacia lentiscus*. The new plants of *C. heterophyllus* had no external effects of hybridization, but they could carry the chromosomic alteration. As a expected bad result, several hybrid young plants were also found in the same PMR. Both individuals of *C. albidus* and hybrids were removed from the PMR in

2013 - 2014. In despite of these results, recent attempts to create a new population without Aleppo pine cover, in 'suitable' conditions have failed. The main reason was the lack of enough support through artificial watering.

Major difficulties faced

- The optimal new individuals should be grown from seeds, and the species is a self-incompatible taxon for seed production. Only rare failures of the incompatibility mating systems can provide new seeds.
- The *in-vitro* produced plants can be maintained as a safety measure for the species conservation. A slight chromosomal difference from the unique wild plant has been recently found, but no morphological differences have been noticed.
- The best site where the implanted plants survived is a bad one to ensure the long-term self-maintenance of a new population without artificial help, due to the risk of hybridization with *Cistus albidus* and the strong competition caused by other local shrubs.
- Although a first generation from seeds has been obtained, the new individuals come from a unique mother plant, so future effects of endogamy could be expected for a long time.

Major lessons learned

- The species is close to be genetically exhausted, so a first genetic recovery *ex -situ* (self-crossing for several generations) will be needed, in order to obtain enough seeds and new plants for the future translocations.
- The *in-vitro* plants can survive and produce new descendants *in-situ*. As an emergency alternative for the recovery program, *in-vitro* plants could be used in a future as a last resort, if the genetic rescue using seeds will fail.
- The recruitment of new seedlings, coming from *in-vitro* parentals, has only been noticed long time after the plantations ~15 years. Therefore a true recovery of the Cartagena's rockrose may last some decades.
- Apparently 'best' conditions for plant growth i.e. sites with deeper soil, tree cover, etc. could ensure the survival and successful reproduction of the Cartagena's rockrose, but the species must face the risk of hybridization, and increased competition caused by other shrubs. The maintenance of those new populations force the managers to remove the white rockrose and their hybrids, as well to reduce competition i.e. pruning or removing competitor shrubs, removing recruited pine seedlings, etc..

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- No successful plantation where at least a big part of the planted individuals had survived for some years has been achieved on the 'suitable' sites for this subspecies. The main reason was the lack of irrigation support.

- The Cartagena's rockrose can survive if planted on sites where the artificial irrigation is not needed due to a higher rainfall amount, bigger plant cover, etc. but these sites hold white rockrose amid strong competition by bigger shrubs.

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Re-introductions of an increasingly rare North American lily to prevent regional extinction

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Introduction

Combined tall grass prairie, mixed grass prairie and short grass prairies once stretched across 1.5 km^2 of the North American continent. Less than 2% of North American native prairies exist in their natural state today. The tall grass prairie has declined 99.9% over the last 200 years, a decline exceeding that of any other plant community. One native forb that has all but disappeared from the landscape is *Lilium canadense* subsp. *michiganense* (Farw.) Boivin & Cody. *L. canadense* subsp. *michiganense* gained appeal in Europe after its introduction there when the explorer Jacques Cartier brought the first plants back to the continent. It was widely planted in European botanic gardens and estates after his North American expedition in 1629 (Hermes, 1993). Thomas Jefferson appreciated the species and contacted John Bartram to provide lilies for his political acquaintances in France (Jefferson correspondence, 1786).

Over time, robust modern lily hybrids, with their vast array of forms and colors eclipsed interest in the wild species and *L. canadense* subsp. *michiganense* slipped into obscurity. The common name for it is Michigan lily, sometimes also referred to as Turk's cap lily, although there is some debate about which of the North American native lilies is the correct one for that title. It is one of the showiest of all the native plant species. The plant was historically used by Native American Indian tribes for several medicinal purposes and the bulbs were used as a foodstuff.

Lilium canadense subsp. michiganense

The lily is listed as an endangered species in New York State and threatened in the state of Tennessee. Several other states report it to be "extremely rare" but do not afford it formal protected status (USDA Forest Service). In all the states where *L. canadense* subsp. *michiganense* still exists, populations are

small and isolated, making genetic exchange sporadic at best among the widely scattered remnant prairies.

Goals

- Goal 1: Conserve native lily germplasm from a minimum of 5 tallgrass prairie sites.
- Goal 2: Propagate the species by cloning various lines *in-vitro*.
- Goal 3: Harden off the propagules and establish experimental populations on protected sites within its historic range.
- Goal 4: Establish self-sustaining populations by distributing propagules to numerous conservation organizations in order to increase prairie biodiversity.

Success Indicators

- Indicator 1: Successful multiplication of germplasm from 5 lily populations.
- Indicator 2: Acclimatization *ex-vitro* and subsequent survival of propagules when planted in experimental plots in the natural habitat.
- Indicator 3: Persistence and reproduction in the habitat for a minimum of 5 growing seasons.
- Indicator 4: Establish multiple colonization sites with re-introduced propagules.

Project Summary

Feasibility: Because of increased urbanization, conversion to cropland and in some cases competition from invasive species, native forb populations have dramatically decreased across the entire tallgrass prairie region. Few Americans are familiar with the Michigan lily or the position it occupies in the prairie plant community. Today the species is found occasionally on tiny remnants of the once vast tallgrass prairie. The Omaha Henry Doorly Zoo Laboratory for Endangered Plants, in collaboration with multiple conservation organizations are carrying out a long-term project to ensure that this beautiful native forb does not disappear from the Great Plains. The lily ranges in height from 1 - 2 m with 1 to 20 nodding flowers that open in July. The flowers are yellow shading upwards to orange-red with magenta-brown splotches inside the throat. The petals recurve sharply giving the flower its Turk's Cap appearance. No seeds were found for the species when this project began in 1992 so it was necessary to collect tissues for cloning from several plants at different locations. The species has been subsequently produced *in-vitro* at the zoo's lab continually since that time. The species appears to seldom produce viable seeds. Possible pollinators include *Speyeria cybele* (great spangled fritillary) and various swallowtail butterflies but it is exceedingly rare to find a fruit in the wild that results from natural pollination events or a fruit that also contains viable seeds.

Some states have as few as 2 - 4 small populations that are found only where the prairie remnants have remained uncultivated. The zoo's lab began propagating and re-introducing the species in protected areas, a project that continues to the present day. Several regional conservation organizations have participated by planting the lilies that are produced in the zoo's tissue culture laboratory. By

Lily habitat - Nishnabotna prairie

creating sustainable populations land managers are taking pre-emptive actions to preserve the species before it reaches endangered status.

Implementation: Small tissue samples were collected from four different sites in Nebraska and one site in Iowa. No flowering plants were removed or translocated to initiate the project in order to avoid any unintentional pollen transfer or hybridization. Cloning several lines was the next best option for propagation since no seeds were available. The tissues were sourced from several sites in order to save as much diversity as was practical from the region given the time commitment in the laboratory and funding limitations. Tissues continue to be cloned, hardened off and translocated to various sites in the same counties in Nebraska and Iowa which originally provided the source materials and to a number of other selected nearby sites with similar habitat.

The lilies are planted in protected prairies that are to remain uncultivated for the foreseeable future. Among the agencies that have participated in the re-introductions are the Audubon Society, the Nature Conservancy and the US Fish & Wildlife Service. Propagules have also been offered through Nebraska's Statewide Arboretum to the association's members who plant them at privately owned sites, increasing the overall number of individual lily specimens within its historic range. Private sites are monitored by the land owners themselves. The translocated populations are considered to be representative of the wild populations that were initially sampled for the project.

Post-release monitoring: Participating institutions monitor the re-introduced populations for survival, growth rates and flowering during each annual growth cycle. Visits are conducted by the zoo's plant scientists to observe overall survival rates. The numerous sites are scattered over a considerable distance and not all sites are visited each annual cycle by zoo personnel. All propagules are identified in the lab by their original collection sites and re-introduced to their respective areas to increase existing populations and in nearby prairies as well. The individuals are relatively small when first planted and flowering usually doesn't commence until after three annual growing seasons. Rodents occasionally dig up newly planted bulbs presenting a challenge in some instances. An underlying layer or top dressing of very coarse gravel has been found to be effective in

repelling most rodents. In cases where predation is a persistent problem land managers have built wire cages to protect newly emerging lilies.

Once the lily bulbs have established at a site the species is quick to colonize provided that the soil conditions and annual rainfall are adequate. Extensive flooding along the Missouri River destroyed one re-introduction site in 2012 but all other sites have survived. Underground stolons with small bulbs forming at the terminal ends begin developing within the first year or two when growing conditions are favorable. The species resents disturbance however, and may not reappear the following year when disturbed. Consequently, excavations are only done once at a planted site in order to verify their ability to reproduce vegetatively. The species generally grows vigorously once established and is capable of persisting for many years provided that growing conditions remain stable. The first site planted in 1993 still supports the lily after more than 20 years.

Major difficulties faced

- Development of a successful tissue culture protocol for a species with a scarcity of originating tissues.
- No publications were available regarding the species' propagation or reproductive cycle.
- Travel distances to population sites and the related costs.
- Weed control at introduction sites.
- Lack of funding.

Major lessons learned

- Lily tissue culture is a highly successful propagation method when using an appropriate media.
- Cloning produces a large number of available propagules in 6 - 12 months.
- The species readily establishes once soil, moisture and light requirements are met.
- Re-introduced lilies require protection from native animals and invasive plants.
- Monitoring multiple sites requires cooperation and commitment from land managers, particularly when funds are limited.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The species survived at a high rate when cultural requirements were met.
- Site selections were made carefully to identify favorable growing conditions.
- Tissue culture multiplication of all five clones was highly successful.
- Plants at most sites are reproducing vegetatively and creating colonies.

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