Global Re-introduction Perspectives: 2011

More case studies from around the globe
Edited by Pritpal S. Soorae



IUCN/SSC Re-introduction Specialist Group (RSG)

RSG

هيئة البيئة - أبوظبي
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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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CONTENTS

Letter from H. E. Razan Khalifa Al Mubarak, EAD viii
Letter from Richard Reading, DZF ix
Letter from Simon Stuart, SSC x
Letter from Frédéric Launay, RSG xi
Overview and analysis of re-introduction case-studies xii

Invertebrates 1
American burying beetle in the USA 1
Mottled grasshopper in the UK 5
Large blue butterfly in the UK 10

Fish 15
Berg-Breede whitefish in South Africa 15
North Sea houting in the River Rhine system in Europe 20
Citico darter in Tennessee, USA 24
Smoky madtom in Tennessee, USA 29
Yellowfin madtom in Tennessee, USA 34
Bulltrout in the Clakmas River, Oregon, USA 39
Bulltrout in the upper Willamette River basin, Oregon, USA 44
Itasenpara bitterling in Osaka Prefecture, Japan 49
Ushimotsugo minnow in Gifu Prefecture, Japan 54
Striped bitterling in Lake Biwa, Japan 59
Oily bitterling in Northern Mie, Japan 65

Amphibians 71
Houston toad in Texas, USA 71
Mountain yellow-legged frog in Southern California, USA 77
Midwife toad and Iberian frog in Spain 81
Chiricahua leopard frog in SW USA 85
Cape Platanna in South Africa 91

Reptiles 94
African spurred tortoise in Senegal 94
Translocation of giant tortoises in the Seychelles Islands 98
Terrapins on Silhouette Island, Seychelles 102

Hawksbill sea turtles in the UAE 106
St. Croix ground lizard in the U.S. Virgin Islands 109
Sand lizard in the UK 116
Turks & Caicos rock iguana in the Long Cay, Turks and Caicos Banks 120
American alligators in Louisiana, USA 125

Birds 130
Northern bald ibis in Syria 130
Red-billed choughs in the UK 135
White-winged guan in Peru 141
Ural owl in Austria 146
Mangrove finch in the Galapagos Islands 151

Mammals 157
Black-footed ferret in North America 157
Eurasian beaver in Sweden 165
Zanzibar red colobus on Pemba Island, Tanzania 168
Mountain gazelle in the Ibex Reserve, Saudi Arabia 175
Mountain gazelle in western Saudi Arabia 180
Sand gazelles in SW Arabia 185
Scimitar-horned oryx in Tunisia 190
Arabian oryx in Oman 194
Przewalski's horse in Mongolia 199

Plants 205
Prickly raspwort in South Australia 205
Leionema equestre on Kangaroo island, South Australia 210
Desert phebalium in South Australia 215
Banksia montata in SW Australia 220
Mangrove rehabilitation in the UAE 224
Seagrass in the Netherlands 228
Stinking hawk's beard in SE England 234
Spanish moon trefoil in Spain 239
Silene hifacencis in Spain 244

Notes 249



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

I am glad to see that a third edition of the *Global Re-introduction Perspectives* has been prepared and as the previous issues has interesting re-introduction case-studies covering all the major taxa from invertebrates to plants! The Environment Agency – Abu Dhabi is keen to be a co-sponsor of this series and supports the dissemination of case-studies on re-introduction projects to a global audience and the lessons learnt from this attempts can assist projects worldwide in designing better re-introduction projects with a higher chance of success.

I was pleased to note that there are some interesting case-studies from the West Asia region and that re-introduction projects and initiatives are being carried out to try and restore the Region's biodiversity. There are projects with gazelles, marine turtles and mangrove restoration initiatives. We hope these will provide readers at a global level on the initiatives being carried out within our region.

The Environment Agency - Abu Dhabi which was established in 1996 to preserve Abu Dhabi's natural heritage, protect our future, and raise awareness about environmental issues. The Environment Agency - Abu Dhabi 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, to ensure clean air and minimise climate change and its impacts.

I hope you enjoy this third edition as I have and hopefully it will provide an insight into re-introduction efforts being undertaken worldwide in the face of challenging issues such as climate change.



Richard P. Reading, Ph.D.
Vice President for Conservation
Denver Zoological Foundation

The Denver Zoological Foundation proudly supports a wide variety of conservation initiatives throughout the world, including continued support to the IUCN Re-introduction Specialist Group (RSG) and the RSG's effort to improve re-introduction success throughout the global. Recently, the world's human population surpassed 7 billion. As people increasingly and understandingly demand better living standards, our species' unsustainable growth in natural resources use accompanies this amazing growth in numbers, crowding out ever more of our companion species. As such, restoration efforts, including translocations, become ever more important to conserving life on our planet. Yet, past surveys of translocation effort found that most fail. Learning to improve success rates is therefore vital.

As a part of the effort to provide lessons from past translocation efforts, Pritpal Soorae provides here his third edited volume of re-introduction projects focused on a wide variety of plants and animals from all over the world. Perhaps not surprisingly, this vast assemblage of case studies includes a preponderance of successful efforts (as most people are reluctant to share their failures). We have much to learn from these successes and I urge us all to consider the factors that contributed to these successes carefully. However, we should also learn from translocation failures to avoid duplicating mistakes or less successful approaches. So, I urge practitioners of failed translocation attempts to share their experiences with the RSG.

We would like to thank the contributors to this volume, to Fred Launay and the RSG for supporting this important publication, and especially to Pritpal Soorae for his great job of pulling together a wide variety of re-introduction case studies from around the world.



Simon Stuart
Chair
IUCN Species Survival Commission

It is a great honour for me to contribute a foreword to this third edition of *Global Re-introduction Perspectives*. As with the two previous editions, I stand amazed to see the breadth of re-introduction projects taking place around the world, covering a huge breadth of taxonomic groups, ranging from insects to fishes, amphibians, reptiles, bird, mammals and plants. The geographic spread of the case studies in this book is similarly impressive, coming from 24 countries and territories on every continent. While there is a preponderance of projects from countries with greater levels of resources, as is to be expected given the significant costs that can be involved in re-introductions, it is still remarkable how many case studies are from poorer countries such as Ecuador, Mongolia, Peru, Senegal, Syria, Tanzania and Tunisia.

Now that we have three editions of *Global Re-introduction Perspectives*, I hope that it will be possible to set up a searchable database on the RSG website comprising all 184 case studies that have been published so far. Such a database would allow users to search, for example, for case studies on all plant re-introductions, or all re-introductions in South America, or for re-introductions of a particular species, or whatever the user chooses. I think that this would make the extremely important information in the case studies available to a much wider audience, and this would be to the great benefit of conservation in general, and re-introductions in particular.

I would like to thank the Environment Agency Abu Dhabi (EAD), and in particular its Secretary General H. E. 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, for its support for this publication. Special thanks are also due to the RSG Chair, Dr Frédéric Launay, and to the RSG's Programme Officer, Mr Pritpal Singh Soorae, who has also acted as the most efficient and effective compiler and editor of all three editions of *Global Re-introduction Perspectives.*



Frédéric Launay
Chair
IUCN/SSC Re-introduction Specialist Group

The RSG is glad to have produced, published and distributed three issues of the Global Re-introduction Perspectives since 2008. We hope these series of books provide a unique insight into the challenging world of re-introduction projects and they difficulties they face in trying to establish viable populations. I am glad to see that there are some interesting projects from all corners of the globe and the surmounting challenges they face!

It is interesting to see that in this issue there were 14 Highly Successful projects, 14 Successful projects, 22 Partially Successful projects and 1 Failure across the major taxa spanning from invertebrates, fish, amphibians, reptiles, mammals and plants. This issues also managed to get case-studies from all the eight IUCN Statutory regions with the majority from North America & Caribbean and Western Europe and the least from Meso & South America and East Europe, North & Central Asia.

We would also appreciate any feedback and comments on this publication and besides printing a limited number of hard copies it is available as a PDF version for a free download from the RSG's website at www.iucnsscrsg.org and this allows the publication to be more widely available.

I would like to thank the Environment Agency - Abu Dhabi in its kind support to the activities of the IUCN Re-introduction Specialist Group as this support has allowed the group to carry out many of its planned activities.

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

Pritpal S. Soorae, Editor

Introduction

This is the third issue in the *Global Re-introduction Perspectives* series and has been produced in the same standardized format as the previous two to maintain 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 and this third issue has 50 case-studies. There are now a total of 184 case-studies available in this format.

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

- Invertebrates - 3
- Fish - 11
- Amphibians - 5
- Reptiles - 8
- Birds - 5
- Mammals - 9
- 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 - 13
2. West Europe - 12
3. South & East Asia - 4
4. Oceania - 4
5. West Asia - 7
6. Africa - 7
7. Meso & South America - 2
8. East Europe, North & Central Asia - 3

Success/Failure of Projects

The projects presented here were ranked as Highly Successful, Successful, Partially Successful and Failure. Out of the 50 projects, there were cases of projects not providing any success/failure rankings as they were still in the initial stages or as in some cases there were multiple rankings as releases were conducted at more then one site.

As can be seen in figure 1:

- 14 projects were Highly Successful
- 14 were Successful
- 22 were Partially Successful
- 1 was a Failure.

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

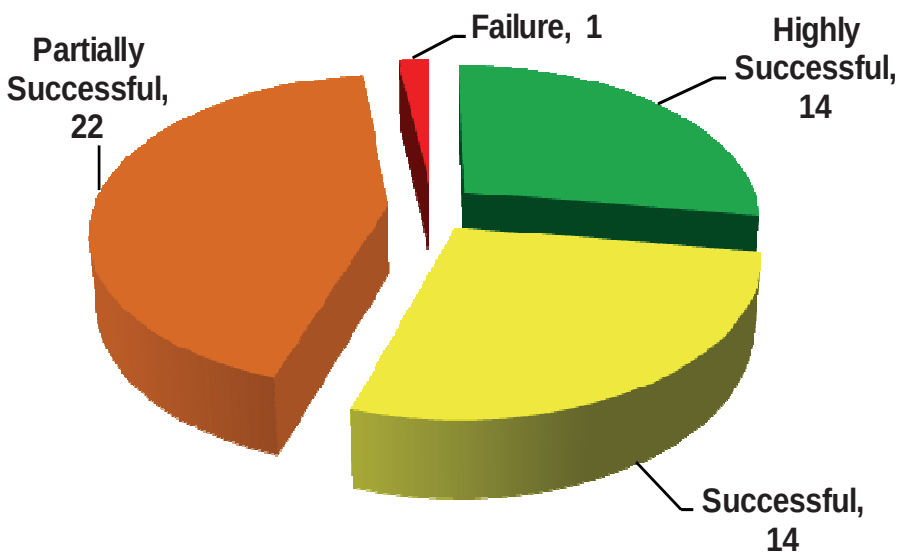
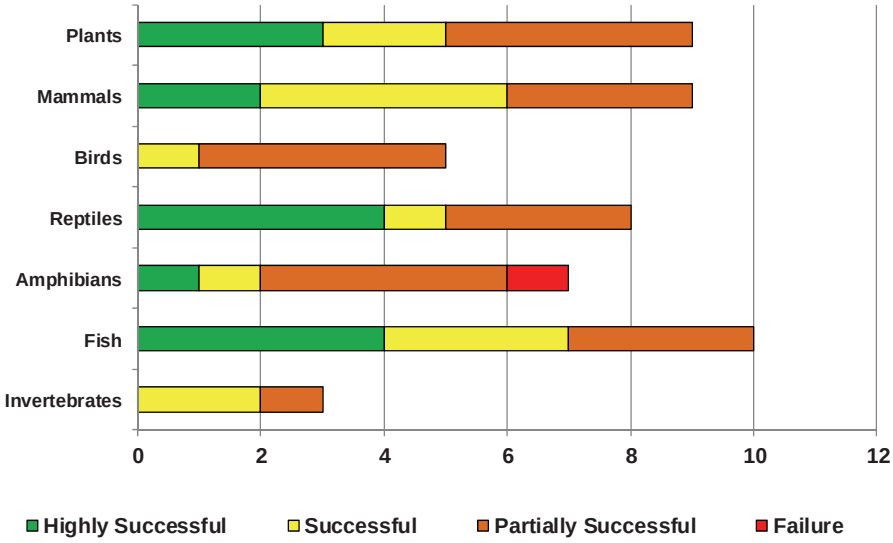


Fig. 2. Success/Failure of re-introduction projects according to major taxa



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 of the seven major taxa only invertebrates and birds did not have a project ranked as highly successful. Successful and partially successful projects were recorded in all the 7 major taxa. Only the amphibians had one project 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: (*pritpal.soorae@iucn.org*) and/or (*psoorae@ead.ae*).

Re-introduction of the American burying beetle to Nantucket Island, Massachusetts, USA

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Introduction

The American burying beetle (*Nicrophorus americanus* Silphidae), is a federally-listed endangered beetle once common throughout the eastern half of the United States and now surviving in only a few isolated or undisturbed habitats in eight states. This species rears its young on vertebrate carrion weighing between 80 g - 180 g and it shows some of the highest levels of parental care known among insects. As part of an 18 year project under the supervision of the U.S. Fish and Wildlife Service, the Roger Williams Park Zoo (RWPZ) and the Nantucket Maria Mitchell Association (MMA) have worked to re-introduce the American burying beetle to Nantucket Island, Massachusetts. Nantucket Island is approximately 41 km from Cape Cod, Massachusetts and is just under 129 km^2 in area. It contains large acreages of open conservation land that provide habitat for numerous state and federally-listed species. Other than feral cats there are no mammal scavengers to compete with the beetles for the carrion resource. The last record of an American burying beetle on Nantucket was in 1926. This is currently the only successful re-introduction of this species in the country.

Goals

- Goal 1: Build a relationship with public and private landowners.
- Goal 2: Identify appropriate release sites on the eastern and western sides of Nantucket Island.
- Goal 3: Establish a genetically-diverse captive population of American burying beetles to provide the numbers of beetles needed for release.
- Goal 4: Conduct annual releases.



American burying beetle (*Nicrophorus americanus*)
© Roger Williams Park Zoo

- Goal 5: Annual monitoring of re-introduced population to determine size and distribution.

Success Indicators

- Indicator 1: Successful captive breeding program.
- Indicator 2: Continued presence of the beetles post release.
- Indicator 3: Expansion of re-introduced population from the original release sites.
- Indicator 4: Self-sustaining American burying beetle population on Nantucket Island.

Project Summary

Feasibility

Natural history and conservation status: The federally endangered American burying beetle is the largest of the *Nicrophorus* beetles in North America, measuring 25 - 35 mm in length. It formerly ranged across the eastern half of the United States extending westward into Nebraska. Little is known about its former habitat-use but current populations persist in open grasslands. *Nicrophorus* species (of which there are 14) rear young on small dead mammals, birds, and reptiles. American burying beetles require larger and higher-quality carcasses for reproduction than other *Nicrophorus* beetles (Kozol, 1990) and this is a key component to reproductive success. High densities of mammalian scavengers may compete with these beetles for carrion and the extinction or drastic reduction of potential carrion species (e.g. passenger pigeons) probably increased this competition. Unusually, American burying beetles disappeared from the middle of their range and have persisted only on the fringes. Natural populations currently only exist from Texas north to South Dakota and on Block Island, Rhode Island.

Implementation: The American burying beetle is not yet in the forefront of the public's awareness and there are few cultural or political issues. There is concern for maintaining genetic diversity between the widely separated western and eastern populations. Little is known about diseases or parasites that affect this species and these issues were not directly addressed in this re-introduction program. The main concern is finding areas with natural sources of carrion and suitable habitat.

A rearing program was initiated at Boston University (BU) and successfully expanded at the Roger Williams Park Zoo (RWPZ) in Providence, Rhode Island (RI). The colonies at both BU and RWPZ were started using beetles from the natural Block Island, RI population. RWPZ has produced over 5,000 beetles for release and for a public exhibit at the zoo. One of the benefits of working with most invertebrate species is the relatively small space required to house entire colonies. RWPZ houses the beetle colony in an 2.4 m x 3.6 m room fitted with shelving. The room is maintained on a twelve-hour light cycle and kept at approximately 20^{o} C. Beetles are housed in clear plastic boxes separated by same sex groups of siblings. Substrate for the containers consists of brown paper towels. The towel is placed in the containers and moistened with aged tap water.

The beetles are maintained on a diet of mealworms, wax worms, and frozen-thawed pinkie mice.



Trapping and provisioning in open grassland and low shrub-land habitat © Roger Williams Park Zoo

Breeding the American burying beetle is a relatively low cost affair. Using protocols developed by Dr. Andrea Kozol of Boston University (BU), five-gallon black plastic flower pots are filled three-quarters full with rich topsoil to serve as nurseries. The soil is firmly packed to make carcass burial and the excavation of a brood chamber possible. Pre-determined pairs of beetles are placed in each bucket. The Association of Zoos and Aquariums (AZA) Species Survival Plan (SSP) maintains a stud book as a tool to insure the genetic viability of the captive populations. Frozen-thawed 80 g - 180 g quail carcasses are placed on the soil surface for the beetles to bury and prepare as a food source for their larvae. In the past, suitable-sized rats have been used in place of quail with equal results. The flowerpots are covered with clear Plexiglas covers and weighted with bricks or rocks to prevent escape. Once their parental role of carcass preparation and larvae rearing is complete the adults are removed from the brood, they are housed separately and heavily feed mealworms for about two weeks. These adults may be used again. The larvae take around 45 days to pupate.

In a pre-Nantucket release pilot study, captive reared beetles were released on Penikese Island, MA and the population persisted for seven years with no other re-introductions. In 1994, Nantucket Island, MA became the site of a full-scale release. Over 13 years, the project released 2,923 beetles. Beetles are released by burying them in pairs or singly with a quail carcass. Each burial is called a brood, and between 50% and 70% of broods successfully rear young on Nantucket. Success and estimates of larvae numbers are determined by exhuming 30% of the broods after 12 days. The broods are reburied immediately.

Post-release monitoring: The first stage of post-release monitoring consisted of trapping as many wild beetles as possible in traps baited with rotten chicken and provisioning pairs with quail carcasses. The number of beetles captured per trap effort has generally increased each year. The second stage of monitoring started in 2011 with a drastic, but planned, decrease in the number of provisioned beetles. Only 24% of the captured beetles (50 out of 212) were provisioned. This is less than half the number provisioned in 2010.The beetles will be monitored in

coming years to determine if provisioning is necessary to sustain the wild population.

Major difficulties faced

- Unknown availability of carrion on Nantucket.
- Difficulty in accurately estimating re-introduced population size.
- With a short active season, trap results and reproductive success can be greatly affected by weather.

Major lessons learned

- Importance of standardized release and monitoring protocols.
- Importance of long-term monitoring and consistency.
- Importance of establishing long-term collaborations and partnerships.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Successful captive breeding component.
- Successful collaboration and support among multiple organizations.
- Monitoring protocols successfully adapted during project using field data.
- Establishment of a self-sustaining population is still uncertain.

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Mottled grasshopper translocation to sand dunes in Essex, England

Tim Gardiner

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Introduction

The mottled grasshopper (*Myrmeleotettix maculatus* (Orthoptera: Acrididae)) is widely distributed, but not necessarily common, throughout mainland Britain. However, in the county of Essex (south-east England) it is rare, and included in the Essex Red Data List (ERDL; Gardiner & Harvey, 2004). The mottled grasshopper has no IUCN endangered species listing. Its habitat requirements are short, dry turf on sandy, nutrient poor soils, with the presence of bare earth essential for basking and ovipositing (Wake, 1997). The largest and most widespread Essex population of the mottled grasshopper is at Colne Point, a coastal shingle spit nature reserve, close to St. Osyth (Harvey & Gardiner, 2006). Low-lying spits such as Colne Point (the site is generally less than 1 m above MSL) are threatened by climate change induced sea level rise, therefore there is a need to move insects to more secure habitats. In 2009 a translocation was undertaken of a small number of mottled grasshopper adults from Colne Point to sand dune flood defences at the nearby town of Jaywick. Full details of the translocation can be found in Gardiner (2010), permission has been given by the editors of Conservation Evidence to reproduce parts of the article in this case study.



Mottled grasshopper (*Myrmeleotettix maculatus)* © Ted Benton

Goals

- Goal 1: Due to the threat posed by sea level rise at Colne Point, it was decided to translocate a small number of adult mottled grasshoppers to recently created sand dune-enhanced flood defences at Jaywick on the north-east Essex coast.
- Goal 2: To create sand dune habitat favorable for mottled grasshoppers on tidal flood defenses in the town of Jaywick. These sand dunes should form a natural flood defense in addition to providing coastal

habitats lost during the 20th century that insects such as the mottled grasshopper would have inhabited.
- Goal 3: To allow the mottled grasshopper to extend its range on the north-east Essex coast.
- Goal 4: To establish a protocol for translocation of the mottled grasshopper.

Success Indicators

- Indicator 1: Survival of the mottled grasshoppers that were released at Jaywick so that mating and egg-laying occurred in the release year.
- Indicator 2: Presence of mottled grasshopper adults in successive years after release indicating a self sustaining population on the sand dunes.
- Indicator 3: Extension of the range of the mottled grasshopper on the north-east Essex coast.
- Indicator 4: Creation of sand dunes as natural flood defenses to allow the mottled grasshopper to extend its range.
- Indicator 5: Increase in population of the mottled grasshopper in successive years after release.

Project Summary

Feasibility: Due to the threat posed by sea level rise at Colne Point, it was decided to translocate a small number of adult mottled grasshoppers to recently created sand dune-enhanced flood defences at Jaywick. The Jaywick flood defences fall within the former range of the grasshopper, which was recorded near Clacton-on-Sea in about 1900 (Wake, 1997). The populations of this grasshopper at Colne Point are only 2.7 km from the proposed release site at Jaywick. However, given the sedentary nature of the mottled grasshopper (Wake, 1997) and the unfavourable habitats between the two sites (sections of hard engineered flood wall with no vegetation), it was deemed that a translocation of this insect was the only feasible way that it might establish in the emerging dunes. Since 1986 at Jaywick, a number of projects have been undertaken to tackle the threat of tidal flooding. Combined with the installation of breakwaters to stabilise existing sand, the Environment Agency (EA) has undertaken a beach recharge project. From September 2008 to January 2009, sand was added and spread by bulldozers to re-profile the beach. To create more natural looking flood defences in front of the existing concrete revetment, stands of marram grass (*Ammophila arenaria*) have been planted. It is hoped that these will promote sand accretion and develop into a linear corridor of sand dune vegetation with slacks and hummocks stretching over 1 km in length. Because of this habitat creation, it was decided to translocate the grasshopper to the dunes so that it would have the chance to spread eastwards through the newly planted marram plots, which should provide a large interconnected area of favourable habitat.

Colne Point (the donor site) is the largest shingle spit in Essex (c. 280 ha) and is a nature reserve managed by Essex Wildlife Trust (EWT). It has extensive dunes and a shingle ridge enclosing an area of salt marsh. There are large areas of lichen heath and shrubby sea-blite *Suaeda vera.* The area from which the mottled grasshopper adults (donor stock) were taken (Ordnance Survey (OS) grid

reference TM 098124) was largely unvegetated shingle with patches of shrubby sea-blite. Following the principles of insect translocation guidelines, the receptor site at Jaywick was very carefully chosen. Given that this grasshopper requires habitats with a high amount of bare ground, suitable habitat was selected at Jaywick behind a breakwater, the installation of which led to stabilisation of the sand behind it. The release site comprised a 1 ha area of emerging sand dune with marram, situated behind the breakwater (OS grid reference TM 139126). Nine fenced plots (each approximately 300 m^2) containing densely planted marram were situated 200 m to the east of the release site.



Jaywick release site © Tim Gardiner

Implementation: On 31st July 2009, 15 female and 15 male adult mottled grasshoppers were collected using a sweep net (30 cm diameter) and transferred into transparent plastic containers (approx. 20 cm x 10 cm in size, no vegetation was provided, about four adults per container) for transit by road to the Jaywick release site. Care was taken to ensure that adults transferred were in good condition (i.e. did not have any legs missing or body damage). Inevitably, a very small number (< 5) were damaged while sweeping; these were released at the site of capture. Once at the receptor site, the adults were released from the containers into suitable dune habitat. The adults were translocated in two batches to keep the time held in the containers to no longer than 2 hours; between 10:00 hrs and 13:00 hrs (10 female:8 male), and 14:00 hrs and 16:00 hrs (5 female:7 male). The hot weather made grasshopper capture very time consuming due to the high activity levels, therefore it was only possible to collect 30 adults in 5 hrs. Due to this slow rate of capture, a further day was needed to catch and move the last 10 adults. The desired number of target individuals were captured on 3rd August 2009 (5 female:5 male), and transferred and released between 11:00 hrs and 13:00 hrs.

Post-release monitoring: Four stridulating males were heard on 18th August 2009 at Jaywick flood defences. This indicated that adults had remained in the immediate vicinity of the release site. During the survey on 23rd June 2010, 3 adult males and 4 adult females were located, indicating that mating in late summer 2009 at Jaywick had occurred, and that eggs were laid and successfully overwintered. Hatching and maturation must have occurred in spring 2010, leading to the establishment of a small breeding population. The small numbers of

individuals observed in 2010 indicated that the initial breeding success at the receptor site may have been very low. However, on 15th June 2011, approximately two years after release, 5 adult males and 11 females were seen, suggesting a population increase from the previous summer.

Major difficulties faced

- Hot weather (air temperature 24° C) made grasshopper capture very time consuming due to the high level of insect activity. The sweep net used to catch grasshoppers was very ineffective as they frequently escaped capture, I suggest using a glass tube to place over the top of grasshoppers on the ground as they stay relatively still in response to this.
- No published evidence of previous translocations of grasshoppers in the UK could be found; therefore the methods used were devised by the author. There was also no evidence to suggest that moving grasshoppers would lead to the successful establishment of a new population at the receptor site.
- The receptor site has a high level of public activity due to its use as a beach in summer, therefore disturbance to the released grasshoppers could be potentially high interfering with breeding.
- Due to time constraints on the project, only a small number of grasshoppers could be moved (40), this appeared to lead to a small number of adults in the post release year, suggesting mating success had been low. Due to the possibility of inbreeding depression it may be useful to supplement an established population at Jaywick with small numbers of individuals from Colne Point in future years to enhance genetic diversity.

Major lessons learned

- Use a large number of insects in the initial release (e.g. more than 40) to establish a larger population at the receptor site.
- If only a small number of insects can be released then these should be supplemented with extra individuals in future years to prevent possible inbreeding depression.
- Use glass tubes to capture grasshoppers, these are apparently more effective as they lead to less escape movements than sweep netting.
- Ensure that the release habitat has a large area of exposed, unvegetated sand/shingle (e.g. 60 - 70%) and is similar to the donor site.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success:

- Number of adult grasshoppers released was large enough to establish a small breeding population that has persisted for two years (generations).
- Habitat at receptor site was similar to the donor site (e.g. plenty of unvegetated sand/shingle).

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The restoration of the large blue butterfly to the UK

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Introduction

The large blue butterfly (*Maculinea arion* L, sometimes known as *Phengaris arion*) occurs in small populations across the Palaearctic from England to Japan. With five congeners, it became an iconic flagship species in invertebrate conservation - and one of three initial IUCN global priorities for butterflies - owing to its beauty, extreme rarity and rapid decline, combined with a fascinating life-cycle that involves feeding on *Thymus* or *Origanum* flowerheads for 3 weeks of the larval stage before becoming a social parasite of *Myrmica sabuleti* ant colonies, in whose nests it lives for 11 - 23 months, acquiring 98% of its ultimate weight by preying on ant brood (Thomas & Settele, 2004).

The Large blue has declined across its known range, and is listed as 'Near Threatened' by the IUCN, downgraded from 'Vulnerable' following successful conservation in the UK. In Europe it is 'Endangered' at continental and EU27 scales, and an Annex II (Berne Convention) and Annex II/IV (European Habitats Directive) species. It became extinct in the UK in 1979 despite 50 years' of conservation efforts, but was successfully re-introduced from 1982 onwards, once ecological research had identified the key driver of decline (specificity to the ant *M. sabuleti*, which was disappearing due to agricultural changes) and how to rectify this (Thomas, Simcox & Hovestadt, 2011).



Adult large blue © D. J. Simcox

Goals

- Goal 1: Understanding the species' ecology and population dynamics, and identifying the drivers of decline.

- Goal 2: Identification and targeted habitat management of potential re-introduction sites in the light of Goal 1, including some sub-optimal sites predicted to become optimal under climate warming.
- Goal 3: Self-sustaining (meta-) populations of the Large blue established across landscapes in former regions on restored and newly-created sites.
- Goal 4: Annual monitoring all large blue, food-plant and ant populations by scientists and volunteers plus, on selected sites, monitoring of changes in other UK Biodiversity Action Plan species characteristic of their ecosystem.
- Goal 5: Promotion of public access to selected sites, plus websites, blogs and frequent media cover to promote the project to the wider public.
- Goal 6: Extension of the project to encompass all five threatened species of *Maculinea* across Europe.

Success Indicators

- Indicator 1: Identification of *Myrmica sabuleti* as the large blue's sole host, and the ability to restore high densities of this ant to former sites under new regimes of habitat management.
- Indicator 2: Identification of suitable donor populations of large blue, physiologically adapted to UK environments under current and up-to-2^{o}C warmer climates.
- Indicator 3: Development of methods to rear large numbers of (cannibalistic) large blue larvae for release on restored sites.
- Indicator 4: Establishment of a wide-ranging consortium of statutory and voluntary conservation bodies, land-owners and scientists dedicated to conserving the large blue butterfly as a UK species.

Project Summary

Feasibility: Since the 1920s, early attempts to conserve the UK's declining large blue butterfly populations failed owing to a lack of knowledge of the main driver of decline and to the mistaken identification of other factors, notably butterfly collectors, as the culprits. In the 1960s all interested organizations and land-owners formed a Joint Committee for the Conservation of the Large Blue Butterfly, creating a dedicated consortium to co-ordinate all aspects of the program, which meets twice-yearly and oversees the project to this day. Early surveys located all remaining sites for the butterfly, protecting most from fundamental destruction but failing to stem local extinctions. Ecological research by the Nature Conservancy and the Institute of Terrestrial Ecology (now CEH) in 1972 - 1977 revealed that: (i) large blue larvae survive only with *Myrmica sabuleti* ants rather than with any *Myrmica* species, as had been previously supposed; (ii) *M. sabuleti* had disappeared from most sites due to a relaxation or abandonment of grazing of semi-natural grasslands, causing the turf to grow too tall for this thermophilous ant, which was replaced by morphologically-similar, but unsuitable, congeners. Unfortunately, this information came too late to save the last UK colony from extinction in 1979.

Management experiments on the National Trust's Dartmoor site (X) showed that regulated grazing during spring and autumn, coupled with annual scrub clearances, caused a rapid recovery of *M. sabuleti*. However, physiological

experiments suggested that surviving Large blue populations in Europe consisted of different races adapted to local environments: the next obstacle was to locate a donor population that was both suited to UK conditions and sufficiently large for permission to be granted to export. Laboratory trials suggested that butterflies on Öland (Sweden) were suitable: an initial field trial, made in 1982 by releasing pre-adoption larvae on (the now-enlarged) site X, confirmed both similar survival to the local phenotype in UK *M. sabuleti* nests and an adult emergence that exactly coincided with the narrow window in the UK when *Thymus* is suitable for egglaying (Thomas, Simcox & Clarke, 2009).

Implementation: After encouraging feasibility tests, an increasing number of partners pledged to manage potential sites to restore or create optimum habitat for the Large blue on former UK breeding areas in four of the five historical strongholds for the species: the Cotswolds, Poldens (Somerset), Dartmoor, and the Atlantic coast of Devon and Cornwall (Bourn, 1995; Simcox & Bourn, 2006). Initial progress was slow, with many setbacks when managers struggled to understand or impose the demanding grazing and scrub-clearance regimes, but gained momentum during the 1990s following the establishment of some exceptionally large populations of large blue coupled with an increase in the abundance of other threatened species on managed sites. By 2011, nearly 100 sites were under active grassland management regimes aimed wholly or partly at creating and maintaining large blue habitat, of which about 60 meet the minimum criteria to support the Large blue. A few sites were successfully designed and created 'from scratch' on new railway constructions on Network Rail land; some others are designed to be sub-optimal under current climates but to become optimal in warm years and if UK climates warm by up to 2^{o}C. Other key land-owners include the Somerset and Gloucestershire Wildlife Trusts, the National Trust, the Clarke Trust, Natural England and private farmers subsidized through Higher Level Stewardship Schemes.

Following the restoration of apparently suitable habitat, two further transfers of 245 and 581 large blue larvae were made in 1984 and 1991 from Sweden to three UK sites on Dartmoor, the Poldens and Cotswolds, the last being unsuccessful. Although about 25 new colonies were established through natural spread, long-distant dispersal is rare in this species, so further introductions of 200 - 300 pre-adoption larvae were made to three distant sites in the Poldens (1995 - 2000), to two sites on the Atlantic coast of Cornwall and Devon, and to two Cotswolds sites, using livestock from the burgeoning colonies in the Poldens.

Key to the success of the program to date has been the harmonious collaboration of a wide body of conservationists and scientists, directed by a full-time Project Leader who encourages and instructs participants in appropriate techniques, briefs land-owners and negotiates grants for individual sites, makes new introductions, and so on. The leader is also part of a scientific team studying pure and applied questions arising from the ecology and conservation of this fascinating species. The science arm has been crucial to implementing the program through: (i) generating ever-more precise knowledge of how to maintain populations under current and predicted environmental conditions; (ii) each new

discovery generates considerable publicity; (iii) similar initiatives involving all five *Maculinea* species have been established across Europe under the EU Framework projects MacMan and CLIMIT; (iv) contributing substantially to the considerable costs. Other major contributions in funding have come from in-kind contributions made by the above organizations, CEH, and Butterfly Conservation and their volunteers; an annual grant (until 2011) from Natural England (and predecessors); SITA, Lottery and Higher Level Stewardship grants; and limited commercial sponsorship. Nevertheless, dramatically reduced funding is today the main threat to maintaining or expanding the program.



Restored habitat at Collard Hill © D. J. Simcox

Post-release monitoring: Annual monitoring by scientists and volunteers occurs in the egg or adult stage of the butterfly on all core sites and most (in some years all) peripheral ones. Recent censuses indicate that colonies have been restored or have spread naturally to 38 sites, although some are small and subject to periodic extinctions (and recolonizations if near core populations), following climatically poor (e.g. drought) years or mismanagement. On the other hand, three UK populations are among the largest known worldwide for this 'Near Threatened' species; two populations have flourished unaided for 20 generations to date. Only in the Poldens has a true meta-population been established across a landscape, but proposals to replicate this elsewhere are underway.

Monitoring of *Thymus* and ant populations also occurs annually on most sites, together with change on other species on a subset of sites. This reveals welcome increases, under this targeted management, by a range of other threatened species that are characteristic of these habitats.

Major difficulties faced

- Uncertain and often inadequate funding.
- Frequent changes in land managers necessitating regular training of new staff.
- In one region, efforts have been hindered by a few statutory and NGO officials who have been reluctant to accept the concept of habitat restoration underpinned by scientific evidence. Consequently many potential sites here have continued to suffer a steady decline in biodiversity.

Major lessons learned

- Management decisions have been informed by a scientific understanding of the ecology of the target species and those with which it interacts.
- The project has benefitted greatly from a harmonious multi-disciplinary collaboration of statutory bodies, non-statutory bodies, NGOs and volunteers, encompassing practical and executive conservationists, land-owners, scientists, industrialists, and the media.
- The project – in its modern form - has been running for nearly 40 years and has evolved gradually as lessons have been learnt from successes and setbacks.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The large blue is securely re-established in the UK, following extinction in 1979, and supports some of its largest known populations in the world, enabling its global status to be downgraded from Vulnerable to Near Threatened.
- The largest-scale and most successful project to date involving the targeted conservation of a declining IUCN-listed insect.
- The populations established in the Poldens match – or exceed – the largest known historically in the UK, and greatly exceed previous records from Somerset.
- Viable metapopulations of populations have yet to be established across landscapes in three former UK regions, hence a project ranking of 'successful' rather than 'highly successful'.

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Re-introduction of endangered Berg-Breede whitefish to the upper Berg River in the Western Cape Province of South Africa

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Introduction

The Berg-Breede whitefish (*Barbus andrewi*) is a large cyprinid endemic to the Berg and Breede River Systems of the Western Cape Province of South Africa that prefers large rivers and deep pools (Skelton, 2001). The species was originally widespread in both systems but is now common in less than 5% of its original range which is almost entirely within the Breede system (Impson, 2007). The species is listed as Endangered (Tweddle *et al*., 2009). The introduction of the predatory smallmouth bass (*Microterus dolomieu*) from the U.S.A. in the 1940's into both systems for angling purposes led to a slow collapse of recruitment of this long lived species (Impson, 2007). CapeNature, the provincial conservation agency for the Western Cape Province, considered the species extinct in the Berg System by 2000. In comparison, the Breede system has very low numbers of whitefish in lotic environments, due to alien fish invasions and habitat degradation, but there are very large populations in Brandvlei and Sandrif dams. The Berg River Dam (130 million m^3) in the upper Berg River was completed and started filling in 2007. *B. andrewi* from Brandvlei Dam were re-introduced from 2007 - 2008 in the hope of establishing another large population of this species in its former distribution range.

Goals

- Goal 1: To create a further large population of this Endangered species in its former distribution range, through re-introduction.
- Goal 2: To determine whether the re-introduction has been a success though fish surveys.
- Goal 3: To involve freshwater fish stakeholders in the re-introduction process for awareness and education purposes.



Berg-Breede whitefish (*Barbus andrewi*)

- Goal 4: To determine via fish surveys whether the species re-establishes itself downstream of the dam.

Success Indicators

- Indicator 1: Re-introduce at least 500 adult fish into dam during filling.
- Indicator 2: Involve a range of fish and dam stakeholders in the re-introduction.
- Indicator 3: *B. andrewi* successfully recruits in the dam and is a significant component (>10%) of the ichthyofauna.
- Indicator 4: Successful re-introduction can help downlist species from Endangered status (increased overall population size, area of occupancy, number of sub-populations).
- Indicator 5: Species is surveyed in increasing numbers below dam, where it is currently absent.

Project Summary

Feasibility: The Berg River Dam is a large water body that offer significant opportunities and constraints to a successful re-introduction of *B. andrewi*. The opportunities include the dam being within its natural distribution range, the dam providing unpolluted waters and varied habitat for all life history stages, the new dam providing a nutrient rich environment (as drowned plant material decays) for this omnivorous species, the inflowing river providing excellent spawning habitat, the large dam providing habitat for hopefully an extremely large population of this species (over 100,000 fish) and finally angling benefits for anglers that enjoy catching indigenous fish species. South Africa's National Yellowfish Working Group promotes wise use and conservation of large cyprinids of angling value, such as *B. andrewi*. The species is also readily available in the Brandvlei Dam, where it is often a dominant component of anglers catches. Angling tournaments at the venue have been utilized by the conservation authority to provide fish for stocking purposes. The two dams are about one hour apart by car on good transport systems, allowing fish to be quickly transported between sites and stocked. The re-introduction was discussed at the Environmental Monitoring Committee (EMC) for the Berg River Dam (required as part of the Record of Decision for the dam) and was supported.

The constraints are substantial and mainly concern the ability of the species to establish a viable founder population in the presence of invasive alien fishes that elsewhere have caused its demise. The only habitat, however, where this species has held its own with alien fishes and has a huge population (estimated to be well in excess of 100,000 adults) has been in Brandvlei Dam, which also has sizeable populations of *M. dolomieu*, largemouth bass (*M. salmoides*), carp (*Cyprinus carpio*) and bluegill sunfish (*Lepomis macrochirus*). However, unlike Berg River Dam, Brandvlei Dam is fairly turbid which is thought to provide *B. andrewi* juveniles with some protection in terms of visual isolation, as the bass species are known visual predators that favour clearer water. Brandvlei Dam now has a new fish invader, sharptooth catfish (*Clarias gariepinus*), which was illegally stocked by anglers in the 1990s. Anglers catches show that it is now flourishing in the dam with unknown impacts on *B. andrewi*. The impact of this large predator, growing in excess of 30 kg on *B. andrewi* in this dam urgently needs to be quantified.



Stocking in the Berg River Dam

Implementation: The completion of the Berg River Dam, a major water supply to Cape Town, in 2007 was the major factor resulting in implementation. The re-introduction of *B. andrewi* was presented as a proposed action to the EMC for the dam in 2006 and was accepted. The proposed introduction was discussed amongst scientific and management colleagues at CapeNature, and a simple plan of action was identified that involved securing adult fish from Brandvlei Dam for re-introduction purposes. It was recommended that interested EMC stakeholders and local angling groups should participate in the re-introduction. Three stockings of adult fish were undertaken, the first on 17th October 2007 of 20 fish, the second on 1st November 2007 of 15 fish, and a final stocking on 9th February 2008 of between 60 - 80 fish. There was excellent participation from a range of stakeholders, including representatives from bait angling (Boland angling clubs), artificial lure angling, flyfishing groups (e.g. Jonkershoek Flyfishing), TCTA (the dam manager) and CapeNature.

Post-release monitoring: The universities of Leuven, Belgium and the Western Cape, South Africa have undertaken a collaborative monitoring program in the dam since its closure in 2007 that has included an annual fish survey (with nets set for one day overnight). Surveys were initially done by fyke net to minimize fish mortalities and were unproductive; thereafter a mixed fleet of gill nets were used successfully. A total of 13 *B. andrewi* of 20 - 30 cm were caught on three occasions (in 2008, 2009 and 2011)(Sean Marr pers. comm.), showing that they had survived the introduction. However, the lack of juveniles caught is of major concern, because the caught fish are likely to have been the stocked fish, as this species grows slowly (one year old fish are <10cm).

Major difficulties faced

- The Berg River Dam catchment already has several alien fish species (*C. gariepinus*, *C. carpio*, *L. macrochirus*, rainbow trout (*Oncorhynchus mykiss*) and *Micropterus dolomieu*), which may proliferate in the dam quicker than *B. andrewi* and prevent its successful recruitment.
- Because of the large size of the dam, and competing fish species, it was important to introduce as many *B. andrewi* as possible to maximize survival of stocked fish, enhance spawning success and the number of juveniles produced, whilst adult alien predatory and competitive fish species were still present in low numbers. This required a well planned and supported fish



Smallmouth bass (*Microterus dolomieu*)

catching operation, which was never attained due to insufficient capacity at the conservation agency (one permanent fish scientist at the time).

- *B. andrewi* caught by bait anglers during a tournament on 9th February 2008 were placed in keep nets and only made available after the tournament. Some fish carried injuries from the nets and handling, and may have died from stress and disease after being introduced into the Berg River Dam.
- CapeNature and other fish research agencies are not capacitated to readily undertake comprehensive fish surveys of dams at regular intervals. Unfortunately for this project, there are many fish research priorities more deserving of attention for the limited funding and resources available.

Major lessons learned

- Fish-introductions in this province need to be better planned and managed in future and will likely be undertaken in accordance with Biodiversity Management Plans for Species as required for endangered species by South Africa's National Environmental Management: Biodiversity Act of 2004.
- Fish re-introductions should adhere as closely as possible to guidelines in the IUCN booklet.
- Good opportunities for re-introduction should, however, not be ignored if there are good merits for utilizing them, as surveys to quantify success of the introduction may determine decades later that the initiative was well worthwhile. However, a competent team of experts should address the proposal first with a written report explaining why the action was authorized and implemented.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Reasons for project adequately evaluated by fish scientist, but no formal project proposal submitted to CapeNature's Wildlife Advisory Committee, which would have increased credibility.

- Good use of stakeholders involved in dam management and angling for local fish species allowed re-introduction to take place.
- Recent preliminary fish surveys indicate that the species is present in the dam.
- Future stockings of species into dams, should focus on dams in natural distribution range free of alien fishes. An offstream dam on the nearby Paarl Mountain Reserve, downstream of the Berg River Dam, meets these requirements and is currently being assessed for re-introduction purposes.

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The successful re-introduction of North Sea houting to the River Rhine System in Europe

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Introduction

North Sea houting (NSH, *Coregonus oxyrinchus*) is an anadromous salmonid, spawning in winter in the lower reaches of rivers draining to the North Sea. Hatched fry are carried downstream with the current, and, when reaching a size of 3 - 4 cm they can tolerate full salt levels and migrate to sea. After 2 - 4 years, adults enter freshwater again for spawning, afterwards returning to sea; they are assumed to come back to freshwater for several years. The species was distributed in the whole Wadden Sea area extending from southern Jutland in Denmark to the Schelde delta in the Netherlands.

Commercial fishery in the river sections caught up to 15 tons/year NSH in the Dutch reaches of the Rhine. A strong decline in the mass of NSH caught was observed from 1916 onwards and the species has been considered extinct in the Rhine since the 1940s. NSH is listed in Annex IV of the Habitat Directive of the European Union and as extinct in the German Red List as well as in the IUCN Red List (probably a mistake as a Danish population survived). The geographical area of the re-introduction project is the River Rhine System in North Rhine-Westphalia (Germany) and the Netherlands.



Jost Borcherding with adult North Sea houting (*Coregonus oxyrinchus*)

Goals

- Goal 1: Identifying major bottlenecks in the life-cycle of NSH.
- Goal 2: Successful re-introduction of NSH to the River Rhine system.
- Goal 3: Prove for natural reproduction of NSH in the River Rhine system.
- Goal 4: Monitoring of migratory routes and spawning sites in the River Rhine system.

Success Indicators

- Indicator 1: Increase of catches in the River Rhine system.
- Indicator 2: Successful transition of individuals to the sea and back to freshwater.
- Indicator 3: Returners to the German part of the Lower Rhine.
- Indicator 4: Natural reproduction in the River Rhine system.
- Indicator 5: Identification of places for natural reproduction.



Dutch colleagues from IMARES implanting transponders at Lake IJsselmeer

Project Summary

Feasibility: Starting regularly in 1996, small numbers of juvenile NSH were stocked to the River Rhine without any feasibility study. Fish were obtained from a fish hatchery in northern Germany that uses adults from the River Treene, a population that originated from descendants of the last known reproducing population of NSH existing in the Danish River Vidå. In 2000, the yearly stocking program was supplemented by a feasibility study that described the historical distribution of NSH, summarized the ecology of NSH and identified major obstacles for a re-introduction program of NSH to the River Rhine system. In this study two major bottlenecks in the life-cycle of NSH were named that should be monitored during the stocking period in order to test how the fish deal with actual conditions in the anthropogenically altered Rhine today. (1) Canalization led to increase in current; how do juveniles behave after stocking? (2) Dams in the delta constructed against sea floods closed natural migrations routes; can the fish pass these migration barriers?

Implementation: Between 2000 and 2006 a mean of about 280,000 juveniles (size range 20 - 40 mm total length) per year were stocked in two sites of the Lower Rhine: (1) in the River Lippe, approximately 15 km before the Lippe empties into the River Rhine; (2) in a gravel pit lake, near the city of Rees (Germany), which is permanently connected with the River Rhine. Monitoring programs were conducted by the Zoological institute of the University of Cologne, and financial support for stocking and monitoring was provided by the Ministry of Environment North Rhine Westphalia, the district government of Düsseldorf, the Rhine Fisheries Co-operative and the HIT-Environmental Foundation. The numbers of catches in Lake IJsselmeer (The Netherlands), one of the two closed off former estuaries of the River Rhine, steadily increased between 1996 and 2007. In autumn 2005, the first NSH was caught in the Lower Rhine near the city



Releasing houting after transponder surgery

of Wesel (Germany), and further catches followed afterwards. In 2006, 50 NSH from Lake IJsselmeer were marked with a transponder (based on the NEDAP-trail system originally installed in the Rhine delta to study migration in sea trout and salmon), and one of these fish was registered in December 2006 (time of spawning migration) at two detection stations in Germany, one at the Lower Rhine in Xanten and the second at the mouth of the River Lippe.

Post-release monitoring: Monitoring studies showed that the majority of the small NSH left the gravel pit lake within 4 days after stocking. In the Lippe, some of the juveniles were found in the drift immediately after stocking, generally preferring the middle surface areas of the river. Other NSH waited until dawn before they started their downstream migration. Juveniles immediately started to feed on the zooplankton resources in both waters (Borcherding *et al.*, 2006). The ^{88}Sr:^{44}Ca ratio of scales of NSH caught in Lake IJsselmeer was analyzed using LA-ICP-MS. The scale analysis indicates different migration patterns for NSH in Lake IJsselmeer and provides evidence that this species (1) is sometimes able to pass the migratory barriers between the Wadden Sea and Lake IJsselmeer, and (2) does not need to migrate to sea to reach maturity (Borcherding *et al.*, 2008). From 55 juvenile NSH caught in the summer 2006 in Lake IJsselmeer, two individuals (3.6%) had an alizarin mark at the centre of their otoliths (in this year the total stock of 400,000 juveniles was marked with alizarin), suggesting that the majority of juvenile NSH in 2006 originated from natural reproduction. This indicates the presence of a self-sustaining population of NSH in the Rhine delta (Borcherding *et al.*, 2010).

Using further marked NSH (same transponder as named above) the spawning time and from this the hatching of larvae was estimated in the River IJssel (where it drains to Lake IJsselmeer). Based on these estimations, about 200 freshly hatched larvae of NSH were caught with drift nets in March 2010 in the River IJssel, giving some evidence of natural reproduction in this part of the Rhine delta.

Major difficulties faced

- Transition of fish between freshwater and sea is hampered in the Rhine delta, the Netherlands, due to large dams constructed against sea floods.

Major lessons learned

- Suitable stocking sites have to be chosen and stocking of large numbers (no spreading) at one point promotes the shoaling juveniles.
- If conditions are suitable for NSH, a self-sustaining population develops rapidly.
- There are signs of a rapid adaptation to local conditions, especially with respect to a non-migratory behavior (70% of the population from Lake IJsselmmeer never was at sea).
- The re-introduction of NSH has to be coordinated not only on a national but on an international level to cope effectively with all problems faced in a large River System like the River Rhine.
- There is a need of long-term studies even after a successful re-introduction to study the adaptation (and change?) of the new population.

Success of Project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Captured fish show good growth and are in visual good condition.
- Even under such massive changes during the last century like in the Rhine system, a vital population of NSH is able to adapt and to establish.
- Scientific co-ordination and monitoring of such a re-introduction program.
- Urgent measures should be taken to improve the habitat connectivity between freshwater and sea (especially at the Haringvliet dam) in order to increase the opportunity not only for NSH to migrate to the sea.

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Re-introduction of the Citico darter, Little Tennessee River drainage, Tennessee, USA

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Introduction

The Citico darter (*Etheostoma sitikuense*, Blanton) is endemic to the Little Tennessee River drainage in Tennessee. The species is listed as Critically Imperiled (IUCN) and federally endangered throughout its range. Until recently this darter was part of the duskytail darter, *E. percnurum* Jenkins, complex. The Citico darter was accepted as a new species when Blanton and Jenkins (2008) described 3 new species of darter belonging to this complex. The species occupies an approximately 3.5 river km reach of Citico Creek in Monroe County; a tributary of Tellico Lake, an impoundment of the mainstem Little Tennessee River. The darter is historically extirpated from Abrams Creek, a tributary of Chilhowie Lake also impounding the Little Tennessee River, in Great Smoky Mountains National Park, where it is known from three specimens collected in 1937 and 1940. This and three other listed fish species were extirpated from Abrams Creek by application of rotenone during 1957, a plan designed to reduce food and habitat competition for a rainbow trout fishery (Lennon & Parker, 1959). Citico darter has been propagated and re-introduced to lower Abrams Creek, below Abrams Falls and stocked in Tellico River using Citico Creek stocks (Shute *et al.*, 2005 & Petty *et al.*, 2011).



Citico darter in Abrams Creek

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Goals

- Goal 1: Identification of re-introduction sites within the species' historic range.
- Goal 2: Captive propagation and restoration management at re-introduction sites.
- Goal 3: Sustainable populations of Citico darter established in all areas where there is suitable habitat and hydrology.
- Goal 4: Annual monitoring of all Citico darter populations (both natural and re-introduced).

Success Indicators

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



Citico Creek © Conservation Fisheries, Inc.

Project Summary

Captive propagation of the federally endangered Citico darter has been part of a joint effort that was initiated in 1986 to re-introduce the species (along with three other listed fish species) into Abrams Creek, Tennessee (Shute *et al.*, 2005) as recommended in the Recovery Plan. Conservation Fisheries, Inc. (CFI) of Knoxville, Tennessee, has managed the captive propagation. These efforts have been funded by the Tennessee Wildlife Resources Agency, U.S. Fish and Wildlife Service, and Cherokee National Forest. Additional cooperators in this re-introduction project include the North Carolina Wildlife Resources Commission, National Park Service, Great Smoky Mountains National Park, and the U.S. Forest Service. CFI's responsibilities in this effort include project coordination, captive rearing of wild-collected nests, captive breeding and rearing, stockings, and annual population monitoring of all four species in Abrams Creek and the source populations in Citico Creek. Eggs and young to rear for the effort have been collected annually from nearby Citico Creek, now isolated from Abrams Creek by Chilhowee and Tellico reservoirs. Work with this species began in 1992, with the first stockings in 1993. The species is reproducing, recruiting, and dispersing into suitable habitats in Abrams Creek, where numbers of fishes now often rival those seen in the source population in nearby Citico Creek (Shute *et al.*, 2005 & Rakes, 2011). In the absence of re-introductions since 2002 the Citico darter population is maintaining itself in Abrams Creek.

Beginning in 2003, the pilot project was extended to a new restoration stream, the Tellico River, following publication of the final rule designating Nonessential Experimental Population (NEP) status under the ESA. Over 3,500 Citico darters have been stocked, wild reproduction has been observed nearly continuously since 2004, and multiple age classes of wild-spawned individuals are routinely observed (Petty *et al.*, 2011). It will take several more years of re-introductions to ensure future success similar to the Abrams Creek re-introductions.

Methods for propagation, restoration, and monitoring are described in Shute *et al.* (2005) and rely upon collection and rearing of wild nests of Citico darter eggs and/or larvae in the CFI hatchery facility. All monitoring and collections of fish and



Citico darter eggs nest
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nests are performed by snorkeling. Fish are captured with hand nets and transported inside plastic bags in a cooler. Nests (i.e. eggs attached to the bottoms of slab rocks) are carefully placed in coolers of river water, on a plastic grid to prevent crushing of hatching larvae in transit. At the CFI facility they are slowly acclimated into a multi-aquarium recirculating system. A portion of the adults kept as breeders are winter-conditioned from November through February by reduction of water temperatures and photoperiod shortened to 9 hours of light. Reproductive condition is induced by gradually increasing water temperatures, photoperiod, and food quantity offered, in concert with natural seasonal changes. An astronomic timer controls artificial lighting inside the facility with automated daily adjustments to closely mimic seasonally changing day length. Attempts to induce captive breeding have been intermittently productive, but determined nonessential to the success of this effort. The successful restoration of this rare species to Abrams Creek and, increasingly likely, Tellico River (Petty *et al.*, 2011), could potentially result in downlisting per Recovery Plan criteria.

Meetings of all project partners have occurred annually to evaluate progress and decide upon future goals. At the onset of the re-introduction project an extensive health screening program of captive fish was established. Approximately one month prior to releases, fish undergo parasitological and bacterial screening. Prior to any transfer of fish from CFI to any other facility, or any re-introductions, a sample of the appropriate captive population, representing each system occupied, if applicable, was sent to the Warm Springs National Fish Hatchery to screen for any detectable disease pathogens. Disease detection would initiate actions necessary to prevent the transfer of any pathogens between facilities or to wild populations of fish. Technologies

Through the Tallassee Fund, Alcoa Power Generating Inc. (Tapoco Division) has funded a genetics study and fish population/ habitat studies. The goal of these studies includes monitoring levels of gene-flow/migration between the Citico, Abrams, and Tellico Creek populations of four federally threatened fish species--Spotfin chub, Smoky madtom, Yellowfin madtom, and Citico darter - as outlined. Preliminary analyses have been completed, and additional tissue samples were collected in 2010 - 2011. The genetics report will provide an objective/quantitative

evaluation for a fish passage strategy. More important, these projects provide needed baseline genetics, demographic, population, and habitat data for these target imperiled species, which may prove vital to their long-term survival and management. Although additional monitoring will be required to document that these reintroduced populations are viable, captive propagation and re-introductions have proven to be a successful means for re-establishment of extirpated populations of these fish.

Major difficulties faced

- Until recently, the National Park Service sought to maintain the historical integrity of the park by allowing cattle farming in Abrams Creek headwaters resulting in sediment loading and elevated nutrient concentrations. Since 1993, a cooperative project between NPS, USFS, University of TN, TVA, Trout Unlimited, and a local wildlife artist improved water and habitat quality by restoring riparian vegetation and fencing and removing cattle.
- Part of the stocking area in Abrams Creek is adjacent to a well-used NPS campground and includes many frequent park users and visitors, locally and from across the country. Educational information was necessary to lessen the impacts of unintentional habitat destruction or fish harassment by these visitors. Campers building small rock dams in the creek reduce the spawning cover available for nesting darters and could also be reducing reproductive success by dislodging eggs.
- Recently the USFS proposed a 4 acre parking area adjacent to Citico Creek and the construction of 17.2 miles of new equestrian trails in the Cherokee National Forest. This is perhaps one of the most sensitive areas within the Citico watershed being the center of the yellowfin madtom and Citico darter populations within the stream.

Major lessons learned

- A partnership of co-operative stakeholders that meet regularly enabled decisions to be made quickly and appropriate actions implemented.
- Management decisions must be informed by scientific research.
- Must continue to work with public and private stakeholders on sustaining and improving the watershed management plan designed to encourage BMPs in construction, forestry, water development, and agriculture. This includes signs and education efforts to reduce dam-building which destroys cover and nesting habitat.
- The program has been running nearly 10 years, and during this time has tried to embrace new ideas and protocols in re-introduction practice as they have been developed. Consequently the whole program has ‘evolved’ rather than been ‘planned’. Our experiences prompt us to caution others looking for success in similar projects not to abandon efforts prematurely. It takes time to document success when stocking limited numbers of benthic non-game fishes because they are small, short-lived, and cryptic. Thus, they probably do not quickly move far from stocking sites.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success:

- Citico darter populations still appear to be well established in Abrams Creek in the absence of any re-introductions in more than eight years.
- Both of the re-introductions appear to have been successful. This has resulted in a doubling of the original geographical range of the species.
- Abundance indices for Tellico River were higher in 2010 than the previous year and we again documented that the species successfully reproduced for the fourth consecutive year.

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Re-introduction of the Smoky madtom, Little Tennessee River drainage, Tennessee, USA

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Introduction

The Smoky madtom (*Noturus baileyi*, Taylor, 1969) is endemic to the Little Tennessee River drainage in Tennessee. It was described from five original types collected during a reclamation (poisoning) project conducted on Abrams Creek in 1957 (Lennon & Parker, 1959), which extirpated the Smoky madtom population from Abrams Creek. The madtom was originally only known from Abrams Creek, Monroe Co., and because of the 1957 project was presumed extinct when it was formally described (Shute *et al.*, 2005). It was subsequently listed as Endangered when an extant population was discovered in Citico Creek which is ~11 river km downstream from the mouth of Abrams Creek (Bauer *et al.*, 1983, Dinkins and Shute 1996, USFWS 1985). Presently one localized natural population occurs in a 14 km stretch of Citico Creek, Blount County. Re-introduction of captive bred Smoky madtoms started in 1986 and these populations re-introduced to Abrams Creek and Tellico River are reproducing and dispersing. The species is listed as Critically Endangered (IUCN Red List) and Federally Endangered throughout its range in Tennessee, except in the Tellico River between the backwaters of the Tellico Reservoir and the Tellico Ranger Station where it's designated as a Nonessential Experimental Population (NEP).



Smoky madtom in Citico Creek

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Goals

- Goal 1: Identification of potential re-introduction sites within the species' historic range.
- Goal 2: Captive propagation and restoration management at potential re-introduction sites.
- Goal 3: Sustainable populations of Smoky madtoms established in all areas where there is suitable habitat and hydrology.

- Goal 4: Annual monitoring of all Smoky madtom populations (both natural and re-introduced).

Success Indicators

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

Project Summary

Captive propagation of the federally endangered (USFWS, 1984) Smoky madtom has been part of a joint effort that was initiated in 1986 to re-introduce the species (along with three other listed fish species) into Abrams Creek, Great Smoky Mountains National Park, Blount County (Shute *et al.*, 2005) as recommended in the Recovery Plan for the species (USFWS, 1985). Conservation Fisheries, Inc. (CFI) of Knoxville, Tennessee, has managed the captive propagation and is the lead in monitoring both source and target populations. These efforts have been funded by the Tennessee Wildlife Resources Agency (TWRA), U.S. Fish and Wildlife Service (USFWS), and Cherokee National Forest (CNF). Additional cooperators in this reintroduction project include the North Carolina Wildlife Resources Commission, National Park Service, Great Smoky Mountains National Park, and the U.S. Forest Service. CFI's responsibilities in this effort include project coordination, captive rearing of wild-collected nests, captive breeding and rearing efforts, stockings, and annual population monitoring of all four species in Abrams Creek and the source populations in Citico Creek. Eggs and young to rear for the effort have been collected annually from nearby Citico Creek, now isolated from Abrams Creek by Chilhowee and Tellico reservoirs. Over the 20 year span, more than 3,400 Smoky madtoms have been released. The species is reproducing, recruiting, and dispersing into suitable habitats in Abrams Creek, where numbers of fishes now often rival those seen in the source population in nearby Citico Creek (Shute *et al.*, 2005 & Rakes, 2011). In the absence of re-introductions since 2002 the Smoky madtom population is maintaining itself in Abrams Creek.



Collecting Smoky madtom larvae in Citico Creek

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Beginning in 2003, the pilot project was extended to a new restoration stream, the Tellico River, following publication of the final rule designating Nonessential Experimental Population (NEP) status under the ESA (USFWS 2001, 2002) for all four species in a reach of the river found to have suitable habitat (Rakes & Shute, 1998). Re-

introductions of the species into its historical habitat in the Tellico River upstream from Tellico Reservoir, Monroe County, are currently ongoing. Over 2,100 fish have been stocked and wild reproduction has been observed every year since 2004 (Petty *et al.*, 2011 & Rakes, 2011).

Methods for propagation, restoration, and monitoring are described in Shute *et al.* (2005) and rely upon collection and rearing of wild nests of madtom eggs and/or larvae in the CFI hatchery facility. Attempts to induce captive breeding have been largely unsuccessful and determined nonessential to the success of this effort. Smoky madtoms have a maximum lifespan of only two years and produce as little as 30 eggs/female/year (Dinkins & Shute, 1996), making long-term maintenance of broodstock populations difficult at best. The successful restoration of this rare species to Abrams Creek and, apparently increasingly likely, Tellico River (Petty *et al.*, 2011), could potentially result in downlisting to threatened status per Recovery Plan criteria.

Meetings of all project partners have occurred annually to evaluate progress and decide upon future goals. At the onset of the re-introduction project an extensive health screening program of captive fish was established. At approximately one month prior to releases, fish undergo parasitological and bacterial screening. Prior to any transfer of fish from CFI to any other facility, or any re-introductions, a sample of the appropriate captive population, representing each system occupied, if applicable, was sent to the Warm Springs National Fish Hatchery to screen for any detectable disease pathogens. Disease detection would initiate actions necessary to prevent the transfer of any pathogens between facilities or to wild populations of fish. All young-of-year captive madtoms were tagged prior to release using the Visible Implant Fluorescent Elastomer (VIE) tags produced by Northwest Marine Technologies. Prior to marking, fishes were anesthetized using MS-222 at a rate of approximately 100 mg/l. Injections of the elastomer material were made using ultra-fine, 1/2cc, 29 gauge insulin syringes.

Through the Tallassee Fund, Alcoa Power Generating Inc. (Tapoco Division) has funded a genetics study and fish population/ habitat studies. The goal of these studies includes monitoring levels of gene-flow/migration between the Citico, Abrams, and Tellico Creek populations of four federally threatened fish species - spotfin chub, Smoky madtom, yellowfin madtom, and Citico darter - as outlined. Preliminary analyses have been completed, and additional tissue samples were collected in 2010 - 2011. The genetics report will provide an objective/quantitative evaluation for a fish passage strategy. More important, these projects provide needed baseline genetics, demographic, population, and habitat data for these target imperiled species, which may prove vital to their long-term survival and management. Although additional monitoring will be required to document that these re-introduced populations are viable, captive propagation and reintroductions have proven to be a successful means for re-establishment of extirpated populations of these fish.

Major difficulties faced

- Since it is known only from a 14 km portion of Citico Creek (with no population estimates), an accidental chemical spill or increased acidity due to run-off from sulfate rich Anakeesta shales in the watershed could quickly eliminate the only known naturally occurring population (Etnier & Starnes, 1993).
- Threatened by logging activities, road and bridge construction, and mineral exploration; water quality may be further degraded as acidic waters leach toxic metals (especially aluminum) from the soil.
- Recently the USFS proposed a 4 acre parking area adjacent to Citico Creek in the vicinity of Citico Creek Road and Buck Highway (Creek Mile 9.0) and the construction of 17.2 miles of new equestrian trails in the Cherokee National Forest. This is perhaps one of the most sensitive areas within the Citico watershed being the center of the population of the federally-threatened yellowfin madtom (*N. flavipinnis*) within the stream. The Smoky madtom is also common in that immediate area.
- Until recently, the National Park Service sought to maintain the historical integrity of the park by allowing cattle farming in Abrams Creek headwaters resulting in sediment loading and elevated nutrient concentrations. Since 1993, a cooperative project between NPS, USFS, University of TN, TVA, Trout Unlimited, and a local wildlife artist improved water and habitat quality by restoring riparian vegetation and fencing and removing cattle.
- Part of the stocking area in Abrams Creek is adjacent to a well-used NPS campground and includes many frequent park users and visitors, locally and from across the country. Educational information was necessary to lessen the impacts of unintentional habitat destruction or fish harassment by these visitors. Campers building small rock dams in the creek reduce the spawning cover available for nesting madtoms and could also be reducing reproductive success by dislodging eggs.

Major lessons learned

- A partnership of co-operative stakeholders that meet regularly enabled decisions to be made quickly and appropriate actions implemented.
- Management decisions must be informed by scientific research.
- Must continue to work with public and private stakeholders on sustaining and improving the watershed management plan designed to encourage BMPs in construction, forestry, water development, and agriculture. This includes signs and education efforts to reduce dam-building which destroys cover and nesting habitat.
- The program has been running for nearly 25 years, and during this time has tried to embrace new ideas and protocols in re-introduction practice as they have been developed. Consequently the whole program has ‘evolved’ rather than been ‘planned’. Our experiences prompt us to caution others looking for success in similar projects not to abandon efforts prematurely. It takes time to document success when stocking limited numbers of benthic non-game fishes because they are small, short-lived, and cryptic. Thus, they probably do not quickly move far from stocking sites.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success:

- Smoky madtom populations still appear to be well established in lower reaches of Abrams Creek in the absence of any re-introductions in more than eight years.
- Both of the re-introductions appear to have been successful. This has resulted in a doubling of the original geographical range of the species.
- Abundance indices for the species re-introduced to Tellico River were higher in 2010 than the previous year and we again documented that the species successfully reproduced for the fourth consecutive year. The annual abundance index for Smoky madtoms for Tellico was nearly equivalent to that for Citico (2.2 vs. 2.3) with a record number of 65 Smoky madtoms observed. This endangered species is becoming so well established that re-introductions in core restoration areas in Tellico are probably no longer necessary and stocking of peripheral localities to accelerate dispersal and expand distribution in the Tellico River should now be a goal.
- The restoration of this species is nearing the point where stocking can be terminated and monitoring and genetic sampling can become the primary recovery activities.

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Re-introduction of the yellowfin madtom in the upper Tennessee River drainage, Tennessee and Virginia, USA

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Introduction

The yellowfin madtom (*Noturus flavipinnis*, Taylor 1969) is endemic to the upper Tennessee River system known from only four widely distributed locations. The species is listed as Vulnerable (IUCN Red List) and federally threatened throughout its range in Tennessee and Virginia and presumed extirpated in Georgia. It was thought extirpated from the drainage in the early 1900's and considered extinct until specimens were collected in 1968 - 1969 from the Powell River, Tennessee, and Copper Creek (tributary to Clinch River) Virginia (Etnier & Starnes, 1993). In 1981, yellowfin madtoms were collected from Citico Creek which is ~11 river km downstream from the mouth of Abrams Creek, Tennessee (Dinkins & Shute, 1996), where the species was collected during a reclamation (poisoning) project of lower Abrams Creek in 1957 (Lennon & Parker, 1959). Based on this, Dinkins and Shute (1996) and others concluded that the species once occurred in the middle and lower reaches of Abrams Creek (Taylor, 1971 & Bauer *et al.*, 1983). A reproducing population, propagated from Citico Creek stock, has now been re-established through re-introduction efforts to Abrams Creek (Shute *et al.*, 2005).



Yellowfin madtom in Tellico River
© Conservation Fisheries, Inc.

The following are listed as Nonessential Experimental Populations (NEPs): Tellico River upstream from Tellico Reservoir and Holston River and all tributaries thereof.

Goals

- Goal 1: Identification of re-introduction sites within the species' historic range.
- Goal 2: Captive propagation and restoration management at re-introduction sites.
- Goal 3: Sustainable populations of yellowfin

madtoms established in all areas where there is suitable habitat and hydrology.
- Goal 4: Annual monitoring of all yellowfin madtom populations (both natural and re-introduced).

Success Indicators

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

Project Summary

Captive propagation of the federally threatened yellowfin madtom has been part of a joint effort that was initiated in 1986 to re-introduce the species (along with three other listed fish species) into Abrams Creek, Tennessee (Shute *et al.*, 2005) as recommended in the Recovery Plan. The species was listed in 1977 with the Powell River and Copper Creek designated as Critical Habitat. The Citico Creek population had not been discovered at the time of listing and is not included as Critical Habitat. Conservation Fisheries, Inc. (CFI) of Knoxville, Tennessee, has managed the captive propagation and is the lead in monitoring both source and target populations. These efforts have been funded by the Tennessee Wildlife Resources Agency, U.S. Fish and Wildlife Service, and Cherokee National Forest. Additional cooperators in this re-introduction project include the North Carolina Wildlife Resources Commission, National Park Service, Great Smoky Mountains National Park, and the U.S. Forest Service. CFI's responsibilities in this effort include project coordination, captive rearing of wild-collected nests, captive breeding and rearing efforts, stockings, and annual population monitoring of all four species in Abrams Creek and the source populations in Citico Creek. Eggs and young to rear for the effort have been collected annually from nearby Citico Creek, now isolated from Abrams Creek by Chilhowee and Tellico reservoirs. Over the 20 year span, more than 1,800 yellowfin madtoms have been released. The species is reproducing, recruiting, and dispersing into suitable habitats in Abrams Creek, where numbers of fishes now often rival those seen in the source population in nearby Citico Creek (Shute *et al.*, 2005 & Rakes, 2011). In the absence of re-introductions since 2002 the yellowfin madtom population is maintaining itself in Abrams Creek.

Beginning in 2003, the pilot project was extended to a new restoration stream, the Tellico River, Tennessee, following publication of the final rule designating NEP status under the ESA for all four species. Re-introductions into the Tellico River upstream from Tellico Reservoir began in 2003 and are currently ongoing. Over 1,900 fish have been stocked, wild reproduction has been observed nearly continuously since 2008, and multiple age classes of wild-spawned individuals are routinely observed (Petty *et al.*, 2011). It will take several more years of re-introductions to ensure future success similar to the Abrams Creek re-introductions.

Methods for propagation, restoration, and monitoring are described in Shute *et al.* (2005) and rely upon collection and rearing of wild nests of madtom eggs and/or larvae in the CFI hatchery facility. Attempts to induce captive breeding have been



Abrams Creek habitat with researchers
© Conservation Fisheries, Inc.

largely unsuccessful and determined nonessential to the success of this effort. The successful restoration of this rare species to Abrams Creek and, increasingly likely, Tellico River (Petty *et al.*, 2011), could potentially result in downlisting per Recovery Plan criteria. The species also is proposed to be released (as a NEP) into probable historical habitat in the free-flowing reach of the French Broad and Holston rivers, Tennessee. The USFWS and others believe that the species once likely inhabited these river reaches.

Meetings of all project partners have occurred annually to evaluate progress and decide upon future goals. At the onset of the re-introduction project an extensive health screening program of captive fish was established. Approximately one month prior to releases, fish undergo parasitological and bacterial screening. Prior to any transfer of fish from CFI to any other facility, or any re-introductions, a sample of the appropriate captive population, representing each system occupied, if applicable, was sent to the Warm Springs National Fish Hatchery to screen for any detectable disease pathogens. Disease detection would initiate actions necessary to prevent the transfer of any pathogens between facilities or to wild populations of fish. All young-of-year captive madtoms were tagged prior to release using the Visible Implant Fluorescent Elastomer (VIE) tags produced by Northwest Marine Technologies.

Through the Tallassee Fund, Alcoa Power Generating Inc. (Tapoco Division) has funded a genetics study and fish population/ habitat studies. The goal of these studies includes monitoring levels of gene-flow/migration between the Citico, Abrams, and Tellico Creek populations of four federally threatened fish species - spotfin chub, Smoky madtom, yellowfin madtom, and Citico darter - as outlined. Preliminary analyses have been completed, and additional tissue samples were collected in 2010 - 2011. The genetics report will provide an objective/quantitative evaluation for a fish passage strategy. More important, these projects provide needed baseline genetics, demographic, population, and habitat data for these target imperiled species, which may prove vital to their long-term survival and management. Although additional monitoring will be required to document that these reintroduced populations are viable, captive propagation and re-

introductions have proven to be a successful means for reestablishment of extirpated populations of these fish.

Major difficulties faced

- Until recently, the National Park Service sought to maintain the historical integrity of the park by allowing cattle farming in Abrams Creek headwaters resulting in sediment loading and elevated nutrient concentrations. Since 1993, a cooperative project between NPS, USFS, University of TN, TVA, Trout Unlimited, and a local wildlife artist improved water and habitat quality by restoring riparian vegetation and fencing and removing cattle.
- Part of the stocking area in Abrams Creek is adjacent to a well-used NPS campground and includes many frequent park users and visitors, locally and from across the country. Educational information was necessary to lessen the impacts of unintentional habitat destruction or fish harassment by these visitors. Campers building small rock dams in the creek reduce the spawning cover available for nesting madtoms and could also be reducing reproductive success by dislodging eggs.
- Recently the USFS proposed a 4 acre parking area adjacent to Citico Creek and the construction of 17.2 miles of new equestrian trails in the Cherokee National Forest. This is perhaps one of the most sensitive areas within the Citico watershed being the center of the population of the yellowfin madtom within the stream.

Major lessons learned

- A partnership of co-operative stakeholders that meet regularly enabled decisions to be made quickly and appropriate actions implemented.
- Management decisions must be informed by scientific research.
- Must continue to work with public and private stakeholders on sustaining and improving the watershed management plan designed to encourage BMPs in construction, forestry, water development, and agriculture. This includes signs and education efforts to reduce dam-building which destroys cover and nesting habitat.
- The program has been running for nearly 25 years, and during this time has tried to embrace new ideas and protocols in reintroduction practice as they have been developed. Consequently the whole program has ‘evolved’ rather than been ‘planned’. Our experiences prompt us to caution others looking for success in similar projects not to abandon efforts prematurely. It takes time to document success when stocking limited numbers of benthic non-game fishes because they are small, short-lived, and cryptic. Thus, they probably do not quickly move far from stocking sites.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success:

- Yellowfin madtom populations still appear to be well established in lower reaches of Abrams Creek in the absence of any re-introductions in more than eight years.
- Both of the re-introductions appear to have been successful. This has resulted in a significant extension of the original geographical range of the species.
- Abundance indices for the species reintroduced to Tellico River were higher in 2010 than the previous year and we again documented that the species successfully reproduced for the third consecutive year. The index for yellowfin madtoms was still much lower than that for Citico Creek (0.56 vs. 1.77; or Abrams Creek, 1.29), but a record number of 14 yellowfin madtoms were observed, including YOY, 1+ and 2+ age classes, all wild-spawned.

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Re-introduction of bull trout to the Clackamas River, Oregon, U.S.A.

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Introduction

Bull trout (*Salvelinus confluentus*) is a species of char native to the northwestern United States and British Columbia. They are commonly associated with cold, clean water in complex stream habitats. Populations have been negatively affected by several factors including habitat degradation, barriers to migration, and the introduction of non-native fishes (Rieman & McIntyre, 1993). In 1999, due to the magnitude of population decline across their native range, bull trout were listed as threatened in the United States under the Endangered Species Act (64 FR 58910).

The Willamette River in northwestern Oregon is a major tributary of the lower Columbia River. Bull trout were historically present in five of the major tributaries of the Willamette River that drain the Cascade mountain range, but by 1990 bull trout remained extant in only one. Several efforts to re-introduce bull trout to areas of extirpation are currently underway within the Willamette River Basin, including in the Middle Fork Willamette River where re-introduction has been ongoing since 1997, and the Clackamas River - the subject of this case study - where a re-introduction was initiated in 2011.

Goals

- Goal: A self-sustaining population of 300 - 500 spawning adults in the Clackamas River by 2030 that contributes to the conservation and recovery of bull trout in the Willamette River Basin and to overall recovery criteria outlined in the species' draft recovery plan (USFWS, 2002).



Bull trout (*Salvelinus confluentus*)
© Joel Sartore/National Geographic Stock with Assistance from Wade Fredenberg, USFWS

Success Indicators

- Indicator 1: Survival, retention and rearing of translocated bull trout in the receiving habitat.
- Indicator 2: Maturation and successful reproduction by translocated bull trout in the receiving habitat.
- Indicator 3: Maturation and successful reproduction by offspring of bull trout translocated to the Clackamas River.
- Indicator 4: No demographic or genetic impacts to the wild donor stock from the removal of individuals for the Clackamas re-introduction.
- Indicator 5: No population level impacts to co-occurring Pacific salmon in the Clackamas River.

Project Summary

Feasibility: Restoring bull trout to historic habitat is a major recovery goal in the species' draft recovery plan (USFWS, 2002) and it is particularly relevant to habitats in the western portion of the species' range due to the reduction in distribution. To address reduction of the species distribution, the Willamette Basin portion of the bull trout draft recovery plan called for a re-introduction feasibility assessment for the Clackamas River. In 2004, an interagency working group comprised of state, federal and private organizations initiated the feasibility assessment. The assessment focused on biological feasibility rather than social or economic feasibility, or implications to other species. In addition, the feasibility assessment did not address whether or not a re-introduction should be done or how it should be done.

The feasibility assessment examined four questions adapted from Epifanio *et al.*, (2003):

1) Is there a high level of confidence that bull trout are no longer present that would serve as a natural gene bank?
2) Is there suitable habitat remaining, what conditions or stressors currently prevent bull trout from occupying suitable habitats, and have these been corrected?
3) Is suitable habitat expected reasonably to be recolonized through natural processes if conditions are improved?
4) Is a suitable or compatible donor population(s) available that can itself tolerate some removal of individuals?

The feasibility assessment, finalized in 2007 (Shively *et al.*, 2007) concluded there was a high level of confidence that bull trout were extirpated from the Clackamas River and that factors leading to their extirpation had been largely ameliorated. The feasibility assessment further concluded that there was sufficient high quality habitat available and forage base to support a re-introduction, and that the limited presence of non-native brook trout was not a substantial threat. Several suitable donor stocks were identified that could support, with low population risk, the extraction of individuals for translocation to the Clackamas River. Finally, nearby extant populations were determined to be unlikely to naturally recolonize the Clackamas River due to geographic distance and isolation due to migratory barriers. Dunham *et al.* (2011) provides a summary

of our approach to assessing the feasibility of re-introduction in the Clackamas River.



Mainstream Clackamas River, Oregon

In 2008, Federal, State and Tribal resource managers in the Clackamas River Basin recommended development of a joint state/federal action with the re-introduction to occur under the experimental nonessential population designation under section 10(j) of the Endangered Species Act (ESA). The less restrictive “experimental” classification, added to the ESA by the United States Congress in 1982, is meant to provide flexibility in implementing recovery actions and improve public receptiveness to restoring ESA-listed species to areas they previously inhabited. This classification exempts anyone who accidentally kills or harms the listed species from prosecution for violating the take provisions of the law. Experimental classification for our reintroduction project was favored over other administrative pathways due to the reduced regulatory burden on public and private land, and management flexibility of the bull trout population in light of concerns expressed by stakeholders during project scoping regarding private hydropower operations and impacts to threatened Pacific salmon.

Implementation: The re-introduction, initiated in July 2011, will be an adaptively-managed 20-year project, split into three phases of equal length. We anticipate phase one will be the primary translocation and learning phase, whereas phase two and three will refine the implementation strategy based on phase one monitoring and evaluation. Consistent with the adaptive management approach for the project, we will continue translocating individuals until either: (1) an evaluation of the program shows the goal of the project has been met, or is on a trajectory to be met through natural reproduction based on monitoring and evaluation; (2) mid-process outcome evaluation suggests the re-establishment of bull trout is unlikely (i.e., the project is not showing success); or (3) monitoring and evaluation indicates unacceptably high population level impacts are occurring to federally listed Pacific salmon in the Clackamas River.

Project costs and the relative abundance of a suitable donor stock within the lower Columbia River in the Deschutes River drainage led the implementation team to favor direct transfer of wild donor stock over other alternatives such as artificial propagation or captive rearing of wild juvenile bull trout. To maximize our ability to learn from this project, our implementation strategy includes the direct



Project partner tour

translocation of various life stages of donor stock (initially juvenile, sub-adult and adult) consistent with project numerical goals and in proportion to donor availability. During phase one, approximately 60 adults and sub-adults, and up to 1,000 juvenile bull trout will be translocated annually to suitable habitat identified during the feasibility phase of the project.

Post-release monitoring: The monitoring and evaluation program has three major goals: (1) monitor and evaluate the effectiveness of bull trout re-introduction; (2) monitor and evaluate donor population status; and (3) monitor and evaluate impacts to Pacific salmon.

Major difficulties faced

- Addressing uncertainty regarding potential impacts of the re-introduction on the riverine food web, particularly impacts to threatened Pacific salmon from bull trout predation and competition.
- Challenge in securing sufficient project funding, particularly for monitoring and evaluation.

Major lessons learned

- Key to moving this project forward was the formation early on of an interagency manager's group that would meet quarterly to assess progress and to provide guidance and decision making for the project's technical committees.
- Another key element was a strong partnership and clear dedication and support for the project from the three key project partners; U.S. Fish and Wildlife Service, U.S. Forest Service, and the Oregon Department of Fish and Wildlife.
- The peer-reviewed Clackamas Bull Trout Re-introduction Feasibility Assessment was a significant undertaking, but this step provided the majority of the science needed to support the project through the regulatory and administrative processes.
- Coordination early and often with our Native American Tribal partners (Confederated Tribes of the Warm Springs Reservation of Oregon) was a key to gaining Tribal support for the project and the utilization of Deschutes River Basin donor stock, which the Tribes co-manage along with the State of Oregon.

- To address scientific uncertainty on several key issues including suitability and availability of a donor stock, and potential impacts from the re-introduction on threatened Pacific salmon, two science workshops were organized by the U.S. Fish and Wildlife Service. The information from these workshops was critical in informing the development of the project and in providing additional science to support regulatory and administrative processes.

Success of project

The re-introduction of bull trout to the Clackamas River, Oregon, was initiated in July 2011 and thus it is too early to provide an assessment of success.

Reason(s) for success/failure:
n/a

Disclaimer
''The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.''

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Re-introduction of bull trout in the upper Willamette River basin, USA

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Introduction

Bull trout (*Salvelinus confluentus*) is a species of char native to northwestern North America from northern California and Nevada, USA, to the Northwest Territories, Canada. The species is iteroparous and expresses a flexible life history that commonly includes long-distance seasonal migrations (>100 km). Threats such as habitat fragmentation, habitat simplification, angling-related mortality, and introduced species led to widespread declines in the past century. Bull trout is listed as vulnerable (A2e) on the IUCN Red List, threatened in the coterminous United States under the Endangered Species Act, and as a species of special concern in Alberta and British Columbia, Canada.

In the Willamette River basin in western Oregon, USA, bull trout historically occupied coldwater drainages in the Cascades Mountains. Populations were extirpated from the Clackamas, Santiam, and Middle Fork Willamette drainages by the 1990s and persisted only in the McKenzie River drainage. An interagency working group has coordinated a comprehensive effort to recover bull trout in the upper Willamette River basin, and a primary component of this effort has been the re-introduction of bull trout to two streams in the upper McKenzie River basin, where impassable culverts were renovated, and to the upper Middle Fork Willamette River drainage.



Small adult bull trout from the upper Willamette River basin © Andrew Talabere

Goals

- Goal 1: Ameliorate sources of excessive mortality to bull trout in the upper Willamette River basin.
- Goal 2: Restore habitat conditions to increase productivity for all life stages of bull trout.
- Goal 3: Re-establish spawning populations in streams where impassable culverts have been modified to restore upstream fish passage.

- Goal 4: Reestablish spawning populations of bull trout in the Middle Fork Willamette River basin.
- Goal 5: Evaluate effectiveness of using various life stages and captive rearing procedures for re-introduction efforts.

Success Indicators

- Indicator 1: Conservation officers and creel surveys report minimal incidence of angling-related mortality and poaching of bull trout.
- Indicator 2: Adequate amounts of spawning habitat, early rearing habitat, and historical prey base (i.e., Chinook salmon) available; connectivity restored, allowing migratory bull trout to utilize downstream habitats and potentially exchange genetic material among populations.
- Indicator 3: Stable long-term spawning abundance in the Middle Fork Willamette River basin and in streams where access to spawning habitat has been restored. Local abundance and genetic exchange among local populations sufficient to minimize risk of adverse genetic effects.
- Indicator 4: Information on success of different release strategies used to adaptively guide this project and made available for other re-introduction projects.

Project Summary

Feasibility: Agency biologists surveyed coldwater streams to determine status of bull trout in the basin. Bull trout persisted in the McKenzie River below Trail Bridge Dam (>100 km reach) and two isolated populations at high-risk of extirpation upstream of dams in the McKenzie River (5 km) and South Fork McKenzie River (35 km). Bull trout were considered extirpated from the Middle Fork Willamette River. The Upper Willamette Bull Trout Working Group identified several historical and contemporary threats to bull trout. These included fishery management practices and angling regulations that failed to protect bull trout, construction of impassable dams that fragmented bull trout habitat and eliminated Chinook salmon runs, and past forestry management practices that led to simplified instream habitat and elevated water temperatures. Resource management agencies specified measures to address many of these threats through management plans, Endangered Species Act consultations, and hydroelectric dam relicensing processes.

Evaluations of potential re-introduction sites in the basin focused on water temperature, spawning and rearing habitat, macroinvertebrate productivity, presence of migration barriers, and occurrence of nonnative brook trout. The Working Group identified two McKenzie River tributaries (Olallie and Sweetwater creeks) where impassable culverts in lower reaches blocked access to over 5 km of former spawning and rearing habitat (Capurso, 1997; Ziller & Taylor, 2000). In the Middle Fork Willamette River drainage, three short spring runs and one 8 km tributary (Swift Creek) were considered potentially suitable for spawning and early rearing (UWBTWG 2007). The Working Group identified Anderson Creek in the McKenzie River drainage as a suitable donor population, and elected to use wild, out-migrating age-0 bull trout trapped in the lower reach. Advantages included:



Monitoring spawning by counting bull trout redds in Anderson Creek © Nik Zymonas

Low impact on the donor population (out-migrating bull trout fry likely exceed tributary rearing capacity and experience high mortality); Relatively high genetic diversity attributable to comparatively high adult abundance and collection of fish from numerous family groups; avoided domestication and selection effects associated with artificial spawning or broodstock programs; Early lifestage likely to imprint on the recipient habitat.

Implementation: Resource management agencies modified angling regulations and trout stocking practices, conducted public education efforts, and posted informational signs to reduce the incidence of angling mortality. The US Forest Service began an ongoing effort to add large woody debris to the main stream and tributary reaches to capture gravel and nutrients, increase channel complexity, and provide cover. Spawning gravel was added to two spring runs that offered suitable habitat for early rearing. Adult Chinook salmon were out-planted upstream of dams beginning in 1993 to increase productivity. We collected and directly transferred annual totals of 142 - 3,386 fry from Anderson Creek to recipient streams during February - May of 1993 - 2005. Fry were transferred to Sweetwater Creek from 1993 - 1999 (N = 6,377), to Olallie Creek in 1994 - 1997 (N = 670), and to the Middle Fork Willamette River drainage from 1997 - 2005 (N = 10,408). Low survival of fry released into Swift Creek inspired the Working Group to initiate a captive-rearing program in 2007 to evaluate survival of larger juveniles. During 2007 - 2011, fry were transferred to Leaburg Fish Hatchery, reared for 5 - 8 months, and released as age 0 juveniles in August - December or as age 1 fish in April.

Post-release monitoring: Biologists established a comprehensive monitoring program to evaluate status of extant and re-introduced populations in the basin. Snorkeling and minnow-trapping surveys indicated fairly high abundance of transferred fry rearing in several re-introduction sites for at least one year. We detected spawning by adult bull trout in Sweetwater Creek in 2000, seven years after the first transfers of fry. Annual totals increased to 9 redds by 2005, then 20 to 22 redds in 2006 - 2009. In Olallie Creek, any effect of augmentation was unclear because bull trout spawned in the upstream reach in 1995, which was the first year access was restored and only one year after the initial transfer of fry.

We first detected mature bull trout in the Middle Fork Willamette River drainage in 2005, eight years after initial transfers. However, total annual redd counts have remained low, reaching only 15 redds. Few directly transferred bull trout fry and no spawning were detected in Swift Creek, although captively reared juvenile bull trout have been detected at moderate densities and may return as migratory adults beginning in 2013. A genetics assessment indicated that re-introduced populations in Sweetwater Creek and the Middle Fork Willamette River drainage held levels of genetic variation comparable to the Anderson Creek source population, with no evidence of genetic input from other populations. Individual cohorts of captive reared bull trout held significantly lower genetic variation than the source population, suggesting that transfers should be conducted over multiple years to maintain comparable levels of genetic variation. Redd counts and trapping efforts indicated considerable variability in abundance of juveniles and adults in the Anderson Creek source population.

Major difficulties faced

- Low numbers of bull trout fry were available for the re-introduction effort in some years, largely because only one suitable donor population was available. Low redd counts in some years elicited concern over potential effects of removing fry; however, relationships among redd counts, fry abundance, and older juvenile abundance are weak.
- Increased abundance in Middle Fork Willamette River drainage may be constrained by limited availability of spawning habitat in tributaries having sufficiently cold incubation temperatures and protection from excessive scouring by high flows in late autumn and winter.
- Direct transfers of fry to the relatively large Swift Creek watershed were unsuccessful in producing spawning adults, possibly because of high predation rates.
- Logistical difficulties (large watershed area, seasonal high flows, and inaccessibility of study sites), low abundance, a migratory life history, and a period of several years before maturation present challenges in precisely quantifying abundance, monitoring survival, and identifying potential bottlenecks.
- Although construction of an upstream fish passage facility at Cougar Dam has been completed and construction of up- and downstream facilities at Trail Bridge Dam is scheduled to begin in 2013, fragmentation and other effects of high-head dams are difficult to remedy and will continue to affect bull trout populations in the basin.

Major lessons learned

- Direct translocation of bull trout fry proved successful in suitable locations holding relatively few competitors or predators; spawning adults returned to re-introduction streams 6 to 8 years after initial transfers.
- Sustained transfers over several years were necessary to build increasing abundance of adults and to maintain genetic variation comparable to levels in the source population.
- Direct translocation of fry was unsuccessful in a relatively large tributary (Swift Creek), given the quantity of fry available for the effort.

- Augmentation was unnecessary in one tributary (Olallie Creek) where spawning occurred in a short reach below a barrier prior to restoring access to upstream habitat and a nearby source population may have contributed spawning adults.
- The re-introduction project required a comprehensive effort to reduce mortality, restore habitat, and increase productivity in a highly altered system.
- Cooperation among various agencies and other groups has greatly facilitated this effort.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Spawning populations have been re-established upstream of corrected barriers in Sweetwater and Olallie creeks.
- A spawning population has been re-established in the Middle Fork Willamette River drainage. Adult abundance has been relatively low to date, but abundance of juveniles originating from spawning by transferred fish has been relatively high for several years and the project has only now reached the point when these individuals should begin to reach maturity.
- Direct transfer of bull trout fry to the larger Swift Creek was unsuccessful, but better survival among larger captive reared juveniles may lead to returns of spawning adults beginning in 2013.
- Conditions for survival of bull trout in the upper Willamette River basin have improved as a result of ongoing restoration activities and reduction of angling-related losses.

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Re-introduction of the Itasenpara bitterling to the Yodo River in Osaka Prefecture, Japan

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Introduction

The Itasenpara bitterling (*Acheilognathus longipinnis*) is a threatened cyprinid species distributed in central Japan. This species lays its eggs in the gill chambers of freshwater mussels. Its natural habitat is lentic water in flood plains affected by flood disturbance. At present, the Yodo River system is highly regulated and rarely inundates the riparian zone. Therefore, the main habitat of the bitterling is



Itasenpara bitterling



Main habitat of the Itasenpara bitterling in the Yodo River until 2005

restricted to pools and embayments along the riverside between embankments. Large-scale improvements to the Yodo River system began in the 1970s, leading to the destruction of many of the river's pools and embayments. Furthermore, widening and deepening of the channel and operation of the Yodo River Weir reduced the annual variation in water levels in the mid-1980s. Additionally, alien plants and fishes have drastically increased since around 2000, especially in backwater areas of the Yodo River Weir. As a result, habitats of the bitterling and freshwater mussels have been further degraded. Consequently, wild populations of these species have not been found in the Yodo River system since 2006. This species was designated as a natural monument of Japan in 1974 and was listed as an endangered species under the Law for the Conservation of Endangered Species of Wild Fauna and Flora of Japan in 1995. The bitterling is listed as 'vulnerable' in the IUCN Red List. The Yodogawa River Office, Ministry of Land, Infrastructure, Transport and Tourism began a restoration project for the environment of this species in the Yodo River in 1997. The Aquatic Life Conservation Research Center of Osaka Prefecture has succeeded in the artificial breeding of bitterlings caught in the Yodo River.

Goals

- Goal 1: To enable the breeding of released adults and the growth of juveniles in the wild.
- Goal 2: To enable breeding in succeeding generations.
- Goal 3: To increase the wild population size.
- Goal 4: To restore habitats in the broader area of the Yodo River.

Success Indicators

- Indicator 1: Breeding of released individuals (adults) in the wild and the appearance of juveniles the following spring.
- Indicator 2: Annual appearance of juveniles born in the wild.
- Indicator 3: Breeding every year and increase in the number of individuals in the wild population.
- Indicator 4: Occurrence of ample and appropriate habitats in the broader area of the Yodo River.

Project Summary



Juveniles of the Itasenpara bitterling appeared in the spring of 2010

Feasibility: The Itasenpara bitterling has not been found in the Yodo River system since 2006. Because most fish die within a year after breeding in the wild, this population is considered to be declining to a critical level, and the possibility of unaided recovery is extremely low. On the other hand, the Yodogawa River Office has reconstructed several embayments within the original habitat, which have been recolonized by mussels and other bitterling species without a remarkable increase of alien plants and fishes. Therefore, reconstructed embayments are considered suitable habitat for the Itasenpara bitterling. Since 1972, the Aquatic Life Conservation Research Center has been breeding the bitterling using specimens originally obtained from the Yodo River. The captive population is large in size, and reproduction has been quite successful. Additionally, the genetic diversity of the captive population has been maintained at a relatively high level. Given these circumstances, the Yodo River Itasenpara Study Committee (consisting of researchers, river managers, and others) began to consider and plan for the re-introduction of this species in March 2009. Re-introduction procedures were planned in conformity with the 'Guidelines for Re-introduction of Fishes for Conservation' (The Ichthyological Society of Japan, 2005). We aimed to implement the re-introduction of the Itasenpara bitterling in the autumn of 2009 as an experimental trial.

Implementation: Mature adults were released in autumn 2009 during the spawning season of the Itasenpara bitterling, as a primary objective of the project was to observe whether the fish could breed in reconstructed embayments. Five hundred individuals (1:1 sex ratio) were selected from the captive population at the Aquatic Life Conservation Research Center and were then released into several embayments in September and October 2009. The bitterlings had grown well after swimming out from the mussels in the spring of 2009, and all fish had matured by the time of release. Predatory alien fish had not notably increased in the embayments, and those present were removed using a seine net prior to the bitterling release. After the first release in September, a large-scale flood caused by a typhoon violently disturbed the embayment environment, possibly flooding the Itasenpara bitterling and mussels out of the embayments.

Post-release monitoring: Hatched larvae of the Itasenpara bitterling spend about half a year in the mussels until the following spring. Subsequently, after swimming out from the mussels, juveniles swim close to the surface of the water. The best method for assessing the status of the population is to count the number of juveniles appearing in the spring, as these numbers reflect breeding during the past autumn. In May 2010, a total of 133 juveniles were observed in the embayments where the bitterlings had been released, indicating that the released adults had successfully bred. Thus, one goal of the re-introduction project was achieved. However, the number of juveniles was rather low, and no juveniles were found in the spring of 2011. None of the 133 individuals were likely able to survive, perhaps because of the frequent flooding.

Major difficulties faced

- Frequency and magnitude of flood disturbances in the bitterling habitat: Suitable habitats for the Itasenpara bitterling are maintained by the adequate frequency and magnitude of flood disturbance. To restore such a habitat is very difficult; however, this issue is one of the main problems that must be resolved to ensure the successful re-establishment of this species.
- Decrease of mussels: Excessive or weak flood disturbance can reduce the population of mussels used for Itasenpara bitterling spawning. Thus, the restoration of the habitats mentioned above is essential.
- Increase of alien plants and fishes: Reduced flooding can lead to increases in populations of alien plants and fishes.
- Illegal poaching: Poaching of the Itasenpara bitterling by aquarists and traders continues in other habitats. After the release of this species in the Yodo River, surveillance by cameras, river managers, the police, and others has been conducted to restrain poaching.
- Anonymity of the habitat: Because this habitat has not been disclosed for conservation purposes, it has attracted limited media interest, thus slowing the rate of public awareness.

Major lessons learned

- Difficulty of restoring the floodplain environment: Although embayments were reconstructed in the area affected by flood disturbance, as required by the Itasenpara bitterling, the species could not survive under conditions of excessive flood disturbance.
- The significance of the accumulation of ecological and hydrologic data: The re-establishment of the Itasenpara bitterling in the Yodo River did not succeed during this trial. However, a great deal of useful ecological and hydrologic knowledge was obtained. To successfully restore the floodplain environment, the collection of such data is crucial.
- The significance of artificial breeding: Because artificial breeding has been successful, and the genetic diversity of the captive population has been maintained, this re-introduction project can still be implemented. Furthermore, in the future, maintaining the condition of the captive population is critical for subsequent re-introduction trials.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Habitat of mussels: Because the mussel habitats were restored in the embayments, the Itasenpara bitterling was able to breed. However, excessive flood disturbance reduced the quality of the mussel habitat.
- Excessive flood disturbance: The Itasenpara bitterling could not survive, probably because of these excessive flood disturbances.

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The re-introduction of the Ushimotsugo minnow in Gifu Prefecture, Japan

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Introduction

The Ushimotsugo minnow (*Pseudorasbora pumila* subsp.) is a threatened cyprinid fish endemic to the Tokai region (Gifu, Mie, and Aichi Prefectures) of central Honshu, Japan. Although this fish remains to be taxonomically described, it is recognized as a subspecies, because its color pattern and mtDNA phylogeny clearly differentiate it from the nominotypical subspecies. In the last several decades, most of its habitat (i.e. brooks and swamps) has been destroyed by human activities such as urbanization and improvement of paddy fields. Wild populations are now found in only approximately 10 irrigation ponds scattered in hilly lowlands. The remaining habitats are facing a crisis of environmental changes, including engineering works, accumulation of litter, vegetation succession, and invasion by the alien predators *Micropterus salmoides and Lepomis macrochirus*. Owing to its drastic habitat loss, this species was listed as an endangered species under the Law for the Conservation of Endangered Species of Gifu, Mie, and Aichi Prefectures in 2004 (Gifu & Mie) and 2010 (Aichi). This species was also catalogued as “Critically Endangered” in the Red Data Book of the Environmental Agency of Japan. An on-going re-introduction program aims to restore its habitat in Mino and Seki cities in Gifu Prefecture.

Goals

- Goal 1: To retain all of the wild populations of the Ushimotsugo minnow in Gifu Prefecture.
- Goal 2: To increase restored habitats surrounding each wild population.
- Goal 3: To restore native aquatic fauna, including the Ushimotsugo minnow, in several areas in the cities.

Success indicators

- Indicator 1: Successful captive breeding without inbreeding.
- Indicator 2: Exclusion of alien predators from destroyed habitats.
- Indicator 3: Establishment of re-introduced population in restored habitats.
- Indicator 4: Settlement of native animals, insects, and plants moved from the surrounding areas.

Project Summary

Feasibility: Gifu Prefecture was known to contain only a few habitats of the Ushimotsugo minnow in the 1990s. In the early 1990s, the habitat in the western

areas of the prefecture had already been destroyed by environmental changes, and since then, the captive stock has been maintained in Lake Biwa Museum. A habitat located in the eastern areas of the prefecture has been protected by the local people. In one of the habitats located in the central area, minnow populations were destroyed by the black bass (*Micropterus salmoides*), introduced by anglers. In 2004 - 2005, only 2 habitats existed in the central area of Gifu prefecture: a field survey indicated that most of the potential habitats surrounding these habitats had been invaded and occupied by alien predators, the black bass and the bluegill (*Lepomis macrochirus*). Therefore, the exclusion of alien fishes and re-introduction of minnows were considered necessary to restore the native habitat.



Ushimotsugo minnow
(*Pseudorasbora pumila* subsp.)

Implementation: In central Gifu prefecture, two native habitats were concealed and protected. The local naturalist group “Gifu Mino Ecological Research Group” appealed to other local groups for support in averting the crisis of habitat destruction for the Ushimotsugo minnow. Thus, in 2005, Gifu Prefectural Research Institute for Freshwater Fish and Aquatic Environments, Gifu World Fresh Water Aquarium, local offices of Seki and Mino cities, and Gifu Mino Ecological Research Group formed “The Group for Conservation of Ushimotsugo minnow.” This conservation group bred a minnow stock from one habitat in Seki, Gifu Prefecture. The stock was divided into sub-stocks, and individuals were exchanged between sub-stocks every year to avoid inbreeding. In the autumn of 2005, the conservation group chose a small irrigation pond for restoration and completely drained the pond. The pond had contained many black bass, bluegill, and non-indigenous carps (*Carassius cuvieri* and Chinese carp *Cyprinis carpio*), but no native fish. After exclusion of alien species, the city office made the billboard to announce the Law for Endangered Species of Gifu Prefecture and the Invasive Alien Species Act of Japan, and set the ropes around the pond to stop lure fishing. Breeding Ushimotsugo minnow stock was released, and a conservation program was announced to the public. Monitoring by the local community proved to be effective in preventing illegal poaching of the minnow and illegal release of the black bass. In 2005, the breeding stock was also released into an artificial pond that was inaccessible to the public. In 2006, the



The restored habitat and billboard

conservation group completely drained two other ponds, excluded the alien predators, and re-introduced the minnows.

Post-release monitoring: After the release, the establishment of the minnow populations was monitored. In the first two ponds, satisfactory breeding of the minnow was observed, and the populations were found to increase. However, in one of the ponds open to the public, the population of the non-indigenous crawfish (*Procambarus clarkii*) increased explosively in 2007, because its predator, the black bass, had been excluded. The crawfish can hide in mud; thus, drying the pond was not effective in excluding them. To control the crawfish population, the Gifu Mino Ecological Research Group and local people catch the crawfish every year. Consequently, the number of crawfish has been controlled at a low level since 2008. Although this open habitat has faced invasion by an alien species, this habitat is useful for conservation education. The condition of another pond inaccessible to the public has been better. The minnow population in this pond has become well established, and many native semi-aquatic insects have also settled. However, re-introduction in the two ponds used for the second attempt in 2006 has not yet been successful. In 2011, some native cyprinid and gobid species were observed in these ponds, and the Ushimotsugo minnow had not been found at all.

Major difficulties faced

- A lack of re-introduction sites: Genetic analyses have already indicated that the remaining local populations of the Ushimotsugo minnow were genetically different (Watanabe & Mori, 2008; Mukai, unpublished data). Thus, re-introduction sites must be within the same areas as source populations to avoid genetic disturbance from other areas. In addition, potential habitats, without alien predators within the restricted area, are often valuable for the establishment of endangered aquatic insects and plants. Thus, these habitats need to be reserved for these endangered species, and disturbance by minnow introduction should be avoided. The best places for restoration were habitats invaded by alien predators, but only where they could be successfully removed. Although many invaded ponds were potentially available, the invasive species could be successfully excluded only from a few ponds.
- Prevention of the illegal release of the black bass: Some anglers want to maintain the black bass or other game fish in irrigation ponds. We experienced

problems entailing the illegal release of black bass and other non-indigenous fishes into ponds where aliens had been excluded.



Alien predators - black bass and blue gills caught from a pond in Seki City

- Controlling of the non-indigenous crawfish and bullfrog: The Ushimotsugo minnow can cohabitate with the non-indigenous invasive crawfish (*Procambarus clarkii*) and the American bullfrog (*Rana catesbeiana*). However, the crawfish and bullfrog eat native aquatic insects, amphibians, and plants, and prevent the restoration of native fauna and flora. Furthermore, exclusion of the black bass often caused explosive increases in crawfish and bullfrog populations.
- Competition among native fishes: In the habitat with successfully re-introduced Ushimotsugo minnow, it was the only the fish inhabited and therefore the minnow did not face competition. In the ponds where restoration failed, however, populations of the competitive cyprinid fishes *Zacco platypus* and *Nipponocypris sieboldii* increased and displaced the Ushimotsugo minnow.

Major lessons learned

- Exclusion of invasive alien species is essential for conservation and restoration: Conditions observed for successful re-introduction indicated that invasion of the black bass is a major factor in the destruction of a suitable habitat for the minnow in central Gifu.
- Public awareness is a powerful aid: The re-introduction project had been announced to the local people through newspapers, the public news, and direct interaction. Monitoring by the people was useful in the protection of the restored pond from illegal activity.
- Combining re-introduced native species poses a difficult problem: Although the native Ushimotsugo minnow sometimes coexists with other cyprinids, the successful cases excluded other fishes. If the restored habitat is very large, there is a possibility that the minnow can establish a population in the presence of other native fishes. However, further ecological research should be conducted on the restoration of native fauna, including the Ushimotsugo minnow and other fishes.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Captive breeding was successful.
- By using breeding stock, re-introduction of minnow resulted in established populations within two restored habitats.
- One of the restored habitats has been successfully protected by local people.
- Another enclosed re-introduction habitat has become suitable for the minnow and native fauna.

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Translocation and re-introduction project of striped bitterling in Lake Biwa and neighboring areas, Japan

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Introduction

The striped bitterling (*Acheilognathus cyanostigma*) is a Japanese endemic freshwater fish belonging to the carp family. The natural region of distribution of this fish is considered to be Kinki District and the central region of mainland Japan, and a large number used to live on the coast and lagoons called “naiko” around Lake Biwa in Shiga Prefecture. Although scattered occurrences of individuals thought to have originated from Lake Biwa have been confirmed across Japan, the number of individuals in Lake Biwa has decreased sharply from the 1990s and no records exist for the last ten years. Owing to its nearly complete extirpation around Lake Biwa, this species has been designated as Critically Endangered by the Ministry of the Environment. It has also been designated as Critically Endangered and in Shiga Prefecture, where Lake Biwa is located and collection of bitterlings is forbidden by the prefectural ordinance.

Lake Biwa where the project is being undertaken is the only ancient lake dating back well over 4 million years in Japan. To speak only of the lake’s fish, about 15 endemic species are found here and therefore is an important water area for biodiversity conservation. It is also important for Japanese culture because Lake Biwa appears in classical Japanese literature and artwork. However, much of the wildlife of



Acheilognathus cyanostigma bred in Lake Biwa

the lake, including the striped bitterling, has been affected adversely in recent years by the invasion of alien species, the disappearance of "naiko", and the fragmentation of the wildlife habitat network formerly provided by rice fields. In this project, we started to produce a number of striped bitterling habitats in ponds and biotopes around Lake Biwa, which works as a means of securing the continued existence of this fish and preparing for the re-introduction of founder stocks into Lake Biwa.

Goals

- Goal 1: Continuation of striped bitterling populations in the wild in Shiga Prefecture.
- Goal 2: Establishment of a management approach for striped bitterlings released into ponds.
- Goal 3: Elucidation of the genetic localization of the surviving population and development of a release plan for Lake Biwa based on these findings.
- Goal 4: Establishment of striped bitterling populations in Lake Biwa.
- Goal 5: Generalization of the progress of freshwater fish conservation and the experience of this project as a role model.

Success Indicators

- Indicator 1: Breeding multiple successive generations of striped bitterling in the release ponds.
- Indicator 2: Breeding multiple generations of mussels as the spawning hosts for striped bitterling and also breeding host fish in the release ponds.
- Indicator 3: Obtaining the agreement to re-introduction and co-operation with the project by various stakeholders.
- Indicator 4: Producing the required number of founders for re-introduction of striped bitterling into Lake Biwa.
- Indicator 5: Confirmation of a large number of surfacing larvae of striped bitterling around the shores of Lake Biwa.

Project Summary

Feasibility: As the core breeding stock for the project, the wild population in a pond in northern Shiga Prefecture and a breeding population maintained in captivity in the Lake Biwa Museum were used.

Northern pond population - The northern pond is the only habitat of striped bitterling which is confirmed in Shiga Prefecture. The result of the investigation shows that since 2005, individuals <50 mm long, have not been sighted and shows no breeding has occurred for one or two years. As a result of the pond mud which is 70 cm thick there are no freshwater mussels that serve as the spawning hosts of bitterlings could not be confirmed there. The number of striped bitterling was presumed to be 57 (±14 SD) individuals. On the basis of further investigations, Miyadame Pond in the upper reaches of an inflowing stream of Lake Biwa was chosen as a candidate for fish translocation trials. Miyadame pond is equipped with drain pipes, so water management can be conducted easily. The likelihood of obtaining local residents' cooperation seemed high, because the

pond is located within the ground of a communally maintained shrine devoted to the area's guardian Gods.



The pond of a traditional Japanese garden at a shrine in Kyoto where striped bitterlings have survived

Moreover, fish poaching hardly occurs because poachers must pass through the village settlement to reach the pond. In order to release striped bitterlings into Miyadame pond, we secured the release founders, to increase the individuals in the northern pond. At the same time, we carried out the draining and drying of a pond called "Ikehoshi", in the northern pond and to improve the habitat.

Breeding population in the Lake Biwa Museum - In 2005 we captured 63 individuals from the pond of a shrine in Kyoto where there is a piped headrace channel to Lake Biwa. We investigated in the southern Shiga where a headrace gate is placed and based on the results we planned the re-introduction to the adjacent pond of Lake Biwa. Moreover, in order to secure a number of founders to release to Lake Biwa which is the biggest lake in Japan, we propagated the breeding population in Lake Biwa Museum and planned the translocation of them to the ponds and biotopes of elementary schools and various companies in southern Shiga. Furthermore, we started the research of the relation between each source and other prefectures, and each group's genetic diversity by molecular genetics investigation.

Implementation:
Northern pond population - In 2007, we prepared founder stocks bred by 22 individual captured striped bitterlings (11 male:11 female) and *Anodonta lauta* as spawning hosts in a concrete pool. Miyadame pond for the translocation was drained and dried by our team and the local residents to exterminate the alien fish such as *Lepomis macrochirus*. Then, we took measures to prevent escape of released individuals and released 100 individual striped bitterlings and 100 individual *Anodonta lauta* to Miyadame pond. Also, 100 individual *Rhinogobius* sp. as hosts of mussels were released there.

Breeding population in Lake Biwa Museum - In 2009, habitat maintenance of the adjacent pond of Lake Biwa was performed the same way as Miyadame pond. Then, 750 individual striped bitterlings propagated by 100 individuals the breeding population in Lake Biwa Museum, were re-introduced into this pond. In



Releasing founder stocks into a biotope at a semiconductor factory (OMRON Corporation)

addition, to produce the founder, the increased individuals propagated from the breeding population in the Lake Biwa Museum, were used for the translocation to a satoyama garden of a Japanese confectionary company (Kanou Shoujuan Sunainosato, 2008), a biotope at a semiconductor factory (OMRON Corporation, 2011), and biotopes and ponds at two elementary schools (Tanakami Elementary School and Ousaka Elementary School, 2010).

Post-release monitoring: Particular researches have been conducted in all released areas. They are the confirming of breeding striped bitterling by observation of mussels molluscan tissue, the counting surfacing larval fish, the investigation of fish species, and the regular research of individual mussels. The management has been conducted based on the result of the investigation. In 2009, it was confirmed the propagation of *Trapa japonica* covered on the water surface of Miyadame pond where the population of the northern pond was translocated. Also the mortality of the *Anodonta lauta* was confirmed there. Therefore we got rid of *Trapa japonica*. Then, additional 50 individual *Anodonta lauta* and 50 individual *Rhinogobius sp* were released from the downstream of Miyadame pond. The breeding striped bitterlings have been confirmed in every year for four years there. On the other hand, new enrollments of *Anodonta lauta* have not been confirmed. The adjacent pond of Lake Biwa where the founder propagated by the breeding population in Lake Biwa Museum was re-introduced, was invaded by a number of alien species. Moreover, it was confirmed the mass mortality of mussels and the decrease of striped bitterling.

We conducted a draining and drying pond and another investigation. As the result, it was confirmed the alien species of *Lepomis macrochirus* (1,560 individuals), *Rhodeus ocellatus ocellatus* (394 individuals), *Rana catesbeiana* (1,996 individuals) and *Procambarus clarkii* (about 10,000 individuals). The striped bitterlings confirmed were only 5 individuals, and most re-introduction individuals have been lost. Many of mussels mortality individuals marked the predation by *Procambarus clarkii*. We believe that the decrease in numbers of *Anodonta lauta* and striped bitterlings was a result of the influence of these alien species. It confirmed the breeding every year in the ponds and biotopes managed at the elementary schools and the company, into which founders propagated by

the breeding population in the Lake Biwa Museum were translocated. Their population have been increasing and amounted to about 2,000 individuals in total in 2011.



"Ikehoshi" (the draining and drying of a pond) with help from local firefighters washing out the mud

Major difficulties faced

- It is an important issue to construct a long-term management role to conserve the translocated or re-introduced water areas.
- Illegal fish poaching from translocated area and sales have been conducted.
- It was a few number of the founder stocks, so that authors are estimating the genetic diversity of both the population of the northern pond and the breeding population in the Lake Biwa Museum.
- There are a lot of stakeholders such as fishermen and many endemic species inhabit Lake Biwa. To discuss the influence by releasing with multidiscipline group of professionals and consensus-building is also a issue though a procedural justice for re-introduction are also important difficulties.
- It is necessary to clarify genetically the relation between the population of the northern pond and the breeding population in the Lake Biwa Museum, and develop a release plan in Lake Biwa.
- Alien species such as *Micropterus salmoides* still inhabit Lake Biwa now.
- It is necessary to investigate their effect on re-introduction and establish the method to reduce this effect.

Major lessons learned

- We showed that striped bitterlings prefer large size individuals which are in a group of Anodonta, and *Cristaria plicata* as spawning hosts. They do not use *Unio douglasiae biwae* which are family of mussels, and there are most numbers of individuals in the lake coast. It is important the fundamental ecological study about Japanese bitterlings for the project.
- It was important that the participation of children in the activity in terms of increasing the number of available hands and thus the work that could be accomplished.
- It is important for the success of the project that encouraging collaborators understand that the re-introduction is a long-term issue.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The population of striped bitterling has been increased to breed multiple generations in translocated ponds. However, mussel breeding has not been confirmed which are the spawning hosts.
- Released striped bitterlings were lost as a result of the invasion of many alien species into the pond adjacent to Lake Biwa. Re-introduction into this pond failed because the administrator decided to abandon the effort.
- A project team consisting of specialists from various fields was formed, and various subjects such as an administration, NGO, museum, have cooperated to the re-introduction into Lake Biwa.

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Re-introduction and re-enforcement of oily bitterling in conjunction with local communities in Northern Mie, Japan

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Introduction

The oily bitterling (*Tanakia limbata*) is the one of the cyprinid species which is distributed to the west of the Nobi Plain in Japan. It is designated as Near Threatened by the Ministry of the Environment in Japan and Vulnerable in the Mie Prefecture's Red List. Many bitterlings such as the oily bitterling have inhabited satoyama areas such as waterways and farm ponds, which have been developed through agricultural use and can assist biodiversity if properly maintained by human activities. Northern Mie where the project was conducted is a satoyama area where agriculture is the main occupation and it is also dotted with automobile factories and electrical related industries, and is also developing as a bedroom suburb of Nagoya. There is a group of ponds which have ichthyophagous alien fish such as the largemouth bass (*Micropterus salmoides*) which influence the native ecosystem.

The changes in agriculture in this area such as the large-scale farming, the decrease in farmer population and the urbanization of local societies results in poor management of the water resources in the area and results in mud being deposited in the ponds and eutrophication. In order to conserve the oily bitterling, it is necessary to reconstruct satoyama management which had been performed by local farmers, to bring a new framework for conservation. We therefore started a project of oily bitterling restoration through the self-sustaining construction of the water environment management system by local residents. We also began the integration project of



Male oily bitterling (*Tanakia limbata*)

Humanities and Science to encourage local residents to participate in biodiversity conservation activities through the Environmental Psychological Action Research.

Goals

- Goal 1: Continuation of the oily bitterling population in Northern Mie Prefecture.
- Goal 2: Restoration of satoyama ecosystem represented by the oily bitterling.
- Goal 3: Construction of voluntary and scientific water environment management systems by local residents.
- Goal 4: Progress on biodiversity conservation in relation to agriculture and conducting the Community Development based on the progression.
- Goal 5: Progress of satoyama conservation and generalization of experience as the role model.

Success Indicators

- Indicator 1: Breeding multiple generations of oily bitterling in multiple ponds.
- Indicator 2: Breeding multiple generations of mussels and common freshwater goby in multiple ponds.
- Indicator 3: Restoration of traditional pond management "ikehoshi" which is the draining and subsequent drying of a pond by the local residents.
- Indicator 4: Extermination of the invasive alien fish, largemouth bass and bluegill, in the project area.
- Indicator 5: Public awareness (including the Place Attachment of their own region) activities for local residents including children.

Project Summary

Feasibility: Japanese bitterlings spawn in the gills of certain species of live freshwater mussels and a decrease in mussel populations have an adverse effect on bitterling populations and on the other hand, mussels are parasitic to other fish during the larval stage. The bitterling habitation is an index of affluence of the familiar satoyama. Oily bitterling habitats have rarely been found in recent years in the Northern Mie Prefecture. They have also thought to have become extinct around Komono town (Shimizu, 1991). However, we found the following mussels *Anodonta sp.* and *Inversidens japanensis* which are listed as Near Threatened in the 2004 Ministry of the Environment and Mie Prefecture Red List, and they are as spawning hosts of the oily bitterling. We started the investigation to restore oily bitterling in the ponds in this area and two individual oily bitterlings were found at Kusune-tame pond in Tabika, Komono town in July, 2005. It was revealed that a number of largemouth bass were found in the Kusune-tame pond and a few oily bitterling remained downstream where no mussels live.

Therefore we started the re-introduction project which is aimed at breeding the population as the re-introduction source for the neighboring ponds and conducting the recovery in Kusune-tame pond. The investigation of the farm pond planned for re-introduction such as Kanshiro-tame pond and Kusune-tame pond revealed that following problems; Habitation of invasive alien fish such as largemouth bass (*Micropterus salmoides*) makes it difficult for oily bitterling to survive. Individual

mussels (spawning hosts) are hardly seen and which may be absent due to a large amount of mud deposition. As the result of those problems, our team planned the re-introduction by restoring the ponds through traditional pond management, removal of invasive alien fish, reducing mud deposition and enhancing new recruitment of mussels.



Many local residents participated in pond airing

Implementation: Our team started to capture fish which would be used for breeding and release in a concrete pool from July 2005 and a total of 23 out of 27 collected were used for breeding purposes. Spring water at a low temperature was used for the pool and prolonged the breeding period and about 300 fish were bred. We conducted the draining and drying of a pond in Kusune-tame pond in October, 2005 which included experts in plants and insects. About 80 participants including researchers, students, local residents and civil servants gathered for draining and drying pond. After setting a net at a drain gate for the prevention of the alien fish spreading, the dirty water was removed. A total of four individual oily bitterling, 48 individual *Anodonta sp.* and seven individual *Inversidens japanensis* (Near Threatened in the Ministry of the Environment and Mie Prefecture in Red List) and other native species were captured. In this process a total of 262 largemouth bass were exterminated.

Draining and drying pond was conducted in neighboring farm pond (Kanshiro-tame pond) in January 2008. About 200 local residents participated and exterminated 1,100 individual largemouth bass. Only 71 individual fish (4 kinds of species), 917 individual *Anodonta sp*. and 4 individual *Inversidens japanensis* were captured. In April, 2008, we dried the bottom of the pond for a month then repaired a sluice and filled it with clear water. After that local children released 100 individual oily bitterling (50 male and 50 female), 100 Amur gobby (orange type) which were captured downstream of the pond, and indigenous fish species which were captured during draining and drying of the pond in April 2008. Furthermore, another draining and drying pond and releasing were also conducted with the local children and residents in neighboring pond in February 2009.

Also lectures on biodiversity were given at local elementary schools before releasing the fish and local volunteers prepared meals at every pond draining and drying and participants increased each time. Preparing the ponds also provided participants experience on satoyama management.



Junya Kitazima explaining mussels to children

This project has been as a part of the Action Plan for improvement of farmland, water and environmental preservation since 2008 and the Japan Fund for Global Environment from the Ministry of the Environment since 2009. Also the Local Contribution Special Support Project of Nagoya University since 2010 and the Subsidy for the promoting communion of food and region from the Ministry of Agriculture, Forestry and Fisheries of Japan since 2011.

Post-release monitoring: The breeding of oily bitterling and the new recruitment of mussels were identified by visual counting and periodic research during the breeding period of oily bitterling. Based on the findings, we continuously conduct habitat management such as the draining and drying of a pond and releasing stock. It was confirmed that some largemouth bass were alive in Kusune-tame pond in June 2006 and Kanshiro-tame pond in June 2008. From the residents reported sighting these were thought to be illegally releases. We then conducted pond airing in Kusune-tame pond in January 2010 and Kanshiro-tame pond in October 2010 and exterminated the largemouth bass and released oily bitterling and other native fish. The number of people such as local residents, children and others from outside the prefecture participates in these management activities and it is counted as a public education opportunity in experiencing satoyama activity.

Furthermore, the promotion of satoyama conservation results in environmental education lessons at elementary schools of Komono town and an exhibition of oily bitterling at the town office. Also, the Social Psychology Investigation is conducted to estimate its effect. About 300 persons participated in the Draining and drying of a pond in January 2010 and 500 persons from 50 nations participated in October at the CBD event of COP 10. These activities were evaluated and the Kusune-tame pond was elected as the one of the 100 selected ponds of the Ministry of Agriculture, Forestry and Fisheries and the local agricultural organization. It was awarded "the Secretary of State for the Environment commendation" and "environmentally-conscious-agriculture contest".

Major difficulties faced

- It may be necessary to evaluate genetic diversity because of the low numbers of founders.

- As the activities of this project spread some anonymous anglers sent e-mails which objected to this project to one project member. Largemouth bass were illegally released. The extermination system against illegal release was conducted not just as one event but for continuous management with local residents.
- Some local residents released other rare freshwater fish and varicolored carps with their kindness outside the project researchers knowledge which influenced the habitat of the mussels which are spawning hosts for oily bitterling. It is necessary to ensure that scientific biodiversity conservation and aspirations of the local residents are considered together.

Major lessons learned

- It is important to know the fundamental ecology of Japanese bitterlings for the project.
- To have a well developed management system for the project to accomplish objectives and not something only for a one-off event.
- The children participating in this activity made the local residents realize that this project is important for the future of the region and ensure the oily bitterling lives into the future.
- The local residents who have the higher Place Attachment were more cooperative for the activity.
- A social survey indicated that people who participated in our activity increases their Place Attachment - what we call " researching ability for local treasure".

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Breeding in multiple ponds is conducted for each species of fish, such as oily bitterling, mussels and freshwater common goby.
- Largemouth bass have not been fully exterminated out of this area because of illegal release by anglers.
- The statement that, “no bass in Tabika” will be declared by the end of this fiscal year.
- This is just the beginning of biodiversity conservation and sustainable agriculture such as agrochemical-free soybean cultivation.
- The road ahead will be long.

Acknowledgments:
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Houston toad population supplementation in Texas, USA

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Introduction

The Houston toad (*Bufo* [*Anaxyrus*] *houstonensis,* Saunders, 1953) is endemic to the forested, deep sandy soils of east-central Texas, USA. It was the first amphibian placed on the United States List of Threatened and Endangered Species in 1970, and is also listed as Endangered by the IUCN and the state of Texas. Since the 'Endangered' listing of the Houston toad, its populations have continued to decline across its range. This is largely synchronous with a reduction in habitat quantity, through conversion of forest to agriculture and urban development, and quality, due to fire suppression and fragmentation. Precipitous declines have been observed concomitantly with prolonged droughts (Brown & Mesrobian, 2005). There are two parcels of state owned property; the 2,400 ha Bastrop State Park and a separate 178 ha tract (Welsh Tract), both in Bastrop County, Texas. All other tracts are privately owned and only with the collaboration of landowners do these tracts provide habitat restoration and stewardship efforts for the species in the wild. The Welsh Tract, owned and administered by Bastrop County is the only tract managed primarily for toad recovery. Other conservation or stewardship tracts have other primary objectives and incorporate Houston toad stewardship alongside those goals.

Goals

- Goal 1: To increase juvenile survivorship above 1% on critical recovery sites, thereby decreasing the likelihood of extinction within the next decade.
- Goal 2: To facilitate natural recolonization of restored habitat by increasing population sizes.
- Goal 3: To establish a captive assurance colony of genetically representative Houston



Houston toad showing vocal sac

toads to supply individuals for re-introductions in the event of extinction in the wild.

Success Indicators

- Indicator 1: Increase in sub-population size (mean over 5 years) to 5,000 adult females for habitat fragments where head-starting has occurred.
- Indicator 2: Increase the number of robust sub-populations to at least two.
- Indicator 3: Achieve a sustainable captive assurance colony containing genetic diversity representative of the remnant wild populations.

Project Summary

Feasibility: A Population Viability Analysis (PVA) conducted by Hatfield *et al*. (2004) determined the Houston toad would likely go extinct within a decade if juvenile survivorship was below 1% and there was only one subpopulation. Field data suggested juvenile survivorship was 0.03% (Grueter, 2004), much lower than originally assumed, and that there might indeed be only one viable subpopulation. A subsequent model-based estimate concluded juvenile survivorship to be 0.75% - 1.5% (Swannack *et al.*, 2009), but again it appears that only one robust subpopulation exists. Thus, it was proposed by one of the authors to the United States Fish and Wildlife Service that without active stewardship the Houston toad would be extinct in the near future. We believe future recovery efforts should address pertinent biological weaknesses identified by the PVA, and focus on head-starting (to improve juvenile survivorship), habitat restoration (to increase the viability of additional subpopulations), and creation of a captive assurance colony. This would not be the first time Houston toads were collected for *ex situ* conservation purposes. In the 1980s nearly 500,000 eggs, tadpoles, toadlets and adult Houston toads were captive propagated and translocated to the Attwater Prairie Chicken National Wildlife Refuge in the hopes of creating a second population in a protected area. This previous Houston toad *ex situ* conservation program provided relevant experience and information for the current work. The 1980s effort has been largely viewed as a failure (Dodd & Seigel, 1991), yet recently generated genetic data from the dissertation work of McHenry (2010) revealed evidence that supports the potential long-term success of those early efforts. Significant pre-existing data from annual surveys, mark-recapture, and habitat restoration efforts were available for the Bastrop County sites, which enabled us to test the efficacy of supplementation at various life stages. With this backdrop, the most recent population supplementation project was initially focused on the robust Bastrop County sub-population, as well as the much less robust, but critically important, sub-population in Austin County, Texas.

Implementation: In the spring of 2007, the first Houston toad eggs were transported to the Houston Zoo for head-starting. For the head-starting efforts, egg strands or partial egg strands, are collected and transported to the zoo's "amphibian conservation quarantine" facility. The eggs are acclimated to captive water conditions and are introduced to the tadpole rearing aquarium rack system. As larvae approach Gosner stage 42 they are transferred to "emergence tanks", which are miniature ponds with a high temperature (32^{o} C - 35^{o} C) basking spot. Upon complete absorption of the tail the toadlets are then transferred to fully

terrestrial enclosures. They are fed a series of gradually larger prey items (springtails, fruit flies, bean beetles, domestic crickets, wax worms, and mealworms) until achieving the scheduled release size. Actual releases are timed to coincide with rain events whenever possible. In 2010, larvae between Gosner stage 38 and 40 were released in an effort to determine if larvae releases would be as effective as toadlet releases (i.e., have the same, less, or more effects on juvenile survivorship). Pre-release protocols mandate a clear fecal parasite history (no parasites for at least 2 consecutive screenings), healthy and normal histopathology results from deceased or screened individuals from the group, and a negative amphibian chytrid qPCR test. The toadlets are released at or just after sunset into the forest surrounding the same pond from which the eggs were collected. For late stage larvae, releases are performed in the early afternoon. In 2007, 500 Houston toads were released, with an impressive 33.5% of juveniles surviving in captivity. In 2009 and 2010, 4,194 and 14,728 Houston toads were released, respectively, with captive survivorship increasing to 50 - 55%. Both 2008 and 2011 were exceptional drought years during which Houston toad reproduction in the wild was not detected, and may not have occurred.



Army of Houston toads ready for release

Post-release monitoring: Differentiating between captive raised and wild individuals is challenging, as most techniques (e.g. toe clipping, elastomers, passive intergrated transponders) have innate failure rates that can reduce the detection of previously marked individuals if releases are made when the individuals are small. Specifically, it is extremely challenging to mark larvae for an evaluation of the success of releasing different life stages. Genetic markers can be used to differentiate individuals from different cohorts or sibling groups (Blouin, 2003), and if a cohort is adequately sampled and released at the same life stage, it is possible to genetically “tag” any individual and determine its origin when recaptured. Our previous population genetics work (McHenry, 2010) provides the highly polymorphic marker suite required, and research by Vandewege (2011) has confirmed the utility of those markers to detect kinship against unknown wild caught individuals.

Major difficulties faced

- Due to the rarity and secretive nature of the Houston toad, very little is known about commensal organisms and naturally occurring pathogens. This results in



Typical habitat with researchers

large delays to any releases when new organisms (e.g. *Mycobacteria sp*.) are detected in head-started toads.

- Juvenile amphibians consume a tremendous quantity of invertebrate prey, which is a testament to the ecological services of amphibians, but can become quite expensive in an *ex situ* conservation program.
- Determining the most effective (highest survivorship for the lowest cost) life stage to release is extremely important, but fraught with difficulties. As survivorship probability is positively linked to size, larger individuals should fare better after release, and the larger a female is, the closer she is to reproductive maturity. However, captive acclimation is likely to be more significant the longer an individual is reared in captivity. Likewise, cost is correlated to duration in captivity, requiring optimization of limited financial resources to either maximize numbers (larval population supplementation) or size (large juveniles). The data necessary to guide these decisions are not yet available.
- As Texas is primarily privately owned, Houston toad recovery will rely heavily on the ability of wildlife agencies to bring private landowners and other stakeholders to the table. Returning head-started endangered species into stakeholder communities, which have a mosaic of opinions about the toad and the government, can cause delays and even halt progress.

Major Lessons learned

State of the Science

- Amphibian declines and consequent stewardship programs are well established, but frameworks for optimizing amphibian population supplementation are not. Endangered species suffer from multiple impacts culminating in their declines. In many cases inherent rarity serves to increase the difficulty of accurate statistically supported assessment methods for a given management option. Seemingly too often, any population increases detected are assumed to be the results of a given management strategy, even if little or no data support those suppositions. We have found very little data to guide decisions about population supplementation strategy and success in amphibian populations. The lack of published evaluations of population supplementation using genetic markers or strong mark-recapture data was surprising to us.

- The math of survivorship reveals that any successful population supplementation effort in the Houston toad will require a much more industrial scale effort than was initially perceived. On average we have been able to head-start and release six egg strands or partial egg strands per year since 2007. On the one hand this is tremendously valuable, as those represent a significant proportion of the total reproduction in the wild, and an even larger proportion of the reproduction for the two largest sub-populations remaining for the species. Thus, reducing mortality from complete (i.e. drought desiccation losses) to “normal” is a significant contribution when reproduction is this rare in the wild. Unfortunately, that low level of overall reproductive success will not enable a population to rebound, much less recover. Wild egg strand head-starting also requires half of the overall program effort necessarily devoted to field monitoring, detection, and acquisition of wild egg strands. While the situation in the wild is improving and we have demonstrated that part of the positive change in abundance is a direct result of head-starts, it will not be enough and captive propagation must be carefully considered as a viable option.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:
Successes:

- As one of the goals is to significantly increase juvenile survivorship, this has been a remarkable success thus far. Both standard mark-recapture methods and genetic tracking have detected head-started individuals months and years after release, albeit at low total numbers but relatively high frequencies given the released life stage (~8% near adults and large juveniles, and ~0.1% among initial metamorphs of annual wild captures) as constrained by the expected natural survivorship frequencies in the wild.
- Another remarkable outcome has been the stakeholder response to head-starting and supplementation. The concept is easily grasped and the close involvement of those private stewards has provided a stronger engagement with the conservation efforts. Seeing juvenile toads hop away is not an abstract conservation program in the way that chorus monitoring or annual pitfall trapping can be. The response to the program has included media attention and the consequential additional public outreach.
- The captive assurance colony is in place and a genetic comparison of the wild populations and captive assurance colony has been completed. While results vary among subpopulations, 67% of the genetics detected in the wild is retained by the current captive colony.

Failures:

- Our field procedural techniques did not account for the resampling of recaptured individuals. We have completed more than a decade of mark-recapture and monitoring of the species at the field sites. Historically, animals

that were recaptured and had been previously marked were not resampled for DNA, with the knowledge that they were sampled at initial capture. For our purposes during the first two years of the population supplementation, this had not been fully modified for the head-start tracking. Previously marked head-starts were recaptured but not resampled for DNA, decreasing the power of our DNA mark-recapture analyses and preventing final confirmation of those individuals as head-starts. This is particularly relevant for metamorphs with a cohort toe-clip released during the first two years of the study. It is less relevant, but still an issue, for larger releases that were microchipped but not resampled at recapture.

- Persistent drought conditions have resulted in very few wild egg strands, with attendant consequences to the study. Captive propagation should have been incorporated during the planning stages to compensate for this recurring problem.

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Conservation and recovery of the mountain yellow-legged frog in Southern California, USA

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Introduction

The mountain yellow-legged frog (*Rana muscosa*) is endemic to California and occupies the Transverse Ranges of southern California and the southern extent of the Sierra Nevada Mountains. The mountain yellow-legged frog occurs almost entirely on protected lands yet has declined from more than 98% of its historic range (Vredenburg *et al.*, 2007). Currently in the Transverse Ranges, nine extant populations exist across three mountain ranges with less than 200 adult frogs remaining in the wild (USGS unpublished data). This species is listed as Endangered by the IUCN, Endangered by the U.S. Fish and Wildlife Service, Sensitive by the U.S. Forest Service, a Species of Special Concern by the California Department of Fish and Game and is being reviewed for listing as California State Endangered. An informal working group was assembled to address conservation activities for the mountain yellow-legged frog in 1999. This group consists of representatives from the U.S. Geological Survey, U.S. Fish and Wildlife Service, California Department of Fish and Game, U.S. Forest Service, San Diego Zoo, Los Angeles Zoo, and the Fresno Chaffee Zoo. This work involves monitoring known populations, surveying for new populations, habitat restoration, disease screening, captive breeding, and re-establishment to sites within the historic range.

Goals

- Goal 1: To establish self-sustaining populations of mountain yellow-legged frogs within the historic range of the species.
- Goal 2: Understand the genetic structure of remaining frog populations to guide captive breeding and reestablishment efforts.
- Goal 3: Understand the dynamics and challenges of restoring Bd positive wild populations.



Mountain yellow-legged frog © Adam Backlin

Success Indicators

- Indicator 1: Develop effective techniques and protocols for captive husbandry and breeding, translocation, and restoration for mountain yellow-legged frogs.
- Indicator 2: Develop successful captive breeding colonies for each of the three conservation units (mountain ranges).
- Indicator 3: Identify suitable reestablishment sites with compliance from all partners.
- Indicator 4: Increase the numbers of approved re-establishment sites.
- Indicator 5: Expand the available habitat to the mountain yellow-legged frogs at sites currently occupied through habitat restoration.

Project Summary

Feasibility: The mountain yellow-legged frog was historically abundant across the Transverse Ranges of southern California. Museum vouchers indicate a large scale decline occurred between 1968 and 1970, likely due to the amphibian chytrid fungus (*Batrachochytrium dendrobatidis* - Bd). By the mid-1990s it was apparent that this species had declined to a point that required active management in order to persist. In 2000, surveys were initiated to understand the population status and identify remaining populations. To date, nine populations have been found, occupying less than 1 km of stream habitat, with all but three populations containing less than 20 adults. Disease screening revealed all populations to be positive for Bd. Mitochondrial and microsatellite analyses show that substantial population structure is evident. This data suggests a high degree of historical isolation within and between mountain ranges and that each mountain range in southern California should be managed separately to protect unique evolutionary lineages of the mountain yellow-legged frog (Schoville *et al.*, in press). As part of an emergency salvage effort in 2006, 86 tadpoles were collected from Dark Canyon, San Jacinto Mountains, Riverside County, CA, USA, to prevent desiccation. These tadpoles were placed in a captive husbandry program at the San Diego Zoo Institute for Conservation and Research and raised to adults for captive breeding. In 2009, 106 additional tadpoles were collected from Devils Canyon, Los Angeles County, CA, USA, as an emergency salvage following a wildfire that burned the occupied watershed. These tadpoles were placed in a captive husbandry program at the Fresno



Typical habitat of the mountain yellow-legged frog © Adam Backlin

Chaffee Zoo with plans to raise these animals to adults for captive breeding. To obtain approval for a location to release mountain yellow-legged frogs, several permit and regulatory processes were required. Both federal and state permits were obtained to collect, relocate, breed, and release mountain yellow-legged frogs. A Memorandum of Agreement was developed and signed by all relevant partners to facilitate and approve releases of mountain yellow-legged frogs.



Preparing for release © Adam Backlin

Implementation: 2010 marked the first successful captive breeding of the mountain yellow-legged frog at the San Diego Zoo Institute for Conservation and Research. Two releases were conducted in April and in August 2010. The April release consisted of three egg masses (approximately 600 eggs) placed in cages in the stream. The August release consisted of 36 tadpoles head-started from the San Diego Zoo that were placed in cages in the stream. All releases were conducted in Indian Creek, Riverside County, California, USA. The breeding in 2010 produced approximately 1,200 eggs. Unfortunately, only 46 of the eggs released were fertilized and 36 tadpoles survived in the head-starting program to be released, totaling 80 released mountain yellow-legged frogs in 2010.

Post-release monitoring: Following the egg mass and tadpole releases, surveys were conducted to monitor the success of this effort. Eggs were monitored bi-weekly in their cages until they hatched. After hatching, weekly surveys were conducted. No tadpoles were detected in the creek following hatching. This is likely due to the small number and size of the newly hatched tadpoles and their cryptic coloration and behavior. All 36 head-started tadpoles were released into four cages at two locations within the stream. At each location, nine tadpoles were placed in each cage. Cages were monitored bi-weekly for the first two weeks then bi-monthly until the onset of winter. After the first week, nine tadpoles were released into the creek at each location. All 18 tadpoles appeared healthy when released. The remaining 18 tadpoles remained in the cages for monitoring until winter, approximately three months. With the first winter storm approaching in November 2010, the remaining 18 tadpoles were released. The bi-monthly monitoring also failed to detect tadpoles within the stream.

Major difficulties faced

- Problem obtaining the appropriate permits for all partners. This required approval by all partners which is challenging due to the complex logistics required for regulatory agencies and land managers to approve sites for reestablishments in southern California.
- Securing long term funding is difficult and requires actively seeking and applying for grants.
- Low fertility encountered in the first year breeding effort.

Major lessons learned

- Initiate restoration and conservation actions before species reaches critical stages.
- Develop comprehensive working group with representation from all required partners at the early stages of restoration.
- Develop long term adaptive recovery planning at early stages of project.
- Species level restoration requires long term commitments from multiple partners.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The partial success of this project was the accomplishment of releasing a captively breed endangered species into the wild in southern California.
- The success of the frogs re-establishing their new site will require at least five years to evaluate.

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Re-introduction program for the common midwife toad and Iberian frog in the Natural Park of Peñalara in Madrid, Spain: can we defeat chytridiomycosis and trout introductions?

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Introduction

The common midwife toad (*Alytes obstetricans*) is a broadly distributed toad in Western Europe cataloged as a near threatened species in the National Red List of Spain (Pleguezuelos *et al*., 2002), although in Madrid it is considered as endangered. In the Natural Park of Peñalara, a rocky montane area with around 250 ponds, the toad population was very abundant in the past, but declined during the late 90's due to the disease caused by the chytrid fungus *Batrachochytrium dendrobatidis* (Bosch *et al.*, 2001). The Iberian frog (*Rana iberica*) is endemic of the Iberian Peninsula and is distributed mostly in the northwest, with few fragmented populations in the center and north of Spain. Its populations have been cataloged as Vulnerable in the National Red List of Spain, being threatened by habitat deforestation and alien species introduction. In Peñalara, due to past introductions of brook trout (*Salvelinus fontinalis*) and translocations of common trout (*Salmo* trutta), the Iberian frog disappeared from vast areas and is now confined to breed in suboptimal ponds where the trout were not present (Bosch *et al.*, 2006)

Goals

- Goal 1: Maintain a captive population of *Alytes obstetricans,* preserving genetic identity, and develop a successful husbandry method.
- Goal 2: Rear *Rana iberica* larvae.
- Goal 3: Reinforce existing populations



Midwife toad (*Alytes obstetricans*) © J. Bosch

and establish new ones for both species, with individuals reared in the Rearing Center.

- Goal 4: Develop effective treatment methods against the fungus infection for a successful re-introduction of *Alytes obstetricans*.
- Goal 5: Eliminate all introduced trout within the Natural Park.

Success Indicators

- Indicator 1: Successful reproduction of *A. obstetricans* in the Rearing Center.
- Indicator 2: High survival rates of metamorphs of both species in the Rearing Center.
- Indicator 3: Increased number of adults of both species found in the field during monitoring programs, and number of reproductive events.
- Indicator 4: Higher rates of uninfected individuals of *A. obstetricans* in the field.
- Indicator 5: Smaller numbers of non-native trout found in the streams from year to year.

Project Summary

Feasibility: The common midwife toad was the most abundant amphibian in the Park before the outbreak of the disease. The male carries the eggs in their limbs for several weeks and then releases them in ponds, where tadpoles can remain in the water for several years before completing the metamorphosis. Such extended larval period increases the probability of contact with the waterborne zoospores of *B. dendrobatidis*. The low number of eggs in the clutches and the high rates of metamorphic mortality due to the disease drove the population almost to collapse within a few years. Two factors hinder the success of re-introductions. Even though the animals are treated before release, they become infected when they come into contact with the fungus. To avoid this problem, the first releases are being conducted in temporary ponds, where there is no overwintering larvae and, therefore, the probability of infection is lower. On the other hand, the genetic variability of the population is now reduced after a bottleneck. Therefore, to ensure the viability of re-introductions a microsatellite study has been carried out, and now we are sorting the crossbreedings to keep the maximum available genetic variability.



Iberian frog (*Rana iberica*) © J. Bosch

The Iberian frog's decline was not so dramatic. The high number of visitants and specially the trout introduction reduced the breeding sites of the species to only a few. The efforts of the Regional Government to recover

natural conditions began in the 1990s, and included the brook trout eradication in the original pond where the species was introduced by using bottom nets. Unfortunately, brook trout colonized the outlet of the original pond and, additionally, local anglers moved common brown trout from nearby downstream sites further upstream. Therefore, we have been electrofishing for trout during the last 9 years until the complete eradication of introduced trout in the Park. Obviously, the feasibility of re-introductions also depends on environmental awareness leading to the abandonment of these practices.



Overview of the habitat © J. Bosch

Implementation: In the case of *A. obstetricans*, since 2006 we have been capturing tadpoles from every location in the Park. These larvae were treated against the fungus using elevated temperature and antifungal drugs. We reared them in aquariums indoors matching environmental conditions to the park and using the same water source until they achieved juvenile or adult size. Most of them were then released in the same places where they were captured, while only some individuals were kept to establish a captive colony. A big effort has been directed to establish a new population in one pond which often dries out at the end of the summer season, keeping a lower chytrid fungus level than the surrounding area. In the case of *R. iberica*, we collected egg masses or tadpoles from a stream which dries out at the beginning of the summer, avoiding the complete development of the larvae. We head-started them in aquariums of 80 liters with up to 50 tadpoles in the Rearing Center, at the same Natural Park of Peñalara, and released them in the field, in streams where fish have been removed. This year, for the first time, we have released not only juveniles but also tadpoles and adults in several locations, in order to compare potential different survival rates across live stages.

Post-release monitoring: We search for active individuals of common midwife toad and Iberian frog two times per week in the summer season. For identification, we previously mark them with VIE (Visible Implant Elastomer tags) or take individual photos. At the moment we have found two males carrying eggs, one gravid female and some tadpoles of *A. obstetricans*. This year we have found, for the first time, some individuals of *R. iberica* that were released last year, and some adults released earlier this year. Additionally, this season we have followed 20 adult animals (15 *Alytes* and 5 *Rana*) by using radio-tracking technology. Additionally, two automatic recording devices (frogloggers) were installed a few years ago to count calling males.

Major difficulties faced

- Length of time between collected tadpoles for head-starting and F1 captive bred toads in *A. obstetricans*.
- The high difficulty to eliminate introduced trout from streams.
- Larval stages are not suitable for re-introduction in both species because they are highly susceptible to both fish predation and fungus infection.

Major lessons learned

- The common midwife toad is easy to maintain in captivity, while the Iberian frog gets easily stressed.
- The mortality of metamorphs in the field during the winter seems to be high, so adult re-introduction at the beginning of the season could be the best choice.
- Indoor rearing of *A. obstetricans* metamorphs under elevated temperatures (around 20º C) is effective, while keeping breeding adults outdoor, under semi-captivity conditions, is the best option to achieve mating.
- Trout eradication from montane streams by using electrofishing requires a great effort but is possible, and recolonization of native amphibian species is considerably quick afterwards.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- In the Rearing Center we have produced over 180 tadpoles of *Alytes obstetricans* this year.
- Metamorphs of *A. obstetricans* and *Rana iberica* have survived almost one winter after its re-introduction.
- Completely successful reproduction (from calling males to tadpoles) of *A. obstetricans* has been recorded this year from released animals.

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Re-introductions of Chiricahua leopard frogs in southwestern USA show promise, but highlight problematic threats and knowledge gaps

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Introduction

Chiricahua leopard frogs (*Lithobates* [*Rana*] *chiricahuensis*) inhabit a diversity of aquatic habitats at elevations between 1,000 and 2,710 m in Arizona, New Mexico, and Mexico (Sredl & Jennings, 2005). The species requires permanent or semi-permanent pools and may be excluded where *Batrachochytrium dendrobatidis* (*Bd*) or introduced predators are present. Additional threats include predation by non-natives, drought, floods, habitat degradation and loss, disruption of metapopulation dynamics, demographic effects of small populations in dynamic environments, and pollutants (U.S. Fish and Wildlife Service, 2007).

Lithobates chiricahuensis is listed as “threatened” in the USA under the Endangered Species Act (67 FR 40790) and “vulnerable” on the IUCN Red List of Threatened Species (Santos-Barrera *et al.*, 2004). The Chiricahua Leopard Frog Recovery Team finalized a recovery plan in 2007. This plan outlines a framework for delisting that, if implemented, will achieve the following recovery criteria: 1) establish at least 16 meta-populations and 8 isolated robust populations



Adult Chiricahua leopard frog, Pima Co., Arizona, USA
© A. King

rangewide, 2) restore breeding habitats and 3) dispersal corridors, and 4) reduce threats so it no longer needs the protection of the Endangered Species Act. This plan also identified management areas (MAs), which are large landscapes with great recovery potential (U.S. Fish and Wildlife Service, 2007).

Goals

- Goal 1: Reduce or eliminate threats in occupied and unoccupied areas needed for recovery.
- Goal 2: Identify sites for population re-establishment and augmentation.
- Goal 3: Develop and operate head-starting facilities.
- Goal 4: Develop and implement release techniques and protocols (collection > pre-release treatment for *Bd* > transport > release).
- Goal 5: Develop and conduct monitoring at re-introduced and other extant sites.

Success Indicators

- Indicator 1: Recovery of natural populations and metapopulations when threats are reduced or eliminated.
- Indicator 2: Successful rearing and release of *L. chiricahuensis.*
- Indicator 3: Establishment of sustainable populations.
- Indicator 4: Dispersal of released frogs to adjacent, unoccupied aquatic sites.
- Indicator 5: Success at creating refugia (assurance populations) when necessary.

Project Summary

We review three case studies that provide insight into key elements of successful *L. chiricahuensis* re-introductions in Arizona and make special mention of the problematic impact of chytridiomycosis in New Mexico.

Case Study 1 - Upper East Verde River Management Area (MA), Arizona, USA: The Upper East Verde River MA is located in north-central Arizona in the westernmost portion of the historical range of *L. chiricahuensis*. The upper Verde River drains approximately 6,500 km^2 and comprises most of the MA. Between 1995 - 2007, 38 surveys found fewer than 16 frogs at three sites and moderate

threats. In 2009 and 2010, captively-reared frogs were released into four perennial tributaries of the East Verde River. A total of 3,542 metamorph frogs and late-stage tadpoles have been released to 13 sites throughout the watershed. Three of which were recipients of 3½ egg masses produced in the wild by released frogs. Post-release monitoring in 2010 - 2011 documented breeding at four of 13 release sites in as soon as 10 months post-release. Released individuals have dispersed and reproduced at four new localities. To date, 32 egg masses have been observed.

Case Study 2 - Pajarita Wilderness and Alamo-Pena Blañca-Peck Canyon MAs, Arizona, USA and Mexico: The Pajarita Wilderness and Alamo-Peña Blanca-Peck Canyon MAs are located in extreme southern Arizona and adjacent Mexico. In the 1930's, the Atascosa-Pajarito mountains supported three native ranid frogs: *L. chiricahuensis*, lowland leopard frog (*L. yavapaiensis*), and Tarahumara frog (*L. tarahumarae*). By the late-1970's, populations of *L. chiricahuensis and L. yavapaiensis* dramatically declined and *L. tarahumarae* was extirpated, likely due in part to chytridiomycosis. In addition, over the last few decades, *L. chiricahuensis* and *L. yavapaiensis* have slowly been displaced by invasive, introduced bullfrogs (*L. catesbeianus*). In fall 2008, efforts to eradicate *L. catesbeianus* were initiated. By 2010, post-removal monitoring confirmed that *L. catesbeianus* had been eradicated. Monitoring indicated immediate changes to *L. chiricahuensis* and *L. yavapaiensis* distributions. Surveys from 2010 - 2011, revealed *L. chiricahuensis* and *L. yavapaiensis* had dispersed into eight and three sites, respectively, that were previously unsuitable due to presence of *L. catesbeianus. Lithobates chiricahuensis* dispersed overland and through ephemeral drainages at least 7.9 km, occupying a site farther north than the species has recently been documented in the region. The results of this project indicate that re-introduction of native amphibians is not always necessary if a key threat is removed. Although *Bd* is still present throughout the mountain range, populations of native frogs are now persisting with the disease, and elimination of bullfrogs has created a landscape where both *L. chiricahuensis* and *L. yavapaiensis* can potentially thrive with minimal management.



Seining to reduce numbers of tadpoles from an earthen stock tank © AGFD

Case Study 3 - Black River MA, Arizona-New Mexico, USA: The Black River MA is located in central Arizona and adjacent New Mexico. This area contains the most mesic habitats and the highest elevation



Juvenile frog being released into a historical site © A. King

historically occupied site and still contains apparently suitable lotic and lentic habitats. Historically, the frog was known from numerous sites throughout the MA, but by the late-1980's it was known from only five sites. In 1996, wild frogs were collected for breeding and head-starting. Although, presence of non-native sportfish and crayfish has made habitat selection for re-introduction of frogs challenging, we considered that the overall complexity and connectivity of the sites in this area would allow for establishment and persistence of frogs. Since 1996, three sites were augmented, but by 2000, fewer and fewer frogs were being detected. Over the past 11 years, re-introduction of captive reared frogs has continued at four historical sites. Although frogs were released multiple times to some sites over several years, most releases comprised fewer than 100 individuals. Generally, post-release monitoring has included surveys shortly after release, followed by subsequent surveys two to three times a year. Survey results show releases have not been successful and *L. chiricahuensis* has not been detected in the Black River MA since 2009. Reasons for failure are not entirely clear; however, we have not detected *Bd* at any of these sites.

Recovery in New Mexico, USA: Re-introductions in New Mexico have not taken place as frequently as in Arizona, partially because the frogs appear to be particularly susceptible to chytridiomycosis. This sensitivity has caused annual population extirpations and has necessitated a different initial recovery strategy focusing on creating off-site refugia to safeguard genetics. To create refugia, wild eggs, tadpoles, or metamorphs are collected, brought into captivity, reared, tested for disease, treated if necessary, and released to confined steel rim tanks. These tanks not only serve as refugia, but in time will also serve as sources for re-introduction efforts. To date, 8 lineages have been established in refugia. Two of the source populations for the eight refugia have since experienced die-offs and are believed extirpated (U.S. Fish and Wildlife Service, 2011). Now that sufficient refugia have been established, the focus of recovery in New Mexico has shifted to augmentations and re-introductions.

Major difficulties faced

- Presence and impact of nonnative predators and pathogens.
- Lack of suitable habitat.

- Poor understanding of habitat requirements.
- Poor understanding of *L. chiricahuensis* metapopulation dynamics.
- Lack of resources for effective post-release monitoring.

Major lessons learned

- Removal of non-natives is possible if done by using a systematic landscape-level approach.
- Disease appears to be a major impediment to success in some portions of the range.
- The success of *L. chiricahuensis* re-introductions is enhanced by multiple releases of late-stage larvae and metamorph frogs (n=100 - 400) to multiple sites within a watershed.
- Egg mass transplants can be successful.
- Close coordination among partners in re-introduction projects is essential.

Success of projects

Overall success summary of all case studies:

Highly Successful	**Successful**	Partially Successful	**Failure**
1	**1**		**1**

Case Study 1 - Upper East Verde MA:

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Large number of frogs released to the watershed.
- Lack of non-natives present at release sites.
- Adequate post-release monitoring.
- Documented successful reproduction and dispersal after releases.
- Determination of success is based on two years of post-release data.

Case Study 2 - Pajarita Wilderness and Alamo-Peña Blanca-Peck Canyon MAs:

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Implemented a systematic, landscape-level approach to remove *L. catesbeianus* from all possible sites.
- Focused on complete removal, not reduction or control.
- Removal of *L. catesbeianus* allowed for re-colonization of *L. chiricahuensis* and *L. yavapaiensis.*

- *Bd*, although widespread in the region, currently does not appear to significantly affect native leopard frog populations.
- Continued monitoring for *L. catesbeianus.*

Case Study 3 - Black River MA:

Highly Successful	Successful	Partially Successful	**Failure**
			√

Reason(s) for success/failure:

- Small numbers of frogs available for release.
- Insufficient post-release monitoring to determine success of releases.
- Presence on nonnative predators.
- Potentially unknown reason for failure (e.g. low genetic variability, extreme susceptibility to disease, etc.).

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Conservation introduction of the Cape platanna within the Western Cape, South Africa

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Introduction

The Cape platanna (*Xenopus gilli*) has a disjunct distribution in the winter rainfall region of the south-westernmost part of the African continent. Records for this frog span a distance of around 160 km from the Cape Peninsula towards Cape Agulhas (de Villiers, 2004). It has been listed as Endangered (B1ab(i,iii)+2ab(i,iii)) in view of its declining extent of occurrence (currently 1,450 km^2) and area of occupancy, and a continuing decline in the extent and quality of its habitat (SA-FRoG & IUCN SSC-ASG 2009). The majority of its recorded acid blackwater localities have been destroyed or degraded through development and associated threats (Picker & de Villiers, 1989). By the late 1980s the species could no longer be found at 60% of known localities, including one of the originally described localities in the Silvermine River, and virtually the entire western population was effectively confined to Cape of Good Hope Nature Reserve (CoGHNR), at the tip of the Cape Peninsula (de Villiers, 2004). Few acid blackwater pools remained in this region, but several were identified in the protected upper catchment area of the Silvermine River. It was thus decided to introduce individuals from CoGHNR, over about 25 km, to this Silvermine area.

Goals

- Goal 1: To establish a new *Xenopus gilli* population in appropriate blackwater habitats in Silvermine.
- Goal 2: To seed the Silvermine River with individuals which might spread onto the Cape flats and surrounds
- Goal 3: To safeguard the genetic integrity of the Cape platanna away from the invasive common platanna (*X. laevis*) and to reduce disease threat.



Freeze brand visible on ventral surface of a recapture after ten years (inset) © G. J. Measey

Success Indicators

- Indicator 1: Sustainable populations of *Xenopus gilli* in acid blackwater ponds in Silvermine.
- Indicator 2: Absence of genetic introgression with common platannas.
- Indicator 3: Spread of *Xenopus gilli* into surrounding water bodies.

Project Summary

Feasibility: A survey of the acid blackwaters in Silvermine Nature Reserve took place in 1987 when waterbodies were also trapped to make sure that none contained existing populations of *Xenopus gilli* or *X. laevis*. Thereafter, larger waterbodies in different geographic areas within Silvermine were chosen as release sites. It was hoped that the released frogs would lead to the colonization of smaller surrounding waterbodies.

Implementation: On 23rd April 1988, 154 newly metamorphosed *X. gilli*, were translocated from the genetically pure Gilli Dam population in the Cape Point area to Silvermine. Metamorphs were released into four water bodies: Nellie's Pool, Hennie's Pool, Silvermine Reservoir and Dammetjie. Most of the froglets (69) were released in Nellie's Pool as it appeared to have the most suitable habitat.

Post-release monitoring: Monitoring was conducted from 1989 to 1990. On April 3rd, 1989 1 male *X. gilli* was captured at Nellie's Pool (by R. Rau, pers. comm.), and on 2nd November 1989 2 males and 4 females were trapped at the same site (AdV). No *X. gilli* were found during a 5th October 1990 visit. Further monitoring was left to reserve staff, but no records exist. In 1998 when we returned to one site (Nellie's Pool) to determine whether individuals were still present. Six females were captured, of which three were marked by freeze-branding (Measey, 2001). A hiatus of 10 more years passed before in June 2008 we again visited all sites where *X. gilli* had been released. Baited funnel traps were placed into each of the release points to ascertain presence of *X. gilli*. Only Nellie's Pool was found to have individuals present. Amongst those captured were two which were still marked with freeze brands from 1998.

In August 2011, we trapped on two occasions at Nellie's Pool catching a single female (and sighting one more individual). The belly pattern on this individual corresponded unambiguously to a female caught in June 2008 and had a freeze brand from 1998. Our results are of interest as we demonstrate the extreme longevity of this species in its natural habitat (>13 years). The individuals that were marked in 1998 were adult and it is not infeasible that these were the same individuals which were released in 1988.

Major difficulties faced

- Finding suitable acid black water release sites.
- Lack of suitable lowland habitat restoration.
- Insufficient monitoring to detect recruitment and dispersal of released population.

Major lessons learned

- No funding or capacity was available to systematically monitor translocated frogs in this study in the short or long term. Approval of such projects should be dependent on such provisions being demonstrated.
- Little is known about the distribution densities of this species in upland areas, with all known populations being in lowland sites. It may be that if upland sites are suitable but they occur at low densities.
- Survival of the frogs in Nellie's Pool could be because it is artificially dammed and thus contains an increased volume of suitable blackwater habitat for this species.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Unexpected longevity of individuals may have facilitated successful breeding spanning unfavorable years with low winter rainfall.
- One of the release sites has remained stable throughout the study and facilitated at least occasional breeding of this frog.
- Other sites either contained predatory fish lacked suitable habitat to maintain viable populations.

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Re-introduction of African spurred tortoise in North Ferlo, Senegal

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Introduction

African spurred tortoise (*Centrochelys sulcata*, Miller, 1779) populations have decreased all over Africa. The main causes of this Sahelian species extinction are desertification, overgrazing, fragmentation of habitats and collection for the illegal animals trade. This species is classed as Vulnerable in the Red Book of IUCN and listed on CITES Appendix II. In July 2006, SOPTOM association released 24 African spurred tortoises in the North Eastern Senegal (Reserve of Fauna of North Ferlo), the last region of the country where this species still living in the wild. Each individual was fitted with a transmitter and a daily localization by radio-telemetry was made for two years to ensure a good adaptation of the group to the natural environment. The two years that followed, daily monitoring was stopped and there were just routine observations without human intervention (to ensure good survival was not due to human intervention). In 2010, after four years of study, the survival rate for this group was over of 80%, which shows the effectiveness of this method in the conservation strategy of the African spurred tortoise. In parallel, awareness and support of local populations have been conducted to raise awareness on biodiversity protection.

Goals

- Goal 1: Sustain the latest African spurred tortoise wild population in Senegal.
- Goal 2: Monitoring the released population to ensure a good adaptation to the wild environment.
- Goal 3: Awareness of local populations to the effects of desertification and overgrazing on the Sahelian environment.



African spurred tortoise (*Centrochelys sulcata*) in mud © L. Garrigues/SOPTOM

Success Indicators

- Indicator 1: Releasing a first African spurred tortoise population reared in captivity.
- Indicator 2: Survival and a self-sustaining released population.

- Indicator 3: Interest of the local community (mainly young and shepherds) about tortoises and about our work by visiting us in the “tortoise house”, awareness house near the re-introduction zone.



Raising awareness with school children

Project Summary

Feasibility: Ferlo region in north-eastern Senegal is a typical but very enclave Sahelian region where live the Pulani, an ethnic group of nomadic shepherds, with vast herds of zebu cattle, sheep and goats that affect the natural resources of the area. Ferlo zone is divided into two Reserves of Fauna (Reserve of Fauna of North Ferlo and Reserve of Fauna of South Ferlo). The government wishes to be more involved in protecting its biodiversity. The re-introduction of iconic species like this tortoise species in the North Reserve (which is managed by the National Parks) is therefore a local and national desire. In Dakar, Senegal there is the “tortoise village" which is an awareness and tortoise breeding’ center. It is jointly managed by SOPTOM and the Senegalese Association SOS Sulcata, and one of its aims is rearing an African spurred tortoise population for future release in the Ferlo. The biggest threats for African spurred tortoise are overgrazing with the large numbers of cattle in the Ferlo zone, habitat fragmentation and collection for the exotic animal trade. Preliminary studies in this last area in Senegal where the African spurred tortoises is still found in the wild (Cadi & Devaux, 2003) shows there is less than 1 tortoise/km^2. This species is more represented in captivity (for local customs or as pets) than in the wild.

Implementation: There is one 600 ha area in the Reserve, protected from livestock by a fence, near the village of Katané with a high biodiversity. This area was ideal for a release site for our population of *Centrochelys sulcata*. The 24 tortoises from the tortoise village were tracked for several months in quarantine and underwent genetic and health tests to ensure their health and geographical origin. Some genetic differences were reported between Eastern and Western wild populations in the species’ geographic range (Devaux, 2000). On 8th July 2006, selected individuals were released in the North Ferlo Faunal Reserve, at Katané after undergoing the final steps (e.g. measurement of weight, size, installation of transmitter, etc.). The Pulani local population had very well received this program and residents of nearby villages have often provided assistance to the smooth running of daily monitoring activities.

Post-release monitoring: Monitoring of the re-introduced population was done in two parts over a four year span. The first two years, from 2006 to 2008, the



Typical burrow of African spurred tortoise

monitoring was done daily by telemetry jointly by scientists from the North and Senegal National Parks guards. Each individual was fitted with a transmitter and with help of a local tracker (poacher reconverted) we found the tortoises daily. After two years of follow up, the survival rate of this population was 90%. It is very encouraging because it means the good adaptation of this species to the harsh natural conditions. Growth and weight of each individual were measured regularly and were good, which shows a good diet. All behaviors observed in wild populations have been in this population (digging burrows to spend the dry season, feeding and mating) and in the same frequencies to the wild population.

From 2008 to 2010, the population was monitored by regular observations without any human intervention to ensure that these very encouraging results were not due to human interference. In 2010, at the end of these two phases, the survival rate of the population was 80%, which is still very encouraging. Mortalities were recorded exclusively due to fighting between males, which results in one tortoise turning on its back and this the main cause of adult death in the wild. The results of this re-introduction is very promising for the future of wild African spurred tortoise in Senegal and is an example of a sustainable conservation strategy for this species in Africa. These results lead us to continue and extend the experience. It is planned to re-introduce a new population of *C. sulcata* in June 2011.

Major difficulties faced

- The lack of protected areas for wild fauna. The Sahelian environment in Senegal is highly degraded particularly because of overgrazing. Wild populations of *C. sulcata* are struggling to find food and rest areas. Only protected areas may allow a successful re-introduction and these areas are still too few.
- The increasing human population in the reserve and its settlement near water points

Major lessons learned

- The involvement of local human population is essential to sustain and make such a re-introduction program successful.
- Even if they are bred in captivity, spurred tortoises can adapt to the local dry climate.

- Even though some of the individuals wander away from the protected area, most of the group stays near the water pond.
- The protocol during release in regard to sex ratios has to be carefully decided as many males result in fighting and stress for the population.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The good adaptation of the released population of African spurred tortoise in wild conditions. All natural behaviors have been observed, digging good burrows to spend the dry season, feeding with a good growth and mating with egg shells found every year in the nests.
- The good participation of the human population in the project which show the interest in this project. Every year, after the wet season, tortoises wander away to the fence to eat grass and local children and shepherds warn us of their locations.

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Translocation of giant tortoises in the Seychelles Islands

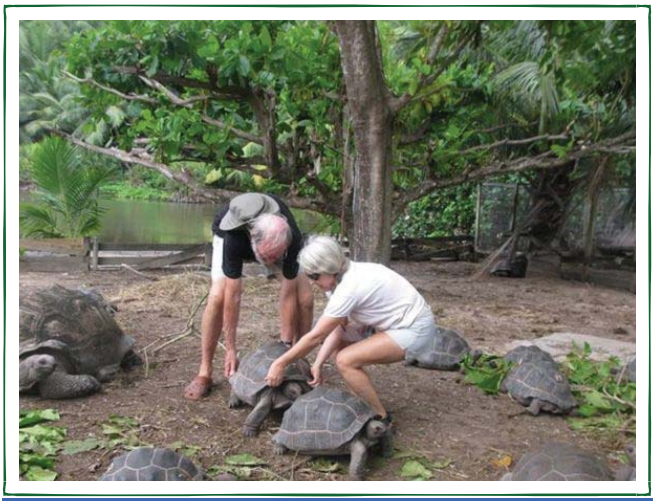
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Introduction

Historically the Seychelles islands supported several forms of giant tortoise. The taxonomic status and their nomenclature is the subject of acrimonious dispute at present. The Tortoise & Freshwater Turtle Specialist Group currently refers to them as either *Aldabrachelys gigantea* or *Dipsochelys dussumieri* (Turtle Taxonomy Working Group, 2010). Since 1997 Nature Protection Trust of Seychelles (NPTS) has been attempting to restore populations of two subspecies formerly considered extinct. Through successful captive breeding the Seychelles giant tortoise (*D. dussumieri hololissa* or *A. gigantea hololissa*) and Arnold's giant tortoise (*D. dussumieri arnoldi* or *A. gigantea arnoldi*) (Gerlach & Canning, 1998; Gerlach, 2004) were to be re-introduced into the wild on Silhouette Island and an initial re-introduction was made in 2006 (Gerlach, 2005; Pemberton & Gilchrist, 2009).

Further releases were planned for 2010 but the eviction of NPTS from Silhouette Island and the refusal of the Authorities to allow the establishment of wild tortoises in the Silhouette National Park necessitated a change in the project. Accordingly the tortoises were released on North, Fregate and Cousine Islands. These two forms are currently listed under the Aldabra giant tortoise as Vulnerable (proposed status as subspecies: Critically Endangered) and all tortoises are listed on CITES Appendix II.



Tortoises selected for relocation to North Island

Goals

- Goal 1: To increase the numbers of individuals of giant tortoises through captive breeding.
- Goal 2: To re-establish viable wild populations of giant tortoises on Silhouette Island.

Success Indicators

- Indicator 1: Captive breeding records showing a significant increase in numbers.

- Indicator 2: Survival of released tortoises on Silhouette Island.
- Indicator 3: Record of wild hatched juveniles on Silhouette Island.



Tortoises en route to Cousine Island

Project Summary

Feasibility: Until the middle of the 19th century giant tortoises were found on most of the granitic islands of Seychelles. These populations were lost through hunting, sale to passing ships and thousands were sent to Mauritius where the native species had been exterminated. On the granite islands, the few remaining native species were subsequently mixed with giant tortoises from Aldabra. Silhouette Island was selected for re-introduction as it was possible to remove the captive Aldabra tortoises and re-introduce the native giant tortoise to the last remaining granite island that has no roads and minimal development. The island supports a wide range of habitats, has a large geographical area (2,000 ha) and has restricted access from the sea. The main settlement area of La Passe is accessible by boat but access is controlled by security guards. The Grande Barbe area is only accessible from the sea for a few weeks of the year and is consequently very rarely visited. The small human population were aware of and supportive of the project and the tortoises were a major attraction for tourists staying at the island's only hotel, and for visitors to the island on small expedition orientated cruise ships. Although no entrance fees were every charged, financial support for the project came via donations and adoption of tortoise hatchlings. Re-introduction of tortoises to Silhouette was proposed in 1996 and approved by the Seychelles government's Ministry of Environment and Silhouette's management, the Islands Development Company (IDC) - a government development company. Reporting of progress on the project was by quarterly reports throughout the life of the project.

Implementation: The captive breeding of the giant tortoises was slow to start as the animals had previously been kept in captive conditions that varied from poor to abysmal. Five years after transporting the tortoises to Silhouette and releasing them into a spacious enclosure, the first viable eggs were produced. By the end of 2010 some 180 hatchlings had been raised. No health problems were ever encountered, the only losses were due to theft, which resulted in improved security for all the hatchlings. In December 2006, five adult *D. arnoldi* were released at Grande Barbe on Silhouette. This is an area with substantial vegetation, an extensive marsh system and a human population that varied from 3 to 8 inhabitants. The second release was planned for April 2010, when 30



Tortoises being released on North Island
© L. Vanherck

juveniles weighing between 15 and 30 kgs were to be released at Grande Barbe to increase the herd size there.

A project document detailing the proposed release of the tortoises and using IUCN guidelines was submitted to the Ministry of Environment and to the IDC. There were two submissions and permission for re-introduction was refused on both occasions based on the possible impact of tortoises on the vegetation and the possible risk of tortoises being poached. This reason completely overlooks the presence of free-roaming tortoises on a number of nearby islands where poaching is not a problem. At the end of 2010, NPTS was evicted from Silhouette and alternative release sites had to be found. In 2011 the tortoise were transferred to North, Cousine and Fregate Islands. On these islands they will be free in the wild but unfortunately mixed once again with Aldabra tortoises.

Post-release monitoring: The tortoises released at Grande Barbe were monitored regularly for the first two months after release by a volunteer who stayed in the release site. Subsequently they have been monitored at 3 - 6 month intervals. On each visit their location was mapped. The 2011 releases on North, Cousine and Fregate are monitored by the ecological managers of the islands according to their management activities.

Major difficulties faced

- The only difficulty experienced was the lack of support for tortoise conservation. The emphasis on development in Seychelles means that conservation projects have no long term security even when plans have been agreed upon. Consequently sustainable conservation depends entirely on privately owned islands, although these are also subject to management changes due to external economic factors.

Major lessons learned

- Re-introduction of tortoises is practical and highly beneficial to environmental restoration.
- To increase the role of tortoise conservation in various agencies in the Seychelles.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Adult tortoises at Grande Barbe have adapted to the wild environment successfully, with evidence of nesting although no juveniles have been located.
- A lack of support for tortoise conservation has prevented what could easily have been a highly successful project.

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Re-introduction and supplementation of terrapins on Silhouette Island, Seychelles

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Introduction

The two Seychelles endemic subspecies of Pelomedusidae terrapin, the black mud turtle (*Pelusios subniger parietalis*) and the yellow-bellied mud turtle (*Pelusios castanoides intergularis*), are categorized on the Red List as Critically Endangered (Gerlach, 2008a & 2008b). This is due to extensive habitat destruction in the past and continuing at present (Gerlach 2008c). In 1998 Nature Protection Trust of Seychelles established the Seychelles Terrapin Conservation Project to determine the conservation needs of these species, to breed them in captivity and to re-introduce them into secure sites.

Successful breeding was achieved for the black mud turtle and re-introduction to Silhouette Island was undertaken in 2002 - 2010 (Gerlach, 2002 & 2005). Only limited success was achieved for the yellow-bellied mud turtle and this was to be the focus of increased research from 2011, however the forced closure of NPTS projects in 2011 prevented this and the captive breeding stock had to be released on Silhouette. This effectively supplemented a relict population.

Goals

- Goal 1: To establish a breeding population of black mud turtle on Silhouette Island.
- Goal 2: To determine the optimal release site by monitoring progress of animals released in different parts of a marsh system.
- Goal 3: To augment a relict population of yellow-bellied mud turtle on Silhouette Island.



Seychelles black mud turtle

Success Indicators

- Indicator 1: Survival of released animals.
- Indicator 2: Evidence of reproduction of released animals.

- Indicator 3: Collection of data allowing comparison of release areas.



Restored terrapin habitat

Project Summary

Feasibility: The two terrapin species are restricted to lowland wetland habitats, the black mud turtle preferring marshes and the yellow-bellied preferring slow flowing rivers. These habitats are under great pressure due to development leading to drainage of wetlands and pollution. The wetlands on Silhouette Island are relatively well preserved and suitable for the establishment of terrapin populations. The island is managed by a government development company, the Islands Development Company (IDC). Since 1997 Nature Protection Trust of Seychelles was mandated to manage conservation on the island under an agreement with IDC and the Seychelles government.

Two potential re-introduction sites were available: Grande Barbe on the west of the island and La Passe on the east. Grande Barbe is the largest natural freshwater marsh remaining in the islands and has marsh and river areas. La Passe has a wetland that runs through the island's main settlement. This includes small marshy areas, a small lake and small streams. This site is occupied by a relict population of yellow-bellied mud turtles, numbering just three adults.

Implementation: Captive breeding was undertaken at the NPTS headquarters in La Passe. This used rescued captive black mud turtles and wild-caught (from Mahe and Praslin islands) yellow-bellied mud turtles. Captive breeding was highly successful for the black mud turtle but only three yellow-bellied mud turtles hatched successfully. In March 2002, five adult black mud turtles (two male and three female) were released at Grande Barbe in an experimental re-introduction. These were fitted with radio-tags with a 6 month battery life and released in the main marsh stream in the center of the marsh system. Eighteen juveniles were released in 2003 in an area of shallow flowing water. In 2009 the decision was taken to cease work on the black mud turtle and to concentrate on the yellow-bellied mud turtle. Accordingly the remaining 6 adult black mud turtles (2 males, 4 females) and one juvenile were released in December 2009 in an area of shallow marsh. The captive yellow-bellied mud turtle population was also restructured and reduced through release of 6 adults in the La Passe marsh.

The project was unexpectedly forced to close in December 2010 when NPTS was evicted from Silhouette Island. As a result it was necessary to make an unplanned release of the remaining 10 terrapins at La Passe.

Post-release monitoring: The 2002 black mud turtle release was monitored for 6 months through radio-tracking. This found wide variation in behavior of the released animals, with some individuals remaining highly sedentary and others ranging widely over the marsh system. Both males and females showed the extremes of behavior. After 6 months when the battery life expired all 5 animals were still present. A trapping survey was carried out in 2003, this located only two animals (still near the release site). Two adult terrapins have been observed since this date (most recently in 2008). The release site for the yellow-bellied mud turtles is within the grounds of the Labriz Hotel which has allowed a greater degree of observational monitoring. At least 5 individuals have been observed.

Major difficulties faced

- The black mud turtle is particularly difficult to observe, being crepuscular and living in marshy habitat. It is very rarely trapped due to the difficulty of trapping in shallow water and their habit of spending extended periods of time buried on land. Radio-tracking was successful but limited funding meant that only tags with a short battery life could be used. This tracking was not cost effective.
- A lack of support from relevant agencies for the project which halted conservation on Silhouette.

Major lessons learned

- Release of black mud turtles requires more intensive monitoring, either using large scale investment in radio tracking or very intensive observation and searching, requiring a large labor force.
- In the long term no meaningful conservation of wetland species can be undertaken without a major change in in attitudes to wetlands by relevant agencies.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Reasonable minimum levels of adult survival (>40%) after 8 years.
- Difficulty of monitoring to determine levels of success for the black mud turtle.
- Lack of support from relevant agencies prevents these being considered fully successful.

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Results from an experimental head starting program for hawksbill sea turtles in the UAE

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Introduction

In the Arabian Gulf, the most common and principal species of concern are the hawksbill turtle (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*) which are also the focus of considerable conservation efforts by the IUCN's Marine Turtle Conservation Program. These two species extensively use UAE waters for foraging and the hawksbill sea turtles use the sandy beaches of several offshore islands of the country for nesting. The hawksbill turtle (*Eretmochelys imbricata*) has declared as an endangered species by IUCN since 1970 and its status has not improved to date. Sea turtles are affected by numerous anthropogenic factors including degradation and loss of nesting habitats, water pollution and impact on hatching success. These threats notwithstanding, the mortality of turtles during the early stages of their life history is relatively high. The hawksbill sea turtle rearing and release (head-starting) program at Jarnain off the coast of Abu Dhabi is an attempt at enhancing wild hawksbill turtle populations in the area.

Goals

- Goal 1: To develop methods of rearing hawksbill hatchlings in captivity with minimum mortality.
- Goal 2: To undertake rearing and release of a small proportion of wild sea turtle hatchlings with the objective of enhancing sea turtle populations in the wild.



Hawksbill turtle © Edwin Grandcourt

Success Indicators

- Indicator 1: Mortality in captivity is less than 30%.
- Indicator 2: Released turtles to become part of the wild nesting population as evidenced by recapture.

Project Summary

Feasibility: A rearing unit was established at Jarnain, an island 140 km off north-west of Abu Dhabi. The unit is fenced



Hatchlings being released into the sea

by thick mesh net to protect tanks from direct sunlight. A small proportion of hatchlings from natural nests of the island are collected for rearing. Tanks of two different diameters (0.6 m and 4.8 m) are placed in a linear fashion to facilitate easy inflow and out flow of seawater through underground pipes. Hatchlings are fed 2% of their body weight with high protein diets (floating 2 mm pellets, 35% protein (TILAPIA 40 CP, ARASCO, Riyadh, KSA). Hawksbills are aggressive in captivity and bite on soft body parts, at times causing serious injuries. The injured hatchlings are treated in nursery tanks until they recover. Once the hatchlings reach a certain age (2, 4, 6 and 12 months) and weight (100 g, 250 g, 400 g and 600 g), they are released, preferably during late evening at the same beach from where they were collected. A small percentage (5%) of hatchlings were reared for over 1 year (yearlings) and tagged before release.

Implementation: A total of 2,640 healthy reared hatchlings including 48 tagged yearlings were released to the sea in last four years. No tag recovery has been reported to date. Behavior and growth of hatchlings in captivity has been documented. Procedures to minimize mortality during the experiment have been developed and standardized. Since main objective of this experiment was to increase the sea turtle population in the wild, hatchlings (hawksbills) were retained for a maximum period of one year. However most (>80%) of the hatchlings were released by the end of 6 months.

Post-release monitoring: The Jarnain experiment in the UAE has been a successful program as long as rearing is concerned however, till we receive tag returns, the objective is not achieved. It is difficult to conclude that the reared turtles have survived well in the wild and have become part of the reproductive population in the region. Hunting of sea turtles in the Arabian Gulf does not exist and the ban of drift net fishing has minimized the suffocation related deaths of turtles. Hence, direct pressure on species is minimal in UAE waters. However, the foraging and nesting habitats of sea turtles in UAE are under natural and anthropogenic pressure. Survey and monitoring of sea turtle nesting, foraging habitats in UAE waters is underway, and the conservation action plan is being implemented. If the habitats are protected, with the existing “no-direct-pressure” on species, we should have a very healthy wild population of sea turtles in this region. By releasing head-started hawksbills to the wild in large numbers, we may create a situation where imbalances in natural resources arise and pressure on critical marine habitats, coral reef and seagrass beds increased. This kind of

natural imbalance may result in various problems pertaining to resource sharing among marine wildlife and habitat. Under this dilemma, results from tag return from the released stocks will provide vital information on head starting as a conservation tool for hawksbills and other species of sea turtles.

Major difficulties faced

- Injury and infection in hatchlings while in rearing tanks.
- Unavailability of long-lasting tags for hatchlings/yearlings.
- Lack of techniques to monitor released hawksbills.
- Remote location of experimental site.

Major lessons learned

- Head starting may not be the best tool for conservation of sea turtles.
- For marine migratory species such as sea turtles, protection of habitat is crucial.
- Re-introduction programs should not be initiated if there is no well defined feasible post release monitoring plan.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Lack of proper monitoring plan.

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Translocation of the St. Croix ground lizard to Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands

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Introduction

The St. Croix ground lizard (*Ameiva polops*: Teiidae) is endemic to St. Croix, U.S. Virgin Islands, and is listed as Critically Endangered by the IUCN and as Endangered by the U.S. Fish and Wildlife Service. *Ameiva polops* was extirpated from St. Croix proper by invasive mongooses (*Herpestes auropunctatus*), and none have been found there since 1968 (Philibosian & Yntema, 1976). Two natural populations persist on Protestant Cay and Green Cay (<10 hectares each), and in 1990, another population was introduced to a dredge-spoil island, Ruth Island (13 ha), with 10 individuals from Protestant Cay and an additional one from Green Cay in 1995 (Treglia & Fitzgerald, 2010). In 2008, we translocated 57 *A. polops* to Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands to expand its range. The species or a congener may have previously existed there, but if so, was extirpated prior to herpetological exploration (Philibosian & Yntema, 1976). The National Park Service eradicated mongooses and invasive rats (*Rattus rattus*) to protect sea turtle nests and make the habitat suitable for *A. polops* (Z. Hillis-Starr, pers. comm.; Treglia & Fitzgerald, 2010). Three years post-translocation, the effort appears successful, with the population growing in number and distribution.

Goals

- Goal 1: Create a self-sustaining population of *Ameiva polops* on Buck Island, St. Croix, United States Virgin Islands.



Lizard with colored glass beads sutured to its tail for visual identification © Lee A. Fitzgerald

- Goal 2: Achieve a population size of 500 individuals in accordance with the Recovery Plan for the species.
- Goal 3: Establish a population of *A. polops* founded entirely with individuals from Green Cay in order that the new population on Buck Island will serve as a replicate of the genetic diversity of *A. polops* on Green Cay. As such, both extant populations would have a replicate.

Success Indicators

- Indicator 1: *Short-term:* Survival of translocated *Ameiva polops* at the translocation site.
- Indicator 2: *Short-term:* Observations of normal behavior of translocated individuals, including courtship and copulation.
- Indicator 3: *Long-term:* Evidence of successful breeding, including documented presence of hatchlings and juveniles.
- Indicator 4: *Long-term:* Documentation of adults, including gravid females, that were not part of the initial translocated population, evidencing that adults hatched from natural nests on Buck Island are reproducing. Population structure consisting of all age and size classes of *A. polops*.
- Indicator 5: *Long-term:* Expansion of the population outward from the initial translocation site.

Project Summary

Feasibility: This translocation was the result of an interagency effort coordinated by the Division of Resource Management at Buck Island Reef National Monument, U.S National Park Service, and involved the United States Fish and Wildlife Service, Virgin Islands Department of Planning and Natural Resources, and Lee Fitzgerald, Michael Treglia, Toby Hibbitts, Amanda Subalusky, and Daniel Leavitt from Texas A&M University. We collaboratively designed this project, achieving consensus on which source population to use, number and sex of propagules, translocation site on Buck Island, capture, transport, and monitoring protocols, and enclosure design.

We used the Green Cay population of *Ameiva polops* as the source of propagules for two reasons. First, it allowed us to achieve the goal of establishing a replicate population of the Green Cay stock. The Protestant Cay population was the founder stock for the Ruth Island population, as genetic analyses by Hurtado *et al.* (pers. comm.) showed that the sole individual introduced from Green Cay is not represented in that population. Second, population estimates clearly showed the Green Cay population was by far the larger of the two naturally extant populations (Treglia, 2010; Treglia & Fitzgerald, 2010), thus removal of individuals would afford the lowest risk to that population. The translocation site was the northwestern beach-forest habitat on Buck Island, which was similar to the habitat on Green Cay, containing mature trees, a mixed understory, and abundant leaf litter that provided ample thermoregulatory, foraging, burrowing, and refuge opportunities.

Implementation: In May, 2008 we translocated 57 (32 males: 25 females) adult *A. polops* to Buck Island and placed them in eight 10 m x 10 m enclosures. The



Part of the translocation team working around the enclosures © Lee A. Fitzgerald

enclosures facilitated habituation of the lizards to the new habitat and enabled us to conduct intense monitoring. The enclosures were open-top, walls were buried a minimum of 15 cm to prevent individuals from burrowing out, and were a minimum of 45 cm tall, which was sufficient to prevent *A. polops* from climbing out. Each enclosure contained 4 females and 3 males (except for one enclosure with 4:4). Supplemental food and water was not necessary. We included several gravid females and courting pairs in the translocation to maximize the potential for reproduction in the founding population. All individuals were permanently marked by toe-clipping, measured and photographed, and fitted with a unique combination of colored glass beads sutured to their tails for easier identification during monitoring. We removed the enclosures on 10th July 2008.

Post-release monitoring: During the enclosure period one observer conducted standardized surveys to monitor the new population of *A. polops*. Once all *A. polops* were translocated, every other day the observer walked slowly around every enclosure for 10 minutes, searching for individuals with the aid of binoculars. We conducted 26 of these surveys and identified 20 of the 57 translocated lizards. Focal animal observations were made on the alternating days, in which the observer walked around an enclosure for 10 minutes or until an *A. polops* was seen. When a lizard was detected, its behavior was monitored for 30 minutes or until it went into a burrow. If no *A. polops* were detected within 10 minutes, the observer went to another enclosure. Other *A. polops* seen were also noted to identify individuals that may not have been detected during other surveys. The observer spent no more than 30 minutes at an enclosure on a given survey, in attempt to observe many individuals from different enclosures. The 64 focal observations demonstrated the translocated *A. polops* behaved as documented on Green Cay and Protestant Cay (U.S. Fish and Wildlife Service, 1984). These lizards spent their activity time primarily foraging and thermoregulating, with other behaviors interspersed, most notably courtship.

From 3rd to 10th July, we also conducted pitfall trapping to confirm the continued presence of individuals that were translocated but not seen during surveys. We



Zandy Hillis-Starr, Chief of Resource Management, National Park Service releasing one of the first individuals into an enclosure © Lee A. Fitzgerald

used five traps, evenly spaced, per enclosure, and opened them from 09:00 hrs - 16:30 hrs each. We only captured two individuals, one of which had never been seen during any of our monitoring. We also captured lizards by hand. Recaptures allowed us to quantify changes in body condition since the onset of the translocation. Eight of the 10 recaptured *A. polops* had increased in body condition ([mass]/[snout-to-vent length]; Dickinson & Fa, 2000), and the increase was significant (paired, one-way Wilcoxon test: V=4, p=0.0068).

One year following the translocation, we surveyed the translocation site for *A. polops*, and captured 11 individuals. Only two were from the translocation; the others included gravid adult females that had hatched on Buck Island, and we also observed numerous juveniles and hatchlings. A standardized mark-resight protocol is being implemented for future monitoring, which should provide reliable population estimates and documentation of increases in the spatial distribution of the population.

Major difficulties faced

- Post-translocation Monitoring: Low detectability of *Ameiva polops* reduced the utility of visual surveys for monitoring individuals in the enclosures. Although we translocated 57 *A. polops*, we only observed 20 individuals during our visual encounter surveys, and never saw more than 10 on a single survey. The detection probabilities were quantified and published (Treglia, 2010; Treglia & Fitzgerald, *in review*).
- Loss of Visual Marks and Low Recapture Success: The glass bead marks were not reliable in our study and many were lost. Additionally, pitfall trapping and hand-capture at the end of the enclosure period yielded low recapture rates and we failed to capture many individuals we knew were present. We did capture one individual that had never been seen in its enclosure, and we were able to estimate average condition from recaptures.
- Escapes from Enclosures: During the enclosure period we documented one *A. polops* that escaped from an enclosure, and promptly sealed the hole through which we believe it escaped. Although we feel that during our time spent in

and around the enclosures we would have seen other escapees, it is impossible to confirm there were no others.

- Funding and Logistics: Budgetary constraints were a challenge that was met by significant, unplanned, in-kind support from USFWS and USNPS collaborators. Collaborators arranged housing, transportation on St. Croix, and large contributions from volunteers. The project was under-funded, especially regarding funds for construction of enclosures, labor for construction, and the researchers' stipends. Project success depended upon graduate student teaching assistant support from Texas A&M University, volunteer participation by members of Fitzgerald's program, and use of available equipment and supplies. In the end, these important collaborations provided much more information and successful outcomes than originally proposed.
- Capture, Handling and Permits: Agencies were concerned about capture and handling methods for *A. polops* on Green Cay, because capture methods can result in death or injury. We met these challenges by working with agencies to develop protocols that would minimize risk to *A. polops* during capture and transport.

Major lessons learned

- Utility of Enclosures: The use of enclosures for this species was extremely valuable for monitoring. The enclosures allowed us to confirm normal behaviors and presumably protected the *A. polops* to a certain degree, as they located and used refugia inside the enclosures.
- Translocation of Gravid Females: We learned that gravid females translocated to Buck Island laid eggs very soon after translocation and hatchlings appeared within two months after the translocation. This is a valuable lesson that highlights the utility of targeting gravid female lizards as propagules in translocation projects.
- Data on Translocated Individuals: Photos of and notes about the translocated lizards were invaluable for visual identification. Some individuals lost bead marks in the enclosures, but were identified based on scars and other unique traits. Morphological data were valuable for assessing condition and growth. In addition to the variables we did measure, we would take additional morphological measurements on translocated animals in future translocations.
- Recaptures: We did not expect such difficulty recapturing individuals from the small enclosures. In retrospect, we would have planned for more and different styles of traps in the enclosures and trapping for a longer period to increase recapture success.
- Radio Telemetry: Radio telemetry of translocated *A. polops* inside the enclosures at the onset of the translocation would have enabled us to determine what happened to some of the lizards that we never saw during monitoring. However, radio-tagging may create additional challenges that should also be considered, such as increased cost, time investment, and possible stress to the animals.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- We define our case as highly successful because it exceeded our expectations in almost every way. The short-term indicators of success (evidence of breeding and behavioral normalization in the new habitat) were all met, as were our three long-term indicators: documentation of numerous juveniles within one year of the translocation; individuals hatched at the translocation site are themselves breeding; confirmation that individuals are dispersing from the translocation site and the population is expanding in area. At this time, 3 or 4 cohorts of hatchlings of *A. polops* have been produced on Buck Island and the population is made up of hatchlings, juveniles, and adults.
- The translocation strategy was a primary reason for success. We used a large propagule size, 32 females and 25 males, and translocated them into 8 enclosures. The use of enclosures in excellent habitat kept individuals in close proximity to each other, which facilitated courtship and breeding. Selection of gravid females and courting pairs was an effective strategy to start a growing population. We observed a hatchling in an enclosure, proving that a translocated gravid female nested soon after being placed in the enclosure. We captured a few courting pairs of *A. polops* on Green Cay and placed them together in enclosures on Buck Island. We documented two copulation events in the enclosures. We also confirmed that *A. polops* reach sexual maturity in less than a year, and the relatively fast generation time allowed the population to increase rapidly.
- Interagency and university cooperation was excellent, and set the stage for success. Cooperation and in-kind support from participating groups allowed the team to accomplish more than anticipated despite limited funding. In addition to the actual translocation, the project enabled a graduate masters degree and thesis and at least seven publications will be produced.
- Eradication of mongooses from Buck Island, an effort spanning decades, was critical to making the site suitable for *A. polops*. Eradication of rats further minimizes potential predation on *A. polops* and helps maintain healthy beach-forest habitat and invertebrate prey.
- Genetic samples from translocated animals enabled us to develop collaborative research on the conservation genetics of *A. polops*. This work clarified the phylogenetic position of *A. polops*, and determined the Green Cay and Protestant Cay populations are genetically distinct and should be managed as significant evolutionary lineages. We also conducted an experiment on detectability of *A. polops* to inform monitoring programs, and an experiment on the effects of *A. polops* on the invertebrate prey base on Buck Island.

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Sand lizard translocation in the UK

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Introduction

In the United Kingdom, sand lizards (*Lacerta agilis agilis*) are listed on schedule 5 of the Wildlife and Countryside Act (1981) and on schedule 2 of the Conservation of Habitats and Species Regulations (2010), designating them "European Protected Species". They are also listed as priority species in the UK Biodiversity Action Plan (BAP). Although most of the species' habitats, i.e. lowland heathland and sand dunes, are now protected, the species status remains classified as un-favourable due to large-scale historical loss of habitat and populations. The main elements of the BAP have been; to legally protect the species' sites, manage and restore the sites' habitats to improve the populations, and to restore the species' range via translocations. The sand lizard naturally remains only in the fragmented heath and dune habitats of Dorset, Surrey and Merseyside. The captive breeding and translocation element of the BAP aims to restore range in England and Wales to c.13 "lost" vice-counties.

Goals

- Goal 1: To re-establish, via captive breeding and translocations, viable sand lizard populations within the species' known and presumed historical United Kingdom range at country, regional and local levels to restore favourable conservation status.
- Goal 2: Re-establishment of the species in both of its primary habitats i.e. lowland heath and sand dunes.
- Goal 3: Re-establishment of the species to protected nature reserves to ensure that long-term population viability is possible.
- Goal 4: Where possible, via landscape



Male Merseyside "race" sand lizard
© Chris Davis

level and site management, assist range expansion of the translocated populations.
- Goal 5: To promote partnerships between all relevant groups and disciplines, to ensure best practice.



Re-introduction site at Morfa Harlech NNR, Gwynedd, Wales © ARC

Success Indicators

- Indicator 1: Establishment of both pre- and post-release monitoring programs.
- Indicator 2: Receptor site habitat suitability index and priority translocation process.
- Indicator 3: Produce an agreed Translocation and Captive Breeding Plan.
- Indicator 4: Establishment of long-term captive breeding vivaria.
- Indicator 5: Produce the Captive Husbandry Manual.

Project Summary

Feasibility: From historical records and on-going monitoring, we have a good understanding of the species' previous and current range, habitat and niche requirements. The funded Species Action Plan (SAP) has allowed pre- and post-translocation monitoring, translocation priority listings, habitat management at receptor sites and continuation of captive breeding vivaria.

Implementation: The sand lizard "fits" within the basic habitat management requirements of the lowland heath and sand dune BAPs. With prior consent, from Natural England or Countryside Council for Wales, we can undertake monitoring to prove species absence, improve receptor sites for the species by habitat management and then initiate the translocation. We have c.10 outdoor captive breeding vivaria, including at Marwell Wildlife Park and Chester Zoo, which mimic the species' heath and dune habitats. For each completed translocation c.150 juveniles (50 per year) are required. Although previously limited, we are currently (with all partners) undertaking research to improve health screening.

Post-release monitoring: Our current monitoring allows assessment of habitat, breeding and range expansion via site-managers, volunteers and researchers. We are currently trying to improve our monitoring and data systems to allow more accurate and efficient monitoring of the species and its habitats and improve data flow between all partners.



Captive breeding vivaria at Marwell Wildlife Park © Tim Woodfine

Major difficulties faced

- Monitoring: All potential receptor sites require 5 years presence/absence monitoring, to ensure the species is not already present.
- Habitat dynamics: Heathlands are naturally prone to fires, some heathland management practices can be damaging to the species and sand dunes are liable to erosion.
- The coordination, planning and delivery of targets can be difficult.
- Long-term funding.
- Climate: This can affect captive breeding success, the numbers of juvenile animals available for translocations and, effects on the heath and dune habitats.

Major lessons learned

- The success of the translocation program has been due to long-term and on-going prior planning, liaison and coordination with all parties.
- The large partnership of organisations involved has combined the specialist knowledge required to deliver all phases of this on-going and evolving program.
- Constant funding has allowed consistent delivery of program targets.
- On-going coordinated pre- and post-translocation monitoring will allow efficient delivery of translocation targets and, long term, assessment of conservation status.
- Many factors are beyond our direct control e.g. fires on heathland, change of habitat management regimes, climate change etc. may all affect the translocated populations and their habitats.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The species has been successfully translocated to 11 vice-counties in England and Wales.
- The species has been restored to 7 vice-counties where they were previously extinct.

- The species has been successfully translocated to both sand dune and lowland heath habitats.
- From the late 1960s to date, there have been 72 site translocations; 47 sites (65.2%) have been successful, 11 sites (15.2%) are on-going with initial signs of progress, 11 sites (15.2%) failed, (8 by heath fires, 3 by insensitive habitat-level management), 3 sites (4.1%) are currently unknown (access/monitoring restrictions). To date; 8,450 animals have been released (1,836 wild animals and 6,614 captive bred).
- Increased on-going research into monitoring, habitat management, husbandry, health screening, genetics etc. will ensure more successful translocations in the future.

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Re-introduction of Turks and Caicos rock iguana to Long Cay, Turks and Caicos Banks

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Introduction

Relatively small, Turks and Caicos rock iguanas (TCRI; *Cyclura carinata carinata*) typically reach less than 800 mm and under 2 kg in size, but are generally much smaller than this. Inhabiting the islands of the Turks and Caicos Banks, TCRIs inhabit a variety of habitats (Burton & Bloxum, 2005), although they appear to prefer rock coppice and sand strand vegetation (Iverson, 1979). The IUCN lists the TCRI as Critically Endangered and the species is included on Appendix I of CITES. Gerber and Iverson (1999) estimated approximately 30,000 iguanas in the Turks and Caicos Islands; however, the species disappeared from 13 islands in the last 20 years and its range contracted by about 94%. Predation by feral animals, notably domestic cats and dogs, likely represents the primary cause of the species' decline (Iverson, 1978); however, tourism development destroys habitat and often leads to the introduction of iguana predators onto islands (Mitchell *et al.*, 2002). The critical status and declining number of TCRIs induced us to explore the possibilities for restoration and re-introduction onto cays that formerly supported the species. Toward that end, we began working with the Turks and Caicos government in the late 1990s to begin an iguana restoration project.



Turks and Caicos rock iguana

Goals

- Goal 1: Eradicate introduced domestic cats from Long Cay.
- Goal 2: Establish a re-introduced population of iguanas from Big Ambergris Cay.
- Goal 3: Prevent future releases of domestic cats on Long Cay.

- Goal 4: Build support for the population among local people.
- Goal 5: Develop sound policies and governmental support for iguana conservation.



Long Cay, TCI - site of the re-introduction

Success Indicators

- Indicator 1: Absence of domestic cats on Long Cay.
- Indicator 2: An established population of Turks & Caicos rock iguanas on Long Cay, with an increase in iguana numbers and distribution following establishment.
- Indicator 3: No future sightings of feral cats or feral cat spoor on Long Cay.
- Indicator 4: Positive attitudes toward the TCRIs among the local public.
- Indicator 5: Supportive legislation and policies and active governmental implementation of those policies and population monitoring for the restored population.

Project Summary

Feasibility: As part of a mitigation effort for planned tourism development on Big Ambergris Cay, Caicos Bank, we conducted a feasibility assessment to re-introduce iguanas that the development would displace (Mitchell *et al.*, 2002). Following evaluation of several possible re-introduction sites, we selected Long Cay in 1999 as a target island for re-introduction because of its size; broad array of food-plant species; habitat diversity, including sandy nesting sites and a limestone ridge with abundant refugia; elevated topography for hurricane protection; absence of introduced ungulates; lack of human development; and the island's status as a protected government reserve (Mitchell *et al.*, 2002). We also examined socio-political considerations. We worked with local people to develop support and understand reasons for people releasing cats onto uninhabited islands. We developed strong relationships with the Turks and Caicos government and worked with government staff on our project. We failed, however, to explore relations with other conservation organizations and how those relationships (or lack thereof) might impact our work.

Implementation: In 1999, we undertook a feral cat eradication campaign as a necessary first step (Mitchell *et al.*, 2002). We began re-introducing iguanas following cat eradication. Re-introductions took place between November 1999 and November 2000, during which time we relocated 403 iguanas from Big Ambergris Cay to Long Cay (Mitchell *et al.*, 2002). We implanted all re-introduced iguanas with PIT (passive integrated transponder) tags in their thighs or lumbar regions so that they would remain identifiable. Our outreach program worked to

educate local people about the dangers to iguanas of releasing cats on islands and we installed signs to warn people not to do so. Throughout implementation we maintained excellent governmental relations, but as we moved into the monitoring phase, we encountered problems. Another conservation organization wanted to begin similar conservation work for TCRIs. We offered to collaborate; however, the other group stated that while they would love our financial support, they had no desire for other collaboration. They offered the government more resources than we could provide if they could run future TCRIs conservation work. Wishing to avoid conflict and the possible loss of these resources, we simply agreed to withdraw from further work.

Post-release monitoring: Following re-introduction, we evaluated the re-introduction twice. We performed a preliminary assessment in January 2001, during which we documented untagged hatchlings and 1-year olds (Mitchell *et al.*, 2002). We conducted a more rigorous assessment in 2004 using distance sampling and trapping. That assessment included both a population survey and an evaluation of the condition and growth of iguanas inhabiting Long Cay. We compared those data with data we collected on the population density and condition of iguanas on Big Ambergris Cay in October 2000. In general, we sighted more iguanas on transects with greater habitat diversity as opposed to transects with only 1 or 2 habitat types. We obtained an estimate of 10.34 (95% C.I. = 7.32 - 14.60) animals/ha or 1,065 (95% C.I. = 754 - 1,504) animals for Long Cay. Our population estimate of iguanas on Long Cay represented a 264% (95% C.I. = 187 - 373%) increase over the 403 animals re-introduced, or an instantaneous growth rate of 17.90% (95% C.I. = 27.77 - 37.63%); a growth rate much faster than recorded elsewhere (Iverson, 1979).

Our density estimates for Long Cay were considerably lower than our estimates for Big Ambergris Cay in 2000. On Big Ambergris Cay in October 2000, density estimates in different habitats ranged from 16.62 iguanas/ha in the dunes to 38.93 animals/ha in the fringe/shore areas. However, we predicted that the iguana population on Long Cay would continue to grow until intra-specific competition begins limiting it. We captured 22 animals to monitoring body condition: 6 marked founders and 16 unmarked animals born on the island. All animals appeared healthy, with no significant differences in body mass or snout-vent measurements between Long Cay and Big Ambergris Cay animals. Iguanas on the island appeared to double their weight each year (e.g. 6 animals born on Long Cay had snout-vent lengths >20 cm, range 20 - 31 cm, after ≤ 3.5 years). We noted, but did not quantify, differences in coloration between iguanas born on Long Cay and Big Ambergris, with Long Cay iguanas appearing more brightly colored, with yellow or yellowish-orange dorso-lateral coloration that was most intense on the legs. In contrast, the majority of Big Ambergris animals appeared dull brown or gray. The brighter color of Long Cay iguanas may result from more frequent shedding due to their rapid growth rate.

We found no evidence of domestic cats on Long Cay. The poor relations we encountered with the other conservation organization have precluded us from conducting further monitoring since 2004, but at last report a good population of

iguanas still inhabited the island. In 2002 The Turks and Caicos government presented us with a conservation award to acknowledge our achievements.



Dr. Numi Mitchell and Tim Trout measuring a captured Turks and Caicos Rock iguana

Major difficulties faced

- Conflict with another conservation organization that wanted to be the primary group through which all Caribbean rock iguana conservation took place and which pressured the government for full control over iguana conservation activities.
- Getting local people to recognize the importance of not releasing feral cats, especially black ones that they consider harbingers of bad luck, onto uninhabited islands.
- Developing benefits to South Caicos residents from iguana conservation through ecotourism.

Major lessons learned

- The importance of eliminating the original cause of the species' decline; in this case the introduction of exotic predators in the form of domestic house cats.
- The critical need to work collaboratively among conservation organizations and avoiding competition - there is plenty of work to go around!
- The potential of small, uninhabited islands for restoration and recovery of threatened island species.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- High commitment by all the conservation organizations and government agencies that collaborated on the project.
- Our ability to effectively eliminate the original cause of decline (introduced cats).

- An effective public relations and government monitoring program to prevent further introductions of cats.
- The presence of a healthy source population of animals available for translocation.

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Supplementation of juvenile American alligators in Louisiana, USA

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Introduction

The American alligator (*Alligator mississippiensis*) is widely distributed in high numbers in the southeastern United States. The species is classified as CITES Appendix II and the 2009 IUCN Red List category is LR1c (lower risk/least concern). Most southeastern states have management and harvest programs for alligators, as their high population numbers now support such programs. In Louisiana, an extensive "ranching" program allows for collection of eggs from the wild, in addition to an annual harvest of adult alligators. Egg quotas and harvest limits are established on suitable wetlands by biologists of the Louisiana Department of Wildlife and Fisheries, and are based on population estimates from annual nesting surveys. Because large numbers of eggs are permitted for collection (to avoid natural mortality from flooding, predation, and desiccation), 12% of the eggs hatched are required to be returned as juveniles to the wetlands where the eggs were collected, which is the quantity believed that might have survived to the juvenile age if the eggs had not been collected. These released juveniles therefore supplement the already healthy population, and essentially allow for the collection and utilization of the eggs, while avoiding the high natural mortality of the eggs and new hatchlings.

Goals

- Goal 1: Maintain a stable or rising alligator population statewide while allowing utilization of the egg resource and adult population.
- Goal 2: Ensure enough alligators are released for supplementation to replace that segment of the population collected as eggs.
- Goal 3: Ensure that released alligators have reasonable growth and survival by



Close-up of a female alligator at a nest site

© Ruth Elsey

releasing in adequate juvenile habitat with good prey base, cover, and permanent water.
- Goal 4: Ensure that alligators released for supplementation after being raised in captivity are later capable of breeding and contribute to future population recruitment.

Success Indicators

- Indicator 1: Stable or rising population indices based on annual nesting surveys.
- Indicator 2: Reasonable growth of alligators released for supplementation (monitored by later recapture of marked release alligators by live capture and release work by biologists, or by recovery if harvested as adults many years later).
- Indicator 3: Reasonable survival of alligators released for supplementation (monitored by later recapture of marked release alligators by live capture and release work by biologists, or by recovery if harvested as adults many years later).
- Indicator 4: Documentation of nesting by alligators released for supplementation (observation of marked alligators at nests) or by examination of reproductive tracts of later harvested adult alligators previously released for supplementation as juveniles.

Project Summary

Feasibility: Supplementation of juvenile alligators in Louisiana was felt to be feasible due to the vast acreage of wetlands (2 to 3 million acres of wetlands) as suitable habitat. A long history of harvest of adult alligators by local trappers has led to a strong sense of stewardship of the wetlands by the trappers and landowners. Alligators had previously been captured as juveniles in Louisiana and released to other southeastern states with more limited populations with success to bolster the populations in those states. A strong economic incentive exists by allowing landowners to sell eggs (which otherwise would be lost to natural mortality) to alligator farmers/ranchers, and this encourages landowners to maintain healthy wetlands. The egg ranching program began in 1986 with the initial wild egg collection permits being established, and the first releases to the wild of supplementation alligators being made in 1988. Wild alligator population assessments are made by annual aerial coastal nest counts conducted by helicopter; the nest counts provide an index to follow population trends. These data are used to establish harvest quotas for eggs on participating wetland properties; nest counts have been stable or rising for many years.

Implementation: The re-introduction of juvenile alligators to the wild requires a seven-person team of biologists and wildlife technicians employed by the LDWF. Alligator farms are located all over the state in remote distant locations. Each alligator to be re-introduced is measured and then permanently marked by cutting out two of the alligator's tail scutes, and two web tags with a six-digit identification number are placed between the toes of the rear feet of the alligator. The sex of each alligator is recorded and the alligators are placed in heavy burlap bags and then moved to a livestock trailer or a shady spot prior to release. Complex

calculations are done to determine how many alligators of a given size are required to fulfill the release obligations for each landowner (more alligators if they are less than 121.9 cm, and fewer if they are over 121.9 cm in total length). The alligators are then transported by vehicle and boat to be released in suitable juvenile habitat (small ponds with ample cover and available prey base). In some cases blood samples and other specimens are taken for health surveillance monitoring; in some cases random full necropsies are done by qualified veterinarians to monitor the health of the alligators for supplementation.



Researchers catching a female alligator at a nest for DNA work © Vida Landry

Initial indications suggested the experimental program worked successfully, and the program has expanded markedly since inception. Now, a normal re-introduction season from mid-March until late August can involve statewide travel to measure, mark, tag, measure and sack 40,000 to 50,000 alligators, for the trip to the marsh to be released to their wetlands of origin. This compensates for the 350,000 - 400,000 alligator eggs collected from Louisiana's extensive wetlands (some 2,557,000 acres) in most years. The success of these programs was highlighted in the summer of 2005, when over 507,000 eggs were collected. That fall coastal Louisiana was adversely impacted by devastation from Hurricanes Katrina and Rita; had the eggs not been collected the mortality of the new hatchlings from that year's crop would have been very high. Similar losses were avoided by high egg collections in 2008, when Hurricanes Gustav and Ike again impacted virtually all the wetlands in coastal Louisiana.

Post-release monitoring: The fate of the released alligators for supplementation is extremely important, as it is a major financial factor for the alligator farmer/rancher, as well as very time consuming for the LDWF to administer, so every effort is made to ensure it is conducted as carefully as possible to ensure maximum survival of the alligators. Most monitoring is done by having biological staff work at "check stations" during the annual harvest of adult alligators, to record data on any marked farm-released alligators. This provides data on growth, survival, and possible reproduction, if a large female shows evidence of having nested. Our annual nesting survey also provides indices of population trends, and thus far (after over 20 years of egg collections and supplementation) the population trends are stable to increasing. We have monitored food habits of

alligators released, and found similar stomach contents in released alligators as in native wild alligators caught in the same area; in some cases the released alligators consumed larger prey at a smaller size. Growth rates have shown the released supplement alligators grow as well as or better than native wild counterparts. We have also documented successful nesting by released alligators. A small series of blood samples showed plasma corticosterone (stress hormone) levels were comparable in released alligators captured months after release as compared to wild juveniles.

Major difficulties faced

- Difficulties in statistical analyses of survival based on mark-recapture (survival models often based on much shorter-lived species such as waterfowl), models often show poor "goodness of fit" since alligators often not recovered/ harvested until many years after release when they become adults.
- Difficulties ensuring alligators are released in appropriate juvenile habitat in suitable quantities (just a few alligators in each pond) due to the program being so voluminous and inability to have staff members present at each release site in the wetlands.
- Inexact data exist on survival of wild alligators, making it problematic to determine how many farm-release alligators are required for release to supplement for those eggs collected.

Major lessons learned

- Selection of appropriate juvenile habitat for release; to enhance survival rates and minimize cannibalism.
- Recommend releasing alligators over large areas of wetlands to avoid crowding.
- Releasing reasonable quantities of alligators within one given day.
- Encourage re-introductions when weather/environmental conditions are optimum (ample water levels and low salinities in small ponds) and recommend avoiding extreme exposure to heat (use of refrigerated trucks and limit the brief storage times in shaded locations).
- Recommend using year-specific tail notches to mark re-introduced crocodilians, to help provide data as to at least the year of re-introduction (if not which specific animal) should the foot web tag be lost with later growth.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Implementation of the program has allowed for collections of hundreds of thousands of eggs annually, which would otherwise be lost to natural mortality, and the economic incentive for egg sales encourages landowners to maintain wetlands.
- Annual nesting surveys show stable or rising populations.

- Large numbers of recaptures of alligators previously released from farms for supplementation are harvested each year as large adults, many 3.35 m alligators and even some in the 3.65 m size class have been recovered and survived 12 – 13 years or longer before harvest.
- We have documented successful reproduction by the released alligators for supplementation; thus they now contribute to future population recruitment.
- The significant economic value of the alligator egg harvest helps ensure participating landowners have a strong incentive to preserve wetlands, and this habitat conservation and the releases to the wild help ensure stable alligator populations.

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Attempted supplementation of the relict wild Eastern population of northern bald ibis in Syria with Turkish semi-wild juveniles

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Introduction

Critically Endangered northern bald ibis has had a precariously small population in the Middle East since rediscovery in Syria in 2002 when seven adult birds were found (Serra *et al.*, 2003), but it has since declined to three birds (one breeding pair) in 2010. Following unsuccessful attempts to release captive birds into wild northern bald ibis populations in the past (Bowden *et al.*, 2007) and given the complex social adaptability of the species (Pegoraro & Föger, 2001) and based on experience from European trials work, it was agreed that further work was needed before a re-introduction could be attempted. The International Advisory Group for Northern Bald Ibis (IAGNBI – www.iagnbi.org) recommended attempting supplementation with juvenile birds only as a last resort. When only three birds returned from migration in 2010, it was agreed that such an attempt was justified despite the low likelihood of success. The Turkish Government agreed to donate birds from the semi-wild population in Birecik



Northern bald ibis

which was considered appropriate genetic stock, and an attempt at supplementation was made using input and recommendations of IAGNBI. Development of the method for the supplementation was largely based on the outcome of experimental projects in Europe with hand-raised free-flying Northern Bald Ibises (Fritz, 2010).

Goals

- Overall Goal: Stop the decline of the eastern population of northern bald ibis.
- Goal 1: To develop techniques to integrate and supplement semi-wild northern bald ibis with the wild population in Syria.
- Goal 2: To increase the population size of the remaining wild Syrian population with genetically similar juvenile stock.
- Goal 3: To facilitate contact between supplemented and wild birds in order to maintain a population with historical knowledge of the migration route and favored feeding grounds.

Success Indicators

- Indicator 1: Selection and transportation of birds from Turkey to Syria.
- Indicator 2: Adjustment of the birds to a new area and maintaining their condition following relocation to a new aviary and site.
- Indicator 3: Social interaction with wild birds and the ability to form new social bonds and join a wild flock.
- Indicator 4: Released birds follow the wild birds to local feeding areas and on migration.
- Indicator 5: Maintain condition and survive to eventually return in later years to breeding area.

Project Summary

Feasibility & Implementation: Two juveniles hatched in 2010 were selected from the semi-wild population at Birecik, and together with four adults selected to found a captive breeding program in Syria, these were transported by vehicle 250 km from Birecik in Turkey to Palmyra in Syria in June 2010 and housed in a permanent aviary 35 km from the wild colony. A temporary pre-release aviary was erected in advance, in close proximity to a regular feeding site of the wild birds to allow the wild birds to become accustomed to it. The captive ibises were transferred to the pre-release aviary (two adults together with the juveniles to ensure social stability) and further attract the wild birds. The three wild birds quickly showed interest in the captive birds (within a day), and approached them closely, particular the unpaired female which appeared most attracted to the adult male in the pre-release aviary. Two of the three wild birds left the area on migration less than two days after the juveniles were brought to the pre-release aviary, leaving just one remaining wild adult bird present - an adult female. It was therefore decided to release the captive juveniles the following day (four days earlier than originally planned). They joined the wild bird, and followed her on migration just one day later along with the one wild juvenile.

Post-release monitoring: The two released juveniles, the wild adult female and the wild juvenile were all fitted with satellite ptts. The juveniles also had VHF tags attached for local tracking. They migrated 1,900 km to southern Saudi Arabia in the two weeks after departing Syria. The three juveniles appeared to migrate together with the wild adult female up to this point, travelling a mean of 240 km/day and a maximum of 350 km/day, but from here the adult female continued alone into Yemen and onward to Ethiopia and the three juveniles appear to have split up and wandered around in southern Saudi Arabia. Attempts were made to locate the birds in the field. One released juvenile was sighted in southern Saudi Arabia three weeks after leaving Syria. The wild juvenile was picked up moribund and later died in captivity two weeks after leaving Syria. The two released juveniles are assumed to have died in southern Saudi Arabia approximately 6 weeks and 8 weeks after leaving Syria. Both satellite PTTS were fitted with mortality switches which, based on movement, suggested they were dead. Temperature data also suggested mortality. However it was not possible to retrieve the tags (permission was not available to use the appropriate VHF receiver in Saudi Arabia to aid the search) so we cannot completely rule out the tags becoming detached in both cases, though this seems very unlikely.

Major difficulties faced

- Permission to acquire the birds from Turkey was finalized only shortly beforehand.
- There were serious practical challenges of transportation and authorization due to the international border crossing.
- Selection of the Turkish birds would have been simpler with a more detailed database and history of the birds available.
- It was also difficult to know where the wild birds would be spending time since feeding sites often change - so predicting where to locate the pre-release aviary was a challenge and could not be planned until immediately beforehand.
- The wild birds departed from the breeding grounds almost two weeks earlier than in previous years, further restricting the opportunity for the supplemented birds to acclimatize and regain condition after the stress of relocation.
- There were problems getting sufficiently accurate locations and appropriate VHF equipment to locate the final sites where signals indicated the birds may have died. Getting fieldworkers to the locations quickly proved a particular challenge even once the locations were relatively precise, not permitting us to confirm the likely cause of mortality.
- Juvenile dispersal behavior is not well understood for this species, so we do not actually know what to expect in terms of juvenile timing of movements, and how long they can be expected to remain together with adult birds. It is likely that juveniles having suboptimal physical condition tend to fall behind the adults during migration, which may cause them to lose contact with the adult leaders. Although this may be natural, it could potentially be a problem, particularly once the population has dropped below a critical level and there are no other adults to follow.

Major lessons learned

- Earlier selection of birds and transportation would allow the birds to regain condition prior to release.
- Supplementation does appear to be feasible despite early indications from other studies that such a technique might not be. The presumed close relatedness between the Syrian and Turkish populations may have contributed to this success.
- Based on this trial, the separation of juvenile birds from adults along the migration route seems likely to occur, Thus, post-separation monitoring and potentially further interventions may need to be considered.



Syrian colony area with pre-release aviary
© Waldrappteam

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Overall the exercise was more successful than anticipated, particularly bearing in mind the very brief period of acclimatization possible before release and migration. The integration of the birds which followed one adult on the major migration just two days after release was remarkable. The fact that the birds apparently did not survive beyond 6 and 8 weeks however means this was ultimately not successful in the overall goal, but knowing that survival rates for wild juveniles are low (Serra *et al.*, 2010), this could be a matter of chance, and further trials are strongly recommended, but which allow more acclimatization time prior to release. The option to provide appropriate post-separation management (such as supplementary feeding, reuniting with adults) at migration staging grounds is also being considered to help improve condition and survival of the juveniles.
- Note that the source population from Turkey is not fully captive - birds are free flying for half the year, reared in the wild and have little direct human contact which may make them more suitable source material than fully captive reared birds.

Acknowledgements
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A pilot release of captive-bred red-billed choughs into Cornwall, UK

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Introduction

The red-billed chough (*Pyrrhocorax pyrrhocorax*) has been in decline for decades, disappearing from significant parts of its European range over the past 100 years. In the UK, coastal populations exist in Ireland, Wales and Scotland, last breeding in England (Cornwall) in 1952 until a naturally dispersing group recolonized Cornwall during 2001. A pair subsequently bred in 2002 and by 2010 there were five breeding pairs. Their decline is believed to result from changing farming practices, exacerbated by human persecution. In the UK efforts to provide suitable habitat through subsidies paid to farmers has taken place since the 1990s and the threat of persecution has largely vanished due to changes in public attitudes and legislation. However their sedentary ecology makes re-establishment slow. A long held aim of a Cornwall based captive breeding center, Paradise Park, has been to re-establish red-billed choughs to Cornwall. Over 30 years Paradise Park has developed husbandry and captive breeding techniques and has a captive population (24 individuals with four breeding pairs in 2010) suitable for a re-introduction program. The release of intelligent and social birds is potentially complex, largely restricted to parrots to date, and is an area of re-introduction biology requiring further applied research.

Goals

- Goal 1: A pilot release to develop protocols for the re-introduction of a social crow.
- Goal 2: Successfully release red-billed choughs with the aim that these would become an establishing cohort, with the intention of subsequently releasing additional birds and establishing a resident breeding group.



Two of the released red-billed choughs with a radio transmitter © Ray & Alison Hales

- Goal 3: Monitor the survival, behavior and habitat use of released birds.
- Goal 4: To add more genetic diversity to the very small naturally occurring founding population.

Success Indicators

- Indicator 1: Success in the release methodology, resulting in individuals feeding and roosting in the immediate area as a social group and behaving naturally.
- Indicator 2: The continued presence and survival of released birds in the locality.
- Indicator 3: Formation of pairs and initiation of a breeding attempt.
- Indicator 4: Released birds and/or their progeny breeding with individuals from the recently naturally colonized population.

Project Summary

Feasibility: A captive breeding program was initiated with birds purchased from private breeders during the 1980s. Paradise Park funded a PhD investigating feeding ecology and the potential to re-establish red-billed choughs into Cornwall (Meyer, 1991 & Meyer *et al.*, 1994) supervised by a leading chough researcher at the University of Glasgow. The study identified sites suitable for re-establishment. Meetings with interested organizations were convened but a lack of consensus prevented progressing together, as we preferred. Considerable care was taken to follow IUCN guidelines however some organizations, although supporting a potential role for re-introduction (Carter *et al.*, 2008), were publically critical suggesting guidelines were ignored (Carter & Newbery, 2004). Specifically this concerned i) lack of suitable habitat, ii) lack of veterinary checks, iii) problems of introducing captive bred birds and iv) uncertain origins of captive birds. However these issues were all addressed. Habitat (and prey) availability was assessed by the PhD study with three areas identified suitable, validated when two were colonized naturally and subsequently supported breeding pairs. Good health had been established by independent vets over several years. Appropriate checks including fecal screening for parasites and microbial pathogens, blood smear for blood parasites, blood sample for haematology and biochemistry tests and a visual examination for ecto -parasites occurred on all individuals prior to release.



Typical chough habitat © Ray & Alison Hales

To reduce problems of releasing species with long learning periods and

complex social behaviors birds were parent raised, while a hand-raised bird was raised with siblings. All birds were socialized with up to 16 conspecifics overwinter in one large aviary and live invertebrate food placed under turf so birds learnt natural foraging techniques. Genetic origin of captive birds was established. A genetic study (Bruford & Tomaskovic, 2001) using samples from museum specimens and wild individuals indicated that extirpated Cornish birds were from the UK sub-species of red-billed chough. The same authors repeated this work using samples from all 16 captive birds; all were also from this sub-species. As was legally required at the time, all founding birds were government licensed and registered, and were believed to originate from Wales.

Two critical organizations also carried out a study on re-introduction to Cornwall. Addressing IUCN guidelines they concluded re-introduction was a possibility but too costly, time consuming and unpredictable and that short-term efforts should focus on habitat management and assessing the progress and viability of the re-colonized population (Carter *et al.*, 2008). Three years prior to the release (May 2000) two red-billed choughs (both females aged five years) escaped from Paradise Park. Both were regularly re-sighted and identified by their color rings. Although separated, both found coastal habitat; one survived 28 days before found dead, the other was re-sighted six months following escape. This showed that even in undesirable circumstances one at least was capable sustaining itself.

Implementation: The PhD research identified three potential release areas containing suitable habitat, invertebrate abundance and nest-sites. Two had become breeding sites for naturally recolonizing birds so the remaining area was used as the release site, 35 km from the nearest wild nest-site. Here an aviary 21 m x 7 m x 3.5 m was constructed within a private cliff-top residence. Two males and four females were sourced from Paradise Park. An older pair was translocated to the aviaries in February 2003, subsequently fledging young in the aviary, with four others translocated in July. Despite the old age of the breeding pair they were selected because they were pre-bonded and experienced breeders. Individuals were also selected to represent different blood lines within the captive population. All were released on 1st August 2003.

Post-release monitoring: Behavior, dispersal and survival of released birds was monitored by radio telemetry and direct observation. Radio transmitters were tail-mounted and birds located daily. Supplementary live food (wax and mealworms) was provided daily to aid monitoring, with birds learning to respond to an audible cue reinforced with a food reward. Within one week of release they formed two distinct groups, a male and female and a group consisting of the pre-bonded pair and two females. Initially the group remained within a small area, the other two over a larger area. Birds roosted in cavities at two coastal sites within contact range of each other. They flew strongly and took many exploratory flights, later dispersing more widely. Individuals showed natural behaviors, foraging in the same way as wild birds. In winter they frequently fed on invertebrates found in or under cattle dung in recently grazed fields, spending more time at coastal sites in the summer. They recognized predators, regularly mobbing raptors. Fecal

samples collected showed evidence of fly and beetle larvae, ants, spiders, adult beetles and vegetable matter.

Three died within four months of release. One female was found dead after nine days drowned in a cattle watering trough. A second female was found dead after 21 days predated by a peregrine. A third female was shot dead by a farm worker after four months. Two disappeared during the second month so by the fourth month only a male survived, last sighted six months after release. None have been re-sighted since, despite an extensive network of co-ordinated birdwatchers who re-sight color ringed individuals fledged from wild pairs.

Table 1. Details and fate of the six released red-billed choughs

Identity	Sex	Age at release	Rearing	Fate
S750	Male	11 years	Parent	Last seen September 2003
S751	Female	8 years	Parent	Last seen September 2003
S752	Female	8 years	Parent	Taken by predatory bird
S841	Female	7 years	Parent	Drowned in water trough
S866	Male	6 years	Hand	Last seen December 2003
S996	Female	4 years	Parent	Shot November 2003

Major difficulties faced

- Poor survival of released birds.
- The level of monitoring necessary was underestimated and more should have been invested in this, particularly during the post-release phase which affected assessing habitat use, social behavior and feeding ecology.
- Difficulty of radio tracking birds due to the terrain and poor weather (sea mist and fog). During a prolonged period of fog an airplane was used to locate individuals.
- Unusually hot and dry weather occurred shortly after release. This made the ground hard for three weeks, which was likely to have affected foraging efficiency and the availability of water. In response to a death in a watering trough, exit ladders and alternative water sources were provided.
- Lack of support from other conservation organizations, which resulted in negative publicity and the publication of misleading information which undermined the project.

Major lessons learned

- Ideally it should have included some younger individuals. The release of adult birds may not be a problem since the release of other social birds, for example the mariana crow (*Corvus kubaryi*), griffon vulture (*Gyps fulvus*) and California condor (*Gymnogyps californianus*) has shown that birds a year old or older may fare better than juveniles. However, the potential number of breeding attempts from older birds is reduced.



Release aviary © Ray & Alison Hales

- Re-introduction likely to establish a viable population would require the release of a much larger number of individuals, over several years. Had this pilot re-introduction been given support by other organizations we would have continued this work applying lessons from this trial. This trial was intended as a basis for future releases, and could have led to further cohorts being released after consideration of the results.
- There was a suggestion of naivety affecting survival, for example drowning in a cattle trough (although not an uncommon cause of mortality in wild birds). However survival of wild fledged young in Cornwall has also been very low (of nine fledged in 2010 five had died within two months and all by the end of the year).
- Release could have waited to see how the recolonized population developed to avoid the resulting ideological conflict with other conservation organizations. These organizations were particularly critical of releasing birds at this time since they felt birds may have had socialization problems and disrupt wild breeding pairs. We feel this was unlikely since the released birds were all socialized together in captivity and none showed abnormal behaviors. The released birds did not interact with the recolonized population, although had they become established that would have occurred in time.
- Failure to publically and clearly make clear how IUCN guidelines were followed which resulted in poor public relations and worsened relations between Paradise Park and other organizations.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Release methods were successful with individuals roosting in the vicinity and responding to an audible cue to facilitate monitoring and assessing health.
- Individuals remained in social groups and a pair remained together and settled in one locality until the female was shot.
- Individuals did not show any abnormal behavior.

- All released birds had died or had disappeared within six months. One of these had been shot by a farm worker, one had drowned in a cattle water trough and one was taken by a predatory bird.
- Poor relationships with other conservation organizations caused lasting damage to future work. Poor public relations also resulted in confused interpretation by the conservation media, as well as the wider media. These both remain very significant issues eight years later, and are hampering restoration efforts by all organizations despite widespread public support.

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Re-introduction of the white-winged guan in Lambayeque, Perú

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Introduction

The white-winged guan (*Penelope albipennis*) is a Cracid (Galliformes) species endemic to the foothills dry forests of the Tumbesian region in northwestern Perú. Its wild population is approximately 200 individuals and its distribution area covers some 1,550 km^2. The species was feared to be extinct over 100 years until its rediscovery in 1977 by Gustavo del Solar and J. O'Neill. The white-winged guan is classified as Critically Endangered by the IUCN and by the Peruvian legislation and is also listed on CITES Appendix I. Major threats for the species are hunting, habitat destruction and degradation including population and habitat fragmentation. A captive breeding program was started in the late 1970's with the aim of re-introducing the species into the wild. Between 2001 and 2007, about 55 guans have been released at two sites within the Lambayeque region in northwest Perú: Chaparri Private Reserve and Laquipampa Wildlife Refuge. Several release methods were proved with different types of captive-raising methods. Some birds were monitored after release using telemetry. Despite re-introduction efforts, its situation is still critical, and more releases are needed to keep connectivity between isolated populations. NGO Asociación Cracidae Perú has been leading efforts to re-introduce the species.

Goals

- Goal 1: Save the species from extinction.
- Goal 2: Establish new viable populations in the long-term.
- Goal 3: Help connect isolated populations of white-winged guan and reinforce existing populations.
- Goal 4: Test rearing and pre- & release techniques.
- Goal 5: Improve the genetic status of the species.



Captive white-winged guan in Olmos Breeding Center © Fernando Angulo

Success Indicators

- Indicator 1: Survival rate over time.
- Indicator 2: Breeding of released birds and survival of offspring.
- Indicator 3: Dispersal distance of released birds.
- Indicator 4: Change in the attitude of local people towards the species.
- Indicator 5: Local communities compromise in the species conservation.

Project Summary

Feasibility: Hunting of white-winged guans has been reported to be opportunistic but involves 15% of the human population around its distribution area. This activity over the years has left large areas of suitable habitat without guans and these areas were chosen to start the re-introduction program on condition that they must be legally protected. Feasibility studies were carried out at least at one site, to establish if suitable habitat conditions for the white-winged guan still existed. Four factors were evaluated: (1) diversity and quantity of plant species that are part of the guan's diet, (2) availability of year-round water sources, (3) cover for nesting and resting during the day, and (4) undisturbed forest and undergrowth. The species distribution area is fragmented into two meta-populations. The southern one is composed of several forest patches with little or no connection between them. Isolated guans populations need to be connected to avoid inbreeding. The captive-breeding program aims to help this, together with other components such as creation of protected areas and awareness campaigns. The breeding center got its first captive bred chick in 1986 and by year 2000 there were over 100 individuals at the breeding center and it was decided to start the re-introduction program.

Implementation: Two release sites were chosen in the southern part of the distribution area, to re-introduce white-winged guans. Both sites were protected areas, in order to avoid hunting of released birds. These sites were the Chaparri Private Reserve (CPR) and Laquipampa Wildlife Refuge (LWR). The first is private and the second is administrated by the government. A feasibility study was carried out for Laquipampa before release, where it was found the presence of the species in the surrounding areas. Individuals for both sites were selected from the captive-breeding center taking into account the following considerations: a) Maximum distance in blood relationship between individuals in the release group to minimize inbreeding; b) 1:1 proportion of both sexes due to the monogamy of the species; c) optimal health status to avoid disease transmission between the release group with the wild population and other fauna; d) birds that have recently reached sexual maturity (2 years old), to enhance reproduction possibilities and at the same time, better adaptation to the new environment; e) First or second generation birds and parent-raised guans (Angulo, 2004). The first 16 guans were re-introduced in CPR in 2001 and between 2002 and 2005, a further 29 guans were released in the reserve. In February 2007, eight birds were released at Laquipampa. A total of 69 guans left the breeding centre between 2000 - 2007 as part of the re-introduction program run by the NGO Asociación Cracidae Perú. After 2007 no more releases have been carried out, although there are individuals and areas available.



White-winged guan habitat in NW Perú
© Fernando Angulo

Post-release monitoring: In the first released group in 2001, nine white-winged guans were attached with backpack radio-transmitters and all individuals were released with leg bands that individually identify them. Anti-predator control and food supplementation was carried out as well. Monitoring in Chaparri reserve was carried out two years after release and survivorship was estimated in 55% - two years post-release. Breeding of re-introduced birds was feasible, with birds breeding within the first six months. A year later, another pair got two chicks (Angulo, 2004). Since 2001, there have been 50 wild white-winged guan chicks born from re-introduced birds, mostly due to artificial food availability (Angulo, 2008a). In Laquipampa, from the eight released birds, one was retired to the breeding center due to inappropriate behavior (too tame) and 20 months after the release, survivorship was 100%. Breeding of re-introduced birds occurred at Laquipampa within the first two months of release, when a pair was observed with two chicks. The same pair was found during the next year with two chicks. These differences in survivorship and breeding success are because habitat at Laquipampa has been former guan's habitat but Chaparri has marginal habitat, with low trees density and lack of key species for the white-winged guan survival such as figs (*Ficus spp*.), *Erythrina smithiana*, *Pithecellobium multiflorum* among others.

Major difficulties faced

- Experimentation with the size of the pre-release cage, time spent by individuals in the pre-release cage, time of the year for release, age of the individuals at the release time, rearing techniques and many other factors involved in the success of the re-introduction program are time consuming and use economical resources, that are not always available.
- Lack of long-term funding to ensure monitoring over the years and understand the released population structure development and determine the survival rate of chicks born from released individuals.
- At CPR, the released guans has been artificially feed to maintain them around a touristic lodge, what resulted in a artificial population growth and density, but no dispersion from the site to connect isolated populations (what was the original aim of the project). This can genetically erode the re-introduced population.

- Development of a health protocol to asses white-winged guans before release was a major challenge since there was almost none information on this topic.
- The mortality rate of guans during transportation to release sites or predation both in semi-captivity and after release.

Major lessons learned

- It is really important to establish and carry out a health screening in the birds to be released, to secure that only the healthy ones are re-introduced. In some cases like the white-winged guan, we had to start by finding what diseases have to be screened.
- Education and public outreach campaigns must be part of any re-introduction project. Any effort to re-introduce birds and the amount of funds involved on these projects can be put at risk if local people are not aware that there will be released birds in their area.
- It is necessary to carry out genetic work with the captive population and with the wild one (if possible), to determine the genetic status of both populations and to better direct future re-introduction efforts.
- It is necessary to create opportunities for the development of the local communities' economy, which does not affect the guan's habitat to ensure the long term conservation of the species. A few possibilities with many advantages include ecotourism (bird watching) and organic beekeeping.
- Feasibility studies prior to release help to determine the best areas to re-introduce birds. Sites must be compared to habitat of wild birds and determine if food, water, cover and breeding places are present. Birds in a site with no suitable conditions will need to be artificially fed to maintain them. This may cause an abnormal population growth that can bias conservation status of the species.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- It is important to carry out feasibility studies to determine the conditions at each potential release site before release. At Laquipampa this was implemented and the site seemed suitable and this was later reflected in the reproduction and survival of the guans.
- Lack of long-term monitoring and funding was one of the most important reasons for not keeping track of project development in areas such as survival and dispersal of released birds. Secure funds are important to determine success of the project.
- Permits from communities, land owners and state agencies in release sites are really important. Knowledge of local people on re-introduction issues is crucial. In the white-winged guan re-introduction program, there were some political issues that did not permit the project to be implemented in the right time in some areas.

- One important reason of success is that the implementation of releases was inside protected areas. In this way, released birds can improve their survival rates when they are not hunted in the initial phase, allowing breeding and later dispersal of wild-born birds. This give time to start educational and public outreach campaigns in areas where the offspring is more likely to disperse.
- Careful selection of individuals to be re-introduced (Angulo, 2006) from captive birds will determine whether they can breed on the wild and produce offspring. The more fast they breed more possibilities to establish a new population, since predation possibilities reduces on released birds and wild-born birds have greater chance to survive.

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Re-introduction of the Ural owl into the Austrian Alps

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Introduction

The Ural owl (*Strix uralensis*) is a large long-lived sedentary species widely distributed in the Paleartic region, being the core of its range the boreal conifer forests, with some isolated populations in south-eastern Europe occupying other biomes than taiga. This south-eastern population extends from the south of Poland and includes the Dinaric (south-east), Carpathian (north-east) and currently in restoration Alpine (west) sub-populations. The Ural owl has the status of Least Concern in the IUCN Red List, and is listed in the CITES (Annex I, 1995) and the European Bird Directive (2009/147/EEC, Annex I). In Austria, the species is listed as DD (Data Deficient) although the last historical reports on breeding in the Austrian Alps date back to the mid 20th century, with some recent scattered observations close to the border with surrounding countries where the species occurs. Whereas the former Austrian population could not be established again by itself, there is a positive growth trend in neighbour countries, especially in the East. Since the late 1970s, there are two more re-introduction projects being carried out with quite promising results, in Germany (Bavarian National Park) and Czech Republic (Národní Park Šumava), started in the 1990s.



Ural owl © N. Potensky

Goals

- Goal 1: Establish a viable self-sustaining population of Ural owls in the Austrian forests through the release of captive-bred birds and facilitation of nesting sites in previously selected suitable areas.
- Goal 2: Release of individuals genetically as close as possible to the original extinct population by following up the genealogy and origin of the founder pairs kept in captivity used in the breeding network.
- Goal 3: Create linkages with neighbouring sub-populations to serve as stepping stones for genetic exchange.

- Goal 4: Promote and strengthen collaboration with the local population and specially the hunting community to avoid some of the conflicts that led to the extinction of the species in Austria.
- Goal 5: Monitor behaviour and survival to better understand the species' ecology in order to improve the conservation actions in this and future re-introduction projects.



Typical Ural owl habitat

Success Indicators

- Indicator 1: Increase the survival rate of the captive-bred young owls by using improved release techniques and monitoring methods.
- Indicator 2: Achieve the reproduction in the wild of the species.
- Indicator 3: Establishment of reproductive couples in protected sites, attracting them to previously selected optimal areas by means of the installation of artificial nest-boxes.
- Indicator 4: Connection and genetic flow between the two release areas.
- Indicator 5: Expansion of the population to adjacent areas and natural connection with extant populations of surrounding countries (Italy, Slovenia, Hungary, Croatia and Slovakia).

Project Summary

Feasibility: The resolution to begin a new re-introduction in the Alps was taken after the European Ural Owl Workshop (Müller *et al.*, 2006) which culminated in the creation of an Action Plan and release of the first birds in 2009. The extinction of the species was primarily consequence of the direct persecution, together with the loss of habitat and nesting sites resulting of the progress of modern forestry. A small re-introduction attempt was conducted in 2001 with the release of some captive-bred Ural owls in Oberösterreich, although these factors were not dwelled with in advance and therefore it was unsuccessful. Together with the implementation of new natural wildlife-protection laws in the last decades, a campaign was started in 2007 to raise public awareness, emphasizing the direct collaboration with the hunting and forestry communities to ensure cooperation instead of confrontation. Ural owls need big cavities in trees as well as broken snags to breed; in actively managed Austrian forests the trees are harvested in early stages and dead trees are removed, reducing therefore availability of suitable sites. In recent years, protected areas such as the Wilderness area Dürrenstein, and the Core zones in the Biosphere Reserve of the Wienerwald



Researcher in tree © M. Graf

(both release areas), have been created to preserve the natural ecosystem. Furthermore, an extensive program was initiated in 2008 to set up nest-boxes in pre-selected areas (based on HSI modelling) in order to attract breeding pairs to the protected sites.

Implementation: The first release of captive-bred Ural owls took place in the summer of 2009, although the project was formally started one year earlier with the establishment of the breeding network and habitat characterization to pre-select the releasing sites. Since then, 50 birds have been released between 2009 and 2010 (29 in the Wienerwald and 21 in the Wildnisgebiet), plus other 36 birds being currently released in 2011. Besides, more than 120 nest-boxes were fixed until August 2011. The juvenile owls are separated from their parents (approx. 75 days-old) and transferred to special aviaries in the woods, were they spend another 3 weeks until they are released (approx. 100 days-old); this method is used to enable the development of natural behaviour including the hunting abilities (training with live prey) and increase the chances that the birds would settle in the area or surroundings. The animals are provided with food while being in captivity (never hand-fed to avoid the imprinting) and also in the wild until they become independent (dispersal phase) by using specially adapted feeding tables.

Several subspecies of *S. uralensis* have been described based on the morphology of different populations. In particular the European populations were traditionally regarded as belonging to the subspecies *liturata* in the North and *macroura* in the South, although recent molecular studies suggest that these belong to one single sub-species that comprises a meta-population. The individuals released have been thoroughly selected to be as close as possible to the original Alpine population thanks to the close collaboration of a well managed breeding network made up of several private centres and zoos throughout Europe.

Post-release monitoring: Thus far, the achievements accomplished by the project are remarkably positive; already in the second breeding season after the beginning of the release of birds, the first pair has been able to successfully raise a chick until fledging, using one of the nest-boxes set up in the Wienerwald. Moreover, 2 to 3 more pairs have already settled and established a territory, raising the prospect for breeding in upcoming years. The presence of Ural owls is difficult to prove due to the size and location (often in remote and mountain areas)

of their home range, little evidence of presence and especially their nocturnal habits; nevertheless, several methods are used jointly for monitoring the species:

All owls (both released and wild-born) are equipped with specially developed plastic colour rings that contain a microchip with a unique code, which is registered by a reading device each time the bird enters a detection zone. Such devices can be attached to the feeding tables, which are also surveyed by infrared photo-traps, or nest-boxes, giving a clear overview on the status of the population to the individual level. In addition to the “intelligent” rings, some of the birds have been equipped with tail-mounted and leg-harness radio-transmitters that allow their location by telemetry. Likewise, in addition to these methods, bioacoustics have been used by displaying male callings during the mating season (with positive results), and furthermore there is a close connection with hunters and landholders to receive data on sightings. Since the beginning of the project, genetic samples of all released birds as well as samples collected from the wild (moulted feathers and pellets) have been stored in anticipation to the creation of a genetic fingerprint of all birds.

Major difficulties faced

- In 2010 and specially 2011 the populations of small mammals were extremely low as a result of a bad seeding season for beeches and oaks. Another consequence of modern forestry is the homogenization of the forest due to reforestation, which hamper the buffer effect in natural mixed forests in case some tree species had a bad productive year. In early stages of re-introduction programs these natural phenomenon might be extremely damaging
- It is practically impossible and highly costly to control individuals when they get far from the areas under survey, especially during the decisive dispersal phase.
- However good the collaboration with the hunter community might be, there are always some conflicting opinions that could be detrimental to the project on the long term, or in the near future in case of direct individual actions
- Prevent other raptor species from coming to the feeding sites and stealing the food, which might cause the early leaving of the young owls in search for new food supplies in case there’s not enough for all birds.
- Accidents such as car knockdowns or collisions with fences can be frequent and frequently lethal in some black spots which owls might find suitable.

Major lessons learned

- The work on public awareness and collaboration among all people involved in the success of the project (from politicians and hunters to volunteers) has proved essential from the beginning on. It is important to remark that since there seem to be hardly any natural limiting factors for the survival and settlement of the species in Austria, it can be asserted that shooting was the main reason for its former extinction.
- It is extremely important that the release methods used imitate and consider the natural adaptation to environmental factors in order to increase the survival probabilities of the birds, as well as continuing a close follow-up on birds once released.

- It is necessary to be totally open when dealing with this kind of project that some might find controversial; transparency is the only way to avoid groundless critics.
- Until a significant number of trees located in the new protected areas reach the right age for providing suitable nesting sites, nest-boxes are the best option for breeding and monitoring of owls.
- In order to achieve the maximum success in such project it is crucial to make use of the valuable work and guidance of experts in the field.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Survival of a high percentage of the released birds to the adult phase being able to self-sustain during hard winter conditions.
- First case of reproduction in the wild of a pair of birds just two breeding seasons after the beginning of the release, in one of the provided nest-boxes
- Positive feedback and even financial support from formerly opposed groups such as the hunter and forestry communities
- It is still not possible to assure whether the re-introduction project will be successful on the long term since it is still in an early stage. We assume that a definitive success will only be achieved after the establishment and correct development of a healthy breeding population outnumbering the amount of released birds.

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A trial conservation translocation of the mangrove finch in the Galápagos Islands, Ecuador

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Introduction

Mangrove finch (*Camarhynchus heliobates*) is one of the 13 species of Darwin's finch endemic to the Galápagos Islands. It is the rarest breeding bird in the archipelago with an estimated population of around 100 individuals. Once widespread throughout mangroves of the two western Islands, Isabela and Fernandina, it is now primarily confined to two small areas of mangrove, (Playa Tortuga Negra and Caleta Black: total area 30 ha), 5 km apart on the north west coast of Isabela. A remnant population of no more than a few individuals remained on the south east coast of the island in 2009. This severe decline in range has occurred during the last 100 years for reasons which are largely unknown. The main threats come from predation by introduced black rat (*Rattus rattus*) and loss of nestlings through introduced parasitic bot fly (*Philornis downsi*). The finch will also potentially suffer in future from loss of genetic diversity, contact with introduced pathogens, climate change effects and stochastic events such as land uplifts. The mangrove finch is classified by IUCN as Critically Endangered and protected under the Special Law for the Galápagos Province, general environmental legislation from Ecuador, and regulations from the Galápagos National Park Service.

Goals

- Goal 1: Develop translocation techniques with wild-caught mangrove finches.



Mangrove finch © Michael Dvorak
BirdLife Austria

- Goal 2: Transfer up to 10 individuals, a mixture of males and females with emphasis on juveniles.
- Goal 3: Follow initial establishment of all birds by radio tracking, thus determining the immediate fate of translocated mangrove finches.
- Goal 4: Establish individuals in a new location and confirm breeding within two years thus creating a geographically distinct population and increasing the currently restricted range of the species.

Success Indicators

- Indicator 1: Arrival at release site of all individuals in good health.
- Indicator 2: Persistence of monitored birds at release site until transmitters stop functioning, a maximum of 22 days determined by battery life of transmitters.
- Indicator 3: Observations of translocated birds for several months following translocation.
- Indicator 4: Persistence of birds into the next breeding season confirmed by observing territory establishment, made evident by calling birds.
- Indicator 5: Breeding of released individuals at new site.

Project Summary

Feasibility: Galápagos National Park (GNP) is responsible for management of native and endemic fauna on the Islands and mangrove finch conservation is undertaken through a partnership of GNP, Charles Darwin Foundation (CDF) and Durrell Wildlife Conservation Trust. Restoration of Playa Tortuga Negra (PTN) and Caleta Black (CB) has seen finch productivity and overall numbers increase. The current restricted range and absence from former sites makes this a fitting species for translocation. Primary habitat is established mangrove of three tree species (*Rhizophora mangle*, *Laguncularia racemosa* and *Avicennia germinans*) flooded at high tide. Sites in western Isabela are further unique in Galápagos as tall (25 m) trees grow behind a 5 m high beach protecting them from open sea where leaf-litter remains within the mangrove. Identical habitat within the birds' historic range is rare and Bahia Urbina, 25 km south of PTN, was chosen as the trial release site through our ability to control rats, proximity to the source population and suitability for post-release monitoring. Urbina lacks large areas of leaf-litter, a popular feeding resource for finches, however, dead wood, another important source of food, was abundant.



Mangrove finch source habitat

© Francesca Cunninghame CDF

The decision to transfer birds directly between source and receptor sites was made by stakeholders following a workshop in 2008. Use of captive-raised individuals was decided against following a trial with closely related woodpecker finch (*C. pallidus*) on Santa Cruz where high-standard aviaries fitted with mosquito-proof netting did not prevent captive birds from suffering with Avi Pox virus. Most finches recovered following treatment but, as it was unclear whether they remained disease transmitters, it was considered too risky to hold and release mangrove finches where they may become a risk to wild populations. Thus, a planned captive program was rejected for direct translocation. Although studied in the wild there was no knowledge about mangrove finch behavior in captivity; prior to the translocation, birds had only been handled for ringing, measuring and blood sampling. It was therefore decided to hold birds for the minimum time and transfer and release all individuals on the same day as capture.

Implementation: Ten mangrove finches were caught over three days at PTN using playback and mist-nets. Only nine were transferred to avoid removing a significant number of breeding aged adults from the source population. A total of five juveniles (sex unknown) and four adults (tentatively identified as two males and two females) were successfully transported to the release site. All birds were fitted with individual metal and color rings and radio transmitters glued to the scapulars prior to being placed in individual transfer boxes built using fine mesh covered by a loose curtain to reduce over-heating. Birds, given perches of locally sourced mangrove and live insects as a food source, were transferred by speedboat and small dinghy. As release was on the same island as capture, disease-screening prior to release was minimal as this would otherwise have involved holding birds until results were available. A veterinarian was present to assess for obvious health problems and all birds were classified as healthy. The field team consisted of staff and volunteers from the CDF, GNP and Durrell, including local Islanders.

Post-release monitoring: Transmitter battery life allowed a maximum 22 days telemetry monitoring during which period birds were tracked twice-daily by staff camped at the release site. Several transmitters became prematurely detached as adults were in moult and juveniles had many blood-feathers reducing the area to which transmitters could be glued. One juvenile finch was sighted back at PTN on the second day while all other birds initially dispersed locally. Two individuals resided in a stand of mangrove trees 5 km north of the release site while the others remained in direct proximity to the release point. One juvenile was subsequently found dead nine days after release and three transmitters that had fallen off were recovered. Once the transmitters stopped, monitoring of color-ringed birds was conducted by direct observation and through listening surveys using playback to illicit response. Field-trips to the release site were conducted monthly and for four consecutive months no finches were seen or heard. However, with onset of the breeding season five months following transfer, one adult male was observed singing at the release site. One month later this individual was observed back at the source population where another adult male

was also found to have returned. In April 2011, 11 months after transfer, one of the adult females was confirmed back at PTN and no mangrove finches have been detected at the release site since November 2010. There is confirmation that four of the nine individuals have returned to the source population and these birds are frequently observed there. Juveniles of this highly cryptic species are not believed to become reproductively active, and sing, for over one year and the whereabouts of four individuals (three juveniles and one adult female) remains unknown.

Major difficulties faced

- No habitat similar to that of the source population exists today on Isabela Island, therefore, mangroves open to the tide were the only option as a release site. The presence of both the main threats (introduced rats and *P. downsi*) at all potential release sites means that thorough and regular control is necessary for the protection of any new established populations. The logistical difficulties in controlling rats in large areas of mangroves meant that the chosen release site had to have a relatively small area. At present no large scale control method is available for *P. downsi*.
- The small number of finches available from the source population and an inability to reliably confirm the sex of individuals in the field meant that 80% of the birds released were of unknown sex.
- The short life of transmitters coupled with the cryptic nature of mangrove finches and difficulties accessing the mangroves meant that long-term monitoring through observation was difficult. The small number of individuals within a large area made it impossible to confirm the absence of birds and this was further complicated by birds only reliably singing during the breeding season (November - April). Females never sing and the age at which juveniles start singing is unknown, therefore, listening surveys are inadequate for monitoring and regular visual observations are extremely difficult outside the breeding season.
- Strict quarantine regulations in Galápagos prohibited the use of invertebrate food only available on other islands and it was therefore necessary to capture invertebrates at the source site to feed birds during the transfer period.
- The isolation of both the source population and the release site (minimum six hours by speedboat from the primary settlement on the island) makes both regular monitoring and predator control an expensive exercise. This will be most apparent once international funding for the project comes to an end in 2012 and GNP take over management of the species.

Major lessons learned

- The durability of the birds during transfer once established in the transport boxes means that future release sites further from the source population can be chosen. This was especially noted with juveniles that were observed feeding whilst being transported in a noisy speedboat in rough seas (i.e. in otherwise stressful conditions). Adults were more prone to stress during long handling periods as required for fitting transmitters.
- Regardless of the reluctance of birds to disperse and transfer between the two mangrove forests studied for several years at the source population, mangrove

finches are capable of flying large distances (22 km) across open lava fields. Site fidelity appears to be strong both in juveniles and adults.



Transfer boxes © Brent Barrett CDF

- The importance of release timing to encourage breeding at release sites. Releasing birds directly prior to onset of breeding is likely preferable so that individuals establish territories at new site before they individually disperse large distances during non-breeding season.
- It is probably very important to confirm that both males and females are transferred.
- Tasks of post-release monitoring were achieved solely by staff and volunteers via international funding, this is not sufficient for the future. Further capacitating GNP staff is required for the long-term management of mangrove finches.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The successful transport of all individuals to the release-site and holding in captivity for up to 10 hours increases our understanding of the durability of the birds necessary for future conservation management decisions.
- The initial establishment of seven individuals observed feeding and to be in good physical condition (capable of making long distance flights back to source population) suggests that the chosen release site supplied ample food for the mangrove finches regardless of differences to the source habitat. This increases our ability to choose future sites potentially further from the source population, therefore, reducing the risk of birds returning home.
- We have been successful in determining the whereabouts of five of the nine released individuals 12 months following the translocation. This knowledge is essential for planning any future translocations.
- The apparent lack of permanent establishment and breeding at the release-site results has so far resulted in a failure to increase the geographic range of this incredibly range restricted species. However, the results are highly encouraging for a future translocation using lessons learned during this trial.

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Black-footed ferret recovery in North America

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Introduction

Black-footed ferrets (*Mustela nigripes*) are mustelids and dependent on prairie dogs (*Cynomys* spp.) as prey and their burrows for shelter. Widespread poisoning of prairie dogs, conversion of rangeland to cropland and exotic disease (plague) severely reduced ferrets and their prey throughout the 20th century. By the 1980s ferrets were found in only one *in situ* population and the last 18 were captured for *ex situ* captive breeding. More than 7,000 ferrets have been produced in captivity since 1987 and 3,500 released into the wild since 1991 at 19 locations in the United States, Mexico and Canada. Four re-introduction sites are considered viable and self-sustaining with annual population counts ≥100 individuals. Captive breeding occurs at 6 zoos/breeding centers (5 in United States, 1 in Canada). Approximately 1,000 ferrets (adults and kits) survive in the wild range-wide and 240 breeding animals are maintained in captivity. The Black-Footed Ferret Recovery Implementation Team (BFFRIT), an advisory group to the US Fish & Wildlife Service, is a tri-national organization of agencies, organizations, zoos, tribes, universities and private landowners. In the United States, ferrets are federally listed as Endangered under the Endangered Species Act (ESA), IUCN Endangered D (2008) and CITES Appendix 1 (1975).

Goals

Goals and success indicators of the black-footed ferret recovery program from the 2007 Draft Revised Black-Footed Ferret Recovery Plan:

- Goal 1: Maintain a captive ferret population of optimal size and structure to support genetic management and re-introduction efforts.
- Goal 2: Reduce disease-related threats, particularly sylvatic plague, in wild populations of ferrets and associated species (i.e. prairie dogs).



Black-footed ferret in Conata Basin, South Dakota
© Travis M. Livieri

- Goal 3: Ensure sufficient prairie dog habitat to support a wide distribution of self-sustaining ferret populations.
- Goal 4: Establish free-ranging populations of ferrets to meet ESA down-listing and de-listing goals.
- Goal 5: Promote partner involvement and adaptive management through regular programmatic review and outreach.

Success Indicators

To down-list from Endangered to Threatened ESA status:

- Indicator 1: Maintain a minimum core captive breeding population of 240 adults (90 males:150 females).
- Indicator 2: Minimize fundamental threats and habitat conservation obstacles currently suppressing black-footed ferret population growth, such that a total national population of 1,500 free-ranging breeding adults, in 10 or more populations, with no fewer than 30 breeding adults in any population, is established.
- Indicator 3: Maintain population objectives for at least three years prior to down-listing.
- Indicator 4: Establish the widest possible distribution of reintroduced black-footed ferret populations across the species' historical range by allocating individual state recovery targets proportional to the distribution and abundance of historical habitats.

To de-list from Threatened ESA status:

- Indicator 5: Accomplish Indicators 3 and 4 and additionally minimize fundamental threats and habitat conservation obstacles currently suppressing black-footed ferret population growth such that a total national population of 3,000 free-ranging breeding adults, in 30 or more populations, with no fewer than 30 breeding adults in any population, and at least 10 populations with 100 or more breeding adults, is established.

Project Summary

Feasibility:

Planning and guidance: Black-footed ferrets were extinct in the wild by 1987 when the last 18 individuals were captured and placed into a captive breeding facility (see Lockhart *et al.*, 2006 for background on the history of recovery efforts). The recovery plan at the time, authored in 1978, provided basic guidance for captive breeding and subsequent re-introduction. A more detailed revised plan in 1988 ably guided recovery efforts and a new plan revision is expected in 2012. The first attempts at captive breeding ferrets in the 1970's did not produce viable offspring but set the stage for successful breeding efforts, allowing re-introductions to commence in 1991. Re-introduction techniques and sites needed to be identified, evaluated, and prioritized. Siberian polecats (*Mustela eversmanii*) acted as surrogates to advance proficiency in radio tagging and tracking of ferrets. A system for evaluating prairie dog complexes to support ferret re-introduction was developed using biological, quantitative factors such as prairie dog colony size and density as well as qualitative factors including disease, predators and political

aspects. Several workshops and symposia were held regarding captive breeding, small populations, prairie dog management, disease and habitat evaluation.

Annually, re-introduction sites can request captive ferrets for re-introduction. Ferrets are allocated using an objective ranking process (Jachowski & Lockhart, 2009). All ferret releases in the United States through 2004 were designated “non-essential experimental” under Section 10(j) of the ESA and subsequent releases are 5-year experimental populations under a 10(a)(1)(A) permit. Agricultural organizations typically wield political clout and generally oppose ferret re-introduction, primarily because of ESA fears and need for larger areas of prairie dogs (Miller *et al.*, 2007). Local attitudes typically range from vehemently opposed to apathetic. In some cases litigation is used to attempt blocking of re-introductions or rescind current efforts.

Implementation:
Captive breeding: Husbandry techniques were refined and the first successful captive breeding occurred in 1987. Disease management in captivity is paramount and strict protocols are adhered to. Genetic management is closely monitored and ferrets are bred using a mean-kinship strategy to maintain ≥80% genetic diversity and provide animals for re-introduction. Genetically ‘surplus’ animals are targeted for re-introduction candidates. Artificial insemination for genetically valuable, but behaviorally-challenged, breeders and sperm banking is used to produce genetically valuable animals, some from males deceased >10 years.

Pre-release conditioning: Captive-born ferrets targeted for re-introduction are placed in outdoor pens, simulating quasi-natural conditions with dirt burrows and live prey. Ferrets that receive pre-release conditioning in outdoor pens prior to release have demonstrated 10-fold higher survival rates in the wild than ferrets that receive no pre-release exposure (Biggins *et al.*, 1998). Pre-release conditioning is now standard for all re-introduction candidates.

Re-introduction: Ferrets are typically released in the fall during natural dispersal and kits (young of the year) are the primary candidates. One site in Arizona experimented with spring releases to coincide with Gunnison prairie dog (*Cynomys gunnisoni*) emergence from



Prairie dog colony (BFF habitat) in Conata Basin, South Dakota © Travis M. Livieri

hibernation. Translocation of wild ferrets from self-sustaining re-introduction sites began in 1999.

Research and operational conservation: Research during re-introduction occurs at most sites to refine re-introduction strategies, learn more about ferret ecology and ultimately to provide feedback and improve the overall recovery effort. Radio-telemetry, while difficult and expensive, was instrumental in early ferret research. One of the primary threats to ferret recovery is sylvatic plague, caused by the bacterium (*Yersinia pestis*), and fatal to both prairie dogs and ferrets. Dusting prairie dog burrows to kill fleas, a primary vector of plague, increases survival of both prairie dogs and ferrets (Matchett *et al.*, 2010). An effective plague vaccine is used in ferrets and expected in the next 5 years for prairie dogs. Continued research is needed in many areas including, but not limited to, plague ecology in prairie dogs, understanding ferret population ecology, and climate change effects on prairie dogs and ferrets.

Post-release monitoring:
Population estimation: Black-footed ferrets are primarily nocturnal, semi-fossorial and most efficiently located using spotlighting. In the initial stages of re-introduction, radio-telemetry was used extensively to document survival and movements relative to pre-release conditioning strategies. Spotlighting surveys, from a vehicle or on-foot, are typically conducted in the fall during dispersal. Passive integrated transponder (PIT) tags are implanted in all released ferrets and wild-born individuals are live-trapped and implanted with PIT tags. Population estimates at a re-introduction site are typically minimum-number-alive (MNA) estimates or, more recently, correlated density estimates (CDE). MNA is simply the number of cumulatively identified individuals and varies with sampling effort. CDE utilizes a more structured sampling approach that yields a population estimate with associated variance.

Current conservation status: As of 2010, there are ~1,000 black-footed ferrets surviving in the wild of which ~500 are breeding adults. Ferrets now occupy 8 of the 12 US states historically inhabited as well as Chihuahua, Mexico and Saskatchewan, Canada. Captive breeding populations remain stable at ~240 breeding individuals.

Major difficulties faced

- Socio-politics: Socio-political views of prairie dogs lead to suppression of prairie dog numbers down to levels that make them functionally extinct (Miller *et al.*, 2007). In many states throughout the range of prairie dogs they are considered a pest species and actively controlled through economically infeasible poisoning programs. New poisons are available and overall negative attitudes towards prairie dogs are slow to change. Rural governments and agricultural interests can have a disproportionately large voice in prairie dog management decisions, even on publicly-owned lands. Many areas that once were prime prairie dog habitat were converted from rangeland to cropland. Despite increasing recognition of prairie dogs as a keystone species and ecologically important (Miller *et al.*, 2007), they continue to be persecuted and

managed at levels generally lower than needed to support black-footed ferret populations.



BFF captured for vaccination against plague in Conata Basin, South Dakota © Travis M. Livieri

- Disease: Plague is exotic to North America and many animals have no natural resistance. Black-footed ferrets and prairie dogs are both extremely susceptible to plague and the disease greatly impacted the prairie dog ecosystem throughout the 20th century. In a matter of months, an epizootic of plague can remove all prairie dogs from thousands of hectares of ferret habitat. Mitigation tools such as dusting of prairie dog burrows and vaccines for ferrets are effective (Matchett *et al.*, 2010), but costly, and not feasible over the long-term. Vaccines for prairie dogs may soon be available but delivery may be problematic and costly. We still understand relatively little about plague ecology in the prairie dog ecosystem and the future of ferret recovery will always need to consider plague.
- Mechanisms to establish new recovery sites: Most of the large prairie dog complexes in North America are identified and contribute to black-footed ferret recovery. Recovery of the species is dependent upon creating new prairie dog complexes of adequate size to support ferret re-introduction. Currently there are few recovery sites in the southern and eastern portions of the ferret's historic range and future recovery sites in those areas are more likely to include private lands. In general, private landowners are wary of endangered species re-introduction and intolerant of large prairie dog complexes. Thus, incentives are needed to encourage active, positive management of prairie dogs for ferret re-introduction. BFFRIT is currently developing a national landowner incentive program that shows promise for developing prairie dog complexes for ferret re-introduction but implementation of the incentive program has yet to occur. Also, legal mechanisms to allow ferret re-introduction are lacking. The recovery program has used 10(j) non-essential, experimental or 10(a)(1)(A) experimental populations in the US with some degree of success. Unfortunately these mechanisms are generally slow and costly to implement. As a result, the opportunity to release ferrets in new areas is sometimes lost because the legal process is too onerous.
- Inter-organizational co-operation and conflict resolution: Earlier years of the recovery program were sometimes marred by conflict between partner agencies (Lockhart *et al.*, 2006). Since 1996, the US Fish & Wildlife Service

asserted a stronger leadership role in the recovery program which improved cooperation and conflict resolution, although gaps remain. Several key partners are not actively participating in the program and often political pressures can change the dynamic of a partner's role in the program. For example, the US Forest Service manages Conata Basin, South Dakota one of the most successful ferret recovery sites. Political pressures from 2004 - 2008 directed US Forest Service leadership to consider poisoning up to half of the prairie dog habitat. Fortunately, the poisoning did not occur, but the commitment of the US Forest Service to black-footed ferret recovery was compromised at the time.

Major lessons learned

- Commit to recovering wild populations before captive breeding and re-introduction are necessary: The opportunity to recover black-footed ferrets failed in the 1970's and nearly failed in the 1980's partly because of inadequate habitat conservation for ferrets. We are now challenged with an extensive captive breeding and re-introduction program, in addition to habitat conservation efforts. Lockhart *et al.* (2006; p.7), from the perspective of recovery coordinators, stated, "however difficult the challenges of recovering wild populations in native habitat may be, those challenges pale in comparison to the trauma, demands and resources required for last-ditch captive breeding and re-introduction efforts."
- Captive breeding of black-footed ferrets should have been initiated earlier: The recovery program failed to act on plans in advance and commit funding for personnel and facilities (Lockhart *et al.*, 2006) which partially was the reason captive breeding of the Meeteetse population was not started earlier than 1986. Had the captive breeding effort begun earlier there would likely be less concern about genetics today. Of the last 18 ferrets, 15 successfully bred in captivity although many were already closely related. It is estimated that of the 18 ferrets there were 7 unique founders.
- Patience and persistence: Two of the four highly successful recovery sites took nearly 10 years of efforts to become established. The first re-introduction site, in Shirley Basin, Wyoming was largely written off as unsuccessful by the mid-1990's. A small population of ferrets persisted there and, when conditions were optimal, the population grew exponentially in the 2000's.
- Pre-release conditioning: Captive-born ferrets are given the best chance to survive in the wild when exposed to pre-release conditioning (Biggins *et al.*, 1998). This is one of the most important biological lessons learned in the ferret recovery program and has contributed greatly to establishing populations.
- Cooperation and creative partnerships are essential: Captive breeding would not have succeeded without the cooperation of zoos and, consequently, captive breeding became a foundation of overall program success. Re-introduction requires cooperation and partnerships between many diverse groups, particularly among private landowners and agricultural organizations. Because the ferret recovery program has been moderately successful, it may be prudent to become even more proactive and creative in efforts to further establish wild ferret populations (Lockhart *et al.*, 2006).

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- Persistence and patience in captive breeding: The first attempts at captive breeding in the 1970's did not produce viable offspring and the initial attempt in 1986 was unsuccessful. Capturing young animals, attention to detail in husbandry techniques, reproductive cycles and pairings resulted in the first viable captive-born kits in 1987. The captive breeding program has grown and developed since 1987 and provides high-quality animals for re-introduction throughout their range. Zoos that captive breed black-footed ferrets (National Zoological Park, Louisville Zoo, Toronto Zoo, The Phoenix Zoo, Cheyenne Mountain Zoo, and, at one time, the Henry Doorly Zoo and Turner Endangered Species Fund) have committed substantial resources, without compensation, to the captive breeding effort.
- High quality habitat and mitigation of disease at self-sustaining re-introduction sites: Re-introduction sites that are currently considered self-sustaining and viable have high quality habitat that is plague-free or the disease is actively mitigated. Dusting prairie dog burrows to kill fleas, a vector of plague, and vaccinating ferrets is effective in managing plague and increasing both prairie dog and ferret survival (Matchett *et al.*, 2010). The substantial commitment by site managers to mitigate plague is a significant reason for success, such as the ongoing dusting/vaccination efforts in Conata Basin/Badlands, South Dakota.
- Pre-release conditioning of captive animals: Releasing captive-born ferrets with outdoor pen exposure (Biggins *et al.*, 1998) allowed rapid and efficient population establishment at some recovery sites. Pre-release conditioning is now standard in the ferret recovery program and translocation of wild animals is an effective tool in establishing new populations.
- Continued research and monitoring: An adaptive approach to program management has allowed research to address issues facing the program and advance recovery. Several examples include pre-release conditioning improving survival (Biggins *et al.*, 1998) and establishment of populations, artificial insemination helped genetic management, and plague research has given us short-term tools to understand and mitigate the disease (Matchett *et al.*, 2010).
- Patience and persistence in re-introduction: Re-introduction of captive-born ferrets into the wild began in 1991 yet the first self-sustaining and viable populations were not observed until 1999. Program partners remained fiscally and politically committed to re-introduction, sometimes without evidence of immediate population establishment. Most sites monitor wild populations annually, allowing yearly assessment of program progress and wild population establishment.

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The case of the Eurasian beaver in Sweden: re-introduction project carried out before the existence of re-introduction guidelines!

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Introduction

The Eurasian beaver (*Castor fiber*) is the sole representative of the family Castoridae (Order Rodentia) on the Eurasian continent. Average weight of adult beavers is 17 - 18 kg. They are herbivorous and semiaquatic with a characteristic life style involving felling of trees and dam-building in small watercourses. The beaver thereby re-shapes its habitat and is a prime example of a so-called ecological engineer. The Eurasian beaver is listed as “Least Concern” by the IUCN (2011). The Eurasian beaver was historically found from Scotland in the west across the whole Eurasian continent, and from the Mediterranean Sea in the south to the tundras in the north. Centuries ago the range and population began to decrease due to overhunting, encouraged by high prizes of beaver pelts and castoreum. Castoreum was highly valued for medical purposes and the fur was used to make hat-felt of high quality. In 1756, an alarming report was presented to the Royal Swedish Academy of Sciences concerning the decline of the Swedish beaver population. At this time the earlier widespread and common beaver was found only in remote areas. Hunting continued however, and the last well documented observations of beaver from the original Swedish population are from the 1870´s (Ekman, 1910).

Goals

- The first re-introduction was the private initiative of museum curator Eric Festin from Östersund in the province of Jämtland. His explicit goal for the project was “to restore our devastated fauna”.

Success Indicators

- n/a

Project Summary

The project initiator, Eric Festin, organized the



Beaver (*Castor fiber*) © Wildwood

necessary fund raising as well as the purchase and transportation of a beaver pair from southern Norway, which was released in July 1922, in the river Bjurälven (*bjur* is an old Swedish word for beaver), in the province of Jämtland. Festin kept the press well-informed so the project and the long transportation of captive beavers from Norway, via Stockholm, to the remote release site, was well known to the public. This first re-introduction was soon followed by others, all private initiatives, and by 1939 about 80 beavers had been imported from Norway and released at 19 different sites spread over the whole of Sweden. Propagule sizes varied from two to nine at each site. Obviously, one was happily ignorant of possible risks for inbreeding depression.

In 1940 reproduction had been observed at 11 of the re-introduction sites (Fries, 1940). During the following decades numerous translocations accelerated the spread of beaver in the country. The population increased steadily and surveys initiated by the Swedish Environmental Protection Board estimated numbers at about, 2,200 in 1961 and 7,500 in 1969. During the 1970´s the population increased rapidly and a nationwide survey in 1977 in an estimated population size of 40,000. In 1992 an attempt to estimate the size of the population by combining a number of local surveys performed during the 1980´s and 1990´s concluded that the population most likely had passed 100,000 (Hartman, 1995). A rough estimate of current population size (2011) is 130,000 - 140,000.

On a local scale, population development has in many areas exhibited an irruptive pattern, i.e. an initial stage of low population numbers is followed by a rapid increase and after reaching peak numbers the population decreases to lower numbers (Hartman, 2003). The most plausible explanation to the pattern is overutilization of food resources.

As the beaver today is a common species in large parts of Sweden it is also a game species. Beaver hunting was first allowed in 1977, in the beginning as a license system in a couple of counties. This was then gradually extended geographically and changed to a system with an open hunting season. Since 2001 beaver hunting is allowed in the whole country. The annual bag (2010) is estimated at 8,000 - 9,000. The beaver is however still increasing in numbers and range.

Major difficulties faced

- No major difficulties were reported, to my knowledge.

Major lessons learned

- Re-introductions may be successful in spite of small propagule sizes and low levels of genetic variation in the founder population (Ellegren *et al.*, 1993).
- Re-introduced populations may exhibit irruptive population development, due to e.g. overutilization of food resources.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The beaver is a generalist and can thrive in many types of habitat, meaning that there was no lack of suitable habitat.
- The public had in general a positive view of the project, so hunting restrictions were respected to a large extent.
- Because of genetic characteristics of either the species or the specific founder population, no signs of inbreeding depression have been observed, in spite of small and isolated propagules.
- Low numbers of large predators.

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Zanzibar red colobus on Pemba Island, Tanzania: population status 38 years post-introduction

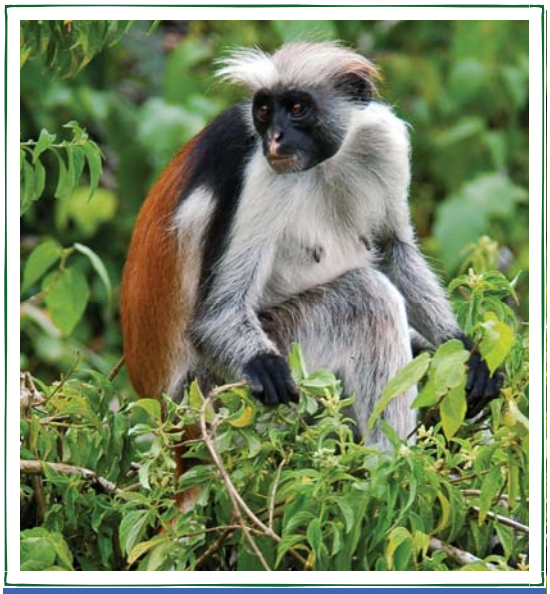
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Introduction

The Zanzibar red colobus monkey (*Procolobus kirkii*; adult body weight c. 7 kg) is an arboreal, folivorous, forest monkey that is endemic to Zanzibar (Unguja) Island (2,461 km²), Tanzania. *Procolobus kirkii* is one of Africa's most threatened species of primate with but 2,000 - 2,500 individuals remaining (Struhsaker & Siex, 1998; Struhsaker, 2010). According to the current IUCN Red List of Threatened Animals, *P. kirkii* is an 'Endangered' species. *Procolobus kirkii* is also a CITES II species. About half of the *P. kirkii* on Zanzibar reside outside protected areas where they are threatened by habitat degradation, destruction, and fragmentation due to logging, charcoal production and clearing of forest for cultivation. There is no captive population.

Fifteen *P. kirkii* (5 males:10 females) were introduced in 1973 to Ngezi-Vumawimbi Nature Forest Reserve, north-western Pemba Island, Tanzania, by the Zanzibar Forestry Department (Maulid Hamad, pers. comm.). These animals were captured on Zanzibar, c. 150 km from Ngezi Forest. Pemba is an oceanic island located c. 50 km off the mainland. Prior to human occupation, Pemba was almost entirely covered with forest. Today, given the high density of people and intensive agriculture, only about 5% of the original forest remains. Nonetheless, Pemba continues to hold a rich and unique flora and fauna which includes many endemic and threatened species (Pakenham, 1984; Beentje, 1990; Nahonyo *et al.*, 2005).



Adult female Zanzibar red colobus monkey
© Tom Butynski & Yvonne de Jong

Goals

- Goal 1: This release occurred 38 years ago. We have not found any documentation as concerns

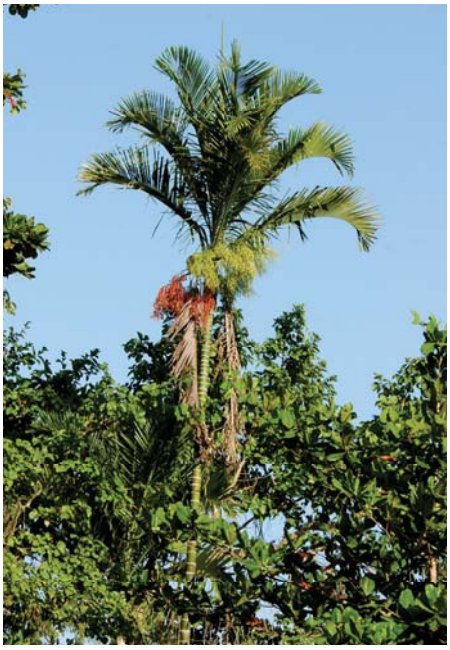
this introduction, and therefore, it is not known what 'success indicators' Forestry Department had in mind. We do know, however, that this was an introduction for the purpose of enhancing the long-term survival of *P. kirkii* and that this was followed in 1977 - 1978 by translocations (probably re-introductions) on Zanzibar itself, into Mayingini Forest Reserve (9 animals), Masingini Forest Reserve (23 animals), and Kichweli Forest Reserve (13 animals; Silkiluwasha, 1981). It seems obvious, therefore, that the primary goal was to establish a new, self-sustaining, population of *P. kirkii* on Pemba Island that would persist into the distant future and contribute significantly to the long-term survival of the species.

- Goal 2: A probable goal was to develop an efficient and inexpensive method for capturing and translocating *P. kirkii* while also minimizing mortality.
- Goal 3: A probable goal was to promote local, national and international awareness of the threats to the survival of *P. kirkii* and, thereby, influence public opinion and foster support not only for the conservation of *P. kirkii* but also for Ngezi-Vumawimbi Nature Forest Reserve and its biodiversity.
- Goal 4: A probable goal was to improve the image of the Zanzibar Forestry Department as a conservation body.

Success indicators

The pre-implementation success indicators are not known, but they, presumably, included the following:

- Indicator 1: The new population is self-sustaining and persistent (for centuries).
- Indicator 2: The new population increases in size so as to contribute significantly to the global population and conservation of *P. kirkii*.
- Indicator 3: Capture and translocation methods are developed that are practical, inexpensive, and that result in low mortality.
- Indicator 4: Public awareness of the plight of *P. kirkii* is raised on Zanzibar, Pemba, and internationally.



Pemba palm: an endemic species important for the survival of colobus

© Yvonne de Jong & Tom Butynski

Project Summary

Feasibility: Ngezi-Vumawimbi Nature Forest Reserve (20 km²), gazetted in 1923, encompasses the only moist forest (c. 10 km²) on Pemba that is of any size. Elevation is c. 0 - 30 m a.s.l. Soils are deep, rich, alluvial sands. The climate is hot and humid. Temperatures range from c. 21 - 34°C. Mean annual rainfall is c. 1,860 mm. The wettest months are March - May and November -

December. The moist forest of Ngezi has been described by Beentje (1990) as showing "…an assemblage of species that is not paralleled in any other East African forest…" and as "…unique in a global sense". Ngezi Forest is important for the conservation of at least six species of plants and 13 species of vertebrates that are endemic to Pemba Island, plus a good number of endemic subspecies and near endemic species, many of which are threatened with extinction (Pakenham, 1984; Beentje, 1990; Nahonyo *et al.*, 2005). It is not known what consideration, if any, was given to the impact that an introduced population of *P. kirkii* might have on the other (many) species in Ngezi Forest, or on the ecosystem as a whole. This monkey is not considered to be an important pest of crops.

The Tanzania Population Census of 2002 found 20,138 people in the 10 villages that are closest to Ngezi Forest. The annual rate of growth of this human population was 5.4% in 2002, which is one of the highest in Africa. Most of the land outside of the Ngezi-Vumawimbi Nature Forest Reserve has been cleared of forest and put under intensive agriculture (mainly cassava, sweet potato, coconut, millet, rice, and banana). Approximately 80% of the local income is derived from farming and 10% from fishing. About 59% of the people keep cattle and 30% keep goats. Many of the local people use the forest, particularly for firewood and timber (Nahonyo *et al.*, 2005).

Implementation: This represents one of the first attempts (if not the first attempt) to translocate or introduce an African primate for the purpose of conservation. No records were found of where on Zanzibar, or how, the *P. kirkii* translocated to Ngezi Forest were captured. As for all of the several captures made during 1977 - 1978, the site of the 1973 capture was probably either a poor habitat for *P. kirkii* or a good habitat that was being cleared for agriculture (Silkiluwasha, 1981). It is also likely that the capture method was the same as used during 1977 - 1978 for translocations within Zanzibar. See Silkiluwasha (1981) for details of the capture method and holding cages. Of 40 *P. kirkii* captured using this method in 1977 - 1978, four (10%) died prior to release.

There is no information on whether the *P. kirkii* captured on Zanzibar for release in Ngezi Forest were quarantined and/or given health checks, but this seems unlikely. On Zanzibar, *P. kirkii* were usually released on the same day that they were captured. *Procolobus* do poorly in captivity (Silkiluwasha, 1981; Struhsaker & Siex, 1998) so it seems unlikely that those bound for Ngezi Forest were held any longer than necessary prior to release. Whether they were moved to Pemba by air or by sea is not known. It is also not known how many, if any, died during the capture or translocation. Maulid Hamad (pers. comm.), who was present at the time of the release, said that all 15 *P. kirkii* were released at one site (Josh).

Post-release monitoring: There seems to be no information, prior to 1991, concerning post-release monitoring of *P. kirkii* in Ngezi Forest. Censuses of this population were conducted in 1991, 1992 (Struhsaker & Siex, 1998), 2000 (Ciani *et al.*, 2001), 2005 (Nahonyo *et al.*, 2005), and 2011 (this study). The 1991, 1992, 2000 and 2005 censuses each encountered no more than one group of *P. kirkii*

and the largest group comprised only six animals. Although the 2000 census located only one group of (at least three) *P. kirkii*, interviews with local people suggested that two other groups (of 5 - 8 and 5 - 7 animals) occurred in Ngezi Forest. A fourth group of 4 - 6 animals was said to be present in an abandoned clove plantation c. 6 km south of Ngezi Forest. The conclusion of the 2000 census is that there were 15 - 30 *P. kirkii* in Ngezi Forest.

During the 2011 census (5 days; 53 hrs of census by two primatologists) we located two groups (of at least 7 and 8 animals) and found strong evidence (leaves from which the petiole had been bitten-off) for three additional groups. We conclude that there are likely no fewer than 35 *P. kirkii* in Ngezi Forest, with the actual number perhaps closer to 40. There were no reports of *P. kirkii* at any other sites on Pemba. Thus, 38 years after the introduction to Pemba, the population has more than doubled, but continues to be small. The five groups were widely scattered across Ngezi Forest with the shortest distance between groups being 700 m and the farthest distance being 6 km. Groups appear to have an affinity for forest edge next to, or over, water (e.g., forest-mangrove ecotone, swamp forest).

Major difficulties faced

- Insufficient information: The absence of any monitoring during the first 17 years (1973 - 1990) post-release, and of a low level of monitoring over the past 21 years (1990 - 2011), greatly limits what can be learned from this introduction. For example, we do not know the rates of growth or decline of this population, nor the problems that this population encountered. A detailed census needs to be conducted of this population so that its size, age/sex composition, and distribution are better understood. Detailed censuses should then be repeated at least once every 5 years. Intensive ecological studies should be undertaken on this population with the objectives of better understanding what impact *P. kirkii* is having on the ecosystem and what factors are most limiting population growth. Genetics research (using fecal samples) needs to be conducted in order to assess the level of inbreeding and the need for translocating new animals into this population (see next bullet point). The genetic diversity of this population should be regularly monitored in order to assess the need for translocations.
- Probable inbreeding depression: Given the size of Ngezi Forest, and the high diversity of plant species, it seems unlikely that food is limiting this population. At present, *P. kirkii* probably occupy less than 10% of that part of Ngezi Forest that is covered by moist forest (c. 10 km^2). Now, 38 years (about four generations) post-release, this population (which is based on only 15 founders), may be suffering from inbreeding depression. If the present objective is to maintain the long-term viability of this isolated population, then at least one supplemental release of *P. kirkii* from Zanzibar is warranted as this should help to over-come what may be a genetic bottleneck. Individuals on Zanzibar that are likely to perish due to habitat loss are the most suitable candidates. The number to translocate, and the time frame, need to be determined, but even a small number might contribute significantly towards out -breeding the Ngezi Forest population.



Pemba vervet monkey is endemic to Pemba Island, Ngezi Forest © Yvonne de Jong & Tom Butynski

- Hunting: Poaching has been put forth as the reason for the low numbers of *P. kirkii* in Ngezi Forest (Nahonyo *et al.*, 2005). While we found no evidence of hunting during our census, the possible impact of hunting cannot be discounted, particularly given the small size of this population and that three of the larger species that are said to have once been common/ abundant in Ngezi Forest are now either at low density or, perhaps, extirpated; Pemba blue duiker (*Philantomba monticola pembae*), wild boar (*Sus scrofa*), and Zanzibar tree hyrax (*Dendrohyrax validus neumanni*) (Pakenham, 1984; Nahonyo *et al.*, 2005; T. Butynski & Y. de Jong, pers. obs.).
- Difficult to census: Unlike other populations of *Procolobus*, *P. kirkii* on Pemba are surprisingly difficult to locate and count. This is a relatively quiet, inactive, monkey that is often high and well-hidden in the canopy of tall trees (>30 m) or else low (<4 m) in extremely dense undergrowth on the forest edge. The high temperatures on Pemba mean that monkeys are typically inactive from 09:00 hrs - 17:00 hrs and that, when inactive, they are hidden in dense shade. Experienced field primatologists are required to lead the census teams (2 - 3 people), make group counts, and assess age/sex. The time required to fully census the population of *P. kirkii* in Ngezi Forest is estimated to be 20 - 28 census team days.
- Insufficient funding and expertise: The absence of monitoring of this introduced population of *P. kirkii* during the first 17 years post-release is attributable to the low budget and lack of relevant expertise in the Forestry Department. While the Forestry Department recognizes the importance of monitoring this population, and gave full administrative and staff support to the five censuses, most of the funds and expertise for these censuses came from several outside sources. The lack of a reliable source of dedicated funds for monitoring and research is expected to continue to be a serious constraint and risk for the management and long-term survival of this population.

Major lessons learned

- *Procolobus kirkii* can be successfully translocated: *Procolobus kirkii* can be successfully translocated and introduced. This has also been demonstrated at Masingini Forest Reserve (2 - 3 km²), Zanzibar. A total of 36 *P. kirkii* were translocated to Masingini Forest in 1977, 1978 and 1981. In 1994 this

population comprised c. 60 animals. This is a 67% increase during the 13 - 17 years post-introduction (Struhsaker & Siex, 1998). This population was still present in April 2011 (T. Butynski & Y. de Jong, pers. obs.).

- Suitable capture method exists: The method for capturing and translocating *P. kirkii*, as described by Silkiluwasha (1981) for the 1977 - 1978 translocations within Zanzibar, is effective, inexpensive, and mortality is low at about 10% (4 of 40 captured animals died). Whether mortality was similar for the Ngezi Forest introduction is not known but might have been higher given the greater distance (c. 150 km) between the capture site and the release site.
- Long-term monitoring scheme is required: Without a good post-release monitoring program in place, the opportunity to obtain information useful to improving the introduction process and post-introduction management of the population, and of assessing the impact of the introduced population on the ecosystem, is lost. A long-term monitoring scheme needs to be put into place.
- Enhance benefits to local people: More benefits to local people through eco-tourism in Ngezi Forest, perhaps with a focus on viewing *P. kirkii*, should bring additional conservation support from the local community and foster a sense of pride and responsibility for the conservation of Ngezi Forest, its biodiversity, and its population of *P. kirkii*.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The introduced *P. kirkii* were placed into what is probably a food-rich habitat; Ngezi Forest is larger and far more botanically-rich than any forest on Zanzibar. The altitude and climate (including rainfall) are similar on Pemba and Zanzibar.
- There are only two species of primate indigenous to Pemba and neither is a competitor with *P. kirkii*; Pemba vervet monkey (*Cercopithecus pygerythrus nesiotes*) and Zanzibar small-eared galago (*Otolemur garnettii garnettii*).
- There are no significant non-human predators of monkeys on Pemba, such as African crowned eagle (*Stephanoaetus coronatus*), robust chimpanzee (*Pan troglodytes*), leopard (*Panthera pardus*), or central African rock python (*Python sebae*).
- *Procolobus kirkii* is not known to be a serious pest of crops and the hunting of monkeys for bushmeat is not an important part of the culture of the people of Pemba, the vast majority of whom are Muslim (Muslims typically do not eat monkeys).
- There seems to be a steady increase in the local, national and international commitment to the conservation of Ngezi Forest and *P. kirkii*. Forestry Department, with support from outside agencies (e.g., CARE, FINNIDA) has continued to improve the protection and management of Ngezi Forest.

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Twenty years of conservation and monitoring of re-introduced mountain gazelle in the Ibex Reserve, Saudi Arabia

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Introduction

Historically, the mountain gazelle (*Gazella gazella*) occurred across most of the Arabian Peninsula into northern Syria and Turkey. Early explorers and scientists reported that the mountain gazelle is closely associated with *Acacia* spp. trees. The current range includes southern Turkey, Jordan, Israel, Iran (Farur Island), Oman, United Arab Emirates, Yemen and Saudi Arabia. The IUCN Red List currently ranks this species as 'Vulnerable' (A2ad). Mountain gazelle numbers have decreased dramatically throughout their range, particularly in Saudi Arabia. The only protected areas in Saudi Arabia with natural populations of mountain gazelle are Al Khunfah, Harrat al Harrah, and Farasan Islands. A few scattered populations occur outside of protected areas in the western Asir Mountains, Hejaz Mountains, and possibly on the Tihama coastal plain. There are only two reports of mountain gazelle occurring historically in the central mountains of Saudi Arabia. Both reports are for mountain gazelle in the Jebel Tuwaiq, which is where the Ibex Reserve is situated. In an effort to re-establish the locally extinct population in the Tuwaiq Mountains (Ibex Reserve), the Saudi Wildlife Authority (SWA) initiated a mountain gazelle re-introduction program in 1990 (Dunham *et al.,* 1993). The released gazelles came from the King Khalid Wildlife Research Centre (KKWRC), Saudi Arabia.

Goals

- Goal 1: Re-establish a mountain gazelle population in the Tuwaiq Mountains, central Saudi Arabia.
- Goal 2: Improve captive breeding at KKWRC so as to produce individuals capable of surviving in the wild.



Mountain gazelle, 20 years after first release into Wadi Ghabah, Ibex Reserve. © T. Wronski

- Goal 3: Establish a post-release monitoring program that would provide the information necessary (e.g. habitat choice, food preferences, dispersal distances, mortality rates) for identifying other suitable sites for re-introduction in Saudi Arabia.
- Goal 4: Establish an indirect, non-invasive, method, based on the use and distribution of fecal pellet latrines, to estimate population size and distribution at other sites.

Success indicators

- Indicator 1: A healthy and genetically diverse mountain gazelle breeding population is maintained at KKWRC.
- Indicator 2: A healthy and self-sustaining mountain gazelle population is established in the Ibex Reserve.
- Indicator 3: The progeny of released mountain gazelles disperse and settle outside the Ibex Reserve.
- Indicator 4: A significant reduction of illegal hunting in the Ibex Reserve.
- Indicator 5: Acceptance of, and support for, the Ibex Reserve increases in the local community.

Project Summary

Feasibility: The Ibex Reserve (1870 km²; 23°30´N, 46°30´E) near Hawtat Bani Tamim in Jebel Tuwaiq, central Saudi Arabia, was established in 1988 by SWA. A primary objective was to protect the last Nubian ibex (*Capra nubiana*) in the Jebal Tuaiq. The Reserve is comprised of an undulating, stony, limestone plateau (800 - 1,100 m a.s.l.) incised by deep wadis. Plant standing crop biomass is extremely low on the plateau, but higher in the wadis, where *Acacia tortilis* dominates the vegetation. No historic information is available on the taxonomic status, distribution, or numbers of mountain gazelle in Jebel Tuwaiq. A study (Al-Shaya *et al.*, 2007) of the local peoples' knowledge of, and attitude towards, the Ibex Reserve revealed a low level of awareness regarding the plants and animals of the Reserve or the importance of wildlife. Their attitude towards the Reserve is hostile. The main reason given for this is the lack of conservation education and public awareness programs. The local people understand that the Ibex Reserve is a protected area, but realize that law enforcement is weak. They believe that improved law enforcement and draconian penalties are the only way to stop illegal hunting.

Implementation: Mountain gazelle for this re-introduction were obtained from captive stock at KKWRC. The Centre was established in 1987 by SWA (under the management of the Zoological Society of London) to develop the private collection of the late King Khalid Ibn Abdul Aziz Al Saud. Several subspecies of mountain gazelles are recognized. The population at KKWC is a mix of subspecies originating from various sites on the Arabian Peninsula. Prior to their release, all gazelles were vaccinated against rinderpest, rabies, pasteurellosis, brucellosis, haemorragic septicaemia, foot and mouth, clostridiosis, and PPR. They were transported one gazelle to a crate (100 cm x 36 cm x 90 cm) during winter or spring in order to avoid heat stress. A dose of long acting Narcoleptic was administered before transportation to keep the gazelles calm. The gazelles

were held at the Ibex Reserve in pre-release pens for 4 weeks to develop site fidelity and to adapt to the natural vegetation as a source of food.



Acacia-dominated mountain gazelle habitat with plateau free of vegetation © M. Klein

Gazelles were released into four wadis (Wadi Ghabah, Wadi Gafar, Wadi Jidr, and Wadi Nukhailan) and on the plateau of the Ibex Reserve. The entrance to all wadis was fenced in order to limit access by people and their livestock. In total, 11 releases were made from 1990 to 2007. During the first release 19 gazelles were put into Wadi Ghabah. This was followed by the release of 10 gazelles in 1991 into Wadi Ghabah, and by the release of 25 gazelles in 1992 into Wadi Gafar. Radio-collars were fitted to 28 gazelles and all were given plastic ear-tags for individual recognition. During 1993 - 1995, 30 gazelles were released into Wadi Jidr but no post-release monitoring was carried out. The last release was in 2007 when 21 gazelles were put into Wadi Nukhailan and seven on the plateau. Radio-collar was fitted to 14 gazelles and all were given plastic collars of different colors. Details on numbers, locations and sex/age composition of mountain gazelle released into Ibex Reserve are provided in Dunham (1997) and Wronski *et al.* (in press).

Post-release monitoring: Marked gazelles were intensively monitored in order to determine survival, dispersal patterns, and home ranges. There were about 185 mountain gazelles in the Wadi Mutim System (Wadi Ghabah and Wadi Gafar) in 1995. The mean annual exponential rate of increase was 0.275; effectively doubling the population every 2.5 years (Dunham, 1997). From 1995 to 1998, gazelle numbers dropped dramatically to about 70 individuals (Dunham, 2001). This decline was attributed to the adverse effects of domestic livestock entering the wadis, to poaching, and to poor relations between the local people and the SWA.

No systematic surveys were undertaken during 1998 - 2000. In 2001, KKWRC and SWA re-established a standardized monitoring scheme. Due to increasing human pressure (particularly recreation, poaching, and livestock grazing), the number of gazelles declined further to 10 - 40 individuals in 2007 (Wronski *et al*., in press). Since 2007, the population in the Wadi Mutim System has been relatively stable at 10 - 20 gazelles. In contrast to the situation in Wadi Mutim, no population increase occurred after the releases in Wadi Nukhailan. The number of

collared gazelles declined rapidly from 14 in February 2007 to one in November 2008. Counts in 2011 indicate that the number of gazelles has stabilized at about 30 - 40 animals. In 2010, a group of mountain gazelle was discovered in Wadi al-Fariah, in the southeastern-most part of the Reserve, 27.5 km from the nearest release site. While this demonstrates successful dispersal, it also suggests limited resource availability and a high level of disturbance by people in the release areas (Wronski, 2010). Nonetheless, the presence of gazelles at Wadi al-Fariah, and at other sites outside of the original release areas, gives reason to hope for the long-term persistence of this re-introduced population.

Major difficulties faced

- No effective control of people or their livestock. The range is over-grazed and over-browsed, leaving insufficient food for gazelles. Poaching is a major problem.
- Population increase above carrying capacity or territorial exclusion of young-adult males led to dispersal outside the protected area making the gazelles prone to harassment and poaching.
- Poor relationships between local people and the SWA means low acceptance of the Ibex Reserve and retaliation in the form of poaching of gazelles.
- The Reserve is on the edge of the historic geographical range of mountain gazelle. As such, the Reserve provides marginal habitat for this species, including low availability of food (Wronski, 2010).

Major lessons learned

- A positive attitude towards, and acceptance of, the Ibex Reserve by the local people appears to be imperative for the success of this re-introduction.
- The long term success of this re-introduction remains dependent on public support and conservation/environmental awareness in Saudi society, with sustained environmental education programs in schools a vital element.
- Marginal habitat and low food availability, together with substantial competition with Nubian ibex and domestic livestock (camel, donkey, sheep, goat) has led to a low but stable population of mountain gazelle in the Ibex Reserve.
- The social organization of mountain gazelle (i.e., female philopatry, male territoriality, dispersal patterns) must be considered when releasing animals into the Reserve.
- Mountain gazelle are tenacious and able to cope without drinking water. They are capable of maintaining a low population density in the Ibex Reserve under present levels of poaching and predation by Arabian wolf (*Canis lupus*).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure

- Mountain gazelle of good genetic background were available for re-introduction.
- Suitable habitat for the mountain gazelle, albeit marginal, was available at several sites in a large protected area. Long distance dispersal of mountain gazelles from release sites led to establishment of groups at new, widely located, sites.
- Adequate financial support and expertise for the re-introduction, monitoring, research, and some law enforcement was available.

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Population development of re-introduced mountain gazelle in the western Empty Quarter (Uruq Bani Ma'arid Protected Area), Saudi Arabia

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Introduction

Uruq Bani Ma'arid (UBM), Saudi Arabia's largest protected area, is bounded to the west by the southernmost extension of the Tuwaiq Escarpment, a remnant Jurassic limestone massif, and forms part of the extensive sands (mainly longitudinal dunes) of the famous Rub' al-Khali (Empty Quarter), the largest sand sea in the world. The area was protected in 1993 because of its unique landscape, an intact habitat with little or no human disturbance, and its potential as a suitable re-introduction site for the Arabian oryx, sand gazelle and ostrich. For mountain gazelle (*Gazella gazella*) the area was considered rather unsuitable due to its location at the edge of the former geographical range of the species, and was thought to provide only marginal habitat. Historically, mountain gazelle occurred primarily in more rocky habitats across most of the Arabian Peninsula. The current range includes southern Turkey, Jordan, Israel, Oman, United Arab Emirates, Yemen and Saudi Arabia, (though recent genetic evidence suggests those from the northern countries should now be treated as a completely separate conservation unit or even species). The IUCN Red List currently ranks the species as 'Vulnerable' (A2ad). Mountain gazelle numbers have decreased dramatically throughout their range, particularly in Saudi Arabia. In an effort to establish a population in the southern Tuwaiq Mountains, the Saudi Wildlife Authority (SWA) initiated a re-introduction program in 1996 (Dunham



Adult male mountain gazelle in its preferred habitat at UBM Protected Area © T. Wacher

et al., 1997). Released gazelles originated from King Khalid Wildlife Research Centre (KKWRC), in Saudi Arabia

Goals

- Goal 1: Re-establish a mountain gazelle population in the southern Tuwaiq Mountains, Saudi Arabia, being isolated from the next indigenous population.
- Goal 2: Support for the captive population that is still in place and subject to research and planning to improve health and genetic status of gazelles for future re-introductions.
- Goal 3: Establish post-release monitoring to provide information on habitat choice, food preferences, dispersal distances and mortality rates in a re-introduction area with marginal habitat and severe environmental conditions (extreme temperature, low precipitation and low food availability).
- Goal 4: Compare those data with other re-introduction attempts (e.g. in the Ibex Reserve; see this volume) and with indigenous mountain gazelle populations on Farasan Islands, in the Asir and Hejaz Mountains and on the Tihama coastal plains.

Success indicators

- Indicator 1: A healthy and self-sustaining mountain gazelle population in the southern Tuwaiq Mountains.
- Indicator 2: Dispersal and settlement of the progeny of released gazelles into suitable habitat outside the protected area.
- Indicator 3: A significant reduction of illegal hunting in Uruq Bani Ma'arid.
- Indicator 4: Increased acceptance and public awareness by the local communities around the protected area, and the recognition of the potential of UBM as a destination for national and international tourism.

Project Summary

Feasibility: UBM covers an area of about 12,600 km^2 and is located at the western edge of the Empty Quarter, approximately 200 km north of Najran in southern Saudi Arabia (19.3˚N, 45.3˚E). The area is located at an altitude between 720 and 940 m a.s.l., with suitable mountain gazelle habitat only along the Tuwaiq Escarpment at the western edge of the Reserve. Mean annual rainfall is low (47 mm), highly variable and unpredictable, making the Empty Quarter one of the driest places on the Arabian Peninsula (Child & Grainger, 1990; Dunham, 1997). Reports of mountain gazelle by local communities indicate that the species previously occurred in UBM. Several subspecies of mountain gazelles are recognized (even within the Arabian populations), but the subspecies status of gazelles historically inhabiting the area is not known. Mountain gazelles released into the Reserve are subspecies hybrids originating from different parts of the Arabian Peninsula. The release site at UBM was chosen to be far from indigenous populations to minimize the risk of re-introduced animals coming into contact with indigenous wild stock in the foreseeable future.

Implementation: Re-introduced mountain gazelle were obtained from a captive breeding stock kept at KKWRC. The centre was set up in 1987 by SWA (under

the management of the Zoological Society of London), to develop an existing private collection of the late Saudi King Khalid Ibn Abdul Aziz Al Saud. All gazelles chosen for re-introduction were vaccinated, transported and released as described for mountain gazelle re-introductions into the Ibex Reserve, Saudi Arabia (see this volume). In January and February 1996, a total of 24 mountain gazelles (10 male:14 female) were released at two sites along the escarpment of UBM. Five animals (2 male:3 female) were equipped with radio collars. All others were made individually recognizable by using colored ear tags or collars. Following a successful first year in which territories were established and at least four calves born, a second release of 49 animals (19 males:30 females) was carried out at both sites in January 1997 (Wacher, 1997). Ten animals (5 males:5 females) were fitted with radio collars in this second cohort.

Post-release monitoring: Estimates of mortality derived from 15 individuals released with radio-collars revealed that 78% survived by the end of the first year post-release. Of the remainder, five gazelle (35%) had been lost to unknown outcomes within following two months. At least three individuals (20%) of the original radio-collared cohort were still alive in 2002, more than 6 years after release (Wacher, 2006). Monitoring of reproductive success was limited by the small sample size of regularly seen females in the early stages of this re-introduction. The radio-collared females had an initial calving rate of *app*. one calf/female during 1996, dropping to 0.33 calves/female in 1997, before rising to 0.5, then 0.7 calves/female in 1998 and 1999 (Wacher, 1998). Between 2001 and 2006 the proportion of calves/juveniles in the population was 23% - 26% (Wacher, 2006).

Post-release dispersal of re-introduced mountain gazelle observed at UBM has shown two major differences to that observed in the Ibex Reserve (see this volume). Both dispersal distances and home range sizes have been far larger at UBM. At least three individuals dispersed up to 50 km from the release site within 6 months of release, then settled into relatively large home ranges (males (N=3): 32.0±13.2 km^2, females (N=6): 63.5±29.1 km^2; Wacher,1998). Habitat preference has been a key feature of dispersal and range expansion in this re-introduction. Released mountain gazelles have dispersed exclusively along the limestone plateau of the western escarpment, avoiding large sand dunes, and particularly settling around elevated sectors of the escarpment dissected by well vegetated drainage lines (Wacher, 1998). The maximum penetration into the gravel inter-dunal corridors (shiqqats) recorded until 2002 has been 20 km, following highest densities of *Acacia* trees.

After two years mountain gazelles were dispersed along >120kms of the Tuwaiq Escarpment reaching from Qaryat al Faw in the North to the plains of Ushayran in the South (Wacher, 1997, 1998). Aerial surveys carried out from 1997 to 1999, and ground surveys carried out from 1999 to 2006 revealed a constant population increase (encounter rates: 2002: 0.016/km, 2005: 0.03/km, 2006: 0.07/km; Wacher, 2006). In 2008 the encounter rate had decreased to 0.025/km. Based on a road counts an estimate of 121 - 307 gazelles in an area of 1,350 km^2 of suitable habitat was made in 2008 by Cunningham *et al.* (2008). From 2008

onwards the National Wildlife Research Centre (NWRC) carried out regular ground surveys along eight transects, each about 23 km long (strip width 400 - 700 m) covering only a belt (100 x 10 km) of suitable habitat east of the Tuwaiq Escarpment (Wronski and Islam, unpubl. data). Population estimates are 224 gazelles for 2009, 307 for 2010 and 282 for 2011. These numbers are likely to underestimate the true population size. A new method, estimating gazelle numbers by surveying dung middens provides estimates of more than 700 mountain gazelles (Wronski & Islam, unpubl. data).



Typical *idmi* habitat © Tim Wacher

Major difficulties faced

- Monitoring has been less intense than that documented for mountain gazelles released at the Ibex Reserve (see this volume), in part because of the smaller number of radio-collars, but mainly because the work was integrated with the monitoring of large numbers of sand gazelle and Arabian oryx re-introduced at the same site.
- Results were only obtained by a combination of incidental encounters, supported by low-intensity conventional radio-tracking and intermittent aerial radio-tracking.
- Due to a lack of resources (finance & labor) no systematic surveys were conducted during the years 2000, 2003, 2004 and 2007.
- Since UBM Protected Area is unfenced and therefore difficult to control, it is open to intrusion by illegal hunters, Bedouins and their camels.

Major lessons learned

- Observation that reproductive rates are comparatively lower, and range use parameters are relatively higher than in areas with more ecologically favorable conditions, are in keeping with the expectation that marginal areas are less suitable for mountain gazelle re-introduction projects. Although UBM lies at the edge of former range, overall the results show that habitat conditions are probably better than originally assessed.
- Mountain gazelle are tenacious and able to cope with no access to free water, low food diversity, limited food availability and human harassment.
- Environmental education to encourage local and national awareness and support for this and other SWA initiatives remains crucial to the long term success of this project.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure

- Despite the marginal habitat being at the edge of the species range, experiencing low rainfall and naturally low food availability for extended periods, mountain gazelle survival and reproduction has resulted in net population growth over the first 5 - 6 years.
- We believe use of a comparative large founder group helped mitigate against stochastic risks that might affect a very small initial population.
- Within a short period mountain gazelles dispersed over a comparatively large area along a belt of suitable habitat.
- Long distance dispersal from release sites led to the establishment of mountain gazelle home ranges outside the protected area.
- Mountain gazelle is tenacious ungulate species well adopted to cope with no access to free water, extremely low food availability, and human disturbance.
- Continued breeding of viable and genetically diverse mountain gazelles at King Khalid Wildlife Research Centre.

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Status of a re-introduced population of threatened Arabian sand gazelles in SW Saudi Arabia: management lessons from an aridland re-introduction

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Introduction

The Arabian sand gazelle (*Gazella subgutturosa marica*), locally known as *reem* was historically distributed throughout Asia, from Palestine and the Arabian Peninsula to the Gobi desert and northern China and due to illegal hunting and habitat loss, the population has declined throughout its range. The majority of historical records are from the north of Saudi Arabia, mostly from gravel plains and black lava deserts to the north and west of the Nafud desert. Due to this decline, a national captive-breeding program was started by the Saudi Wildlife Authority at its King Khalid Wildlife Research Center near Riyadh and produced sand gazelles to re-introduce them to the wild with the objectives to establish a free-ranging, self-sustaining population in Mahazat as-Sayd Reserve. National Wildlife Research Center based in Taif has been managing the re-introduction in Mahazat since the first release and historically *reem* was distributed in the Mahazat area and the habitat was suitable for re-introduction. Mahazat is 2,224 km^2 fenced area and is a special Nature Reserve established in 1988 to re-introduce Arabian oryx, sand gazelle, Houbara bustard and red-necked ostrich. IUCN Red List currently lists this species as 'Vulnerable' (A2ad) with declining population in the range and Appendix II of CMS.

Goals

- Goal 1: To re-establish wild and self-sustaining populations of sand gazelle in Saudi Arabia.
- Goal 2: Studying the most suitable habitats and establish protected areas in which vegetation can recover.
- Goal 3: Managing the re-introduction of the herds in the protected areas.



Reem in Mahazat © M. Zafar-ul Islam, NWRC

- Goal 4: Re-introducing in suitable habitats.
- Goal 5: Studying the ecology and biology of the sand gazelle in the protected area.

Success indicators

- Indicator 1: Healthy and self-sustaining sand gazelle population in Mahazat as-Sayd Protected Area.
- Indicator 2: The captive herd at KKWRC is maintained for re-introduction programs for other protected areas.
- Indicator 3: The re-introduction of sand gazelle in Mahazat for more than 20 years, which now has a significant self-sustaining population is considered to be a success.
- Indicator 4: Productivity by wild sand gazelles is high.
- Indicator 5: Society and government supports re-introduction and Mahazat has been suggested as a destination for national and international tourists.

Project Summary

Feasibility: Sand gazelles were previously occurred in Mahazat area (22°15'N - 41°40'E), which is tract of open desert steppe habitat of tropical and arid climate with gentle topography in southwest of Saudi Arabia c.150 km northeast of Taif. Historically the species had been extirpated, primarily by excessive hunting. After the identification the area as wildlife reserve with fencing and proper protection from livestock grazing, within five years the recovery of the vegetation increased the chances of re-introduction of *Reem* in the area as compared to areas outside the Reserve, which was overgrazed and disturbed. The local community was taken in confidence during the process and Saudi Wildlife Authority got full support both from civil society and the Government for the re-introduction of native wildlife. *Reem* were obtained from KKWRC and Al Sudairy Gazelle Research Center in Al Qasim. All the translocated gazelles are believed to have been born in captivity at these centres, while the origin are not well known.

Implementation: *Reem* were captured just before dark and put in individual crates constructed of plywood and measuring 100 cm x 36 cm x 90 cm. Crates could be opened from both ends and had 30 - 40 ventilation holes of 1 cm diameter. Animals were transported the 800 km to Mahazat at night by truck. Upon arrival at the Reserve the gazelles were placed in four quarantine enclosures identical in size (40 m x 30 m) and features to those at the KKWRC. Shade, food and an automatic water point were provided in each enclosure. All animals were tested for tuberculosis, vaccinated against rabies, foot and mouth disease, rinderpest, and pasteurellosis, marked with either eartags, marker collars, or radio transmitters, and placed in quarantine pens. Within 2 - 3 months they were transferred to a 25 ha pre-release enclosure, where they were held for 10 - 14 months prior to release.

Post-release monitoring: Between May 1991 and February 1994, five groups of animals were released from the pre-release enclosure into wild when the vegetation condition was favorable and calves had been weaned. All animals were softly released by opening gates of pre-release enclosure and animals were

allowed to leave of their own, while water was provided outside of the enclosure for a week. All animals, which were radio-tagged were monitored twice a week by ground telemetry and at least once a fortnight by aerial telemetry using Maule aircraft and date, time, location, activity, habitat and group compositions were observed (Haque & Smith, 1996). Post release dispersal of *reem* have been recorded from the intensive monitoring programs. After the release the productivity by wild gazelles recorded high. Initially, all seven radio-tagged females gave birth to calves within one year of release and similarly other females have produced calves. We used Distance Sampling techniques to estimate population size on 14 pre-defined transect lines in Mahazat. Mortalities are recorded by random search and animal's skulls are cut whenever dead animal is found and systematically kept. Mortalities were recorded high during drought like periods.

Table 1. A total of 135 (58 males:77 females) sand gazelles were translocated in Mahazat

Date	Male	Female	Source
Feb 1990	10	14	KKWRC
Feb 1991	11	17	KKWRC
June 1991	14	8	Qassim
May 1992	6	17	KKWRC
June 1993	17	21	KKWRC

Sand gazelle are known to move long distances in search of more favorable areas during stressful conditions where food is available (Islam *et al*., 2010a). The fenced reserve blocks the movement of the gazelle and they finally die near the fence. Most of the dead gazelles were found mainly under big green *Acacia tortilis* or *Maerua crassifolia* trees, which were typical shading places for ungulates at Mahazat during summer months. Then more dead gazelles were found in the vicinity of the external Mahazat fence especially southern and south-north and north-western parts of the Reserve.

Table 2. Population and mortalities of sand gazelles in Mahazat

Year(s)	Annual Population (between 1991 - 2010)	Mortality (between 1991 - 2010)
1991 - 2010	66, 120, 220, 300, 450, 413, 812, 856, 1034, 1104, 1245, 1683, 700, 800, 1537, 1200, 800, 654, 583 and 352	13, 12, 3, 5, 0, 9, 0, 31, 939, 644, 8, 0, 77, 21, 77, 679, 302, 151, 41 and 259

Since the Sand gazelle lives in extremely hot arid environment, it was possible to carry out studies on thermal biology or adaptive heterothermy and from the studies it was found that body temperature and activity patterns, implanted miniature temperature data loggers into the abdominal cavity, and activity data



Regular monitoring in Mahazat as-Sayd Reserve

loggers under the flank skin in free-ranging sand gazelles, which envisaged that the body temperature of gazelle dropped mainly in the day. During these studies activity levels of gazelle showed a biphasic or crepuscular rhythm during the warm wet season but shifted to a more nocturnal rhythm during the hot dry season. Gazelles seek shade during the heat of the day and activity was attenuated over daylight hours during the hot dry months compared to the warm wet months. Therefore, Arabian ungulates employ both adaptive heterothermy and cathemerality to survive the extreme, hyper-arid conditions of Arabian deserts (Ostrowski & Williams, 2006). Studies related to its habitat use, feeding ecology, range and space use, group composition have been carried out in Mahazat.

To curtail the mass mortality of gazelles during the drought like or stressful periods, a Strategy and Action Plan was prepared in 2008 (Islam *et al*., 2010b) that suggests to manage the animal numbers in compliance with carrying capacity that means capture and translocate surplus animals to other reserves.

Major difficulties faced

- Maintaining long-term regular monitoring.
- Lack of skills for mass capture techniques for sand gazelle.
- Lack of management plans dealing with the transferring surplus animals.
- No study on the genetic diversity of gazelle in released sites has been done in recent years.

Major lessons learned

- When wide-ranging species are confined to restricted areas, even if such areas are large, it is essential that an effective population management plan is in place BEFORE any re-introduction is carried out and that the plan is properly implemented. If this is not done, large-scale mortalities will occur.
- Prior to any transplantation, range conditions in the release area have to be improved and the area protected from livestock exploitation. Once pasture conditions show adequate signs of improvement and the site is adequately protected, re-introduction of the animals can be contemplated.
- The time of release should coincide with suitable vegetation conditions.

- Keeping the animals in pre-release enclosures within the re-introduction site to get them acclimatized to the natural environment and provide minimal amount of food and water.
- Regulate tourism in re-introduction areas as this can lead to increased habitat degradation.
- A public-awareness program should in place to inform citizens of the biological and historic significance of the sand gazelle in the society.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- The sand gazelle was locally extinct in the southwestern Saudi Arabia and now have self-sustaining populations through the captive-breeding and re-introduction programs.
- The population of sand gazelle withstood the drought without further supplemental re-introduction support.

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Re-introduction of scimitar-horned oryx to Dghoumes National Park, Tunisia

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Introduction

Scimitar-horned oryx (*Oryx dammah*) once ranged over large tracts of north Africa, occupying arid steppe and wooded grasslands in the periphery of the Sahara desert. Once thought occur in large numbers, the species declined rapidly in recent history due to over-exploitation, exacerbated by habitat fragmentation and competition with domestic livestock. The scimitar-horned oryx is now thought to be Extinct in the Wild (IUCN Red List), is listed in Appendix 1 of the Convention on Migratory Species (CMS), and Appendix I of Convention on the International Trade of Endangered Species (CITES). Historically, scimitar-horned oryx occurred across Tunisia's southern steppes. While persisting in the more remote parts of its range elsewhere in North Africa until the 1980s and possibly early 1990s, the species had disappeared in Tunisia by 1910 due to over-hunting. However, during the last 25 years, scimitar-horned oryx have been returned to four protected areas in Tunisia, including this latest initiative in Dghoumes National Park. Created in 1995, the park is located close to the oasis town of Tozeur on the northern side of a large salt pan, the Chott El Jerid.



Scimitar-horned oryx (*Oryx dammah*)

Goals

- Goal 1: Restoration of previously degraded habitat.
- Goal 2: Create a founder population of scimitar-horned oryx in Dghoumes National Park.
- Goal 3: Establish long-term monitoring of oryx and the habitat.

Success Indicators

- Indicator 1: Increases in biomass, botanical and structural diversity.

- Indicator 2: Oryx population established and growing.
- Indicator 3: Oryx remain in good health.
- Indicator 4: Locally collected biological and environmental data maintained and informing management decisions.



Rangers monitoring released scimitar horned oryx

Project Summary

Although extinct in the wild, scimitar-horned oryx are abundant in captivity. There is a well managed International Studbook (Gilbert, 2010) and regional cooperative breeding programs which have provided source animals for previous releases in Tunisia. Hence, the project at Dghoumes National Park was able to draw on locally born animals from Bou Hedma National Park (originally founded with oryx from the UK) with genetic augmentation using animals specially selected from Europe and the USA. The background and process of re-introducing scimitar-horned oryx to Dghoumes National Park was previously described in detail by Woodfine *et al*. (2009), and is summarised below. Tunisia has long established legal, strategic and institutional frameworks to support the re-introduction and protection of scimitar-horned oryx. This initiative was therefore undertaken as part of a national plan for the restoration of Sahelo-Saharan antelopes and their habitats, and contributed to the country's national biodiversity strategy. It was led by the Générale des Forêts (DGF), the statutory authority responsible for the management of reserves and national parks. Dghoumes National Park is situated within historic range of the scimitar-horned oryx, with habitat typical of sub-desertic continental steppe. Previously overgrazed by domestic livestock, a process of vegetation restoration was carried out for a decade prior to the release of oryx using a range of techniques including protection, scarification to create germination sites, and the planting of native trees and shrubs. Recovery of vegetation was monitored to ensure the habitat was in favourable condition prior to the release of oryx.

Two operations were carried out to bring oryx to Dghoumes National Park. An initial group of eight animals was captured and translocated from Bou Hedma National Park, facilitated by the Convention on Migratory Species (CMS). A second group comprising nine animals arrived from the USA and Europe in an international operation implemented by a joint team representing the European Endangered Species Program (EEP) and the Species Survival Plan (SSP). Animal selection was informed by the International Studbook (Gilbert, 2010), and genetic studies (Iyengar *et al*., 2007). Veterinary health screening was undertaken in accordance with Tunisia's statutory requirements, guidelines for best practice,

and informed by previous experience. Reception and pre-release enclosures were constructed to facilitate quarantine and acclimatization of oryx prior to their release into the park. Husbandry of the animals during this phase followed established guidelines (Gilbert & Woodfine, 2003).

Training and equipment were provided for local personnel to establish a routine monitoring programme based on daily observations of the oryx. Records were maintained of social structure, movement patterns, and diet selection and use water resources, together with significant life history events (births & deaths). Body scores were also used to evaluate changes in condition of the oryx over time. Since their release in 2007, the population has been in a rapid growth phase. Both translocated and imported females conceived soon after arrival with all giving birth within a year. By October 2009, the number of oryx born in the park exceeded the number of founders and by April 2011 the population surpassed 50 animals. The population performance and high calf survivorship to date suggests that the oryx are not currently affected by predation or limited by the wider environment. The oryx have formed stable social systems, are exploiting a wide range of food plants, seek water during the dry hot season, and body scores indicate that animals remain in generally excellent health with minor seasonal variations in their condition.

Major difficulties faced

- Although scimitar-horned oryx are plentiful in captivity, selection of suitable individuals to ensure genetic diversity and low inbreeding coefficients of founder stock means acquiring animals that are geographically dispersed. Transporting oryx from the USA and Europe proved to be administratively and logistically complex, and expensive.
- International restrictions on livestock movements due to outbreaks of foot & mouth disease and bluetongue delayed the export of oryx, and could have threatened the entire operation.

Major lessons learned

- Investment of time into planning and preparation including pre-feasibility studies and site assessments proved critical for anticipating logistical and technical requirements of the project, both internationally and locally.
- Well designed animal management infrastructure, including inter-connected reception enclosures were important for managing oryx during quarantine and acclimatization phases, and were particularly valuable for socialization of imported animals. Social bonds formed during this period lasted beyond the release phase with an unintended benefit that breeding was not dominated by a single male in the early stages of the project.
- Use of highly visible ear tags was critical for monitoring individual oryx at distance. Some animals arrived on site with small black or white ear tags or ear notches that were easily overlooked amongst mingling animals and copious ear-twitching. Large numbered yellow, blue or red tags proved the easiest to see and made monitoring efforts more efficient.
- Ongoing monitoring has been invaluable for improving understanding of the social behavior and ecology of a species that was little studied before its

disappearance in the wild. This in turn has provided both novel and important information to support management decisions, and planning new projects.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- International cooperation along with national & local support for the project was critical for fund raising and ensuring the requisite breadth of expertise was available. Transfer of skills and knowledge to the local team ensured appropriate ongoing monitoring and management.
- Vegetation responded positively to long term restoration measures, providing abundant grazing opportunities for oryx and other herbivores.
- A genetically diverse founder population of oryx was established.
- Rapid population growth occurred during the first five years in line with modeling expectations.
- Long term success is dependent on the implementation of a plan to maintain oryx below carrying capacity in Dghoumes National Park, and create an integrated meta-population management strategy for the species across Tunisia.

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The re-introduction of Arabian oryx to the Al Wusta Wildlife Reserve in Oman: 30 years on

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Introduction

Arabian oryx (*Oryx leucoryx)* is the largest endemic antelopes in the Arabian Peninsula that used to freely roam the entire region, and is uniquely adapted to survive in extremely harsh and arid environment. Recently, it has been re-classified as Vulnerable by the IUCN Red List. The final disappearance of this species from the wild in 1972 represented a significant loss for biodiversity worldwide, but the event also galvanized conservation efforts. These efforts have become a classic conservation success and serve as a model for similar programs worldwide. The first ever successful re-introduction of Arabian oryx to the wild took place in Oman in 1982 as an initiative from His Majesty Sultan Qaboos bin Said (Stanley-Price, 1989). The wild population at the Al Wusta Wildlife Reserve (formerly known as Arabian Oryx Sanctuary) thrived to more than 400 individuals in mid 1990s. Such increase seemed to attract poaching that lead to serious collapse of the wild population. Therefore, a captive breeding program was established in 1998 (Spalton, 1999). The captive group has increased to more than 380 individuals. As a measure to control poaching, the government decided to fence the reserve of an area about 2,824 km^2. In early 2011, more than 60 individuals have been released into the fenced area and more herds are planned to be released in the near future.

Goals

The initial and ultimate goals of the project are:

- Goal 1: To establish a self-sustaining free-ranging viable oryx population in the wild.
- Goal 2: To improve local livelihood through wildlife-based jobs.

However, after the start of poaching, the project concentrated its objectives to the following, in order to reach the ultimate goals (1 and 2):

- Goal 3: To secure Arabian oryx by establishing a viable captive breeding program until the poaching issue is solved.
- Goal 4: To solve the poaching issue and stop future illegal hunting by fencing the reserve and applying an integrated security system.

Success Indicators

- Indicator 1: Arabian oryx successfully thrived, breed and become independent in the wild to more than 400 individuals before the poaching challenge appeared.

- Indicator 2: To secure oryx from being poached in the wild, some were successfully captured and transported to Jaaluni enclosure for captive breeding.
- Indicator 3: The captive breeding of Arabian oryx at the Jaaluni enclosure was successfully monitored and the number increased frequently since 1998 to 2011 (from 38 to 381 oryx).



Arabian oryx at Al Wusta Wildlife Reserve

- Indicator 4: Zero breeding was applied to control undesired increase in numbers between 2005 - 2010.
- Indicator 5: A fence has been successfully established of about 230 km around the reserve to control poaching and it is nearly complete and 60 oryx so far have been released to the fenced area and more are prepared for release soon.
- Indicator 6: Arabian oryx re-introduction provides work for local people and integrates them in the oryx conservation and management context, besides enhancing the aesthetic and scientific value by providing a tourist attraction in the future.

Project Summary

The re-introduction of Arabian oryx in Oman is summarized in the following timeline:

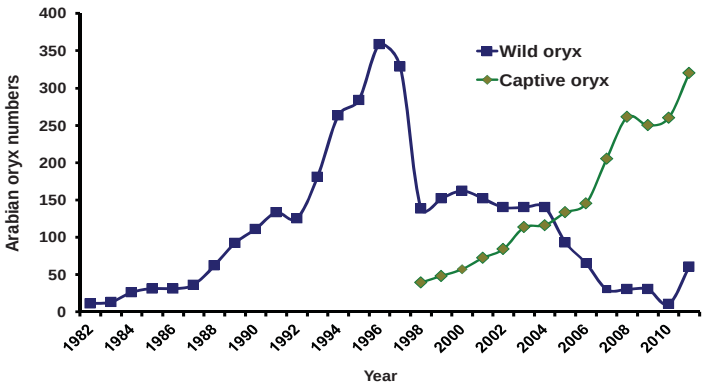
- **1963:** Establishment of the World Herd of Arabian oryx in the USA, with capture of some wild oryx near the Omani-Yemeni border.
- **1972:** Extinction of Arabian oryx in the wild in Oman.
- **1977:** Initiation of the Arabian Oryx Project (AOP) to re-introduce oryx to Oman.
- **1980 - 1982:** Captive breeding of Arabian oryx received from the World Herd in a 1 km^2 enclosure.
- **1982-1996:** Oryx released to the wild and high success in the wild until 1996.
- **1994:** The Al Wusta Wildlife Reserve was officially proclaimed as a protected area by a Royal Decree (4/94) and enlisted by the UNESCO as a World Natural Heritage Site.
- **1996:** Heavy poaching commenced and led to the wild population collapse.
- **1998:** Captive breeding establishment until now.
- **2002:** An anti-poaching force unit was established in the AOS and the security of the fence will be its responsibility.

- **2007:** AOS declared to resize the total area from 34,000 km^2 to 2,824 km^2 and then delisted from the UNESCO World Heritage List.
- **2009:** Fencing of the reserve started and is nearly complete now.
- **2011:** One hundred Arabian oryx was donated to the AOS and the first herd was released into the fenced area.

The feasibility study (1977 - 1978) concluded that Al-Wusta Region in the central desert of Oman and plains of Oman (21-23° N, 45-47° E; approximately 34,000 km^2 in size) is a suitable habitat for Arabian oryx (Stanley Price, 1989). The high success of the project until 1996 proved this conclusion. The re-introduction area is an open landscape desert consisting of flat and sometimes irregular plateau. It forms a discrete limestone unit characterized by different habitats such as shallow depressions called haylahs, sandy dunes, gravelly wadis with scattered vegetation patches. Climatically, it has many features of hyper-arid deserts including high summer temperatures (can reach up to 47°C in the shade) and low rainfall (AlJahdhami, 2010). Fog moisture from the Arabian Sea increases water amounts available to biodiversity elements in such an arid area. Common tree species in the area are *Acacia tortillis*, *Acacia ehrenbergian*, *Prosopis cineraria* along with other abundant grasses (e.g. *Stipagrostis* sp., *Dicanthium foveolatum*). Other wild animal species recorded include Arabian gazelle (*Gazella gazella cora*), sand gazelle (*Gazella subgutturosa marica*), Nubian ibex (*Capra ibex nubiana*), red fox (*Vulpes vulpes arabica*), Arabian wolf (*Canius lupus arabs*) and caracal (*Caracal caracal*). The Al Wasta Region is inhabited by local bedu of several tribes situated between three districts (Hayma, Duqum and Mahout). They are principally mobile pastoralists, camel-goat breeders and fishermen.

The biggest challenge to the project started in 1996, as intense poaching probably triggered by the increase in the numbers of free-roaming oryx in the area and assisted by the easy access to the area with absence of any physical boundary i.e. fence. This was partly because the reserve area was too large (34,0000 km^2) to be fenced and to be covered by anti-poaching patrols. The area of the AOS was reduced in 2007 to (2,824 km^2) and the government decided to fence this smaller area. In the mean time, since 1998 a captive breeding program was initiated and the numbers of oryx increased in captivity as shown in Figure 1. Now the total number of oryx at the

Figure 1. The number of Arabian oryx at the Al Wusta Wildlife Reserve in Oman, in the wild (estimated by sight mark re-sight method, Arabian oryx project, unpublished data) and in captivity (counted) between 1982 and 2010.





Rangers monitoring Arabian oryx

AlWusta Wildlife Reserve exceeds 380 and this includes a donation of a 100 oryx from His Majesty the Sultan to the AlWusta Wildlife Reserve. In early 2011, about 60 Arabian oryx have been released to the fenced area. Fortunately, just after the release, the reserve received a good rain after a prolonged drought for several years. The released herd is being monitored. At the release site a water trough is regularly filled with water and the captive-born released oryx come to drink during this hot summer. There is a plan in place to release several batches of Arabian oryx to the fenced area. The released oryx will be closely monitored by the biologists with assistance of patrolling rangers.

Fencing for conservation is a good solution for many conservation problems such as poaching, but it creates new issues especially in arid and hyper-arid areas where drought is not uncommon. We expect that the next major challenge for this re-introduction project is drought (Al Jahdhami, 2010). The area of the AlWusta Wildlife Reserve was reduced to less than 10% of its previous size. Despite the fact that oryx used to live in unfenced area with a range of more than 34,000 km^2, mortality and no reproduction were reported during prolonged drought (Spalton, 1995). In the current fenced area of 2,824 km^2, the effects of drought will be more pronounced as the fence is a physical barrier for oryx that is known of crossing long distances looking for better grazing which could be outside the fenced area. In Saudi Arabia, Arabian oryx and sand gazelles faced mass mortalities in the fenced Mahazat As Sayed Reserve (Islam, 2010). Most mortality cases occurred near the fence. We hope with preparing an action plan for feeding and provision of water in certain locations will help in keeping the wild population viable within the fenced area.

Major difficulties faced

- The large size of the unfenced reserve lead to spread of oryx to remote areas and this triggered local people to poach those animals and lead to the difficulty to protect free-roaming oryx by any patrolling force.
- The local community around the reserve should be involved in the reserve. For the last 30 years, one local tribe dominated the jobs within the reserve and therefore recruitment from other local tribes should be considered.
- The management of a captive group in a healthy condition while maintaining the numbers without sharp increase was a challenge, but a zero breeding was

introduced to control the numbers by separating males and females in different sub-enclosures.

Major lessons learned

- Without fencing the protected area, poaching proved very difficult to control.
- Captive breeding of Arabian oryx after intense poaching, helped in building a safe healthy herd of oryx and increasing their numbers with close monitoring.
- Fencing is a good solution for poaching but might create another problem during prolonged drought as the animals are restricted to an area and cannot travel beyond the fence seeking better grazing.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The declaration of re-classification of Arabian oryx in the IUCN Red List to Vulnerable was a historical record for a species that used to be “Extinct in the wild” in 1972 and passed three categories to a low category of threatened. Oman is proud to be the first country in the world that led a re-introduction of a large mammal from the early 1980s and the species was re-introduced and is now away from the brink of extinction.
- The Omani Arabian oryx wild population is back on track by gradual release into a fenced reserve with close monitoring.

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Re-introduction of the 'extinct in the wild' Przewalski's horse to the Mongolian Gobi

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Introduction

The Przewalski's horse (*Equus ferus przewalskii*), *takhi* in Mongolian, became extinct in the wild during the 1960s. The reasons for the extinction of Przewalski's horse are seen in the combined effects of pasture competition with livestock and overhunting. The last confirmed sighting of a Przewalski's horse in the wild occurred in the Dzungarian Gobi of SW Mongolia in 1969. The entire captive population is based on 13 founders and led to the establishment of the Przewalski's horse studbook at Prague Zoo and the initiation of a European Endangered Species Programme (EEP). By the mid 1980s the captive population had grown to over 1,000 individuals. With Mongolian independence in 1990, the "Takhin Tal" project in the Dzungarian Gobi was initiated. In 1992 the first captive born animals arrived at the adaptation enclosures and in 1997 the first harem group was released into the wild. In total 89 Przewalski's horses on 10 transports were airlifted from Europe to Takhin Tal. By 2009 the Takhin Tal population was entirely free-ranging and had grown to 138



Przewalski horse harem group © Kaczensky

animals. In 2010 a winter disaster (*Dzud*) stuck and while Mongolia lost millions of livestock, the Przewalski's horse population crashed to 49 animals.

Goals

- Goal 1: To re-establish a self-sustaining and free-ranging population of Przewalski's horses in the Dzungarian Gobi.
- Goal 2: To protect the integrity of the Dzungarian Gobi ecosystem as habitat for re-introduced Przewalski's horse and other rare and endangered plants and animals.
- Goal 3: To study the behavior and ecology of Przewalski's horses in their native environment.
- Goal 4: To manage the Great Gobi B Strictly Protected Area and its buffer zone in the spirit of the man and biosphere concept, acknowledging the millennium old presence of semi-nomadic herders in the region.
- Goal 5: To raise awareness and support for sustainable use of natural resources, biodiversity conservation and protected area management by improving the socio-economic situation of the local population and providing information.

Success Indicators

- Indicator 1: Number of free-ranging Przewalski's horses >140, distributed throughout suitable habitats within the 9,000 Great Gobi B Strictly Protected Area (SPA) in the Dzungarian Gobi.
- Indicator 2: Efficiency of the park management measured by overall budget, number of staff, technical equipment and working facilities on the one side and number and severity of conflicts on the other side.
- Indicator 3: Number of peer-reviewed publications, PostDoc, PhD, Master and Bachelor thesis on Przewalski's horses, other wildlife or the habitat.
- Indicator 4: Formalized land use agreements between local people and the SPA administration.
- Indicator 5: Low conflict levels and number of people earning money from alternative income projects that are in line with sustainable use of natural resources.



Releasing Prezewalski horses in enclosure
© Kaczensky

Project Summary

Feasibility: The Mongolian Gobi in Central Asia constitutes a vast, largely intact and continuous stretch of non-equilibrium dry land which

is home to several endangered or critically endangered large migratory ungulates and a millennium old semi-nomadic livestock herding culture. A major challenge of Przewalski's horse re-introduction lies in the fact that the species only survived due to captive breeding and that little behavioral or ecological data had been collected prior to their extinction in the wild. Consequently there was little experience to draw from and it was generally assumed that Przewalski's horses would have similar habitat requirements and show a similar social organization as feral horses or plains zebras.

The Przewalski's horses likely went extinct due to the combined effect of pasture competition with livestock and overhunting. However, since the eradication of the Przewalski's horse Mongolia's human and livestock population have increased, thus the original cause of the species demise is still present. Furthermore, Przewalski's horses and domestic horses are closely related, can interbreed and produce fertile hybrids. In order to conserve the Przewalski's horse as a distinct species, the gene pools of the two species need to be separated. The Great Gobi B SPA is and always has been used by semi-nomadic herders and their livestock. When the SPA was established, local people were granted the right to continue to use their traditional winter camps at the southern edge of the SPA and cross during spring and fall migration. About 100 families with c. 60,000 livestock (5.5% domestic horses) use the park for grazing, predominantly in winter. Local economy is heavily based on livestock, with cashmere generating the main income of local herders. Recently the protected area's integrity has been compromised by illegal pacer mining activities.

Implementation: The Takhin Tal research station is 1,500 km straight line distant from the capital Ulaanbaatar. The camp is located at the NE corner of the Great Gobi B SPA and is surrounded by five separate former adaptation enclosures with a total of 2,600 ha. In each enclosure a stable provides thermal protection and the Bij river provides drinking water. In the past Przewalski's horses in the enclosures were fed hay one to two times a day, depending on available natural forage and body condition. In the initial phase of the project mortalities were high and the project received much international criticism. However, management changes were implemented in 1999/2000 and veterinary care was vastly improved and local infrastructure upgraded. Equine piroplasmosis, a tick-transmitted disease caused by *Babesia caballi* or *Theileria equi*, which is endemic in Takhin Tal was identified as an important mortality factor in naive introduced Przewlski's horses. Subsequently, all newly arrived animals where treated with a subtherapeutic dose of Imidocarb (Carbesia®, Schering-Plough, France) while under control in the adaptation enclosure.

Because the Przewalski's horse are very conservative in their range use and tend to stay in the vicinity of the release facilities, the last harem group which arrived in 2004 was transported 120 km to the west after having spent one year in the adaptation enclosure in Takhin Tal. To familiarize the horses with the new environment, they were kept in a temporary enclosure, delineated by electric fencing at the new release site. This soft release approach was very successful as the new group indeed settled in and around the new release site.



Ranger monitoring © Ganbaatar

Post-release monitoring: Przewalski's horse groups are been checked by park rangers 1 - 2 times a week. Individual animals are identified based on overall appearance. An additional 15 Przewalski's horses were tracked by satellite telemetry between 2001 and 2008. Comparison between telemetry data and ranger monitoring showed that the latter is sufficient to document spatial organization of the different groups and distribution range development. Since 2002 - 2003 the Przewalski's horse population finally started to show positive population growth, independent of released animals. By the end of 2009 the population had reached 138 animals, than the 2009 - 2010 the *dzud* winter hit and the population crashed to 49. However, the catastrophic winter allowed for lush spring vegetation and summer rains further improved grazing conditions. The winter 2010 - 2011 was normal and we expect high foaling rates for this year.

To speed up population recovery we are presently looking into the possibilities to receiving additional Przewalski's horses from the breeding center in Jimsar, Xinjiang province, China. Horses would already be pre-adapted to the climate and equine piroplasmosis. Transporting Przewalski's horses from China to Mongolia will also strengthen cross-country cooperation in nature conservation. The border strip between China and Mongolia in the Dzungarian Gobi is sparsely populated and could potentially connect the two Great Gobi A & B SPAs (together 53,000 km^2) in Mongolia with the Kaamaili reserve (18,300 km^2) in China, where there are presently also initiatives to re-introduce Przewalski's horses. If managed in common the area could potentially house a large trans-boundary Przewalski's horse population.

Major difficulties faced

- Initially the project was plagued by shortcoming in infrastructure and training which resulted in rather high mortality rates of introduced Przewalski's horses.
- Not before routine veterinary procedures and post-mortem pathologic examination were introduced in 1999 was equine piroplasmosis as a mortality factor discovered and management changed accordingly.
- Initial project focus was only on the Przewalski's horses and the immediate release area surrounding Takhin Tal research station. The spatial requirements of a self-sustaining population and the interactions with wildlife and local people were initially largely ignored or underestimated.

- The logistical challenges of running a long-term project in a remote and difficult to reach location were underestimated: animal transports are very expensive, recruitment of scientific personnel is difficult, and communication and mobility are major cost factors.
- To secure funding for measures accompanying the re-introduction of the Przewalski's horse which need a long term perspective – monitoring and socioeconomic projects - are much harder to sell than spectacular transports or exciting science projects.

Major lessons learned

- Identification of equine piroplasmosis as an important mortality factor in naïve Przewalski's horses re-introduced from Europe, high-lightened the importance of state-of-the-art post mortem analysis and allowed us to improve the adaptation process.
- Upgrading the infrastructure and in particular investment into communication and mobility (vehicles and a gas station) was a prerequisite to enabling efficient and year-round patrolling, monitoring, and scientific work at Takhin Tal.
- Broadening the focus from a species to an ecosystem conservation project allowed for a holistic approach incorporating the habitat, other wildlife and local people. The Przewalski's horse turned out to be an ideal flagship species to promote the conservation of the Dzungarian Gobi ecosystem and less charismatic species, e.g. the endangered Asiatic wild ass (*Equus hemionus*).
- Bi-weekly ranger observations and the use of radiotelemetry in combination with intensive habitat mapping allowed us to understand Przewalski's habitat use and helped to identify a suitable new release site in order to speed up population expansion and reduce the vulnerability of the population to localized catastrophic events.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- We are dealing with a small population with limited spatial extent in a non-equilibrium dry land prone to extreme weather events – it is too early to make a final success or failure statement.
- The population showed the potential for re-adaptation to a harsh environment and population growth in normal years.
- Very good and efficient ranger monitoring has been implemented and linked to the collection of additional ecological data from multiple accompanying research projects (other wildlife, plant community mapping on the landscape scale, socioeconomic data)
- The highly liked (locally, nationally & internationally) and charismatic Przewalski's horse is an excellent vehicle to promote biodiversity protection in the Dzungarian Gobi.

- Environmental and funding stochasticity, the lack of formalized land use agreements and increasing poverty hinders the progress of alternative income projects and still results in conflicts over sustainable resource use (illegal collection of firewood, grazing, illegal mining, poaching); however, due to the remoteness of the area and the poor infrastructure the problems are rather minor when compared to other areas of Mongolia.

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Trial translocations into edaphically modified habitats enhanced the regeneration of prickly raspwort on Eyre Peninsula, South Australia

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Introduction

Prickly raspwort, *Haloragis eyreana* Orchard (Haloragaceae) is a perennial herb 10 - 30 cm high with a deep stoloniferous rootstock. Endemic to southern Eyre Peninsula, South Australia, it favours grey, brown or reddish clay to clay/loam soils that set hard in summer and may become waterlogged in winter. It is usually found growing in more or less disturbed, open grassland communities dominated by *Danthonia caespitosa*, often in low-lying wet sites such as drains, seepage hollows, crabholes, or areas of high water run-off (roadsides, road intersections, rail corridors). Less frequently it is also found in relatively undisturbed sites under mature mallees (*Eucalyptus incrassata* or *E.* aff *dumosa*) or under *Melaleuca decussata*. Regeneration occurs from seed or as regrowth from root suckers. Plant numbers at five population monitoring points have been steadily declining over the last 12 years. The species 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 B2b(v)c(iv)). Extensive surveys over 1997 - 1999 counted approximately 16,000 individuals with an extent of occurrence of 711 km^2 and an area of occupancy of 0.8 km^2, reflecting the



Layout of excavation showing 4 crests (H,L,H,L) and interstitial trenches © M. Jusaitis



Haloragis eyreana plants ready for translocation © M. Jusaitis

rather specific habitat requirements of this species and the fragmented nature of its habitat.

Goals

- Goal 1: Examine the influence of planting-site proximity to the water table on translocation success.
- Goal 2: Create artificial habitats with microsites optimized for the establishment and regeneration of *H. eyreana*.

Success Indicators

- Indicator 1: The completion of an experimental trial to evaluate the success of translocating *H. eyreana* to sites that have been artificially-lowered by soil excavation.
- Indicator 2: Creation of micro-habitats where *H. eyreana* translocants successfully survive, flower, reproduce and recruit over a period of 8 years following translocation.

Project Summary

The available habitat for *H. eyreana* has been in decline since most of its natural range was cleared for agriculture, leaving remnant populations largely restricted to roadside and rail reserves. Weed encroachment and soil compaction caused by road working machinery, particularly at road intersections, has contributed to losses of *H. eyreana* at many sites within its population range. In its current state, the species requires ongoing investment of resources into weed management at many extant sites. The natural habitat of *H. eyreana* covers low-lying sites prone to inundation following heavy rainfall in winter (Jusaitis & Freebairn, 2010). We wanted to explore the importance of this edaphic property for successful translocation and establishment of this species. If it were possible to artificially create such habitat, *H. eyreana* numbers could be augmented, new population sites could be established and potentially, weed control could be minimised. These trials were set up in collaboration with the local council in an attempt to engage them in species conservation and to demonstrate the potential for development and conservation to coexist.

At four locations along a roadside near Cummins, a backhoe was used to excavate a series of five trenches (400 - 500 mm deep, 700 mm wide), spaced about 500 mm apart. Trenches were separated by four undisturbed remnant soil columns (crests) about 5 m long and 500 mm wide. Two of these crests were left at natural soil level, and two were lowered by scraping about 200 mm of soil from

the surface. Thus, we were left with three surface levels; crests at natural soil level (high), crests at 200 mm below soil level (low), and five interstitial trenches at 400 - 500 mm depth. All excavated soil was removed from the site. *H. eyreana* was micropropagated using explants sourced from eight local provenances (Lee & Jusaitis, 2000). In August, 2003, ten plants (2 - 5 cm high) were transplanted onto each crest, a total of 40 plants per location. No planting took place in trenches. At the same time, 20 plants were transplanted as controls in undisturbed soil near the excavation. Survival and regeneration of *H. eyreana* at the three soil levels (high, low, trenches) and control sites were monitored annually.

Although plant survival on low crests and in controls was generally slightly higher than on high crests, the number of original transplants in all treatments declined steadily over 4 years, when none remained alive. However, during year 3, recruitment of new seedlings and sucker regrowths was observed around the original transplants on all crests. The total number of regenerants did not vary significantly between high or low crests, ranging between 1 - 5 plants/m^2 over years 4 - 8. Natural recruitment was also observed in trenches during year 3, and from then the number of plants increased exponentially so that trenches averaged 18 plants/m^2 by year 8. Trench plants were more likely to perenniate from year to year than crest plants. Controls showed no recruitment until the 5^{th} year, averaging 2 plants/m^2 by year 8. The lower recruitment in controls and on crests may be at least party due to competitive effects of weeds and other herbs, which were less prevalent in trenches. Measurements of soil moisture content demonstrated that trench soils had consistently higher moisture levels than crest or control soils, regardless of time-of-year. Trenches occasionally flooded with water during wet winter periods, but the ensuing transient submergence of plants did not appear to adversely affect their subsequent survival, growth or flowering.

A separate trial was set up to study translocation by direct seeding. A pre-weighed quantity of *H. eyreana* seed (0.3 g per quadrat, 3 replicates) was sown on crests and into control quadrats (30 x 30 cm) in August 2003. Some seedlings had germinated and emerged by December that year, albeit in low numbers (0.14% on low crests, 0.03% on high crests, 0% in controls). More seeds germinated the following winter, yielding a total germination of 1.1% on low crests, 0.8% on high crests, and 1.0% in controls. By the end of their second year, low crests had significantly more seedlings (6/quadrat) than did controls (2/quadrat), with high crests falling in between (4/quadrat). Seedlings usually did not flower until their second year, whereas transplants flowered and set seed in their first year.

The four planting locations varied considerably in their ability to sustain translocants over the long term. Differences in soil structure, moisture holding capacity, and weediness contributed to sustainability, with one site performing outstandingly better than the others. Although this variability reduced the power of statistical analyses, general trends in the data showed that trenches supported the best growth and regeneration of *H. eyreana*, followed by low crests, then high crests, and lastly controls. The improved performance of high crests compared



Natural recruitment in trenches in year 5 - note weeds along far rim of trench © M. Jusaitis

with controls may be attributable to the additional soil disturbance and vegetation clearance afforded the former during their construction.

Major difficulties faced

- Translocation sites varied considerable in soil structure and weediness so that some proved less suitable than others for plant establishment on crests. However, most trenches proved to be ideal sites to support good growth and regeneration of *H. eyreana*.
- Presence of water in trenches during wet winters made monitoring difficult.

Major lessons learned

- Natural regeneration of *H. eyreana* was significantly enhanced by edaphic modification of its habitat.
- Construction of low-lying drains, trenches or swales can create suitable micro-habitats that retain and conserve soil moisture to support successful germination and proliferation of this plant.
- The plant appears to respond favorably to a certain amount of soil disturbance, provided weed encroachment is minimized.
- Trenches supported the best regeneration of *H. eyreana* in these trials, probably due to their closer proximity to the water table and ensuing protection from drought conditions. Furthermore they provided ideal catchments for seed, which mostly falls within 0.5 m of parent plants.
- The four translocation locations tested varied considerably in their ability to sustain *H. eyreana*, indicating that proximity to the water table was not the only factor involved. Optimal locations also required appropriate soil structure and moisture-holding capacities, as well as low competitive pressure from weeds and other vegetation.
- Translocation was successful using either transplants or direct seeding. However, transplants resulted in more rapid establishment, flowering and subsequent recruitment than occurred with direct seeding.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success/failure:

- Edaphic amelioration provided an ideal micro-habitat for growth, flowering and recruitment of *H. eyreana*. In 8 years, the population was increased by over 1,000 new plants regenerating at four new sites within the population range.
- Trenches provided excellent soil-moisture conditions and protected plants from wind damage and drying. When ideal conditions were provided, plants had no difficulty in regenerating from seed, rootstocks and suckers.
- Consecutive years of below average rainfall (2006 - 2007) caused marked reductions in *H. eyreana* numbers, but populations recovered in subsequent good seasons.
- At one location, severe weed competition led to reduced survival and failure to recruit new individuals.

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Trial translocations of *Leionema equestre* on Kangaroo Island, South Australia

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Introduction

Leionema equestre (DA Cooke) Paul G. Wilson (Rutaceae) is a dwarf, spreading shrub with small, saddle-shaped leaves, bearing terminal white-pink flowers in late winter-spring. It is endemic to Kangaroo Island, South Australia, where it occurs on sandy to lateritic soils. The natural population was restricted to a 10 km x 10 km area lying between D'estrees Bay and Nepean Bay, until in 2002 an outlier population was discovered near Stokes Bay, about 44 km away. The total population of *L. equestre* on the island has been estimated at approximately 2,600 plants (Taylor, 2008). Most plants occur on roadsides, although about 35% are presently conserved on private land under Heritage Agreements (Jusaitis, 2000). Roadside populations are threatened by encroaching agricultural and environmental weeds as well as road maintenance operations. *L. equestre* growing in seral communities were found to decline as ecosystems approached climax. The species prefers open, well-lit areas for establishment from seed. Recruitment occurs primarily in response to land clearance or bushfire events, both of which also encourage weed spread into small roadside populations adjacent to agricultural land. *L. equestre* is listed as Endangered under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and under IUCN (2001) criteria (CR B1&2ab(ii)(iii)(v)).



Flowers and buds of *L. equestre* © M. Jusaitis

Goals

- Goal 1: Safeguard the natural populations of *L. equestre* by establishing a new population in a nearby protected Conservation Park.
- Goal 2: Examine the influence of herbivores and propagule type on translocation success.

Success Indicators

- Indicator 1: Survival, flowering, reproduction and recruitment of *L.*

equestre over a period of 18 years following translocation to a secure, conserved habitat.

- Indicator 2: The completion of an experimental translocation to evaluate the effects of herbivores and propagule type on establishment success.

Project Summary

Trials were set up at 3 sites in Beyeria Conservation Park, about 4 km from the nearest remnant population (Jusaitis, 1996). The sites varied in soil texture: Site 1, sandy with ironstone gravel; Site 2, sandy; Site 3; lateritic soil with ironstone gravel.

Direct seeding and herbivory: Translocation by direct seeding was trialled at each site by clearing a 1 m^2 quadrat of vegetation using a fire rake and loosening the soil surface sufficiently to provide a friable seed bed. *L. equestre* seeds were pre-scarified with concentrated H_2SO_4 for 5 min, then incubated with 50 mg/l gibberellin $GA_{4/7}$ for 5 days before sowing in May, 1992 (Jusaitis, 2000). Fifty pre-treated seeds were sown into each of 3 replicate quadrats at each site, and the soil packed down tightly to cover the seed. Wire baskets (430 mm x 430 mm x 100 mm; L, W, H) were up-ended over a portion of each quadrat as protection from herbivory.

Maximum seedling numbers were observed after 4 months, when 39%, 55% and 62% of sown seed had emerged at Sites 1, 2 and 3 respectively. Survival subsequently declined at all sites over time, but remained stable at about 10% for 13 years. From 2006 - 2008 we experienced three consecutive years of severe drought, resulting in further declines in seedling survival. Most recently (2009) 5%, 3% and 1% of sown seed survived as seedlings at Sites 1, 2 and 3 respectively. All survivors were growing under the protection of wire baskets. Seedlings emerging outside baskets were always shorter in height than protected seedlings, and none survived beyond Year 10. Thus herbivore grazing contributed substantially to seedling mortality.

Growth of seedlings (measured by plant height) was highest at Site 1 and lowest at Site 3. Flowers were first observed on seedlings in their 7^{th} year (although plants were not checked in Year 6). This contrasted with naturally occurring seedlings that flowered in their 4^{th} year of growth and also tended to be taller at an equivalent age.

Transplants and the effect of propagule type: In May 1992, one-year-old seedlings were transplanted in 3 replicates of 10 plants at each site. At Site 3, an additional 3 replicates of five cutting-propagated plants were transplanted to compare their growth with that of seedlings. Site 3 consistently showed the best survival of transplants for the first 14 years, at which time (2006) 13%, 7% and 27% of transplants remained at Sites 1, 2 and 3 respectively. However, this was followed by 3 consecutive years of drought which left no survivors at Site 2 and only 3.3% and 2.2% at Sites 1 and 3 respectively, by 2009.



A 16 yr old plant translocated from seed at Site 1 under the protection of a wire basket © M. Jusaitis

Grazing damage to transplants was evident at all sites, as no grazing protection was provided in this trial. Plants were able to recover from quite heavy grazing, as long as 30 mm - 50 mm of basal shoots remained, by regrowing from dormant axillary buds (Jusaitis, 2000). However, repeated bouts of grazing, probably by kangaroos, at all sites meant that survivors did not grow significantly over the course of this trial (18 years), remaining at average heights of between 100 mm - 150 mm. Grazing damage appeared to be correlated with the degree of exposure of transplants; those in exposed, open areas were usually more severely grazed than those planted under or amongst other shrubs. Sheltered transplants may have evaded grazing because they were less conspicuous to herbivores, or because adjacent plants discouraged close scrutiny by herbivores because of spiny leaves or other defensive properties.

In comparing seedlings with cutting-derived transplants at Site 3, survival did not differ significantly between the two founder propagule types. However, plant growth (measured by height) was affected. At planting, seedlings were (on average) taller than cuttings, but by the first assessment date, their heights no longer differed. Cutting-derived transplants grew rapidly during their first spring, but seedlings decreased in height over this time, showing evidence of grazing damage. After acclimatisation, grazing rates for both sets of plants equalized. This result suggests that early in establishment, seedlings were more palatable than cutting-derived plants and were thus more often targeted by herbivores. Indeed, shoots of transplanted seedlings were generally softer and more tender than those of cutting-derived plants. Furthermore, the initially larger seedlings may have been more conspicuous to grazers than the smaller cutting-derived plants.

Cutting-derived plants flowered earlier than seedlings. All cutting transplants flowered in their first spring (4 months after planting), but 15% of seedling transplants first flowered two years after planting. Seed-set of translocated plants was compared with that of wild populations in 2002 and 2003. An average of 15% of flowers set seed in wild populations in both years, although individual populations varied widely (2% - 28%). However, translocants had a significantly

lower average seed set, particularly in 2002 (1%) which was a dry year, compared with 2003 (4%).



Translocated *Leionema equestre* seedling showing regrowth from grazing damage © M. Jusaitis

Major difficulties faced

- Three consecutive years of severe drought (2006 - 2008) resulted in significant plant losses in the translocated population.
- Herbivores grazed foliage of exposed translocants throughout the course of the trial.
- Sites chosen for translocation were not within the known natural range of the plant (although only 4 km from it) and so may not be perfectly ideal habitat.

Major lessons learned

- Early protection of transplants and seedlings from herbivore grazing is important. All translocation sites were close to the edge of the park, and this may have amplified grazing pressure.
- Chose planting sites near or under the protective canopies of herbivore-deterrent plants such as *Grevillea ilicifolia* or *Petrophile multisecta*.
- Germinating seedlings rapidly developed a deep tap root to optimize survival over their first summer. This may give them an early advantage over transplants.
- *L. equestre* established and flowered sooner from cutting-derived transplants than from seed-derived transplants. Direct seeding using pretreated seed was also successful, although resulting seedlings took longer to establish and become reproductive.
- Lower growth rates, delayed flowering, reduced seed set, and heavier grazing of translocants compared with wild plants suggest that the 3 translocation sites chosen in Beyeria Conservation Park may be less than optimal habitats for *L. equestre*.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reasons for success/failure:

- As of September 2009 (Year 18), 20 translocants remained alive in Beyeria Conservation Park, consisting of 15 seedlings from the direct seeding trial, 3 cutting-derived transplants, and 2 seed-derived transplants. Eleven of these survivors were at Site 1.
- Translocants reached reproductive capacity and set seed, but natural recruitment from seed was not observed at any site within the timescale of this project.
- Several consecutive drought years caused significant plant losses.
- Ongoing grazing by kangaroos reduced growth and reproductive capacity of translocants.
- Preliminary research on propagation methods for *L. equestre* (Jusaitis, 2000) enabled sufficient plants to be propagated for translocation trials.

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Translocation of the desert phebalium to Yookamurra Sanctuary, South Australia

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Introduction

Desert phebalium (*Phebalium glandulosum* Hook. ssp. *macrocalyx* RL Giles) (Rutaceae) is a rounded, compact shrub growing to 1.5 m high, bearing dense, terminal clusters of yellow flowers during spring. Although this subspecies has a relatively wide distribution throughout New South Wales and Queensland (Giles *et al*., 2008), it is listed as Rare in Victoria (Gullen *et al*., 1990) and Endangered in South Australia under the National Parks & Wildlife Act 1972. The South Australian population represents the western-most outlier, significantly disjunct from its nearest neighbour in Victoria, giving it vital biogeographic and genetic significance. Its range in South Australia extends from the upper Yorke Peninsula to the Mt. Lofty Ranges, and remnants are restricted to roadsides or privately-owned scrub surrounded by agricultural land. Threats include stock-grazing on private land and roadworks, weed encroachment and isolation for roadside populations. Trial translocations were conducted to examine the effect of propagule type on transplantation success and to establish secure populations in suitable protected habitat.

Goals

- Goal 1: Conserve the local genetic diversity of *P. glandulosum* by establishing a new population in a protected and secure habitat.
- Goal 2: Examine the influence of propagule type on translocation success.

Success Indicators

- Indicator 1: Survival, flowering, reproduction and recruitment of *P. glandulosum* over a period of 20 years following translocation to a suitable secure site.



Phebalium glandulosum at full bloom © M. Jusaitis



P. glandulosum in flower 20 yr after planting seedlings (LHS) or cutting-derived (RHS) transplants © M. Jusaitis

- Indicator 2: The completion of an experimental translocation to evaluate the effect of propagule type on establishment success.

Project Summary

P. glandulosum was translocated into two protected parks; Yookamurra Sanctuary, secured against rabbits and feral animals by a 2 m high electric fence around its boundary, and Brookfield Conservation Park, ostensibly free-range to rabbits, goats and other vermin. These parks are respectively 75 km and 60 km from the nearest wild population of *P. glandulosum* and are the closest conserved areas of similar habitat and soil types to those in the natural range of the species. Propagating material for all translocations was sourced from wild populations on Yorke Peninsula. Plants were propagated from seed or cuttings in a nursery and hardened-off in 100 ml propagating tubes prior to translocation (Jusaitis, 2000).

In June 1991, in a preliminary trial to assess microsite suitability, 80 plants were planted at each of three sites in each park. Transplants at all sites in Brookfield Conservation Park died within 6 months of planting, possibly due to insufficient soil moisture and herbivory by rabbits, goats, kangaroos and possibly sheep. However, two sites in Yookamurra Sanctuary located in low-lying, wetter areas showed prolonged survival of transplants and these favourable microsites were selected for the main translocation trial the following year.

In June 1992, three replicates of 10 plants each (cutting-derived), were planted at the first site at Yookamurra. At the second site, seedlings were compared with cutting-derived transplants and three replicates of 10 plants of each propagule type were planted. The two sites varied significantly in the response of cutting-derived transplants. Site 1 plants grew taller over 20 years, reaching a height of 830(±23) mm, while Site 2 plants averaged 650(±35) mm. However, more plants survived at Site 2 (55%) than at Site 1 (13%). Survival of transplants at both sites declined steeply after the first year, but stabilized after about 3 years. Losses appeared to be due to local soil moisture deficits. Surviving plants continued to put on growth over 20 years of monitoring and at no time was any significant herbivore grazing damage observed. Flower buds were first seen on plants at both sites a year after planting and from then plants flowered and set seed

annually. In 2003, seed production was examined and the average percentage of flowers that set seed was found to be similar for translocated (Yookamurra) and wild plants (Yorke Peninsula). Wild plants set seed on 30(±4.0)% of flowers, while translocated plants at Sites 1 and 2 set seed on 32(±3.8)% and 18(±3.6)% of flowers respectively. The lower seed set at Site 2 may be a reflection of the plant's smaller size at this site.

In 2010, eighteen years after translocation, the first recruitment of new individuals was observed at both sites. Twenty seven seedlings were found clustered around the base of, and up to 4 m away from, parent plants. Most were at the 2-leaf stage, but a few were older and up to 250 mm in height, suggesting they may have germinated a year or two earlier. A year later, the total number of recruits had risen to 49. Thus the full cycle of establishment, flowering, reproduction and recruitment took at least 16 years for this species at these sites. Some intrusion of Ward's weed (*Carrichtera annua*) was observed at both sites and may adversely affect future recruitment of *P. glandulosum* if allowed to continue unabated.

In the trial examining the influence of propagule type on translocation success, seedlings grew at a far greater rate than cutting-derived plants, particularly during their first summer when they almost doubled in height over 7 months (Jusaitis, 1996). Growth rates slowed subsequently, but seedlings continued to consistently outgrow cuttings over 20 years of monitoring. Seedlings demonstrated higher survival than cuttings, so that after 2.5 years, 95% of seedlings survived compared with 75% of cuttings. These proportions remained stable over the following 8 years before several drought years between 2006 and 2009 resulted in a few more plant losses. Survival after 20 years was 90% for seedlings and 55% for cuttings.

Significantly more cutting-derived plants (87%) than seedlings (53%) flowered in their second year, although by their third year the proportion of each propagule type with flowers was the same (95%). Seed was observed on all plants in the fifth year after translocation, although it is possible that seed may have set in earlier years but not been observed because plants were monitored when flowering rather than during seed set.

In summary, these trials showed that *P. glandulosum* could be successfully established at suitable sites in the Yookamurra Sanctuary. They also demonstrated that seedlings are the preferred founder propagule for *P.*



Naturally regenerated seedlings at Yookamurra Sanctuary © M. Jusaitis

glandulosum, yielding higher growth rates and superior survival compared with cutting-derived transplants.

Major difficulties faced

- Lack of suitable conserved habitat within the population range of *P. glandulosum* in South Australia resulted in translocation occurring outside it.
- Selection of microsites with suitable edaphic, biotic and environmental attributes to perpetuate the species was difficult. Adequate soil moisture was a vital attribute for prolonged survival.
- Grazing and uprooting of transplants by introduced or native animals at Brookfield Conservation Park.
- Several years of below average rainfall (between 2006 and 2009) in the region contributed to plant losses.

Major lessons learned

- The preliminary trial showed that *P. glandulosum* would not establish if exposed to animal damage or if planted into sites where soil failed to retain sufficient moisture during the establishment phase.
- Protection of translocants from grazing and uprooting damage caused by some animals is important to maximize survival.
- Use of seedlings rather than cutting-derived transplants will optimize growth and survival.
- Although seeds are ejected up to a metre from parent plants and potentially dispersed even further by ants (Jusaitis, 2000), many new seedling recruits were found clustered around the base of parent plants. It is postulated that the shade and resultant moisture retention around the base of parent plants provided an important germination niche for recruitment of new seedlings.
- Patience was necessary to observe the first naturally recruited seedlings, which did not emerge until at least 16 years after translocation. Recruitment did not require a disturbance event.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reasons for success/failure:

- Established a new population of 33 *P. glandulosum* plants at 2 sites in the Yookamurra Sanctuary.
- The highly effective 2 m high electric fence around the Yookamurra Sanctuary was crucial to exclude feral animals from grazing or disrupting transplants.
- A preliminary translocation trial to examine microsite suitability resulted in subsequent translocations being sited in more appropriate locations. Choosing suitable microsites was an essential element of success.
- Demonstrated that the source of transplants (seed *vs.* cuttings) has a significant influence on translocation outcomes.

- Natural recruitment of the next generation of *P. glandulosum* was observed around parent plants 18 years after translocation, demonstrating completion of the full life cycle for this species at this site.
- Preliminary research on propagation methods for *P. glandulosum* (Jusaitis, 2000) enabled large numbers of plants to be propagated when required for translocation.
- Commitment to long term management and monitoring of translocated populations ensured goals were successfully achieved.
- The commitment of the Australian Wildlife Conservancy to maintaining Yookamurra as a conservation sanctuary for wildlife and for supporting research and education on threatened species.

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Conservation introduction of a threatened narrow range endemic species, *Banksia montana*, from the Stirling Range National Park, southern Western Australia

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Introduction

Banksia montana is a narrow range endemic listed as Endangered under the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and Critically Endangered in Western Australia (WA) under IUCN (2001) criteria due to ongoing population decline. This species occurs in mountain habitat in the Stirling Range National Park near the south coast of WA. The primary threat to its ongoing survival in the wild is the introduced root pathogen *Phytophthora cinnamomi* (Phytophthora dieback). Grazing, inappropriate fire regimes and the interaction of fire and Phytophthora dieback have contributed to population decline (Moore, 2006) such that this species is now at very high risk of extinction (Barrett *et al*., 2008). Based on its refugial mountain habitat, climate change is also a threat with anticipated increase in summer drought and subsequent fire occurrence in the region. Re-introduction is considered to be the recovery action most likely to significantly increase the number of individuals of this species. Unfortunately, a major barrier to recovery of the species has been the lack of disease-free 'critical habitat' within its historic range. In 2003, a proposal was developed to establish this species in a secure site outside its known range. This paper provides a case-study of this introduction.



Close up of *Banksia montana* © A. Cochrane

Goals

- Goal 1: Create a secure population.
- Goal 2: Provide insurance against species extinction.

- Goal 3: Provide a source of material for future introductions (seed & cuttings).
- Goal 4: Provide a source of material for research purposes.



Private property owner planting first *Banksia montana* at conservation introduction site 2003 © A. Cochrane

Success Indicators

- Indicator 1: New population established with survival of at least 40% of all plants planted beyond year 1.
- Indicator 2: New population established with at least 80% of surviving plants producing material for future re-introduction, research and *ex-situ* conservation.

Project Summary

Feasibility: A member of the family Proteaceae, *Banksia montana* is an erect woody shrub to 2.5 m tall. The species is restricted to mountain habitat in the Stirling Range National Park and is characterised by a small number of populations, low total population size and a very small area of occupancy. *Banksia montana* is an obligate seeder, killed by fire and relies on seed storage in the canopy (serotiny) for its persistence. Plants of this species have a long primary juvenile period, with flowering in natural populations first recorded at nine years post-fire. This long juvenile period makes it particularly vulnerable to extinction from too-frequent fire. The species is highly susceptible to Phytophthora dieback and all known populations are infested with the pathogen. *Banksia montana* is currently known from 38 mature individuals in four small populations across several mountain peaks.

In Western Australia threatened species recovery is the responsibility of the Department of Environment and Conservation (DEC) and includes the implementation of actions such as seed conservation and subsequent species re-introduction as measures to safe guard species and prevent extinction (Cochrane *et al.*, 2011). Seed collection for *Banksia montana* began in the mid-1990s, with material collected from as diverse a parental source as possible. However, seed resources for this highly endangered species were limited by the size of known populations, with less than 45 mature individuals at the time of collection. Over 10 years, repeated seed collection trips were made to remote mountain locations to ensure sufficient material was conserved for any future recovery work.

Unfortunately, by 2000, the extent of *Phytophthora*-infestion in the Stirling Range was such that no suitable sites for re-introduction were available within the

historic range and habitat of the species. A search for introduction sites outside the species' range yielded a secure disease-free site in a privately owned vegetation remnant. The site was located away from the species' mountain-top habitat, in lowland vegetation, some 50 km south of natural populations. In 2002 a proposal for the anticipated introduction was developed and assessed by independent reviewers and detailed planning and consultation with private property owners, land managers and scientists preceeded any on ground works. When approval was granted, seeds were germinated at DEC's Threatened Flora Seed Centre and seedlings were transferred to the accredited disease-free nursery at the Botanic Gardens and Parks Authority, Perth, for cultivation until planting time.

Implementation: *Banksia montana* plantings commenced in 2003 with the establishment of 14 seedlings. Further plantings in 2004, 2005, 2009 and 2010 brought the total number of plants at the site to 136. Following planting, seedlings were protected from vertebrate grazing with wire cages and watered weekly. Plants were permanently labeled in order to track their origin, status and health over time. Disease hygiene was stringently controlled to ensure that *Phytophthora cinnamomi* was not inadvertently introduced to the site. Access was restricted to dry soil conditions and foot baths containing methylated spirits were used on property boundaries to ensure that infected soil containing the *Phytophthora* spores was not vectored via footwear.

Post-planting monitoring: Monitoring of individuals commenced at planting and continued on a six to twelve monthly basis. Data on survival, growth, reproduction and plant health were collected. Monitoring of the wild populations occurred at the same time as monitoring of the introduced plants providing essential baseline data for assessing the performance of the new population. By 2010 species survival was high (85%), with the number of mature individuals in the introduced population more than double the number of mature plants existing in the wild (115 versus 38).

The production of flowers and fruit at the introduction site occurred after only 3 - 4 years from planting. This is considerably earlier than flowering has been observed in the wild populations, most likely due to less extreme environmental conditions at the lowland site. As fruit production increased with plant maturity, it became apparent that many flowers and fruit were being predated at the early development stage by invertebrates. Subsequently, the site was used to trial invertebrate control to enable successful reproduction and to facilitate comparative research on invertebrate diversity between wild and introduced populations (Moir *et al.*, in press). Regardless, this early flowering and fruiting has allowed small quantities of seeds to be collected for *ex situ* conservation since 2010, providing further insurance against species loss. This introduction project was considered so successful that a second introduction site was established as further security for *B. montana*. Continued monitoring of the health and survival of this species will occur as a matter of course.

Major difficulties faced

- Severe limitations in selecting appropriate introduction site due to extent of Phytophthora dieback within the range of the species.
- Limited seed material available for propagation due to declining *in-situ* populations.
- Incidence of invertebrate predation (foliage and fruits).

Major lessons learned

- Capacity of restricted species to survive outside natural habitat shown though ability of species to be moved from montane to lowland situation.
- Capacity of species at introduction site to flower and fruit much earlier than in the wild due to milder lowland location which enhanced plant growth.
- Need for ongoing monitoring of plant growth and health, for example monitoring of invertebrate predation on foliage and fruits which could impact on reproductive output.

Success of project

Highly Successful	Successful	Partially Successful	Failure
√			

Reason(s) for success/failure:

- Detailed planning and consultation prior to on ground works.
- Successful collaboration between scientists and land managers who brought practical and technical skills to the project. In addition considerable input from volunteers and support from regional NGOs, Western Australian government and local industry.
- Capacity of species to survive and flourish outside known geographic range.
- Strict adherence to disease hygiene standards.

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Rehabilitation of mangrove habitats as mitigation against impacts of coastal development on Saadiyat and Jubail Islands, Abu Dhabi, UAE

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Introduction

The United Arab Emirates is the home of the grey mangrove (*Avicennia marina*) and total area under the mangrove forests is 110 km^2. The Emirate of Abu Dhabi possesses extensive mangrove areas on its islands and coastal belt. Some of the mangroves are natural while others are planted. Some of the planted mangroves are over 20 years old and can be compared with well-grown natural mangroves. Some of these mangrove areas are currently under stress mainly due to dredging and coastal development activities. As part of mitigation measures, the Environmental Agency-Abu Dhabi encourages developers to rehabilitate the affected areas by undertaking extensive mangrove plantation programs.

The Saadiyat, Jubail and Yas islands are undergoing widespread development which has affected the naturally growing mangrove habitats around the islands. In order to mitigate the degradation process and loss of mangrove habitat, Abu Dhabi Tourism Authority (ADTA) and Environmental Agency Abu Dhabi (EAD) in collaboration with Barari Forest Management (BFM), Abu Dhabi initiated a pro-active plan for large scale mangrove rehabilitation/plantation in and around these islands. A field visit was conducted by the senior management of the ADTA, BFM and EAD to identify potential areas for mangrove plantations followed by detailed site visits by EAD and BFM technical Team. A total of 16 sites potential sites were selected for plantations and some 800,000 *Acicennia marina* nursery raised plants were planted at these sites.



Mangrove plantation site

Goals

- Goal 1: To rehabilitate mangrove habitats impacted by the coastal development activity.
- Goal 2: To transform sparse mangrove forests into dense forests.
- Goal 3: To maintain plantation areas with minimum mortality.



Offloading mangrove seedlings for planting

Success indicators

- Indicator 1: Establish mangrove plantations on impacted areas of islands under development.
- Indicator 2: Convert sparse mangrove forest into dense forests.
- Indicator 3: Mortality of planted mangroves is below 20%.

Project summary

Feasibility: An aerial survey followed by detailed field survey of Saadiyat and Jubail Islands was conducted by BFM and EAD team during the month of October 2009 to identify and demarcate most suitable areas for plantations.

The criteria for selecting the plantation sites were as follows:

- Tidal flats with muddy substratum and natural channels where regular tidal inundations occur.
- Bare, non-vegetated areas where mangroves occurred in the past.
- Sparse natural mangrove areas.
- After critical evaluation of all potential sites, 16 sites were finally selected for plantations. The procurement of "quality planting stock" was the second most important step to execute the project. The Private Affairs Office of "H.H. Sheikh Mansoor Bin Zayed Al- Nahyan", "Barari Forest Management" and TDIC generously donated all the planting stock to EAD from their nurseries located at Shatti Palace, Abu Dhabi, Maqta Bridge, Abu Dhabi and Saadiyat Island respectively. *A. marina* container plants were transported from nurseries to plantation sites by trucks and motor boats.

Implementation: This massive rehabilitation/plantation project was implemented in three phases. The details are as follows, Phase 1: From November 2009 to January 2010, Phase 2: From February 2010 to April 2010 and Phase 3: From October 2010 to December 2010. The selected areas for planting were carefully demarcated by fixing flags on the outer boundaries. Temporary holding nurseries were established near the planting sites for the storage of plants. Before shifting



Preparing mangrove seedlings for planting

of plants from the nurseries to planting sites, each plant was evaluated and only healthy plants having 50 cm height and above with 3 cm - 4 cm root-collar size were selected. The selected plants were put in the plastic boxes for safe handling and transportation. The plants were transported by trucks and boats up to temporary holding nurseries. The plants were further transported to planting site by boat.

The plantation operations were carried out during the low tide period during the day time. The location of each plant was demarcated on the site. The labor and the labor supervisors were provided adequate training and knowledge on handling and planting saplings before start of plantation operations. The plantations were established in a square shape at 1 m x 1 m spacing. A total of 69,615 *A. marina* plants were planted during phase 1 followed by 430,385 plants during phase 2 and 300,000 plants during phase 3. A total of 800,000 *A. marina* plants were planted on 16 plantation sites located in and around the Saadiyat and Jubail Islands.

Post-planting monitoring: All the plantations established at various sites were monitored on a quarterly basis. The survival data was recorded from the permanent randomly selected plots.

Major difficulties faced

- Stormy and rainy weather conditions.
- Rough high tides.
- Muddy site conditions difficult to work.
- Daily change in planting time due to change in low and high tide time.
- Limited planting season.
- Transport of saplings to planting sites during low tide period.
- Lack of skilled/trained labor force.

Major lessons learned

- Site selection for mangroves plantations is most important. Survival and growth of plants depends on proper site selection.
- Predominantly bare sandy soils should not be selected for plantations.
- Plantations should not be established on low tidal mud flats.

- Healthy and appropriate sized planting stock is one of the major factors for success of mangrove rehabilitation/plantation programs.
- The survival rate is more when planting is done during the low tide period and there is no wave action.
- Quarterly monitoring of plantations is must for evaluation and management of plantations.

Success of Project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success

- Selection of most suitable plantation sites.
- Selection of healthy and proper sized planting stock.
- Planting operations at proper time and planting season.
- Care in handling and transportation of plants from nursery to plantation sites.
- Effective technical guidance and supervision.
- Regular monitoring.
- Building teamwork and ownership among the labor and supervisors.

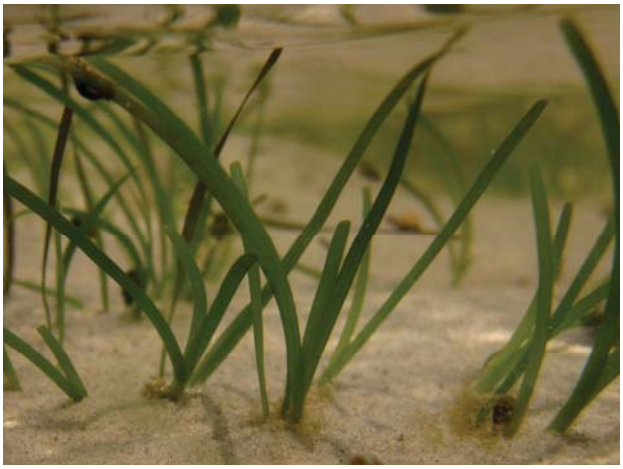
Re-introduction of seagrass in the Netherlands Wadden Sea

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Introduction

Two seagrass species occur in the Netherlands Wadden Sea namely eelgrass (*Zostera marina*) and dwarf eelgrass (*Zostera noltii*). *Z. marina* occurs in two forms, a robust perennial submerged form and a flexible annual intertidal form. *Z. noltii* is a smaller, flexible perennial species found in the intertidal zone. Both species have declined in the Netherlands since the 1970s, and eelgrass has gone from being a widespread, commercially exploited species, to an uncommon species of conservation concern. Eelgrass and dwarf eelgrass are listed as 'least concern' by IUCN, but are reported as 'decreasing'. This trend is apparent world-wide for many seagrass species (Short *et al.,* 2011). *Zostera marina* is protected by Dutch law (Flora- en Faunawet, 2002), while seagrass beds of both species are protected by the EU Habitat Directive. Re-introductions were carried out on in the Netherlands part of the Wadden Sea, one of the world's largest international marine wetland reserves. It extends over 6,000 km² along the coasts of the Netherlands, Germany and Denmark. A 250,000 ha section of the Netherlands Wadden Sea has been declared a Ramsar wetland of international importance since 1984. In June 2009 the Wadden Sea was added to the UNESCO World Heritage List.



Dwarf eelgrass (*Zostera noltii*) with leaves only 6 - 22 cm long © Laura Govers, RU Nijmegen

Goals

- Overall goal: Restore nature values.
- Goal 1: Assessment of habitat requirements and site suitability for re-establishing seagrass populations.
- Goal 2: Experimental testing of donor populations for seagrass re-introduction.

- Goal 3: Field testing of various planting methods for the two seagrass species.
- Goal 4: Re-establishing viable seagrass beds at various locations in the Netherlands Wadden Sea.



Zostera marina the leaves are 20 - 50 cm (can reach 1m) long © Arthur Bos, RU Nijmegen

Success Indicators

- Indicator 1: Self-sustaining population (s) of seagrass permanently re-established in the Netherlands Wadden Sea.
- Indicator 2: Seagrass beds in the Netherlands Wadden Sea being a significant ecological feature, and playing a role once again as a habitat for fish (brood) and shellfish.

Project Summary

Feasibility: The Netherlands Wadden Sea once had extensive seagrass beds, with more than 150 km² remaining at the turn of the 20th century. Two species occur, namely *Zostera marina* (eelgrass) and *Zostera noltii* (dwarf eelgrass). *Z. noltii* has always been far less common than *Z. marina* in the Netherlands Wadden Sea. The robust form of eelgrass was of economic importance as insulation and filling material and was extensively harvested until the early 20th century. In the early 1930s, 'wasting disease' wiped out many robust, submerged eelgrass populations throughout Europe (den Hartog, 1987). Most populations recovered, but those in the Netherlands failed to do so and disappeared entirely. This was at least partly attributable to the closure of the dike separating the former Zuyder Sea from the Wadden Sea. As a result, permanent changes in hydrology and turbidity occurred. What remained in the Netherlands Wadden Sea were scattered remnant populations of dwarf eelgrass and of the flexible, annual form of eelgrass. These subsequently largely disappeared from the western Wadden Sea during the 1970s, due to a combination of eutrophication (and increase in turbidity), and the mechanical cockle and mussel fishing industries (Giesen *et al.*. 1990; van Katwijk *et al*., 2009). However, both seagrass species are still abundant in the north-eastern parts of the Wadden Sea.

Since the 1980s, measures were undertaken to improve water quality and habitat conditions along the Dutch coast. By the 1990s turbidity and eutrophication had decreased, and shellfish industries were largely banned. In spite of these improvements, natural recovery of seagrass in the western Wadden Sea was considered unlikely to occur. Potential donor populations were located downwind of the western Wadden Sea (where westerly winds dominate), or were too distant

(e.g. estuaries in south-western part of the Netherlands). Therefore, a seagrass restoration program was started in 1987 for *Z. noltii* and the flexible, annual form of *Z. marina.* It was decided not to focus on the robust, submerged form of eelgrass as this had already disappeared in the 1930s, and environmental changes were considered too great (van Katwijk *et al.,* 2009).

Implementation: Prior to the re-introduction program, mesocosm experiments were carried out on eelgrass from potential donor populations from France (Roscoff), Germany (Sylt), Denmark (Yderfjorden, in the Baltic), and the Netherlands (Grevelingen and Terschelling). Aim was to assess survival rates, and if plant reproductive strategies were suited to local conditions. As a result of these experiments, eelgrass from Yderfjorden and Roscoff were deemed unsuitable (low survival rates) and re-introduction focused on donor sites in the Netherlands and Germany (van Katwijk *et al.*, 1998). From 1991 - 2004, 39 seagrass transplantations were carried out at 14 locations in the Netherlands Wadden Sea: Balgzand (3 sites), Texel (3 sites), Vlieland, Terschelling (4 sites), Schiermonnikoog, Ems Estuary, Friesland coast (van Katwijk *et al*., 2009). At four sites seagrass had disappeared in the 1970s, while at 6 sites disappearance had occurred before 1970. Three sites had remnant seagrass populations and functioned as donor and control sites, as did the donor population in Sylt, Germany. One transplantation site was not known to previously have a seagrass population.

Altogether 10,000 *Z. noltii* shoots and 23,000 *Z. marina* shoots were used in these transplants. On average about 800 seagrass shoots were transplanted per site. Sylt (Germany), Ems Estuary and Terschelling (both located in the Netherlands Wadden Sea), Goese Sas and Grevelingen (both south-western part of the Netherlands) were donor locations for *Z. marina*, and Sylt and Terschelling for *Z. noltii.* All *Z. noltii* transplants used the 'bare root' method, whereby sediment is removed from rhizomes before transport and replanting. With *Z. marina* transplants, the bare root method was also most commonly used, but sods and seed-bearing shoots were also utilised. Time between harvesting and replanting was kept to a minimum and was always less than 48 hours, during which plants were kept cool and moist (to reduce stress and desiccation).

Post-planting monitoring: *Z. marina* transplants had a highly variable performance, witnessing years of significant expansion and massive contraction. Eventually they all disappeared, the longest period of survival being eight years. Problems were due to premature die-off before seed formation at muddy sites (prone to high macro algae cover) or a low seedling survival in sandy areas. Also, seagrass patches were thinly spread, and lack of pollination may also have affected these annual plants (van Katwijk *et al.,* 2009). *Z. noltii* transplants were more successful, with a population on Balgzand still surviving after 13 years (i.e. the last time this was monitored). The difference is noteworthy, especially as fewer transplants of dwarf eelgrass were carried out and the re-introduction program was more focused on *Z. marina.* The main reason for this difference is probably because dwarf eelgrass is a perennial, and not dependent on seed

production, germination and survival as is the annual form of eelgrass (van Katwijk *et al.,* 2009).



Eelgrass planting using bare root method
© Marieke van Katwijk, RU Nijmegen

Major difficulties faced

- Formidable logistic hurdles were faced in order to keep the time between harvesting and replanting within acceptable limits (e.g. many volunteers, long hours, muddy habitats).
- Optimal transplantation techniques were not well understood when the program began, and had to be learned during the process. This included understanding the self-facilitation processes of seagrass beds, and the effects of mussel beds, shell armouring, anchoring techniques, etcetera on seagrass growth.
- Results were highly variable, with successful and total loss plots next to each other. Also year-to-year variation was large. This stochasticity made results more difficult to interpret.
- Disappearance of the plants after the adverse season (winter).
- High macroalgae cover preventing seed production (due to early die-off) at muddy sites, and a lack of recruitment at sandy sites.

Major lessons learned

Adapted from van Katwijk *et al.* (2009):

- **Reverse habitat degradation:** Prior to any restoration or re-introduction effort, the causes of the decline should be known and alleviated or reversed. Most seagrass recoveries have been reported following habitat improvements such as reduced eutrophication and restored hydrology. Reduction of eutrophication and turbidity and a ban on mechanical shellfish harvesting had taken place in the Netherlands Wadden Sea by the time the reintroduction program began in 1991.
- **Select the appropriate location:** Transplantation locations should: i) have a past history of seagrass occurrence; ii) depth should be similar to that of nearby natural seagrass beds; and iii) meet other habitat requirements (e.g. micro-topography, hydrodynamics, sediment, nutrients, competition). Note that a past history of seagrass occurrence is no guarantee for plant survival, as conditions may have changed at a site.
- **Select an appropriate donor population:** General criteria for selecting a donor population is that it should i) be large enough not to be impacted by the donation; ii) survive the transplantation to the new environment; iii) be able to

expand, either sexually or vegetatively; and iv) have the traits to be able to survive in the long-term.

- **Spreading of risks:** In a dynamic coastal and estuarine environment, the spreading of the risk of plant losses (e.g. due to storms, ice scouring, salinity fluctuations, temperature fluctuations, desiccation, foraging by geese, disease) in time and space is important. Natural seagrass populations survive the vagaries of nature by maintaining genetic variation, phenotypic plasticity, and multiple reproductive or growth strategies. Spreading risks can be carried out by: i) transplanting to areas with different hydrodynamic exposure and habitat differences; ii) planting replicates at intervals (e.g. of tens of metres) at each site; iii) transplanting at different dates and in different years; and iv) transplanting genetically diverse material. Larger transplants over a large number of sites will result in a spreading of the risks, and is likely to result in a more permanent seagrass population.
- **Hydrodynamics:** Optimise techniques and account for ecosystem engineering effects. The distribution of most seagrass species is often governed by the presence of shelter. Accordingly, the results of most transplants are shaped by hydrodynamic stress or disturbances. Transplantation of plants with intact sediments (e.g. using sods) generally yields the highest rate of success, but is more costly and labour intensive. Various enhancing techniques tested during the transplants revealed that in the Wadden Sea i) anchoring techniques had no positive effect on seagrass growth; ii) shell armouring benefited seagrass at exposed sites only; and iii) mussel beds had a positive impact on seagrass survival.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- Due to permanent habitat changes, only the intertidal annual form of *Z. marina* can survive in the Netherlands Wadden Sea. However, this form also faces problems for re-establishment. Premature die-off at muddy sites (with high macroalgae cover) stifles seed production, while low recruitment rates affect hydrodynamic sandy areas. Also, thinly spread eelgrass patches face a lack of pollination (and low seed production), and higher risk of plant loss due to fluctuations in environmental conditions (e.g. storms, ice scouring, and so on). Planting larger numbers at (many) more sites will spread the risks and should lead to overall survival of the species.
- *Zostera noltii* dwarf eelgrass transplants survived for up to 13 years (i.e. when monitoring ended) and appear successful. Dwarf eelgrass is a perennial that survives the winter period underground, and unlike the annual form of eelgrass it does not depend on the vagaries of seed production, germination and survival.
- Eutrophication is likely related to the low seagrass transplantation survival via the stimulation of macro-algae, which was also shown to be related to the

extinction of the most western located donor population of *Z. marina*. The flourishing seagrass populations in the Northern Wadden Sea support the relationship with nutrient loads, as these are twice as high in the Dutch Wadden Sea. Also the decline in the Eastern Wadden Sea coinciding with increased agriculture points to a relationship with eutrophication.

- The success at the Balgzand area, with a 8-year survival of the *Z. marina* population and the 13 year survival of the *Z. noltii* populations, notwithstanding the very low numbers that they had to start with in such a dynamic environment– a strong support that this site is still very suitable for seagrass colonisation and shows that seagrass transplantations in the Wadden Sea have been successful; upscaling can be recommended.

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Re-introduction of stinking hawk's-beard into South-East England, UK

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Introduction

Stinking hawk's-beard (*Crepis foetida foetida*) is an annual/biennual member of the Asteraceae, characterised by its nodding flower buds, pure white 'plume' of seeds and, when bruised, the smell of bitter almonds, from which it gets its name. It is widespread in southern Europe but declined across north-western Europe in the 20th century, leaving only isolated populations (Ferry, 1999). Historically it was known from open, coastal or chalky habitats in England but was last recorded in 1980 on coastal shingle at Dungeness, South Kent. It is listed as Extinct in the UK Red List. Herbarium seed collected from Dungeness was successfully germinated at Royal Holloway College, London which prompted the start of a project to reintroduce the plant to England in 1992. Stinking hawk's-beard subsequently became a UK Biodiversity Action Plan (BAP) priority species in 1998, with the RSPB as Lead Partner. It is protected by Schedule 8 of the Wildlife and Countryside Act 1981. The project has been directed by a steering group comprised of Natural England, Royal Holloway College and the RSPB with funding from NE and RSPB.



Crepis foetida flowers © Barry Yates

Goals

- Goal 1: Determine whether any populations remain in the wild at Dungeness.
- Goal 2: Determine appropriate methods for the successful establishment of *Crepis foetida* populations.
- Goal 3: Determine factors adversely affecting viability of the species.
- Goal 4: Establish three self-sustaining populations of *Crepis foetida* by 2010.
- Goal 5: Maintain established populations.

Success Indicators

- Indicator 1: The discovery of any wild populations.

- Indicator 2: The establishment of an experimental translocation to determine suitable substrate and growing conditions.
- Indicator 3: To have carried out genetic studies into the viability of the UK stock in comparison with populations from the European continent.
- Indicator 4:.The determination of factors affecting the survival of plants under different seasonal conditions and clearer understanding of the habitat requirements of the plant.
- Indicator 5: The establishment of three self-sustaining populations by 2010 with management in place for their long-term maintenance.



Effects of grazing on *Crepis* plot at Rye LNR
© Barry Yates

Project Summary

Feasibility: Extensive surveys in the 1980s were unable to find the species at its last known location in Kent. From 1992 onwards a series of experimental re-introductions have been undertaken to a range of habitats: vegetated shingle, disturbed chalk, and to a gravel-based garden for direct observation.

Implementation: Initial attempts were made to re-introduce the plant to vegetated shingle at its last known site within the Dungeness Estate. In 1993 a replicated plot experiment was set up at the RSPB's reserve within the Dungeness National Nature Reserve, using varying mixes of shingle and fine material. Plots were planted with pot-grown plants and seed, and were protected from rabbit grazing with wire cages. Numbers at both sites rapidly peaked and then declined, with no plants recorded from 2001 onwards. Succession was believed to be a cause of early failures. Historically the shingle beach was heavily disturbed by local residents, and had also been grazed by free-ranging sheep and goats. Grazing ceased after the construction of Dungeness nuclear power station in the 1960s and protection of the shingle beach has resulted in the vegetation becoming more "fixed". Further experimental work at RSPB's reserve included controlled grazing and surface scarification to try to restore early succession conditions and to encourage any seed within the substrate to germinate, but with no success. In 2000 the species was re-introduced to a second shingle location at Rye Harbour Local Nature Reserve in East Sussex where the plant was last recorded in 1920. For the following four years a small population persisted, never exceeding ten plants.



Dungeness RSPB reserve plots showing seedlings at rosette stage © Brian Ferry

Given these early failures, a visit was made to other populations in north-west Europe, including Maastricht, in the Netherlands, where the species flourishes on large chalk spoil heaps kept bare through disturbance. With historic records of stinking hawk's-beard on chalk in England, an attempt was made to introduce it to three chalk pits in North Kent. Plants introduced in 2003 established small populations of annual plants at each site, but they were all extinct by 2007. A genetics study was undertaken at The Royal Botanic Garden in Edinburgh to investigate whether the gene pool of our ex-Dungeness stock was too restricted and lacking in genetic variability compared with material from Maastricht and the Auvergne region of southern France, but there was no evidence of a genetic bottleneck (Squirrel *et al.*, 2006). Detailed observations into factors affecting seedling survival was facilitated by the transplanting of two pot-grown plants into a gravel-based garden of one of the collaborators at Northiam, in East Sussex in 2003. These plants produced prolific seed, resulting in a population subject to cycles of boom and bust, peaking at over 1,800 plants in 2011, some dispersing as far as 105 m from the original planting, colonising a range of substrates including bare clay soil, limestone and flint scree.

In February 2005 the Rye Harbour LNR plot was surrounded by exclusion fencing to protect another rare plant from rabbit grazing. Following this, numbers of stinking hawk's-beard started to increase almost exponentially, resulting in a large population that appears to be self-sustaining in the medium term. In time the vegetation cover may become too fixed and may require several plots managed asynchronously with alternating periods of disturbance, followed by protection from grazing.

Post-planting monitoring: All experimental re-introductions have been monitored annually by recording the numbers of flowering plants. Most germination occurs shortly after the seeds are produced, between July and September, with only a very few appearing during mild weather in the winter and early spring. The productivity of plants growing in different locations was compared by counting the number of flower-heads per plant and the average number of seeds. The largest and most prolific plants were those growing on bare

clay soil and limestone scree at Northiam, which were much more robust than the plants growing on shingle at Rye, Dungeness and the chalk pits.

From November 2005, the development of seedlings at Rye and Northiam was monitored each month within selected plots. Overall levels of seedling mortality at both sites were typically 50% and often much higher. Causes of mortality include grazing by invertebrates (mainly slugs and snails) between November and May, and late spring droughts, killing plants as they start to flower. The relative importance of grazing by rabbits and molluscs was examined through a replicated plot experiment at RSPB's Dungeness reserve in a former arable field. More than 11 times the number of flower-heads were produced in plots that were protected from rabbit grazing, but any effects of molluscs were inconclusive because of the limited time-scale of the investigation. In 2010 a further population was discovered within the Dungeness Estate and is now being monitored. Investigations are underway to establish if this is remnant of the original wild population.

Major difficulties faced

- The lack of detailed knowledge of the ecology of the species and its apparently anomalous response to different conditions has required a prolonged period of experimental re-introductions.
- As a plant that is prone to cycles of boom and bust, the impact of adverse climatic conditions, or grazing by invertebrates in winter or rabbits in summer can make this species vulnerable to chance extinctions in a landscape in which populations are restricted to small isolated areas.

Major lessons learned

- The value of re-introducing plants to areas where they have been lost, with targeted monitoring and experimental management to establish the ecology of the species and reasons for its vulnerability.
- The need for periodic anthropogenic disturbance and modification of habitat to maintain this species, rather than relying on it growing successfully on pristine undisturbed habitats.
- The nature and level of anthropogenic disturbance on shingle habitats is different now to in the past, and this coupled with increased fragmentation of habitat, resulted in this species being vulnerable to chance extinctions in localized populations.

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- *Crepis foetida* is readily propagated in greenhouses and pot-grown plants can be planted at translocation sites.
- The plant died out before it's ecological requirements were fully understood and these have had to be discovered by a process of trial and error, resulting

in limited success in the short term, but in the longer term a clearer understanding of what the plant requires.
- Reserve managers who were willing to allow manipulation of habitat plots to determine the impacts on the plant (excluding rabbits for instance).
- There has been good collaboration between academic researchers, statutory conservation agents, conservation land managers and volunteers.
- Dogged determination from collaborators over 20 years!

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Re-introduction of Spanish moon trefoil in Illa Grossa, Columbretes Islands, Spain

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Introduction

Spanish Moon Trefoil (*Medicago citrina*) is a shrub endemic of small islands of the Mediterranean Spanish coasts. Its population, less than 2,000 specimens, is scattered through 10 islets of 4 archipelagos: Columbretes Islands and Illot de la Mona (Valencian Community region) and Ibiza and Cabrera Islands (Balearic Islands). It is listed as Critically Endangered of the Top 50 Mediterranean Island Plants (Crespo *et al.*, 2005), and strictly protected in the Spanish List of Endangered Species. Formerly covering most part of the Columbretes archipelago (18 ha, Valencian Community), *M. citrina* went extinct in the main island (Illa Grossa, 14 ha) by the 1960s, there are only two remaining small populations in the close islets Foradada (1 ha) and Ferrera (1 ha).

The extinction was caused by overgrazing (introduced pigs, goats and rabbits) and the overexploitation for fuel, made during the building works of the lighthouse of Illa Grossa (1856 - 1860), and the maintenance of its keepers between 1860 and 1975. The strong climatic conditions such as rainfall (200 mm/ year) with a 8 - 9 month drought period with sandy volcanic soil, which cannot maintain the rainfall water, added serious troubles for the natural re-colonization of the native population (Fabregat & Laguna, in press).

Goals

- Goal 1: Eradication of introduced rabbits, to ensure the recovery of native vegetation in Illa Grossa.
- Goal 2: Partial eradication of invasive plant competitors (introduced prickly-pear *Opuntia ficus-indica*).
- Goal 3: Production of new plants from the two close populations (Ferrera and Foradada) of *M. citrina*.



Medicago citrina in Illa Grossa

- Goal 4: Plantation of *M. citrina* in selected sites of the island Illa Grossa.
- Goal 5: Maintenance of the re-introduced population against the effect of new pests (biological control of *Icerya purchasii*, Hemiptera).

Success Indicators

- Indicator 1: Number of planted specimens.
- Indicator 2: Number of adult plants remaining in the long term after plantation.
- Indicator 3: Effective recruitment of new plants in the re-introduced population.
- Indicator 4: Number of damaged/resistant individuals of *M. citrina* after attacks of *Icerya purchasi*.

Project Summary

Feasibility: In 1986 the Columbretes Islands archipelago, formerly used as a military area, was transferred to the regional government of Valencia (Generalitat Valenciana) to ensure its protection and nature conservation tasks. Columbretes is 56 km off the Valencian coast. The archipelago is formed by 4 main islands (Illa Grossa, Foradada, Ferrera and Carallot), but the 3 last are less than 1 ha. Only 2 of them (Foradada and Ferrera) still contain remainders of the native vegetation, a dense Mediterranean, cushion-shape shrubland partially dominated by the Spanish endemic shrub *Medicago citrina*. The vegetation of the main island (Illa Grossa, 14 ha) was extensively destroyed during the 19th and 20th century, used by their ancient lighthousers as fuel or as a food for introduced species; in addition the island suffered the invasion of the prickly pear (*Opuntia ficus-indica*).

By mid 1980s, *M. citrina* was fully extinct in Illa Grossa, and the 2 other islands held 600 adult individuals, as a remnant of the native population. A time the archipelago was abandoned by the lighthouse keepers and the Spanish Navy, the Service of Biodiversity of the Generalitat Valenciana (SBGV) drafted a long-term program to recover the ancient vegetation of the main island, including the re-introduction of *M. citrina* from the close minor islands of the same archipelago (Ferrera and Foradada), placed 1 - 2 km from Illa Grossa (Laguna & Jimenez, 1995). In 1987 the whole archipelago was protected as Natural Park, reclassified in 1992 as Nature Reserve. In 1998, Ferrera and Foradada islands were also protected as Plant Micro-Reserves (Laguna, 2001).

Implementation: During 1987 all the introduced rabbits were hunted using traps, bow and arrows, in order to not to cause troubles to the endangered seabird colonies living there. A total of 213 rabbits (*Oryctolagus cunniculus*) were hunted, and the vegetation of lower stages, herbaceous and low-size perennials, quickly started recovering. More than 400 young individuals of *Opuntia ficus-indica* (Cactaceae) were removed, using their stems to make compost, further used to fertilize the holes made to plant *M. citrina*. Ancient, monumental trees of *Opuntia* were maintained to get fleshy fruits useful to feed migrant birds, as well as to ensure the life cycle of several insects acting as major local pollinators.

During the period 1988 - 1996 the SBGV produced *in situ* and planted more than 800 specimens of *M. citrina* on selected sited with deepest soils or partially shaded slopes; the seeds were collected in the two close islands Ferrera and

Foradada. For most specimens, additional irrigation was provided during their 2 - 3 first post-plantation years.



Re-introduced *Medicago citrina* (with yellow flowers) at Illa Grossa

In 1996, a new pest affected the *Citrus* crops (orange and tangerine trees) covering most part of the agricultural landscape near the Valencian coast, and the landowners combated it using strong pesticides. The biocides produced the imbalance on the equilibrium between a former agricultural pest (*Icerya purchasi*, Hemiptera) and its predator (*Rhodolia cardinalis*, Colleoptera).

During 1996 - 1997 a sudden increase of populations *I. purchasi* was noticed on the continent, and this species entered Columbretes, carried on the feathers of migrant birds. In two weeks, by mid-April 1997, *Icerya* had destroyed nearly 66% of the native population of *Medicago citrina*, as well as most part of the re-introduced plants in Illa Grossa. To combat the pest, the SBGV, assessed by the regional Department of Agriculture, quickly released the predator *Rh. cardinalis*, stopping the decline of *Medicago*. This practice is done every spring since 1997 as a preventive action.

Post-planting monitoring: The plantation has been continuously monitored and censed by the Nature Reserve keepers, including the re-plantation of low-success sites (i.e. sites where the specimens of *Medicago* died by *Icerya*). Regular censuses are conducted by SBGV's Plant Officers every 4 - 5 years since the mid -1990s.

By 1995 - 1996, the first re-introduced plants of *Medicago* flowered and started to produce fruits. Currently the new population consists of 220 adult plants and an active recruitment of new plants is noticed in open vegetation surrounding the older specimens. Each one of the older plants (more than 1.5 m high) of *Medicago* can produce over 3,000 seeds per year, but a strong recruitment only can be expected after very long periods of accumulation in the soil seedbank, due to seed dormancy. The germination capacity can be conserved for very long periods, and the dormancy also can be suddenly broken by the direct incidence of sunlight, i.e. after wildfires or clear cutting practices. Paradoxically, most part of the success in seed production depends on a pollinator diptera (Pérez-Bañón *et al*., 2003) whose larvae host the fleshy fruits and stems in decomposition of the

invader *Opuntia ficus-indica*, maybe as an alternative food, instead of the fruits of native shrubs that have locally become extinct in the past.

Major difficulties faced

- The resistance of young re-introduced plants to very long dry periods (summer). During the first 5 years, ~40% of specimens died because of the excessive drought period of 6 - 9 months without rainfall every year.
- Enhancement of pollinator populations. The extinction of several species bearing berries or fleshy fruits, reported from the islands by 1832, as *Olea sylvestris* and *Pistacia lentiscus* probably forced the main pollinators (*Syrphidae*, Diptera) of the Moon Trefoil to choose the invader cactus *Opuntia ficus-indica* as an alternative food for their larvae period (Pérez-Bañón *et al.*, 2003)
- Fight against the new pests as *Icerya purchasi*. Fortunately the biological control provided by *Rhodolia cardinalis ongoes*, but in a first stage *Icerya* destroyed a significant part of the specimens of the re-introduced population, just coinciding with the first successful episodes of seed production.

Major lessons learned

- The re-introduction of the species was possible although the negative initial perspectives (i.e. lack of plant cover, excessive drought period, slow growth rate of *Medicago*, etc.). The success can be mainly attributed to the constant effort and continuous work of the Nature Reserve keepers.
- The needing of agreed decisions taken by animal and plant officers. The decision proposed by the animal officers of SBGV to maintain the *Opuntia* specimens even being an invader plant, was a key issue for the success of the re-introduction of *Medicago*. Due to the key position of the archipelago, at mid-distance between the continent and the Balearic Islands, it deals with a major site providing plant food for a lot of bird species in the Western Mediterranean migration routes. *Opuntia* pears are the only food that those birds can find in Columbretes. The optimal alternative solution (plantation of extinct, native berry species) could be undertaken but due to the extreme local drought they could need more than 30 years to get the adult stage and to provide fruits to feed the migrant birds.
- The projects for threatened plant re-introduction in small islands can face unforeseen serious problems, like herein indicated on pests or pollinators. Even having the most updated scientific knowledge on the biology of the plant species, the answer of managers after any stochastic negative event can be crucial.
- Special care of re-introduced plants can be maintained for years (for instance water supply) at least to ensure that they are reaching the adult age.

Success of project

Highly Successful	**Successful**	Partially Successful	Failure
	√		

Reason(s) for success/failure:

- The main reasons for the success has been the eradication of risk factors (invader plants and rabbits) and the continuous assessment and management of the re-introduced population, made by the keepers of the Nature Reserve of Columbretes Islands.
- Complementarily, the quick answer to the invasion of the new pest *Icerya purchasi* by means of biological control and release of its predator *Rhodolia cardinalis*, has ensured the conservation of adult plants.
- The water supply provided by the Columbretes' keepers during the long period of drought, maintained during the 4 - 5 first years of life of each re-introduced plant, has been a key point in ensuring their survival.

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First phase of the re-introduction of *Silene hifacensis* (Caryophyllaceae) in Cap de Sant Antoni, Valencian Community, Spain

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Introduction

Silene hifacensis (Ifac Champion) is a Spanish endemic plant protected by the Bern Convention and the European Habitats Directive. It is a cushion-shaped perennial shrub up to 50 - 60 cm living on calcareous outcrops and coastal cliffs near the Mediterranean sea, forming meta-populations through two isolated areas (Blasco *et al.*, 2011): Balearic Islands (Ibiza: 695 individuals in 14 sub-populations) and the Iberian peninsule (Coast of NE Alicante, Valencian Community: 91 plants, 4 sub-populations). The Iberian population was considered extinct for a long time (Gómez-Campo & Malato-Béliz, 1985). It was rediscovered in 1987 near its original sites, but several unsatisfactory re-introduction projects have been undertaken. The species is absent from the two original sites described in the past (Cap de Sant Antoni [CSA] and Penyal d'Ifac [PDI]). This case-study is focuses on the re-introduction efforts in the CSA site, the native area of the lectotypus designated by Jeanmonod (1984). CSA is a coastal cape with a big vertical cliff (130 m). A decade ago a new 'donor' sub-population (7 individuals) was found on a small islet (Illot de la Mona [IDM],



Silene hifacensis (Ifac Champion) © E. Laguna

0.067 ha, 19 m), placed 20 m far from the cliff foot, and 200 m south from the original site.

Goals

- Goal 1: Establishment of an *in situ* pool of reproductive individuals of *S. hifacensis*, on a site with recruitment possibilities (habitat availability, low predator pressure, low risk of accidental damages), as a first step for a long-term re-introduction project.
- Goal 2: Production of high amounts of seeds, in separated production lines from the Iberian sub-populations, in order to ensure the future sowing activities
- Goal 3: Depuration of a tested protocol for future sowing and plantations on vertical rocky falls.
- Goal 4: Progressive experimental contrast of plantation techniques (use of seeds vs. seedlings, vertical vs. sub-vertical substrata, best seedling age for plantations, etc.).

Success Indicators

- Indicator 1: Number of planted specimens.
- Indicator 2: Number of adult plants reaching the adult age (2 - 3 years).
- Indicator 3: Number of resistant individuals (2 - 3 years after plantation) undamaged by predators, accidental damages, etc.
- Indicator 4: Number of adult plants producing seeds *in situ*.
- Indicator 5: For the next re-introduction phases, number of recruited seedlings, to be found below the planted specimens.

Project Summary

Feasibility: The four known native sub-populations of *S. hifacensis* in the Iberian Peninsula are spread on 50 km of coastal cliffs from Xàbia to Calp (NE Alicante). All these sites are strictly protected as Valencian Plant Micro-Reserves (VPMR, see Laguna, 2000 and Laguna *et al.*, 2001), managed by the Biodiversity Service of the Generalitat Valenciana (regional government of the Valencian). *Silene hifacensis* is strictly protected by the Spanish and Valencian laws, and there is an official recovery plan, legally passed by the Valencian government in 2008. Both the receiver site CSA and the donor IDM, are also protected as VPMR, and they also form a part of the Nature Park 'El Montgó'. The species is a self-compatible plant with high germination (65 - 95%) and seed production rates (up to 1,000 - 10.000 seeds per plant in nursery crops).

The Iberian native sub-populations are compound by strictly rock-dwelling plants, living on vertical cliffs facing the sea. All the former re-introduction efforts undertaken on the Iberian native sites since the species re-discovery in 1987, failed to obtain new viable, permanent sub-populations. An artificial population in Denia (3 km north from CSA) introduced in 1992 and reinforced by 2003 on horizontal soils in a mixed rock/grassland/shrubland habitat yielded unsatisfactory results; the plants did not live more than 10 years and the recruited seedlings did not overpass two years in age.



Planting on the cliffs in Cabo de San Antonio © E. Laguna

Another unsatisfactory re-introduction attempt in 1999, on vertical cliffs, where 3,200 seeds were sowed on the crevices and low cornices at two VPMRs of the Penyal d'Ifac (ca. 40 km south from the CSA site). Twelve years later the re-introduced population only holds two adult individuals but they are situated very close to the cliff bottom, where the new seeds cannot find available habitats to germinate. Formerly (1993 and 1996), plantation of adult or mid-aged plants completely failed on the same habitats, only remaining for 1 - 2 years.

These experiences gave us lessons on the choice of optimum micro-sites to try the re-introduction in CSA under similar climatic conditions, but advising against the use of combined techniques (sowing and plantations) and water supplementation. The re-introduction goal for SCA site is to set up a new small viable pool of reproductive individuals of *S. hifacensis* just bordering the cliff crown cornice (130 - 135 m a.s.l.), occupying a unsuitable habitat for rabbits or rats which are exposed to seagull attacks. The site is also risky for human visitors (tourists, etc.) who can cause accidental damage to the plants. In order to ensure that the new seedlings can reach reproductive age, they should be supplemented with a regular water supply. As a long-term expected result, the flowering stems of the re-introduced plants could disperse their seeds on the available habitat, rock crevices and cornices, below them.

Implementation: Since 2008 the regional Biodiversity Service and the Nature Parks Service develops a joint project to produce separated seed pools from each one of the four Iberian sub-populations, in order to ensure future re-introductions using seeds from their native sites. In this way, 240 new adult mother plants have been obtained after cultivation during two years in four separated nurseries, no genetic crossing is possible, but it can be done in the future if advisable. The donor population (IDM) for CSA site only holds four accessible specimens able to harvest seeds, but they have shown a good germination rate. The IDM reproductive pool (50 adult plants) is maintained in the nursery of the same Nature Park El Montgó, and they produced more than 100,000 seeds in 2011.

The re-introduction strategy for CSA has been drafted combining initial sowing in crevices and rock-holes and its regular plant reposition using young seedlings on the failed microsites. The experience frame has been designed to make if possible a long-term monitoring testing the effect of microsite, plant age and predation. From October 2009 to February 2010 the Nature Park keepers, who are experienced rock-climbers, sowed 30 microsites (5 seeds per hole) along 250 m of the cliff crown. Afterwards regular reposition with seedlings has been required for 10 microsites; seedlings were formerly grown in micro-alveolus containers (1 - 2 cm wide). The regular visits to the site (at least 1 per month) are complemented with water supplementation during the drought periods.

Post-planting monitoring: Until the summer of 2011, 34 monitoring visits have been made, as well as intermediate interventions for water supplementation during the extreme drought periods. More than 200 seedlings have been planted during the reposition operations, apparently affecting the worst microsites for the species installation. During the spring of 2011, a total of 3 individuals (10% of the initial pool) produced flower stems and new seeds. Only sporadic episodes of predation have been reported, apparently made by snails.

Major difficulties faced

- The obtaining of seeds to initiate the pool of reproductive plants, due to the inaccessibility of the donor site.
- The plantation in high-risk conditions (tall vertical cliffs), as well as the periodical monitoring.
- The production of seedlings under new, unusual technical conditions (micro-alveolus, able to plant them afterwards in very tiny crevices or rock-holes).
- The *in situ* maintenance of seedlings with water supplementation, made by climbers.
- The finding of good micro-sites to sow or plant the seedlings. Most good sites are already occupied by other species; in the case of empty sites, we cannot easily know in advance the opportunities that they offer for a successful plantation.

Major lessons learned

- The establishment of a first reproductive pool to re-colonize the cliffs requires a huge human effort (plantation in high-risk conditions, regular assistance for watering and monitoring).
- The external appearance of rock-holes and crevices is not reliable to implant new seedlings (as a future challenge we should find new techniques to test these conditions before planting).
- The crown cornices at the top of tall coastal-cliffs seem to be a good habitat to try future projects (i.e. to enlarge the current population, or to generate close neo-populations).

Success of project

Highly Successful	Successful	**Partially Successful**	Failure
		√	

Reason(s) for success/failure:

- The experience has been drafted to be only a first step for a successful re-introduction, in order to overcome the problems found in former re-introduction attempts to establish the first generation (*in situ* seed-producer plants). True success can only be tested after a long period i.e. to make regular monitoring climbing below the current plants along all the cliffs which are 130 m tall.
- The success of this first phase is due to the permanent work of the Nature Park keepers. In natural conditions (without human assistance) the regeneration would need millions of seeds.
- The site conditions, the cornice at the cliff top, is able to ensure a reduced access to predators and human visitors.
- Most micro-sites cannot be tested before the plantation (i.e. to know the soil or rock crevice deep); in this case at least 1/3 of the micro-sites (chosen because of their external good appearance) could really be unsuitable for a re-introduction.

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